The
Telecommunication Journal of Australia

VOL. 11, No. 6 — Registered at the General Post Office, Melbourne, for transmission by post as a periodical. — FEBRUARY, 1959

CONTENTS

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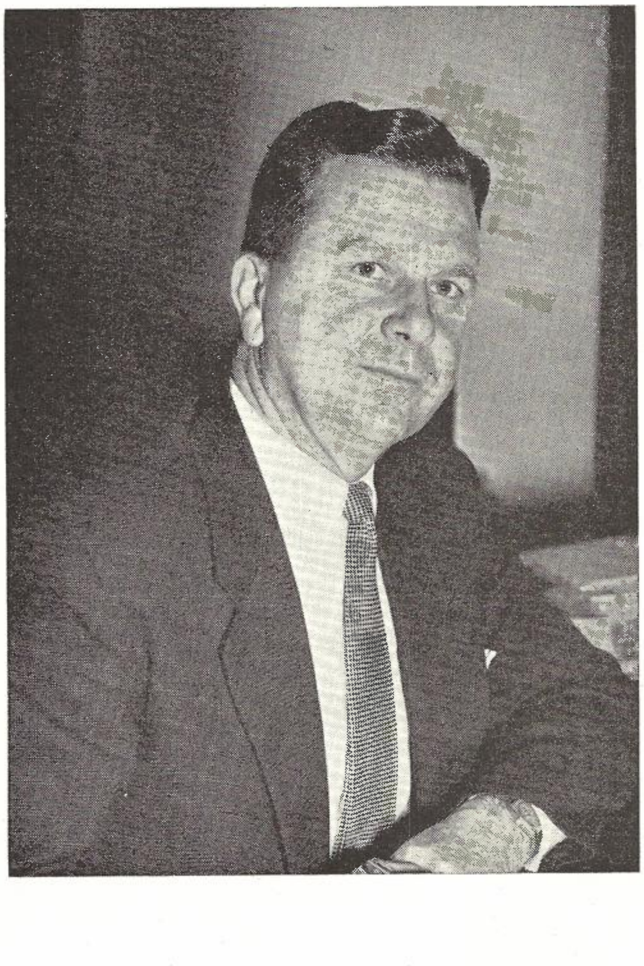
VOL. 11, No. 6 FEBRUARY, 1959

DIRECTOR-GENERAL—CHANGE IN APPOINTMENT



MR. M. R. C. STRADWICK, O.B.E.

On January 2, 1959, Mr. M. R. C. Stradwick, O.B.E., succeeded Mr. P. E. R. Vanthoff, O.B.E., M.V.O., as Director-General, Posts and Telegraphs.

Mr. Stradwick began as a Telegraph Messenger at Perth in 1920. After service as a Draftsman in Melbourne, he went to Sydney in 1938 to the newly created position of Assistant Superintendent, Education and Welfare, in the Personnel Branch. Four years later, he was transferred to Headquarters and, in 1948, became Chief Inspector (Personnel). In 1951, he was promoted as Assistant Director-General (Telephones) and, in 1954, with the establishment of the new Telecommunications Division to direct all activities of the Telephone, Telegraph and Radio Branches, he became its first Assistant Director-General.

During recent years, Mr. Stradwick has handled several special assignments with outstanding success. He was Chairman of the Departmental Royal Visit Communications Committee and of the Communications and Broadcasting Committee for the 1956 Olympic Games. He is also Chairman of the Post Office Policy Planning Committee and of its Administrative Review Committee. Mr. Stradwick is a Fellow of the Australian Institute of Management. He has always been interested in the promotion of youth welfare and is a member of the Board of Directors of the Y.M.C.A. (Melbourne) and of its Finance and Executive Committee.

In 1957, Her Majesty the Queen honoured Mr. Stradwick with the award of O.B.E.

The Board of Editors congratulates Mr. Stradwick on his appointment, and on behalf of the Postal Electrical Society offers him full support in the work which lies ahead.

MR. P. E. R. VANTHOFF, O.B.E., M.V.O.

With his retirement from the position of Director-General, Mr. Vanthoff, O.B.E., M.V.O., ends a successful and colourful career in the P.M.G.'s Department. As reported in our June 1958 issue Mr. Vanthoff commenced in the Department as a telegraph messenger in 1908. He occupied a variety of positions in the Telephone and Postal Services Branches until his appointment in 1958 as Director-General. The Society takes this opportunity to wish Mr. Vanthoff a long and happy retirement.

TOOWOOMBA–LINK TYPE CROSSBAR AUTOMATIC EXCHANGE

*F. P. O'GRADY, M.I.E.Aust., S.M.I.R.E.Aust.**

INTRODUCTION

Toowoomba, a thriving city of 45,000 population in Southern Queensland has reached the stage where the existing manual telephone exchange, part magneto and part common battery, is no longer adequate for the telephone needs of the city itself and of its surrounding area. An automatic exchange is required to ensure satisfactory service under present-day conditions. Advantage was taken of the adoption of new switching principles laid down by the A.N.S.O. (Automatic Network and Switching Objectives) Committee to provide Toowoomba with an automatic exchange which would incorporate equipment capable of meeting all of these requirements. Toowoomba will thus be the first part of Australia to have exchange switching equipment suitable for the application of the A.N.S.O. principles. These principles, in brief, make it possible for a fully subscriber dialled trunk line service to be provided ultimately for Australia.

GENERAL FEATURES OF EQUIPMENT ORDERED

The equipment now on order for Toowoomba is of the crossbar type. It uses the link type trunking principle now in rapidly expanding use in the United States, Sweden and other countries. The equipment is being supplied by L. M. Ericsson Telephone Company Pty. Ltd. of Sweden. The equipment will have an initial capacity of 3,800 lines and is capable of expansion to 6,300 lines.

The system is a register controlled system utilising what are known as complete or central registers. In this system all the digits dialled by the subscriber are stored in the one register. This gives the register complete information to enable it to determine the subsequent switching operations required, either in the Toowoomba exchange itself or in any other part of the network. In the first installation at Toowoomba the register will be suitable for setting up calls locally within the city area, to branch exchanges in Toowoomba, to nearby R.A.X. or manual exchanges, or to the metropolitan area of Brisbane. At a later stage it will be possible to provide registers which will enable Toowoomba subscribers to dial to the remaining parts of Australia.

*Mr. O'Grady is Deputy Engineer in Chief.

The initial installation will include multi-metering equipment which will be fully in conformity with the A.N.S.O. requirements. The subscribers' meters will be pulsed at a rate proportional to the appropriate trunk charge to be applied. In the incoming direction other towns and the Brisbane main trunk exchange operators will be enabled to dial direct into Toowoomba and through Toowoomba to other branch automatic exchanges (Middle Ridge and Newtown).

The main features of the central registers are:—

(a) They can receive digits from telephones with dial speeds between 8 and 22 impulses per second. This is a considerable departure from the normal Strowger equipment in which the dial speed must be maintained within much closer limits.

(b) The dial ratio of make to break can vary from 30/70 to 50/50 without difficulty. This is also a big improvement on step-by-step operation without registers, where the dial ratio must be very closely maintained to ensure satisfactory stepping of the vertical and rotary magnets.

(c) The registers can translate the dialled number into other appropriate codes where necessary and thus permit the group selector stages to handle the traffic via direct, tandem or alternate routes. The number of selector stages will consequently be independent of the proposed or future numbering schemes.

(d) The registers will transmit the digits to the crossbar selector stages by means of a high speed D.C. code pulse train.

(e) The registers will transmit decimal impulses at the normal speed and with normal ratio of make to break to the branch automatic exchanges (Middle Ridge and Newtown) which are step-by-step equipments.

(f) The registers are suitable also for the future transmission of signals to distant exchanges by means of the high speed multi-frequency technique.

CONCLUSION

Exchanges of the crossbar automatic type are in use at present at Templestowe, near Melbourne, and Sefton, near Sydney. These exchanges are relatively small (500-1,000 lines approximately) (Ref. 11). Because of their relationship to the rest of the metropolitan networks and their small size, they have not been equipped with the full register system nor with many other of the interesting features which will be incorporated in the Toowoomba equipment. They do, however, use the crossbar switches and many of the basic principles of this type of exchange. The experience to be gained in the new Toowoomba installation will supplement the Departmental experience already being obtained with Templestowe and Sefton and will be of considerable interest to the officers of the Department who are concerned with the planning for the full adoption of a system which will be suitable for an ultimate subscriber dialled network.

This article is intended purely as an introductory one and in subsequent articles more details of the Toowoomba equipment will be discussed.

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GENERATION OF ARTIFICIAL TRAFFIC BY AUTOMATIC ROUTINERS

*J. K. PETRIE
*J. B. TAYLOR

INTRODUCTION

Artificial traffic equipment is now in common use in the Australian Post Office and has been proved to be a valuable aid to qualitative maintenance as an indicator of the standard of service being given in automatic exchanges. This type of equipment was originally developed for use in the British Post Office [1] and was first installed in Australia in the City West Exchange, Melbourne[2].

The artificial traffic equipment as supplied to the Australian Post Office suffers from two main disadvantages:—

(i) The equipment is connected to a maximum of 24 spare line circuits from which traffic is originated; this traffic is directed to 25 spare multiple numbers. As these lines are usually jumpered to the artificial traffic equipment on the I.D.F., alterations to either group of lines cannot be made readily without a considerable amount of work.

(ii) The traffic is limited to local calls and calls to nearby exchanges because the terminating equipment is an integral part of the artificial traffic unit, and three wire connections are required between the I.D.F. and the unit.

Of the traffic originated in an exchange only about 30% terminates locally, whereas up to 70% of traffic is routed over junctions to other exchanges in the network. In order to assess the standard of service in a network it is essential that the artificial traffic equipment should be capable of directing traffic over any junction route. Experience in the Brisbane network has shown that while the standard of service in the local exchange is generally very good, it falls off considerably over junction routes, due mainly to the impulse repetitions involved on calls from one side of a network to the other. This point is emphasised here because it is essential that the standard of service over junction routes should be oversighted to ensure satisfactory service.

USE OF ROUTINERS FOR ARTIFICIAL TRAFFIC

Following the installation of the first artificial traffic equipment in Brisbane, it was soon apparent that additional equipment would be required to adequately cover the network. As additional units could not be obtained quickly from overseas, it was decided to make up some form of artificial traffic generator locally. At that time relay set repeater routiners at some main exchanges had already been altered to provide dialling facilities for testing over junctions, so the logical step was to investigate the possibility of altering group selector routiners for artificial traffic generation and to design a terminating relay set which could be used at a remote location.

The use of the group selector routiner offers the following advantages:—

(i) Ready means of access to all first selectors.

(ii) Dialling facilities already exist on the routiner test unit.

(iii) Common services and alarms exist and can be utilised.

(iv) Some of the existing relays and circuits on the routiner perform functions which can be used to provide similar functions under artificial traffic conditions.

(v) A tone detector circuit exists on the routiner and this can be used in identifying the called number and for checking transmission.

(vi) Continuous routine facilities exist and can be used to advantage in the artificial traffic unit.

There are also some disadvantages in using the group selector routiner for this purpose. However, the advantages outweigh the disadvantages which are:—

(i) Existing routiner wiring has to be changed although the routiner facilities are not affected. In altering the routiners for artificial traffic working in Brisbane the routiners have never been out of commission for more than a few hours at a time.

(ii) More than one routiner may have to be altered in larger exchanges, but this is not the case where one routiner has access to all first selectors. It may also be convenient in some cases to originate traffic from other than first selectors.

(iii) The routiner is permanently installed and cannot be transported to another exchange. This disadvantage is not regarded as serious because the authors consider that the artificial traffic unit can be used for many other testing purposes, so that there is sufficient use for an artificial traffic unit in most exchanges where automatic group selector routiners have been installed.

(iv) While the artificial traffic unit is being used, it precludes the use of the automatic routiner for purely routining purposes. However, under qualitative maintenance, it has been found possible to reduce the routine test frequency to such an extent that this disadvantage is not serious.

(v) Because the artificial traffic generating circuit becomes part of the routiner circuit, it would not be possible to buy the artificial traffic unit as a separate item to be attached to the routiner, but certain parts of the unit could be manufactured as units and pre-wired.

Further examination showed that the artificial traffic facility could be added to the routiner circuit without altering any of the normal facilities of the routiner. There are sufficient spare contacts on the routiner test switch for the test to be applied by the artificial traffic equipment and space is available on most routiner racks to accommodate the extra equipment.

DESCRIPTION OF THE UNIT

The extra equipment required in the group selector routiner for the artificial traffic unit consists of 25 relays, two 8 level uniselectors, a jack field for the easy changing of called numbers and a simple twenty second electronic delay circuit. The uniselectors and most of the extra relays are mounted at the bottom of the rack below the access control unit as can be seen in Fig. 1.

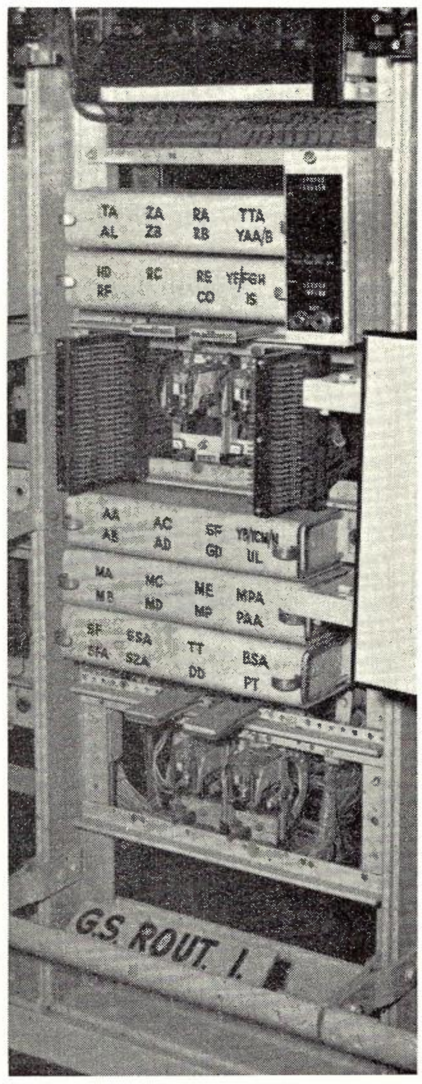


Fig. 1—Showing Mounting of Extra Equipment.

*Mr. Petrie is a Divisional Engineer, Service Brisbane. Mr. Taylor is an acting Group Engineer, Telephone Equipment Section, Central Office.

A few relays closely associated with the routiner test unit circuit, have been mounted in spare relay spaces on the test unit itself. The jack field which consists of traffic recorder type connection strips is mounted on a hinged frame at the rear of the control panel (see Fig. 2), while the twenty second delay circuit is fitted in a six-way vertical mounting at the top of the rack adjacent to the existing valve circuits, as shown in Fig. 3. The keys, lamps and meters are mounted in spare spaces on the existing control panels (see Fig. 4).

FACILITIES PROVIDED BY THE UNIT

The artificial traffic unit may be used for fault tracing or to assess the standard of service being given by the exchange equipment. It provides the following facilities:—

For Fault Tracing:

(i) Access to all first group selectors via existing routiner access equipment.

(ii) Selection of all first selectors, incoming or local selectors separately if desired. This can be extended to other special selectors such as early or late choices.

(iii) Engaged selectors can be omitted from test to prevent waste of time in "Camping On." (The latter two facilities may be associated to provide flexible selection).

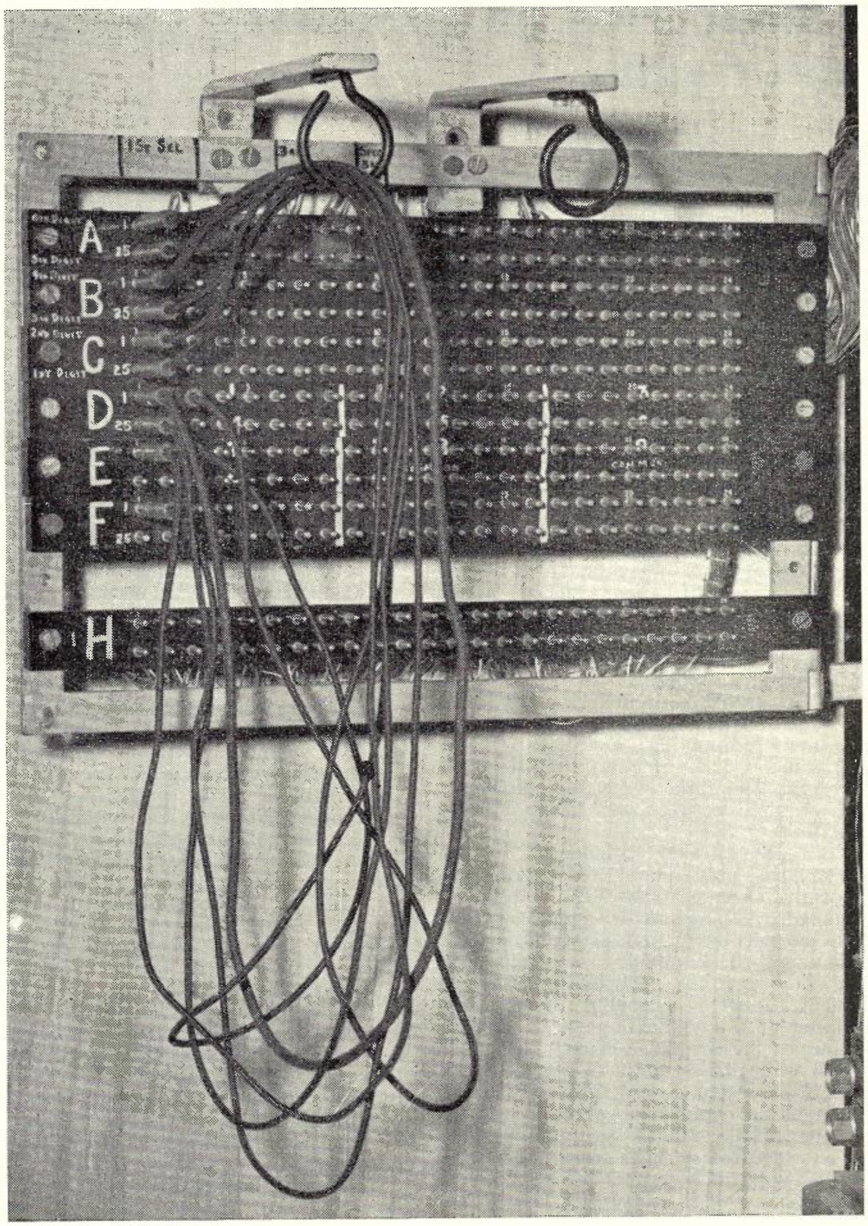


Fig. 2.—Jack Field showing One Set of Cords Plugged Up.

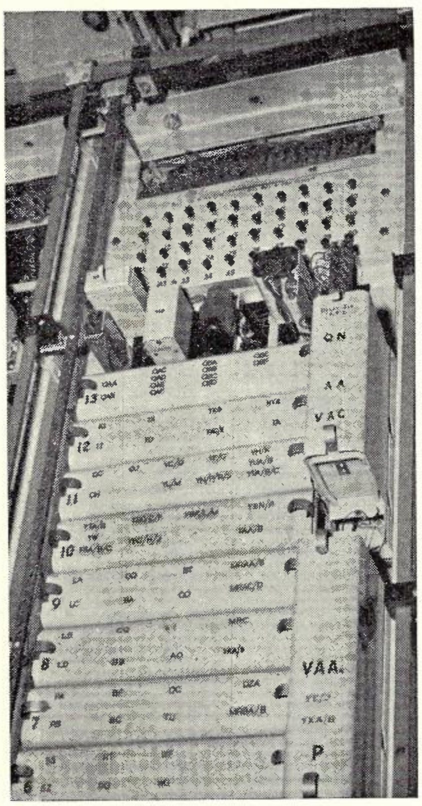


Fig. 3.—Top of Rack showing Test Number Keys.

(iv) Normal routiner tests deleted when the artificial traffic key is operated.

(v) A minimum of two and a maximum of seven trains of impulses may be sent. (The equipment being described is arranged for a maximum of six trains only).

(vi) Lamp indication of which train is being sent.

(vii) Up to twenty numbers may be called.

(viii) Lamp indication of the number being called.

(ix) The numbers to be dialled may be easily changed by means of cords in the jackfield.

(x) Called number automatically changed after each selector is tested.

(xi) Interdigital pauses of constant duration (approximately 800 milliseconds).

(xii) During each interdigital pause the connection is tested for a reversed trunk.

(xiii) Connection checked for premature metering during setting up of the call.

(xiv) Connection checked for open circuit negative, positive or private leads, the local portion of the call being held and the selector prevented from releasing.

(xv) Remote terminating relay set used for called number, thus allowing tests to be carried out over any junction network.

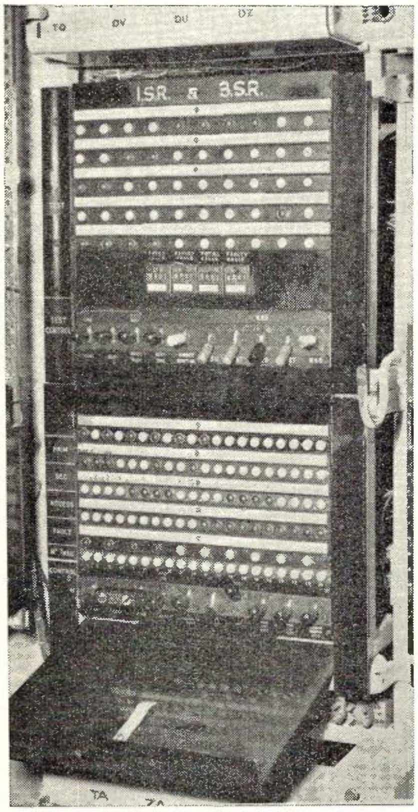


Fig. 4.—View of Control Panels.

(xvi) Ringing current from the final selector is checked by the terminating relay set.
(xvii) Call is tripped by the terminating relay set.
(xviii) Final selector at the terminating exchange tested for reversed positive and negative leads to the called party.
(xix) Metering checked.
(xx) Reversal checked.
(xxi) Called number positively identified.
(xxii) Transmission checked by level of tone fed back over the connection.
(xxiii) Two calls originated from each selector, the first via a lower choice and the second via an upper choice, to the same called number.
(xxiv) During the previous test the busying earth to the alternate choice is of pulse duration only.
(xxv) Testing may be from one or all of first selectors to one or all the selected test numbers.
(xxvi) Continuous testing from all selectors to one selected called number if desired, the called number being selected by a selecting key.
(xxvii) Total number of test calls registered.
(xxviii) Total number of faulty calls registered.
(xxix) If fault encountered or called number not identified within twenty seconds call is held, an audible alarm and a visual indication of the type of fault is given.
(xxx) Test cycle of two calls from each selector is thirty-six seconds.

As a "Standard of Service" Tester:

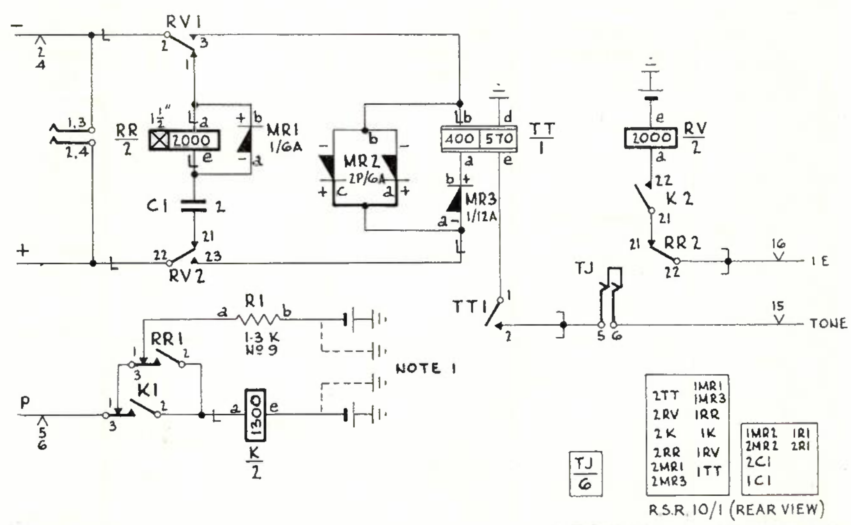
The facilities provided for this method of testing are similar to the above with the following variations:—
(i) Only one call made from each selector, no direction as to lower or upper choices being made.
(ii) If any test fails the equipment is automatically reset after operation of the "Faulty Calls" meter, and testing recommenced from the next selector.
(iii) Test cycle of one call from each selector is eighteen seconds.

OPERATION OF THE UNIT

The required test numbers are set up on the jack-field by means of cords and plugs. Fig. 2 shows the jack-field with the first number 7 7411 set up. The required quantity of test numbers, up to a maximum of 20, may be set up in this manner. The test numbers, which may be in any exchange or exchanges in the network are connected to the terminating circuits shown in Fig. 5. In the Brisbane network, at least one of these relay sets (2 circuits) has been installed in each exchange and a number of test numbers paralleled to each circuit. In the larger exchanges a larger number of test numbers are permanently connected to the key panel which may be seen at the top of the rack in Fig. 3. These test numbers are normally connected to N.U. tone via the keys, but when the appropriate key is operated the test number is disconnected from the N.U. tone and connected to a terminating circuit. To save multiple numbers it would be possible to connect the terminating circuit to existing routiner test lines and arrange the unit to dial 9 and 11 as the last two impulse trains.

In making the tests the unit may be directed to originate traffic from (i) all first selectors (ii) local first selectors only or (iii) incoming selectors only by the operation of the key "Incoming or Local" to the appropriate position. To obviate the delay caused by the unit "Camping on" busy selectors it can be arranged to step over these by the operation of the "Busy Unequipped" key.

The operation of the "Artificial Traffic" key disconnects the normal routiner circuits and prepares the unit for artificial traffic generation and use under fault finding conditions. The operation of the normal routiner "Start" key causes the access control circuits to function in the usual manner and the first (or first free) selector is connected to the test unit. After looping, a check is made to ensure that earth has been returned on the private wire and the unit commences to send the first train of impulses, at the end of which the P2 wiper is earthed during rotary search to ensure selection of a lower choice. During the call the private wire is checked continuously to ensure continuity and that premature metering does not occur. At the end of each train the negative and positive wires are checked for correct polarity and after a constant interdigital pause of 800 milliseconds the following train is sent. If premature metering occurs, or an open circuit negative, positive or private wire is encountered in the local exchange, the connection is prevented from releasing, the unit ceases sending, the alarm is operated, and a lamp indication of the cause of failure given.



RELAY DATA

RELAY	COIL		SPRINGSETS	ARMATURE			LABEL
	RESISTANCE	B.P.O CODE		TYPE	RESIDUAL	TRAVEL	
K	1300	9/SCO/440	K / M	ORD	4M STD	31M	W
RV	2000	4/SCO/441	C / C	"	"	"	"
RR	2000	11/SCO/468	K / B	"	10M SCW	"	"
TT	400 + 570	13/SCO/451	M / -	1STH	"	"	"

Fig. 5.—Circuit of Terminating Relay Set.

These lamps are designated "Early Meter", "Reverse Trunk", "Negative" and "Positive Disconnect" and "Open Circuit Private". During the sending of each train of impulses an appropriate lamp indication that is "First Train", "Second Train" etc., is given to assist in determining the switching stage at which the failure occurred.

At the conclusion of the last train the tone detector circuit is connected to the line and a start condition applied to the twenty second delay circuit. The ringing current from the final selector is checked by the terminating circuit, the call is tripped, the polarity of the battery feed from the final selector checked and tone fed back over the line. Sub. flashing conditions controlled by interrupted earth are then applied to the line so that loop and tone, then no loop and no tone, are alternately presented to the D relay in the final selector. The artificial traffic unit checks (i) that a positive battery meter pulse is received followed by a line reversal and tone at the correct level, (ii) that the tone and reversal are removed and (iii) that the reversal and tone are reapplied. If these three conditions are received before the end of the twenty second time delay the call is accepted as having been effective and the connection is released. A second call is then set up from the same selector to the same test number, but this time the P 1 wiper is earthed to ensure connection via a HB choice. If the call fails to mature within the required twenty seconds, the alarm is operated and the relevant fault lamps are displayed, that is "No Meter". "No Tone" and "No Reversal". During each test call the "Total Calls" meter is operated and in the case of a faulty call, the "Ineffective Calls" meter is also operated.

After completion of the second call from the first selector the routiner access switch is stepped to the next (or next free) selector while the called number switch is stepped to the next number to be called. If so desired, the "Continuous Test" key (as distinct from the "Continuous Routine" key) may be operated so that the same number is dialled from all selectors. Any particular called number among those already set up may be selected by stepping the called number switch with the stepping key, a lamp indication is given of the particular called number circuit being used. By operating the "Continuous Routine" key, calls may be made continuously from one selector, the called number being changed after each two calls (one via the lower choice and one via the upper choice). If both the "Continuous Test" and "Continuous Routine" keys are operated continuous calls from one selector to one test number may be made.

The standard of service of the exchange or junction route may be observed by operating also the "Observe Service" key. Under these conditions only one call is made from each selector (no control of lower or upper choice) and if a fault is encountered the ineffective call meter is operated as before but no alarm is given, the unit automatically resets and continues testing.

The unit can originate two hundred calls per hour under "Observe Service" conditions since each call takes only eighteen seconds, while under fault tracing conditions each two calls (one lower choice and one upper choice) takes thirty-six seconds, that is one hundred test cycles or two hundred calls per hour. If used continuously the unit causes an added traffic load of approximately .85 Erlang per switching stage over the route tested, and, assuming test calls to six figure numbers over two junctions, the total current requirements are approximately 3.5 amps. for the unit itself and 1.7 amps per Erlang for switching, that is a continuous current drain of approximately 5 amps.

This artificial traffic unit, which was placed in service in June 1957, and the other similar units since completed, have proved very successful in detecting defects in the Brisbane network. Some modifications are still being investigated, one of these being the inclusion of a busy tone detector to register automatically any congestion experienced.

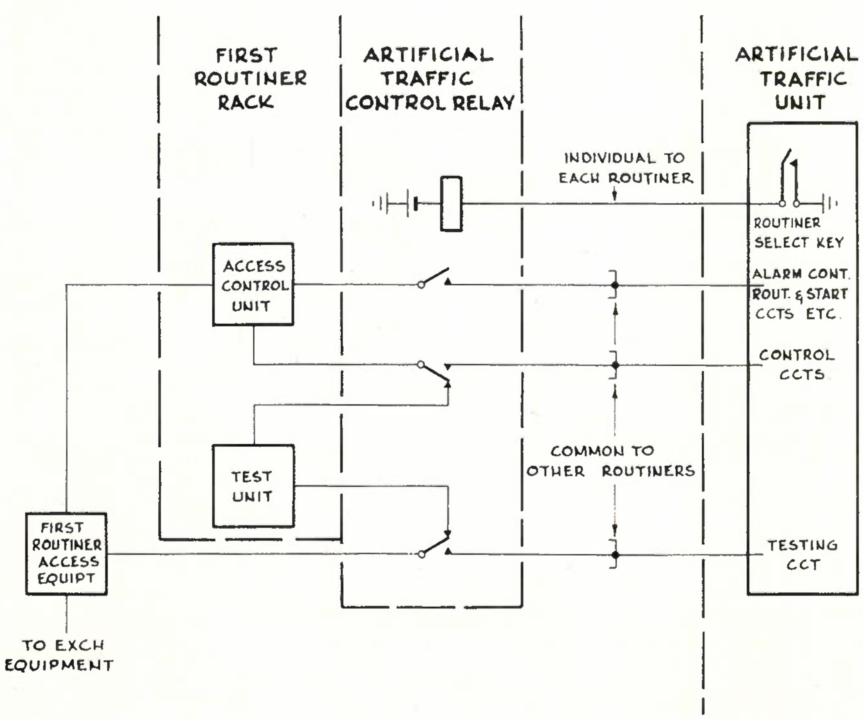


Fig. 6.—Suggested Method of Connecting Artificial Traffic Equipment.

APPLICATION TO D.S.R. ROUTINERS

In order to extend similar facilities to branch exchanges, action has been taken to adapt a D.S.R. routiner to provide similar artificial traffic generation. Some variation in facilities has been necessary and these are briefly:—

(i) Under fault tracing conditions three calls are made from each D.S.R.—one local call, one call to a branch exchange and one call via the junction hunters. One or more of these calls can be eliminated by the operation of the appropriate key.

(ii) After discrimination has occurred the D.S.R. is checked to determine whether or not the call has been alternate routed and if so an appropriate alternate route meter is operated to indicate the number of calls alternate routed.

(iii) "Standard of Service" tests can be made under any of the three conditions required—local call, branch call or junction hunter call — by the operation of the appropriate "eliminate" keys.

(iv) By operating the "Alternate Routing" key local or branch calls can be forced to take the alternate route to check the service via this path. By alternate routing local test calls, the incoming route to the local exchange can be tested by the local artificial traffic unit.

A modified D.S.R. routiner has now been in service for a period and has proved to be as satisfactory as the group selector unit.

OTHER USES OF ARTIFICIAL TRAFFIC UNITS

The normal use of artificial traffic equipment is generally well appreciated and experience in Brisbane has shown that when all artificial traffic results are recorded and analysed many circuit and equipment deficiencies can be discovered and corrected. Analysis of faulty calls over several junction routes have resulted in improvement to conversion circuits between 2,000 type and Siemens No. 16 exchanges where previously the circuit weaknesses had existed undetected.

It has been found also that artificial traffic units can be successfully put to uses other than those for which they were primarily intended and some of these are discussed below:—

(i) An intermittently faulty subscribers uniselector can cause subscriber's complaints of "can't be raised" and "busy when not"; these faults have been successfully located by means of a special terminating relay set in association with the artificial traffic unit. This relay set provides the same facilities as the one previously described but in this case it is connected to the subscriber's line by means of a shoe on the M.D.F. via a circuit similar to that used for Test Set No. 12, that is the subscriber's multiple is connected to the terminating relay set while the line is connected to a spare line circuit so that the subscriber can continue to make outgoing calls. Artificial traffic is directed to the subscriber's multiple number in the usual way but at the conclusion of each call the line circuit is momentarily looped by the terminating relay set so that the subscriber's uniselector drives and the succeeding test is carried out with the second set of wipers on the home contact. This method has proved easier and more successful than the usual method of making a few test calls from each final selector.

(ii) Complaints from P.B.X. and P.A.B.X. subscribers have been similarly handled by directing artificial traffic to a spare number at the end of the subscriber's number sequence. In Siemens No. 16 exchanges in Brisbane an open circuit A or positive wire anywhere in the exchange common equipment causes complaints of "calling no voice" and other troubles on C type P.A.B.Xs. By the use of artificial traffic this type of fault can be quickly localised. The previous method was to institute link testing, a slow and laborious operation in a Siemens No. 16 exchange and this could only be undertaken during periods of light traffic.

(iii) Reduction in normal routine testing is possible when artificial traffic tests are carried out. As an experiment all automatic routining of first selectors in one 2,000 type main exchange was eliminated for a period of three months and all testing performed periodically by the artificial traffic unit. At the end of the three months a full automatic routine test was carried out and only one fault was detected, that being an unstandard condition. Therefore a routiner adapted for artificial traffic working has been proved to be a satisfactory unit for routining group selectors under service conditions fulfilling a need which has long been felt in 2,000 type exchanges.

(iv) In some exchanges artificial traffic units have been successfully employed as link testers, the unit being set up to dial an appropriate number while the technician busies out each choice in turn. This application is particularly successful in Siemens No. 16 exchanges where link testing has been shown to take up to six times as long as the equivalent in a 2,000 type exchange.

(v) Calls can be originated from subscriber's line equipment following complaints of trouble on outgoing calls, "can't get exchange" etc. This can be done with the routiner type artificial traffic unit, if connection to the subscriber's line equipment is made via a spare outlet of the routiner access selector.

The preceding cases have been quoted in order to show that the possible uses of an artificial traffic unit are many and varied. Even though the usual artificial traffic tests would only require to be performed periodically the equipment can be usefully employed at other times.

POSSIBLE DEVELOPMENT

While the two artificial traffic units described in this article have shown that the generation of artificial traffic from automatic routiners is practical the authors consider that further development will produce better and more flexible artificial traffic equipment. One suggested line of development is the provision of the artificial traffic equipment as a separate unit but employing remote terminating relay sets along the lines described in this article capable of being connected to any number and type of routiner in the exchange by means of keys. (see Fig. 6).

The advantages of this development would be:—

(i) If the unit could be connected to any number or type of routiner, artificial traffic could be originated from any desired point in the exchange.

(ii) All equipment in the exchange would be directly tested by the unit.

(iii) The artificial traffic unit could be standardised.

(iv) The complete unit could be manufactured, easily installed, and connected to existing routiners causing less interference to existing routiner wiring.

(v) Only one unit would be required in each exchange.

(vi) Provision could be made for additional facilities such as a loud speaker, additional meters for analysis of types of faults, special tone equipment for ease of fault tracing, etc.

The main disadvantages of this scheme appear to be:—

(i) As the unit would be associated with all routiners in the exchange it would be necessary to refer to the lamps on both the unit control panel and the routiner control panel. In an existing exchange these could be some distance apart.

(ii) Some equipment already existing on the routiners would have to be duplicated on the artificial traffic unit resulting in a more expensive unit. However, as only one unit would be required in any exchange this is not a serious disadvantage and in fact the unit would probably cost little more than the present standard artificial traffic equipment.

CONCLUSION

In this article the authors have described a method of ready access to automatic exchange equipment for the purposes of artificial traffic generation and have shown that this type of equipment may be adapted to fulfil many additional functions in automatic exchange maintenance. A suggestion has been made as to a possible line of development for the production of better artificial traffic units. Artificial traffic equipment is a valuable indicator in carrying out qualitative maintenance and the development of better units will pave the way towards better maintenance and improved standard of service in automatic exchanges.

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PRINCIPLES OF CROSSTALK AND NOISE SUPPRESSION AT OPEN-WIRE AND BALANCED CABLE CARRIER STATIONS

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

INTRODUCTION

The noise and crosstalk performance of a communication channel may be controlled satisfactorily by a combination of measures based on two different principles; suppression and cancellation. The suppression principle is based on the provision of adequate attenuation in all paths leading from sources of noise and/or crosstalk to the point of pick-up in the disturbed channel. As an example of this method may be mentioned the efforts usually made to obtain close matching between the impedances of lines and their associated equipment. The close matching minimises reflections at this point with the result that crosstalk effects due to near-end crosstalk between different lines may be kept within acceptable limits. The cancellation principle is based on artificial injection by controlled means of noise and/or crosstalk in antiphase with noise and/or crosstalk due to "natural causes". Crosstalk balancing of cable pairs, and the transposition of open-wire pairs used as bearer circuits for carrier equipment are good examples of the application of the cancellation principle.

An investigation of noise and crosstalk paths at long line equipment stations was undertaken recently in connection with the necessity to increase the number of channels per cable pair on several trunk cables, and the necessity to provide basic information for the preparation of installation engineering instructions and performance specifications for carrier equipment. This investigation revealed the existence of a large number of crosstalk and noise paths to which scanty references only may be found in the literature. The crosstalk and noise due to these paths were found to be controlling for the upper channels of ordinary 12-channel cable and open-wire systems and also to be prohibitive for the proposed operation of 24- and 34-channel cable systems. It was found however that the suppression in these offending paths could be increased by relatively simple and inexpensive modifications to such an extent that the resulting crosstalk and noise was virtually non-existent.

The initial investigations were carried out at stations on the Melbourne-Seymour cable route, and the principles established were later applied to a number of open-wire carrier stations.

This article describes the offending paths together with the most practicable methods of providing the required suppression. The actual work involved in the modifications and the resulting improvements in crosstalk and noise will be described in a later article. The crosstalk paths concerned are usually from the output of a transmitting amplifier (that is from a "high" level point) to the input of a receive amplifier (that is a "low" level point), and "third" circuits are very often involved. For these reasons the resulting crosstalk is referred to as "interaction" or "run-around" crosstalk.

The investigations included numerous laboratory measurements, more than 100,000 measurements of interaction crosstalk at cable carrier stations, and many thousands of measurements at open-wire stations. A considerable number of theoretical considerations were also involved. Many details of interest for the preparation of engineering instructions and equipment specifications have not been included here, but are given in two Long Line Equipment Laboratory Reports on the subject (Refs. 1 and 2).

DEFINITIONS AND CROSSTALK REQUIREMENTS

Some of the examples and figures given in this article are applicable to cable stations only, but they would with few alterations apply equally well to open-wire stations, except that the complexity of the "third" circuits is usually much greater in open-wire stations than in cable stations. In the following text such words as "pair", "repeater", "stations", "equipment", etc., are preceded by "cable" or "open-wire" when the description applies to one only of the two types of installation. If the description applies to both types the word "cable" or "open-wire", is omitted. In cases where the description applies to one type of installation only and there is little risk of ambiguity, the word "cable" or "open-wire" has also been omitted.

"Interaction crosstalk" as used herein means the crosstalk from the "output" of a repeater (or terminal transmitting equipment) to the "input" of other repeaters (or terminal receiving equipments).

Since interaction crosstalk attenuation, in accordance with the definition given, is measured between points of different test level, the requirement for this type of crosstalk attenuation must be greater by this difference in level than the requirement for the channel crosstalk resulting therefrom.

In case of cable carrier installations, the interaction crosstalk may be controlled readily and economically. Furthermore, due to the relatively close spacing of repeaters and the large number of repeaters at each station, a large number of interaction crosstalk paths exist. For these reasons the channel crosstalk caused by each interaction path should be better than 80 db, and consequently the limit for each interaction crosstalk attenuation is 80 db plus the difference between the test levels. However no significant advantages are obtained from an increase in interaction crosstalk attenuation beyond the value where it equals the difference between the level transmitted to line and the thermal noise level per channel.

The thermal noise in a terminated circuit is —138.5 dbm (assuming a temperature of 20°C. and C.C.I.F. 1951 psophometric weighting, the equivalent bandwidth of which is 1800 c/s). The requirement for interaction crosstalk attenuation on cable routes is thus the lower of the two values:

80 db + the difference between the two test levels.

138.5 db + transmitted level per channel.

For operation over 60 db cable sections employing a transmitted test level of +5 dbm per channel, the requirement for interaction crosstalk attenuation would thus be 140 db. In the case of the Melbourne-Seymour route operation over 80 db sections, employing a transmitted level of +20 dbm per channel for the higher frequency channels was proposed, resulting in a requirement of 158 db.

In case of open-wire installations it is often difficult and expensive to control completely all "third" circuits, particularly if they are owned by other authorities (power lines, railway signalling and railway communication lines). Furthermore, due to the relatively large spacing between repeaters and the relatively small number of repeaters usually provided at each station, the number of interaction crosstalk paths is much smaller than in the case of cable carrier installations. For these reasons it might be necessary at certain stations to accept interaction crosstalk attenuation of such value as to result in channel crosstalk of 65db, but it is considered that the target, wherever economically possible, should be 80 db. For operation over 40 db open-wire sections employing a transmitted test level of +17 dbm per channel, the requirement for interaction crosstalk attenuation would thus be 120 db, with 105 db being acceptable in certain special cases.

PRELIMINARY INVESTIGATIONS AND METHOD OF MEASUREMENT

The initial interaction crosstalk attenuation tests were carried out in the "normal" fashion, that is the carrier equipment was disconnected from the two pairs under test and replaced by an oscillator connected to the transmit pair and a selective db-meter connected to the receive pair. These tests revealed that the interaction crosstalk attenuation between any two chosen pairs was dependent to a large extent on whether equipment was connected to other pairs and on the terminating conditions of the

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non-carrier lines. Thus, in case of cable carrier installations, interaction crosstalk attenuation of 160 db at 108 kc/s was obtained from the pairs of "send" cables into the pairs of "receive" cables, if all pairs were disconnected from the equipment by removing the U-links at the cable-heads. With the normal office equipment connected to all pairs, except the two under test, most figures were in the order of 125 db, whilst the worst and best figures were 110 and 150 db respectively. (Ref. 3). It was consequently suspected that conditions would be still worse if the pairs under test were also left connected with their equipment, so that all equipment and pairs remained in their proper operation conditions.

It was therefore essential to develop special test gear, permitting measurements to be made on a bridging basis, leaving the equipment and lines in the normal operating conditions. A bridging loss (Ref. 4) of 1 db was considered acceptable. Furthermore, the transmitted levels and frequencies had to be so chosen that the normal operation of the equipment was not significantly impaired, and conversely the levels and frequencies used for normal operation of the carrier systems would not interfere into the crosstalk measuring receiver. The test set-up was required to enable measurements of attenuation to be made up to 160 db or better on the Melbourne-Seymour route (proposed 24-channel working, up to 108 kc/s); 145 db or better on the Sydney-Maitland route (proposed 34- channel working, up to 140 kc/s), and 140 db in the case of 60 db repeater sections. For measurements on the Seymour route a frequency of 115 kc/s was chosen, this frequency being above the proposed upper frequency of 108 kc/s and also half way between this and the 120 kc/s group modulating frequency. By this choice, the selective db-meter would not be influenced by the 108 and 120 kc/s carrier leaks. For the Sydney-Maitland route the frequency chosen was 160 kc/s, this being well above the proposed upper channel frequency of 140 kc/s and the 144 kc/s group modulating frequency. Furthermore, the upper channel frequency of a 36-channel system is 156 kc/s, and the test frequency of 160 kc/s would be suitable for that type of system also. For convenience the frequency of 160 kc/s was also used for investigations of 12-channel open-wire routes operating in the 36-143 kc/s range.

In case of measurements on "go" and "return" carrier cables made by transmitting across "Repeater Out" and measuring across "Repeater In" in the opposite direction of transmission, if the measurements are carried out at a frequency inside (or close to) the line-frequency band of the equipment operatnig on the pairs, interaction crosstalk at all the station further along the route will be "seen" unattenuated; the figures obtained are thus not representative of the performance of the station at which the measurements are performed. This difficulty may be overcome to a great extent, by measuring at a frequency well above the equalized band of line frequencies, that is at a frequency of about twice the frequency of the upper nominally equalized frequency. Thus, when the equipment on a route utilizes line-frequencies up to for instance 108 or 140 kc/s, interaction crosstalk should be measured at a frequency of 160 and 265 kc/s respectively, and "reference sets" of readings for future references and checks should be taken at these frequencies at a time when it is known that the station performance is good at frequencies in the normal operating band.

Details of test set-ups meeting the above requirements and employing instruments readily available in the Department as "building-blocks" will be given in the later article.

Using these measuring circuits and measuring on a bridging basis, leaving the equipment and associated lines in normal operating conditions, a deterioration in the order of 20 db relative to the figures taken when the two pairs under test were disconnected from their equipment was evident at cable carrier stations.

COUPLING AND CROSSTALK

The term "coupling" is used to indicate that a current and/or voltage in a circuit causes a small current and/or voltage of the same frequency in other circuits. The coupling may be inductive (mutual inductance), capacitive, or take place via common impedances, such as common earth impedance and impedance of a common power supply. Most of the couplings considered in this report are unwanted. Their magnitudes are quoted in terms of the ratios in db between the causing and the caused voltages. The voltage considered may be of a transverse or longitudinal nature, as described later.

The term "crosstalk" is used in lieu of coupling, if the causing as well as the caused voltages are:—

transverse, and:

associated with transmission circuits, and:

inside the frequency band of these transmission circuits.

"LONGITUDINAL" TRANSMISSION

The usual type of transmission considered is the transverse type, that is the signal is applied between the two input terminals of an equipment unit (say a repeater) and the resulting signal between the two output terminals is of interest.

In case of crosstalk investigations, it is necessary to consider also longitudinal transmission. This case is obtained simply by commoning the two input terminals together and connecting the signal source between this point and "earth". At the output the two output terminals are commoned together, and the signal is measured between this point and "earth". Longitudinal transmission is in general no more complicated than the usual transverse. Thus for instance, the longitudinal impedance of a line is synonmous with the "cailho" impedance of that line. This particular impedance is one of some importance in crosstalk considerations. For cable-pairs the value is in the order of 40-50 ohms (resistive) at carrier frequencies, and in the order of 200-300 ohms (resistive) for open-wire pairs (Refs. 5 and 6).

However complicated the signal carried by each wire of a pair may be, it can always be resolved into a longitudinal and a transverse signal, which, if superimposed upon each other, would be equivalent to the original signal. Normally, carrier systems employ transverse transmission on balanced lines (except in the case of co-axial equipment), but a perfectly balanced circuit is not possible in practice, and the "degree of balance" actually existing is a matter of considerable importance. The lack of perfect balance causes a fraction of a transversely transmitted signal to convert itself into a longitudinal signal and vice versa. In this article the degree of balance is defined as the ratio in db between a transversely applied voltage and the resulting longitudinal voltage. It may be shown (Ref. 1) that the overall balance of a circuit is a function of the balance of the individual elements (such as lengths of screened pairs, repeater input and output transformers, etc.) as well as of the longitudinal impedances of the elements. Consequently a full description of balance must include the degree of balance as well as the longitudinal impedance.

Typical figures for balance and longitudinal impedance of common items are shown in the above table.

	Balance	Longitudinal Impedance
Screened Cable	35-50 db	120-200 pF/yard
Carrier Input or Output transformer	35-45 db	500-1000 pF.
VF Input or Output Transformer	25-40 db	750-2000 pF.
Carrier Cable Pair	40-60 db	40 to 50 ohms (see Text).
Open-Wire Pair	20-40 db	200-300 ohms (see Text).

NEAR-END COUPLINGS—CARRIER CABLES AND OPEN-WIRE LINES

Transfer and conversion (from transverse to longitudinal and vice versa) of energy occurs between the pairs of the same cable and between the pairs on the same pole route. The conversion is caused by the same factors as those governing the conversion within a pair as described above.

A series of tests led to the following conclusions concerning these phenomena:

(a) A transverse voltage transmitted on a pair causes a transverse voltage on all other pairs (in the following this is abbreviated to: T/T Coupling.)

(b) A transverse voltage transmitted on a pair causes a longitudinal voltage on all pairs (abbreviated: T/L Coupling).

(c) A longitudinal voltage transmitted on a pair causes a transverse voltage on all pairs (abbreviated: L/T Coupling).

(d) A longitudinal voltage transmitted on a pair causes a longitudinal voltage on all other pairs (abbreviation: L/L Coupling).

The actual magnitudes of these conversions depend of course on the relative positions of the pairs in the cable or on the pole, and on a number of other factors. As a guidance to the order of the magnitudes to be expected, the worst values obtained at two cable stations and one open-wire station are given in Tables 1 and 2.

INTERACTION CROSSTALK DUE TO COMMON EARTH IMPEDANCE

Fig. 1 has been prepared to illustrate the most common paths of interaction crosstalk. This figure and the explanations given below apply to cable stations. The appropriate drawing and explanations relevant to open-wire stations are so similar, that it is not necessary to repeat the explanations for that type of station.

Interaction crosstalk paths due to common earth impedance are indicated by arrows at the terminal station, whilst the arrows at the repeater station are used to indicate interaction crosstalk paths due to lack of adequate suppression in the various paths leading from the transmit pairs to the receive pairs. This lack of suppression is often referred to as "backward" transmission (or lack of "backward" suppression) and is dealt with in the next section of the article.

To illustrate the interaction crosstalk paths due to common earth impedance, pair 1 has been chosen as the disturbing pair and the arrows at the terminal station indicate how the longitudinal currents (caused by the transverse signal on pair 1 due to near-end T/L Couplings) in pairs 2-8 inclusive find their way to earth. Briefly the paths are:

Pair 2: Through the capacitance of the screened pair interconnecting the cable head with the transmitting output transformer (120-200 pF/yard) and the capacitance between the output winding and screen of this transformer (500-2000 pF).

Pair 3: Through the centre-tap of the "cailho" coil and the "cailho"-box to earth. There is virtually no suppression in the coil, and in the ordinary case the suppression in the cailho-box (representing in most cases a DC control circuit) will also be small at carrier frequencies.

Pair 4: This pair represents a "physical" circuit, for instance a "physical" programme circuit or a "gas alarm circuit". In case of a physical programme circuit, it may be extended into a V.F. cable. The longitudinal voltage causes a current to flow via the sheath of this cable into the station earth. Longitudinal voltages will also be set up in the other pairs of the cable, and a considerable fraction of the resulting currents are in turn likely to flow into the station earth.

In the case of a gas-alarm circuit, the pair will be terminated in a control-box, presenting a small impedance at carrier frequencies to earth, and the longitudinal voltage on the pair will therefore cause a considerable current to flow into the station earth.

Pairs 5 and 6: These pairs carry a superimposed phantom circuit. The paths to earth consist of all the paths mentioned under pairs 2, 3 and 4.

Pairs 7 and 8: These pairs carry a superimposed phantom circuit and one leg of a superphantom. The paths to earth are as in case of pairs 5 and 6, with additional paths created by the superphantom leg.

These currents to earth will produce a potential difference (indicated by: PD) across the common earth impedance (indicated by: Z). Seven "third" circuit pairs only, have been shown, but it will be appreciated that all pairs in the transmit cable or open-wire route may produce similar third-circuit effects.

Pair 9 has been chosen as the disturbed pair. Arrows indicate how the potential difference across the earth impedance is supplied to the transmitting amplifier of this pair (via the power supplies and iron-work). This potential will to some extent be "picked-up" by the amplifier and appear at the far terminal as crosstalk.

The above illustrates interaction crosstalk paths from outputs to inputs of transmitting amplifiers. Receive amplifiers (not shown on Fig. 1), are affected to an even greater extent, the mechanism being as follows: The potential difference PD across the common earth impedance is extended to the screen of the input transformers (and also to a lesser extent to the receive cable pairs). The resulting voltage between the receive cable pairs and the transformer screens are equivalent to a longitudinal voltage, and this voltage (by L/T-Coupling processes) causes transverse voltages which are amplified by the receive amplifiers and finally appear as crosstalk at the near terminals. At repeaters identical processes take place.

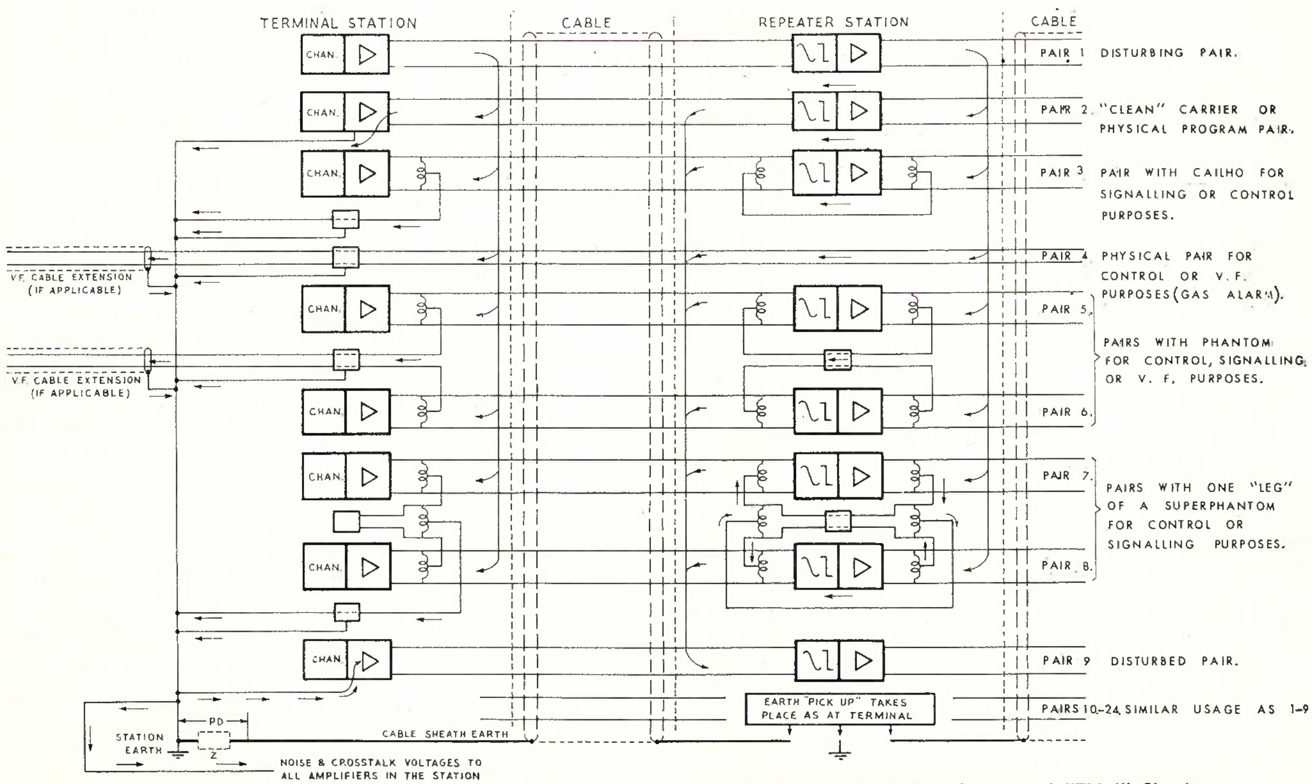


Fig. 1.—Interaction Crosstalk Paths at a Cable Carrier Station via Common Earth Impedances and "Third" Circuits.

A.P.O. practice at the time of commencement of the investigation was to provide several "earths", each "earth" being insulated from the others. The number and types of "earths" provided differed somewhat between the various States. Some of the various "earths" in use were:—

Protective Earth.

Cable Sheath Earths: ("A-Side" and "B-Side" in case of 12-channel Open Wire Installations, and "Transm." and "Rec." in case of cable installations.)

Noisy Earth.

Silent Earth (or Screen Earth).

Battery Earth.

Mains Neutral Earth.

Rack and Ironwork Earth.

It was thought that such a separation of "earths" would enable the various types of potentials across the earth impedances to be kept within certain physical boundaries in such a fashion that no harmful effects would be experienced. At Kal Kallo cable repeater station on the Melbourne-Seymour route, a large number of man-weeks was spent refining the separation of earths and certain modifications were made to the equipment installed to enable appropriate earth connections to be made. As each refinement was introduced the interaction crosstalk became progressively worse.

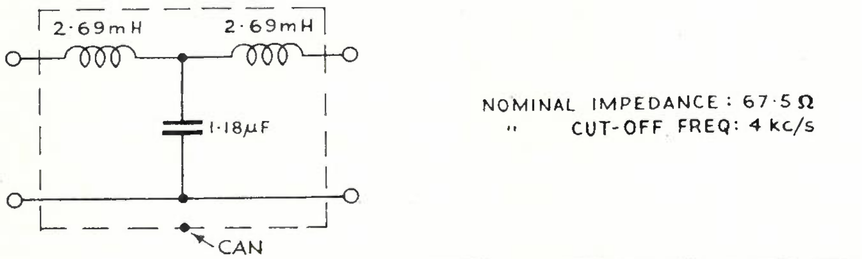
After weeks of experimental work, it was established that the best earthing arrangement at cable stations was obtained by extending the potential of the cable sheaths to all the points in the equipment room, which require an earth, by means of low impedance (that is low resistance as well as low inductance) connections. The required low impedance could conceivably be obtained by covering the floor of the equipment room with a solid sheet of copper to which all earth connections, including the connections to the cable sheaths were made, but such a drastic step proved unnecessary. Instead, all connections were made to the existing earth-busbars, and by connecting these together at their "free" ends an earth-mesh system of low impedance is obtained.

It appeared beyond doubt that the same findings would apply to open-wire stations with long entrance cables, but different conditions could exist if the entrance cables were very short. Experiments with different earth arrangements were therefore carried out at Yass Junction open-wire repeater station which has short entrance cables of approximately 200 ft. length. The results confirmed the superiority of the single-earth scheme.

The author believes that it would be possible, if enough effort and time were spent on the project, to obtain even better results with "separated" earths, but the single-earth arrangement has proved to give most satisfactory results at all stations where it has been introduced, and there seems thus no reason to pursue a separated earth scheme with its very considerable practical disadvantages of cost, complexity and hazard to personnel.

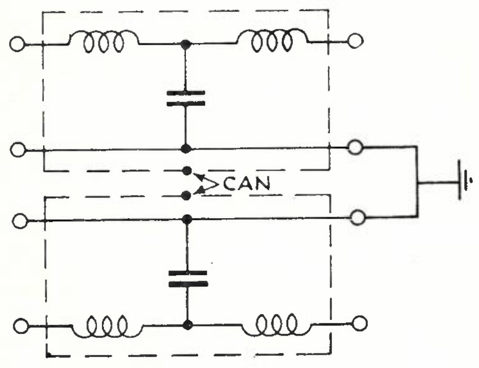
The efficient operation of the single-earth scheme may perhaps best be understood by considering the cable sheaths as "true" earth, and if the points requiring an earth connection are connected to the sheaths via connections of the lowest possible impedance, the harmful potential difference PD in effect becomes very small (short-circuited). This is substantiated by the fact that the inductance of a few turns of wire on a pencil inserted in the connections to the cable sheaths very markedly reduces the efficiency of the single earth arrangement.

Referring again to Fig. 1, it is seen that the longitudinal voltages on the cable pairs deliver current into the earth impedance via circuit elements, such as cailho and phantom deriving coils, which exhibit a low impedance to these currents. A reduction of the potential across the earth impedance, and a consequent reduction of interaction crosstalk due to this cause, may be achieved by "retarding" the longitudinal currents. Suitable methods of retardation are described later in conjunction with the methods used to suppress other types of interaction crosstalk.



NOMINAL IMPEDANCE : 67·5 Ω
" CUT-OFF FREQ: 4 kc/s

TWO OF THE ABOVE UNITS MAY BE USED TO FORM A 135 Ω BALANCED FILTER WITH EARTHED CENTRETAP



NOMINAL IMPEDANCE: 135 Ω
CUT-OFF FREQ: 4 kc/s

The characteristics of the filters operated between the appropriate nominal impedances are:—

f (kc/s)	Atten. (db)	Longitudinal Impedance of Balanced Filter (ohms)
0-4	Pass Range	—
8	18	—
12	29	100
20	42	170
40	60	340
80	78	675
160	96	1350

The current carrying capacity should be not less than 50 mA.

Fig. 2.—Unbalanced and Balanced Crosstalk Suppression Filters for use in Cable Carrier Stations.

INTERACTION CROSSTALK DUE TO LACK OF BACKWARD SUPPRESSION

The need for suppression in the backward direction of transmission may be explained with reference to the repeater station shown as part of Fig. 1. Pairs 1 and 9 are again the disturbing and disturbed pairs respectively, whilst pairs 2-8 inclusive illustrate common types of "third" circuits. Due to near-end T/T and T/L-couplings between the pairs of the transmit cable, the transmission of a transverse signal on pair 1 will cause transverse and longitudinal signals on all other pairs of the cable (in the order of 40 db down on the voltage transmitted on pair 1 in the worst cases). These signals will flow through the paths interconnecting the transmit and receive pairs (in the backward direction), and if they are not subjected to any suppression in these paths, they appear at the same levels on the pairs of the receive cables. Pair 4 as an example has no suppression in the interconnecting path and the transverse and longitudinal signals on that pair of the receive cable would cause transverse signals on the other pairs of the receive cable (the appropriate T/T

	XT/T db	XL/T db	XT/L db	XL/L db
When the send and receive cable pairs being considered are both associated with carrier equipment	$G_R + 30$	$G_R + 45$	$G_R + 45$	$G_R + 10$
All other cases	$G_R - 20$	$G_R - 5$	$G_R - 5$	$G_R + 10$

where G_R is the repeater gain in db.

and L/T-coupling again being in the order of 40 db). An interaction crosstalk in the order of 80 db only could thus be experienced in the worst case. Since the requirement is in the 120 to 160 db range, a suppression in the interconnecting paths in the order of 40 and 80 db respectively is seen to be necessary.

A more detailed analysis of the backward suppression requirements at cable carrier stations is given in Ref. 1. This analysis shows that it is necessary to consider the following types of backward suppression:

Transverse/Transverse Symbol: XT/T
Transverse/Longitudinal Symbol: XT/L
Longitudinal/Transverse Symbol: XL/T
Longitudinal/Longitudinal Symbol: XL/L

and that the appropriate minimum tolerable suppressions at 108 kc/s assuming a resultant worst channel cross talk of 80 db are shown in the above table.

Suitable methods of obtaining the necessary backward suppression are described later in conjunction with the methods used to suppress other types of interaction crosstalk.

INTERACTION CROSSTALK DUE TO DIRECT TRANSVERSE/ TRANSVERSE COUPLING FROM TRANSMIT CIRCUITS INTO RECEIVE CIRCUITS

Since this type of crosstalk is due to direct coupling between the two circuits concerned no "third" circuits are involved, and it may perhaps therefore not be classed as true interaction crosstalk. The means employed to control this type of crosstalk are however very similar to the means employed to control the true types of interaction crosstalk so that for the purpose of this article it has been classed as such.

In general the wiring associated with the transmission circuits of carrier equipment is run in screened pairs, and terminal blocks, U-link frames, jacks, keys and any similar items associated with transmit circuits are usually kept separate from those associated with receive circuits. The investigation revealed, however, that the appropriate low degree of coupling had not been realised in a considerable number of instances, and Table 3 has therefore been prepared as a guide to the likely minimum order of couplings obtained in some typical cases assuming nominal circuit impedances in the 125-600 ohms range and a frequency not exceeding 150 kc/s.

Table 4 gives the minimum order of transverse/transverse coupling between pairs associated with common types of multipair transmission equipment which usually carry circuits of same nominal level that is transmit circuits or receive circuits. These couplings may result in direct crosstalk, and a knowledge of their magnitudes is essential for the proper design and installation of equipment.

NOISE PATHS

Many types of channel noise are due to potential differences between various earth points in the carrier frequency transmission paths and this type of noise is very greatly reduced by the adoption of the "single" earth arrangement, where all points which require an earth are interconnected by connections of the lowest possible impedance.

Other types of noise, mainly noise induced in pairs due to variations of soil-potential along a route and noise due to static, radiation from welding and other types of apparatus, follow in many cases the same paths as interaction crosstalk before appearing as channel noise. Consequently reduction of interaction crosstalk helps in two ways to reduce channel noise.

METHODS OF INTERACTION CROSSTALK SUPPRESSION

It has been shown in the preceding sections that interaction crosstalk may result from:

(i) excess longitudinal currents to earth and excess earth impedance,

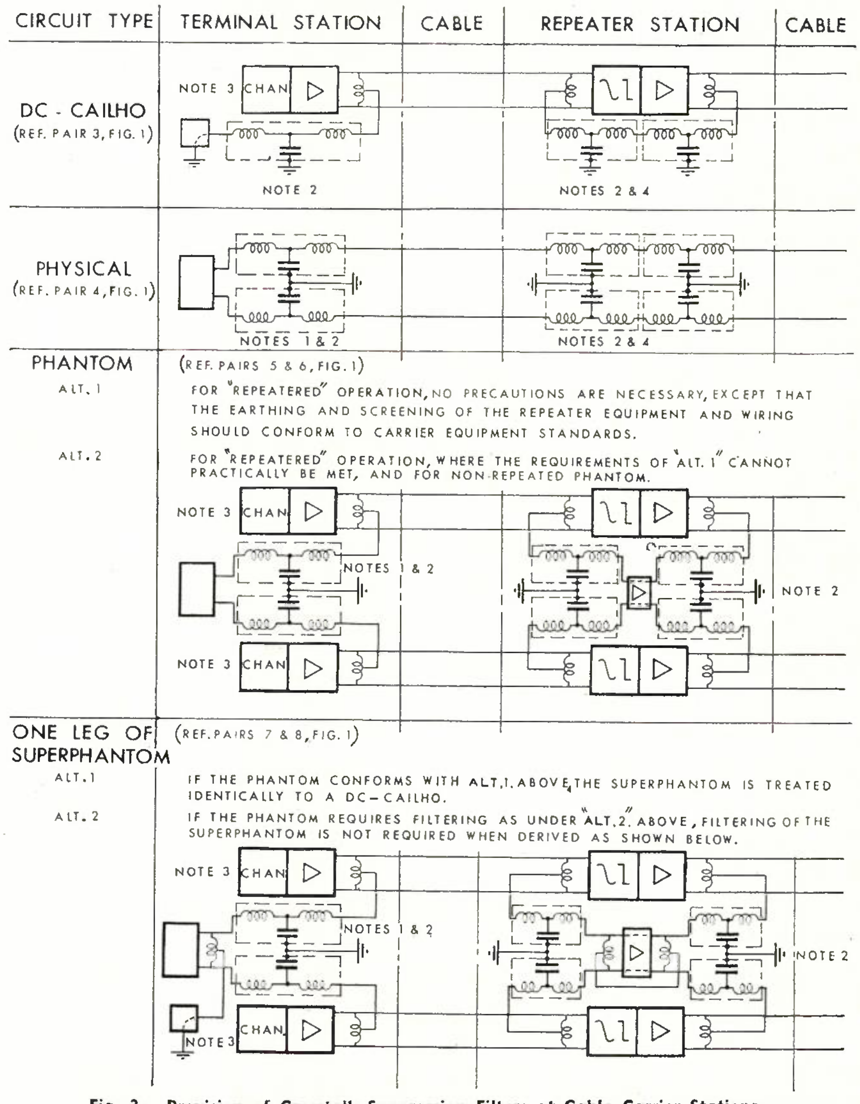


Fig. 3.—Provision of Crosstalk Suppression Filters at Cable Carrier Stations.

NOTES: 1. Screened Transformers may be used instead of filters, in case of circuits used for V.F. purposes.
2. See Fig. 2 for filter details.
3. The terminal equipment is shown as transmitting, but identical arrangement is used at the receiving end.
4. Two units in tandem as shown were used on Melbourne-Seymour route, but one unit should be adequate if the repeater gains do not exceed about 60 db.

(ii) lack of T/T, T/L, L/T and L/L backward suppression in the paths interconnecting transmit and receive pairs,

and (iii) direct transverse/transverse coupling from transmit circuits into receive circuits.

Consideration to these phenomena would have been given previously in the design and manufacturing stages of the equipment associated with carrier as well as non-carrier pairs of a carrier route. It cannot be emphasised too strongly that equipment associated with non-carrier circuits (such as DC-control, DC-supervision, gas-alarm, order-wire, subscribers, V.F. and Programme) and employing pairs of carrier cables or carrier open-wire routes is much more likely to cause poor interaction crosstalk between the carrier systems than the carrier equipment itself. In fact it is generally neither economical nor practicable to design these non-carrier circuits in such a way that their "third" circuit effects are negligible and special components such as crosstalk suppression filters (abbreviated: XTS-filters), longitudinal retard coils (abbrev.: LR-coils) and longitudinal retard transformers (abbrev.: LR-transformers) must be included as required to reduce the "third" circuit effects.

Considering firstly the design and installation of carrier equipment, the more important rules to be observed are:—

(a) High and low level wiring must be run in separate forms, and all wiring associated with the signal paths must be screened. The minimum distance between a high and a low level pair must not be less than 3 inches. If this minimum distance cannot be maintained shields of 14-22 BG sheetmetal should be inserted to ensure that the minimum distance measured wholly in air is 3 inches.

(b) All screens of screened wiring must be earthed (in as many places as convenient, but at least in one place) to a solid common earth wire run vertically in the centre of the rack framework (or alternatively an earth wire may be run inside each of the two U-shaped side members, the two wires being connected together at the top, at the middle and at the bottom.). The earth-wire(s) is connected to an earth terminal at the top of the rack (or to a rack earth-busbar). This terminal is also used for the earth return of the HT and LT supplies, and for "rack-earth".

(c) High and low level wiring must not come together on the same key-panel, jack-field, U-link block or terminal block. High and low level keys, jacks and terminal blocks must be well separated, or if this is not possible shields of 14-22 BG sheetmetal should be inserted between them.

(d) High and low level transformers, such as input and output transformers, should be well separated. In case of line transformers, and phantom deriving coils the high and low level groups should preferably be mounted on opposite sides of the rack.

(e) Panel and bay terminal blocks should be so arranged that the separation of high and low level wiring (see (a)) is readily accomplished.

(f) Within panels the input and output wiring must be screened and well separated, and the panel terminal blocks should be arranged in accordance with (e).

(g) Line transformers should have electrostatic screens between primary and secondary windings. These screens must be earthed, and must not be associated with any feed-back potentials.

(h) In the case of phantom deriving coils and line-transformers the centre-tap must not be earthed, since this would result in excess longitudinal currents to earth. It must be ensured that the impedance to earth of any circuits connected to such centre-taps is high at carrier frequencies.

(i) All components, such as input and output transformers, directional filters, line filters, XTS-filters, LR-coils, screened wiring, arrestors, fuses, etc., forming part of the "line" should be well balanced.

The expressions "high level" and "low level" refer to signal levels. Thus high level wiring is associated with the transmit side of a repeater, and the low level wiring with the receive side.

Program equipment for operation over physical and phantom circuits of carrier cables should be made to the same rules as carrier equipment in order to avoid the necessity for XTS-filters and the resultant restriction of frequency range and deterioration in performance. Open-wire program circuits are usually restricted in frequency range by 5.6 kc/s line filters and XTS-filters of the same

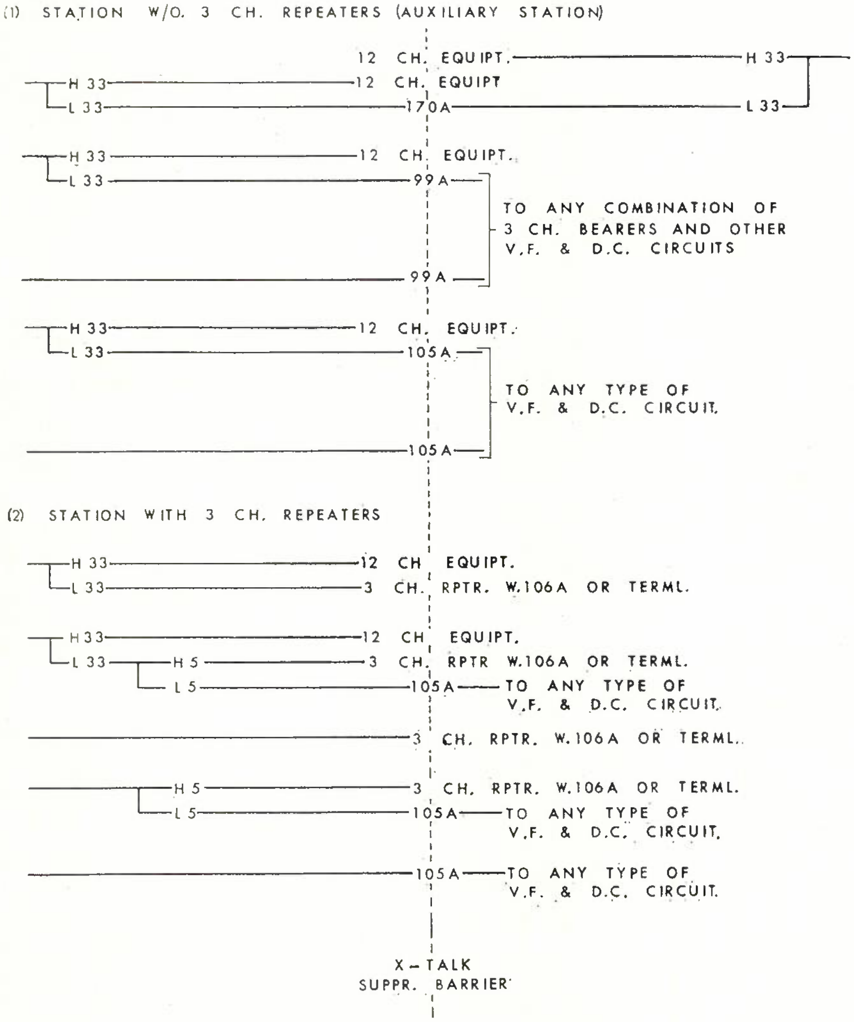


Fig. 4.—Provision of Crosstalk Suppression Filters at 12-Channel Open-Wire Stations.

Crosstalk suppression filters should be provided as indicated above, except in the following Cases:—

(a) Stations with Terminals of one Type only (that is either "A" or "B" Terminals) and no Repeaters.

(b) Stations with one Repeater only and no terminals.

Legend: "H" and "L" signifies "High-Pass" and "Low-Pass" respectively, whilst the succeeding figure signifies the approximate cut-off frequency in kc/s.

Note: H3's and L3's may be used in lieu of H5's and L5's if desired.

or higher cut-off frequency may therefore be used without detrimental effect. Consequently it is not necessary from the point of view of interaction crosstalk to follow "carrier rules" in the design of such equipment, but from the point of view of standardisation the two types of equipment should be made identical.

All pairs, other than pairs exclusive to cable carrier equipment and 12-channel open-wire equipment must be suitably equipped with XTS-filters. These filters are of the low-pass type and of varying complexity.

A "universal" XTS-filter with a nominal cut-off frequency of 4 kc/s was designed for all applications at cable carrier stations. The particulars of the filter are given in Fig. 2, and the rules of application are illustrated in Fig. 3. It will be seen that these filters are provided in such a manner that they, together with the carrier and the programme equipment, create a "crosstalk suppression barrier" between transmit and receive pairs. This barrier ensures that the required degree of T/T, T/L, L/T and L/L suppression exists in all paths leading from any transmit pair to any receive pair. In order to ensure that the barrier is effective, that is that no crosstalk signals "jump" the barrier, it is necessary that all stray couplings leading from one side to the other be avoided as far as possible. The stray couplings most likely to offend are of the same type as those described in the section treating direct T/T couplings between transmit and receive pairs. Consequently all wiring, tag-blocks, jacks, keys, etc., between the XTS-filters and the cable-heads should be made in accordance with the "carrier rules" given above.

The impedance of the XTS-filter to longitudinal currents to earth must be high, and this is achieved in the balanced filter by using four separate inductors in the filter, rather than two double-wound inductors (with coupling between the windings associated with each wire of the pair). The impedance to longitudinal currents to earth could be greatly increased by disconnecting the earth applied to the centre-tap of the shunt capacitors, but this would result in nearly complete loss of L/L suppression between the two sides of the filter, and it is essential therefore that this earth-connection is maintained. In order that the required L/L suppression should be obtained this centre-tap must be connected by low-impedance connections to the mesh-earth in the equipment room.

In stations with 12-channel open-wire equipment, three types of XTS-filters are used, namely:

W.E., Type 99A: A balanced 30 kc/s LP-filter.
,, ,, 105A: A balanced 10 kc/s LP-filter.
,, ,, 106A: An unbalanced 30 kc/s LP-filter.

In addition a so called "Auxiliary Network" Type 170A is used.

The principles to be followed in the provision of the crosstalk suppression barrier at open-wire stations are the same as for cable stations, and the use of four different types of "filters", instead of one as in the case of cable stations is based on cost and space considerations, rather than on necessity for electrical reasons. Thus the 99A 30 kc/s LP-filter could be used in all instances where a XTS-filter is required, but the other simpler and less expensive types may be used in lieu under the following conditions:

105A, when the path concerned does not employ normal operating frequencies above 10 kc/s.

106A, when the path concerned contains a 3-channel repeater. The 106A may be thought of as an unbalanced version of the 99A, and is inserted at an unbalanced point in the B to A (high-frequency) path of the repeater.

170A, to interconnect two "33 kc/s LP-Drops" in a station. The 170A auxiliary network is essentially a phase-shift network, which, when inserted between the two 33 kc/s LP-filters, control the reflections in the stop-range of these filters in such a way that satisfactory T/T, T/L, L/T and L/L losses are obtained from the two filters without additional proper XTS-filters.

The arrangements of equipment and circuits are shown in Fig. 4, in which the location of the crosstalk suppression barrier has also been indicated. The circuits may take any form to the right of the crosstalk suppression barrier, if the circuits on the left are established as shown. If this is compared with the principles followed at cable stations (Fig. 3) one important difference between the two is realised, namely: In cable stations a barrier is established between each cable and the non-carrier equipment (which in the simplest cases is station wiring only); this results in a "neutralisation" (that is virtual elimination of carrier frequency voltages and currents) of the non-carrier equipment and of possible non-carrier cable and open-wire routes radiating from the station. At open-wire stations one only crosstalk suppression barrier is established. This barrier "neutralises" the station from the "A"-side or "B"-side of the route only, and the non-carrier equipment and non-carrier routes are therefore "live" with carrier-frequency voltages and currents from the opposite side of the station, that is the side without the barrier.

It is obviously an advantage to "neutralise" a station and its voice frequency routes from the carrier routes in order to prevent carrier signals from going to places where they could be picked-up and finally appear as channel crosstalk. Conversely the undesirable carrier frequency noise and signals incoming on the V.F. routes or generated in non-carrier equipment are by the same process prevented from entering the carrier routes and appearing as channel crosstalk and noise. If this approach were adopted also at open wire stations, the suppression in each of the two barriers needs obviously to be in the order of half only of the suppression in the single barrier. Information recently received from a leading overseas manufacturer recommends the use of a double-barrier at open-wire stations, but no filter details are as yet available, nor have any trials been made by the Department.

Two further means of crosstalk suppression are available, namely longitudinal retard transformers (LR-transformers) and longitudinal retard coils (LR-coils). The LR-transformer is simply a suitable ordinary type of transformer inserted in a transmission pair to retard longitudinal currents to earth and to provide L/L suppression. The results

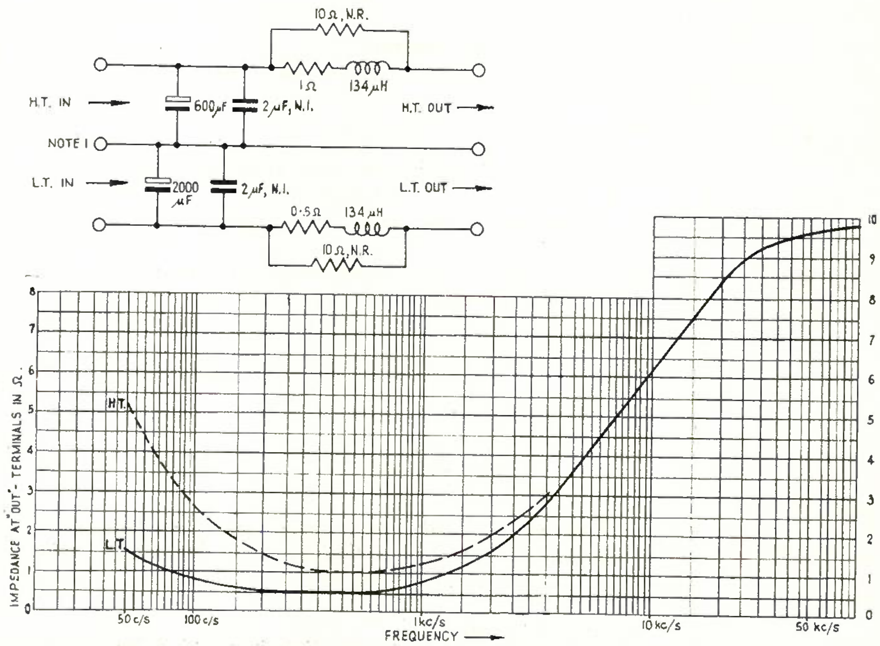


Fig. 5.—Configuration and Impedance Characteristics of "Artificial Power Supply Impedance-Networks.

of the investigation have so far not indicated any great need for such transformers (see Fig. 3). LR-coils consist in their simplest form of double-wound inductors of which one winding is inserted in each wire of a pair and the windings are so poled that the impedance to longitudinal currents is high, whilst it is insignificant to normal transverse signals. LR-coils serve the same purpose as LR-transformers, namely to retard longitudinal currents to earth and to provide L/L suppression. The LR-coils leave the DC-path of the pair intact, whereas LR-transformers interrupt the DC-path.

No need for longitudinal retard coils has so far occurred in cable stations. In case of open-wire stations, Bell System Practices specify for interaction crosstalk reasons the use of pole-mounted LR-coils in all pairs at the open-wire terminating pole at both the "A" and the "B" side of stations. Departmental practice has been to equip LR-coils to all pairs on one side, but only to the pairs used as bearers for 12-channel open-wire systems on the other side. It appears that this practice followed verbal advice from the Western Electric installing engineer who attended the installation of the first 12-channel open-wire equipment in Australia (cut-over in January 1940). The results of the interaction crosstalk investigation described herein have so far not been conclusive in respect of LR-coils due to the existence of "third" circuit effects from railway lines. Modifications to the offending railway lines are however being carried out, and when these are completed further tests will be made. In this connection it may be noted that LR-coils tend to reduce noise due to static (see for instance Ref. 7) and assist to some extent in protecting entrance cables and equipment from the effects of lightning.

CROSSTALK DUE TO COMMON POWER SUPPLIES

The equipment at carrier stations is usually fed from common power supplies, such as 24V and 130V DC supplies. The impedances of these supplies cause coupling and crosstalk between equipment. In order to obtain satisfactory noise and crosstalk performance it is therefore necessary to ensure that:

(a) the impedances of the power supplies do not exceed a certain maximum value.

(b) disturbing equipment does not produce a voltage across the power supply impedances exceeding a certain maximum.

(c) the maximum interfering voltage across the power supply impedance does not produce interference exceeding a certain maximum into disturbed equipment.

The power supply impedance at the point of power take-off for an equipment unit depends on a very large number of factors, such as impedance of primary source (usually AC-mains and rectifier), impedance of secondary source (battery), dimensions and type of distribution, physical location of the distribution system relative to ironwork, physical location of primary and secondary sources relative to the equipment, and of the impedance of other equipment units connected across the distribution system at other points.

Most of these factors are not readily controllable, and their contribution to the power supply impedance may vary greatly from station to station, and may result in impedances exceeding 10 ohms at certain points of the distribution system at certain frequencies. Impedances of such high values are not satisfactory,

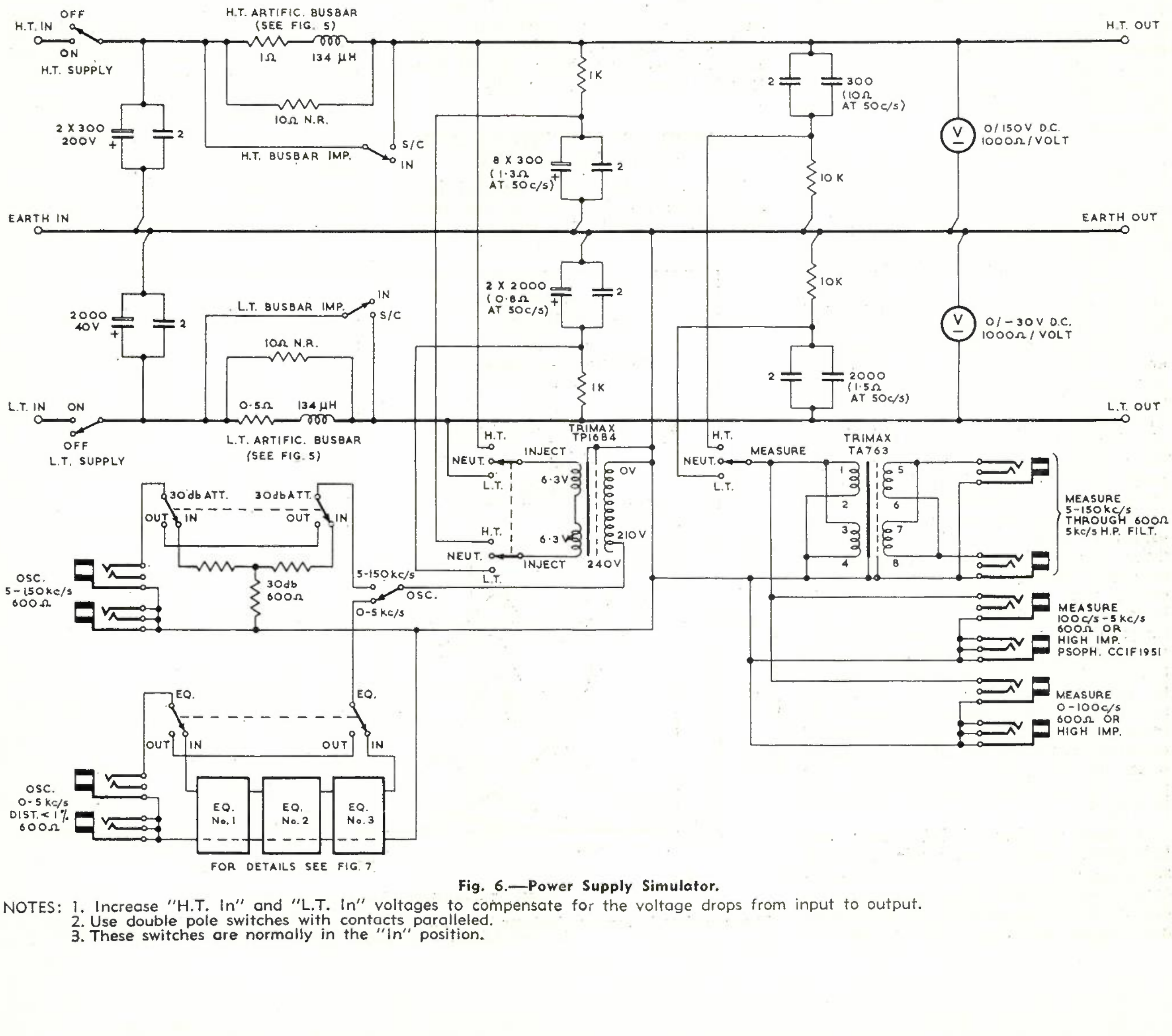


Fig. 6.—Power Supply Simulator.

NOTES: 1. Increase "H.T. In" and "L.T. In" voltages to compensate for the voltage drops from input to output.
2. Use double pole switches with contacts paralleled.
3. These switches are normally in the "In" position.

and consequently a method of impedance reduction by means of decoupling capacitors connected from each supply busbar to earth was devised. When using such capacitors it is necessary to take precautions to avoid resonance effects giving high impedances at the resonant frequencies.

The method devised employs large decoupling capacitors, say not less than 600 μF on the HT and not less than 2000 μF on the LT supply, at the power board, or at a point in the equipment room if the power board is more than say 200 ft. removed from the equipment room. This ensures a low main-resonant frequency and a resulting low associated impedance peak. At higher frequencies the inductance of the distribution busbars (in the order of 1μH per 5ft.) contributes significantly to the impedance at the power take-off point, and auxiliary decoupling is therefore employed at the feed-end of each lateral. Suitable capacitance values are 40 and 100 μF for the HT and LT supply respectively. Electrolytic capacitors often exhibit an inductive component at high frequencies and to ensure proper decoupling at these frequencies each should be parallelled with say a 2μF capacitor of low inductance. In order to minimise impedance peaks at the resonant frequencies, a 0.5 ohms non-inductive resistance is inserted in series with each decoupling assembly (consisting of the parallel connection of the electrolytic and the non-inductive capacitor).

The "artificial busbar" networks shown in Fig. 5 were devised to simulate at all frequencies the maximum impedance expected at any power take-off point. A complete "power supply simulator", incorporating these networks and applicable both to field and laboratory testing, is shown in Fig. 6. This simulator enables measurements of busbar noise to be made in three frequency ranges: 0-100 c/s (flat), 100 c/s-5 kc/s (psophometric) and above 5 kc/s (flat). It also facilitates injection of "artificial" noise at any frequency from an external oscillator. The equalisers marked EQ. No. 1, EQ. No. 2 and EQ. No. 3 serve to equalise the output from the oscillator over the range 100 c/s-5 kc/s in such a way that the level versus frequency characteristic of the voltage injected on the power supply is roughly inverse to the sensitivity characteristics of the Psophometer over this range. This is necessary to ensure that harmonics from the oscillator, particularly in the 100-300 c/s range, do not cause incorrect measurement (due to the rapid increase in sensitivity of the Psophometer from 100 c/s to 300 c/s), and it also facilitates measurements of frequency responses by reducing the amount of adjustment required to the output of the oscillator when its frequency is changed. The particulars of these equalisers are given in Fig. 7.

A large number of laboratory and field measurements were made using this simulator, and a study of these measurements and existing Departmental specifications led to the adoption of the busbar noise figures given in Tables 5 and 6 to ensure satisfactory noise and crosstalk performance. However due to the large number of types of equipment in service it has not been practicable to examine them all to see whether they would operate satisfactorily under these conditions, but there appears to be little doubt that the decoupling arrangements would, in most cases, if applied to existing installations, reduce the impedance and consequently the noise voltages of the power supplies to such an extent that satisfactory operation of the equipment is achieved. A special type of noise on the D.C. power supplies is due to its association with the A.C. mains via rectifiers, A.C./D.C. converters or similar. The longitudinal and transverse high frequency "noise" components (due to corona effects, static, switching, mercury-arc rectifiers, electro-medical instruments, arcing at points of poor contacts, electric welding apparatus, commutator motors, etc.) have a tendency to penetrate into the D.C. supply system, but these noise voltages on the D.C. supplies are also greatly reduced by the decoupling described above. In most cases, the smoothing chokes in the A.C./D.C. conversion equipment are associated with the active D.C. supply lead. However, some H.T. rectifiers supplied in the past had the chokes associated with the earthy lead, which aggravates this type of noise, and the smoothing chokes should therefore be removed to the earthy lead.

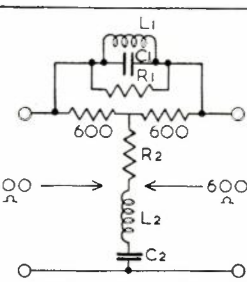
CARRIER ON V.F. TRUNK AND JUNCTION CABLES

The mechanisms of noise and interaction crosstalk described in this article have been derived by a study of equipment operating on "go" and "return" carrier type cables. The same principles apply also to equipment operating on "go" and "return" or "single" V.F. trunk and junction cables. In these cases the need for crosstalk suppression filters would depend on the frequency range employed. There appears little doubt that they are desirable for 60 kc/s working, but no investigations to determine the critical frequency have been made.

V.F. trunk and junctions cables normally have a large number of pairs, of which a relatively small number only are used as bearers for carrier systems, and the cost and effort required to equip all non-carrier pairs with crosstalk suppression filters becomes quite significant. If the V.F. pairs are repeatered it is possible to make the V.F. repeaters form part of the crosstalk suppression barrier, thus avoiding the need for filters in these pairs It is also possible to reduce the number of filters required by employing a system of "cable-frogging" at repeaters (Ref. 8) and/or "frequency-frogging" (Ref. 9) as employed for instance in Western Electric Type N Systems, Siemens & Halske Type Z 12 N Systems and Philips Type STR.113 Systems.

CARRIER ON COAXIAL CABLES

It appears from information available that a one-earth arrangement is also preferred by most makers and users of this type of equipment. The "Coaxial chokes" used in some cases to reduce crosstalk and harmful effects of low-frequency earthcurrents (mainly hum) are to be compared with the longitudinal retardation coils employed with bearer-circuits for 12-channel open-wire equipment.



	EQ. No.1	EQ. No.2	EQ. No.3
FREQ. c/s	417	1000	2400
L1 Hy	0·68	0·28	0·118
C1 µF	0·216	0·090	0·0374
R1 Ω	6960	6960	6960
L2 mH	78·0	32·4	13·5
C2 µF	1·88	0·782	0·326
R2 Ω	51·7	51·7	51·7

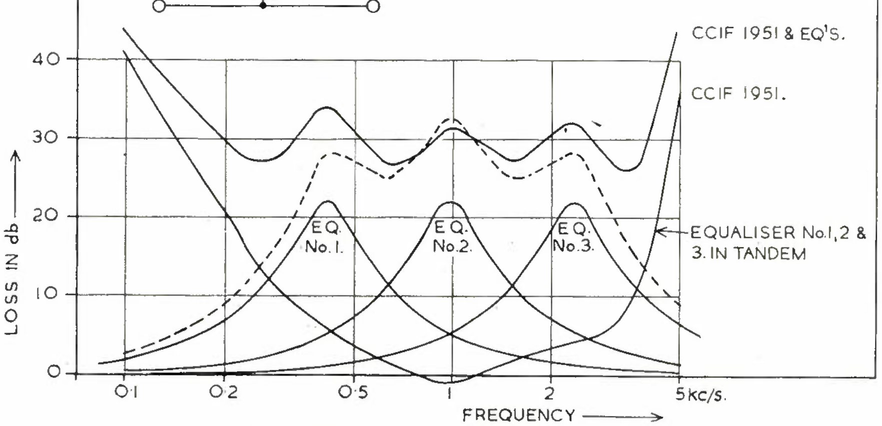


Fig. 7.—Anti-Psophometric Equaliser.

The equaliser is used as indicated in Fig. 6. The attenuation characteristic approximates the inverse C.C.I.F. 1951 psophometric weighting.

TABLE 1

Worst near-end couplings between pairs of the same cables at Kal Kallo and Kilmore Repeater Stations

24/40 lb cables. Measured after completion of all modifications. Stations and cables in normal operating conditions. The presence of the cable balancing networks on the "receive" cable tends to make the "receive" cable results poorer than those relating to the "transmit" cables.

	Type of Coupling (db—ratios)			
	T/T	T/L	L/T	L/L
60 kc/s	55	40	40	3
108 kc/s	50	35	35	2

TABLE 2

Worst near-end couplings between pairs of the Yass Junction/Goulburn pole route measured at the cable heads inside Yass Junction Repeater Station.

12-Channel open-wire pairs are in D.I.S.Q. entrance cables.

All other pairs are in 54/40 M.T. entrance cables.

Length of entrance cables: 60 yards.

Measured after completion of all modifications and with all equipment and lines in normal operating conditions.

Test frequency: 160 kc/s.

The following abbreviations are used: L.R. = Longitudinal Retard Coil (pole-mounted). J/J = (Coupling from) pair used as bearer for 12-channel open-wire system into same type of pair.
J/non–J, non–J/J, non–J/non–J: similar to J/J.

The measurements were performed over a period of ten days, and changes in weather, switching conditions, etc., would account for somewhat varying results. Consequently, minor differences under the three conditions of L.R. coils may have been caused by these changes. Significant changes believed due to the insertion of L.R. coils have been marked with an asterisk.

		Type of coupling (db—ratios)			
		T/T	T/L	L/T	L/L
No. L.R.'s fitted	J/J	35	40	24	8
	J/non–J	20	31	21	15
	non–J/J	23	37	13	12
	non–J/non–J	24	25	12	7
L.R.'s fitted to all J–pairs	J/J	No change	35	35*	3
	J/non–J		28	54*	44*
	non–J/J		58*	19	39*
	non–J/non–J		20	12	7
L.R.'s fitted to all pairs.	J/J	No change	40	45	10
	J/non–J		56*	53	47
	non–J/J		69	32*	41
	non–J/non–J		31	20*	7

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8. Bell System Technical Journal, Vol. XVII, January, 1938, Page 137; Crosstalk and Noise Features of Cable Carrier Telephone Systems, by M. A. Weaver, R. S. Tucker and P. S. Darnell.

9. Bell System Technical Journal, Vol. XXX, January 1951, Page 1; The Type N1 Carrier Telephone Systems, Objectives and Transmission Features, by R. S. Caruthers.

TABLE 3

Minimum Order of Transverse/Transverse Couplings between Transmit and Receive Circuits due to Common Types of Circuit Elements.

Circuit Impedance: 125-600 ohms

Frequency: 0-160 kc/s

Screened Cable Pairs, laced together	110 db
Screened Cable Pairs, spaced 3" apart	160 db
Terminal Blocks, two circuits separated by one row of earthed tags	110 db
Terminal Blocks, two circuits on two adjacent blocks, 4" apart, dustcover in position	140 db
Terminal Blocks, as above, but dustcover removed	150 db
U-Links on Cable Balancing Bay, two circuits on adjacent blocks	140 db

TABLE 4

Minimum Order of Transverse/Transverse Couplings Between Pairs Associated with Common Types of Multipair Transmission Equipment (in db)

		600 ohm Circuits				150 ohm Circuits			
		5 kc/s	10 kc/s	30 kc/s	150 kc/s	5 kc/s	10 kc/s	30 kc/s	150 kc/s
Between Adjacent Pairs	Protector, wiring split over mounting bar (1)	98	91	82	70	96	90	81	68
	Protector, wiring not split over mounting bar (1)	98	92	82	71	100	96	87	73
	Fuse Mounting (2)	95	89	80	68	101	95	86	73
	Panel Tag Block (3)	111	107	101	90	109	105	99	84
	Jackstrip (4) and (6)	130	125	118	107	110	107	99	90
	Cable Head (5)	97	93	84	73	108	103	93	79
Between Adjacent But One Pairs	Protector, wiring split over mounting bar (1)	114	107	98	87	108	100	93	82
	Protector, wiring not split over mounting bar (1)	117	111	101	89	120	115	106	92
	Fuse Mounting (2)	113	107	97	86	113	107	97	86
	Panel Tag Block (3)	—	—	—	—	—	—	—	—
	Jackstrip (4)	—	—	—	—	—	—	—	—
	Cable Head (5)	—	—	—	—	—	—	—	—

Notes: (1) Protector, H.C. and Test 40B, 20 pair, Stock Title 11/2 (no Heat coils fitted).
(2) Mounting, Fuse, 25 pair, Stock Title 11/6C.
(3) Panel Tag Block, similar to Tag Block shown on CN.650, Sheet 4 (20 pair).
(4) Jackstrip, Drawing C.1382, Sheet 11, Stock Title 24/63.
(5) Cable Head, experimental resin-moulded type to Drawing CSK 4078, Sheets 1 and 2.
(6) Figures quoted relate to the condition when carrier plugs are plugged in. If this is not the case, figures may be up to 15 db better.

TABLE 5

Maximum Permissible Noise Voltage on Busbars.

The maximum total noise voltage at any power-take off point should not exceed the figures in the Table, and conversely equipment should operate satisfactorily in the presence of these noise values.

	24V Busbar		130V Busbar	
	mV	db ref. 775 mV	mV	db ref. 775 mV
0-100 c/s, flat	135	–15	450	–5
100 c/s-5 kc/s, C.C.I.F. 1951 Psophometer	1.2	–56	4	–46
Above 5 kc/s, flat	1.2	–56	4	–46

TABLE 6

Maximum Noise Voltage Generated by Equipment.

The maximum noise voltage across the artificial busbar networks generated by a rack or a unit of equipment should not exceed the values in the Table.

	24V Busbars		130V Busbars	
	mV	db ref. 775 mV	mV	db ref. 775 mV
0–100 c/s, flat	66.5	–21	225	–11
100 c/s–5 kc/s, C.C.I.F. 1951 Psophometer	0.6	–62	2	–52
Above 5 kc/s, flat	0.6	–62	2	–52

SUGGESTIONS SCHEMES—AN AID TO MANAGEMENT

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INTRODUCTION

A suggestions scheme of one kind or another has been in operation in the Postmaster-General's Department for over 40 years. This article sets out the various aspects of suggestion schemes including the relation of the Departmental scheme to others in outside industry. The operation of the scheme is described, and the effects and benefits of such schemes are discussed with particular emphasis on the telephone equipment aspects of the Engineering Division.

The importance of suggestion schemes throughout the world is shown in the multiplicity of articles appearing in various journals in the years since the war. Suggestion schemes have grown in number very considerably in the last few years, particularly in the United States of America, and also it has been found that there is an increased awareness and use being made of these schemes by employees. It is generally considered that in an enterprise of even small size there is a definite place for an empoyees' suggestion scheme, and that such a scheme can contribute substantially to the output efficiency of the firm and the contentment of the employees.

It is generally accepted that a suggestion scheme is "any formal procedure whereby employees can submit, and earn rewards for, ideas that will benefit the undertaking in which they are employed". This is, of course, a very broad definition and does not cover the advantages derived from such a scheme by management. On closer examination, it appears that a properly conducted suggestion scheme can achieve four distinct purposes.

Firstly, it will assist management to improve production or operational techniques. In many cases this will result in reduced expenses, higher output, greater revenue, or a speedier meeting of commitments or fulfilment of contracts. Secondly, it may enable employees to benefit from work methods improved by the submission of suggestions. Thirdly, and simultaneously, it enables them to profit financially from awards. Fourthly, it enables the workers to communicate with management, and may well result in work or condition changes which will remove sources of tension or resentment. Bound up with these gains is the possibility of increased safety precautions which can accrue, thus providing better working conditions for the employee.

THE HISTORICAL DEVELOPMENT OF SUGGESTIONS SCHEMES

The need for studying the ideas of the workers about their work conditions and methods was first realised by William Denny Pty. Ltd., a shipbuilding firm in Glasgow, which introduced a suggestions scheme as early as 1880 (1). The advantages derived were apparently substantial as other firms soon followed their example, and by the end of the 19th century the idea had travelled to America and the Continent.

It was not long before the British Post Office realised the possibilities of such a scheme, and in 1906 the first Public Service organisation for encouraging and investigating suggestions for improvements was set up in London[2]. In its earlier stages it was regarded as a means of enabling only employees in the Post office factories to submit suggestions for the improvement of factory processes and equipment. It quickly expanded, however, and very soon extended over the whole field of British Post Office activities, being open to all staff. To the beginning of February, 1955, 142,000 suggestions had been received, and about £49,000 paid as awards.

First Australian Post Office Improvements Board: The Australian Post Office in 1916 established a suggestions scheme to encourage and stimulate the submission of suggestions from its staff[3]. This scheme was conducted along the following lines:—

(a) Boxes were provided in all Chief Offices for the reception of written suggestions.

(b) Suggestions were considered by a Suggestions Board of three senior officers especially selected because of their knowledge of the subject matter of the suggestion.

(c) This Board's decision was not final and, if it was thought desirable, any suggestion might be referred to a second Board.

(d) Cash bonuses were paid for beneficial suggestions.

(e) Notices advertising the Board were placed in prominent places throughout all Departmental establishments.

However, it soon became obvious that this system had several serious defects, the chief ones being:—

(a) Each suggestion was dealt with separately by a Board specially formed for the purpose. This was often uneconomical in that three senior officers sometimes spent considerable time on what were often trivial suggestions.

(b) As the members of the Board were selected for their particular knowledge of the work to which the suggestions related, they were, in many instances, the suggestor's own supervisory officers, and were thus liable to be accused of bias.

(c) It was possible that a suggestion rejected by one Board could be accepted by another. This created confusion and could cause ill feeling, as well as preventing consistency.

Although at first the scheme was successful, these faults soon became evident and interest in submitting suggestions rapidly waned. A thorough investigation

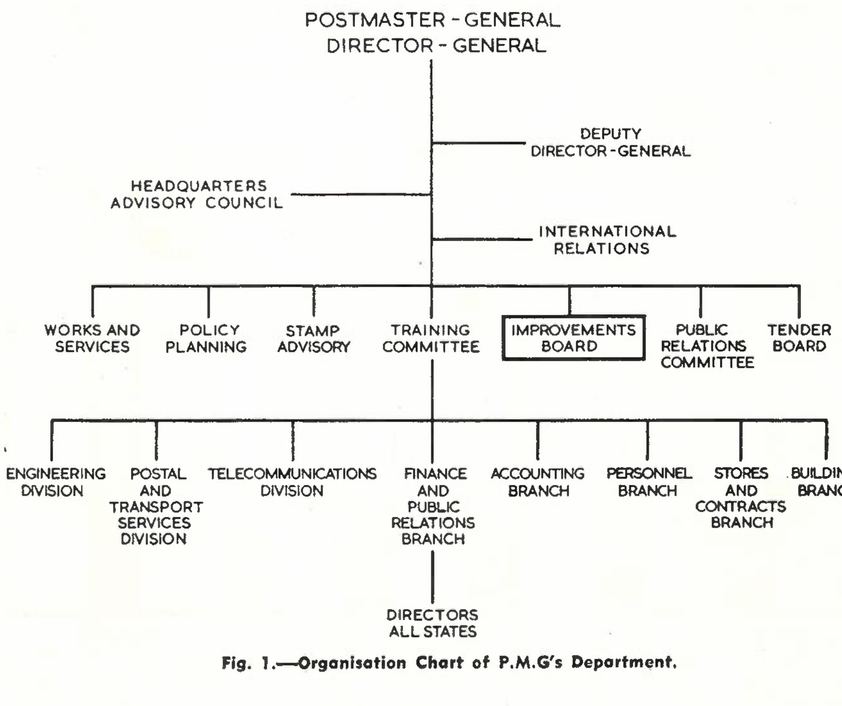

Fig. 1.—Organisation Chart of P.M.G's Department.

*Mr. Melgaard is a Divisional Engineer in the Telephone Equipment Section, Headquarters. Mr. Finlay, who was recently at Headquarters, is now a Group Engineer at Geelong, Victoria.

was made of suggestion schemes existing both in Australia and abroad and, as a result of this research, a reorganised suggestions scheme was constituted in November, 1926, based largely on those schemes operating in the British Post Office and the New South Wales Railways Department, and combining the best features of both these schemes.

Reorganised Australian Post Office Improvements Board: The most obvious need revealed by the investigations was for a Central Committee to preserve consistency and impartiality. Neither of these features was likely to result while a separate Board was set up for each suggestion, and while the Board so set up included the supervisor of the suggestor's section. In addition, it was considered that a Central Committee would more readily permit uniformity of treatment and adoption of suggestions applicable to all States. Consequently, the new scheme revolved around a Central Improvements Board, still comprising three members, but with this difference: the same three members were to examine and consider all suggestions and, if necessary, seek advice and assistance from experts in the field of operations concerned. This ensured uniformity of procedure, and impartiality was ensured as far as was possible by the suggestor remaining anonymous until a decision had been made.

Experience of the previous scheme showed that the largest number of suggestions came from the operative Branches, that is, Engineering, Postal Services, etc. Accordingly, the newly-formed Board comprised the Assistant Director-General (Engineering) as Chairman, and the Assistant Director-General (Postal and Transport Services) and the Assistant Director-General (Telecommunications) as members. To assist the Board, a full-time Secretary was appointed with an appropriate office staff to handle routine administrative matters of acknowledging, recording, etc.

THE PRESENT COMPOSITION OF THE BOARD

Recently, a further reorganisation has taken place so that the Committee now comprises the Assistant Chief Engineer (Services), Engineering Division, as Chairman, with the Controller, Planning and Development Branch, Postal and Transport Services Division, and the Controller, Planning and Development Branch, Telecommunications Division as members. Fig. 1 shows a chart of the top level organisation of the Department. From this chart it will be seen that the Improvements Board is placed immediately under the Deputy Director-General and is directly responsible only to that officer or the Director-General. The Board's office staff includes a secretary who is assisted by four clerical officers and two typists.

The Board meets formally as required but between meetings the Secretary circulates reports on suggestions to the Board members for consideration, deals with correspondence as required and keeps the Board informed generally.

To encourage suggestions from staff the scheme is publicised by the periodical display of posters and appropriate articles in the Monthly Circular, Branch Journals, and Union and Association Journals. These articles and pamphlets all invite staff to submit suggestions. As suggestions may be posted to the Board free, every pillar box becomes, in effect, a suggestions box.

PROCEDURE IN BOARD'S OFFICE

On receipt of a suggestion in the Board's office it is immediately registered and acknowledged. Every effort is made for suggestions to be acknowledged within twenty-four hours. To facilitate the checking of suggestions for originality and to assist in the preparation of reports, two separate indexes are maintained, one listing alphabetically names of suggestors and the other, according to subject matter, the nature of suggestions received. Cross reference is made to any similar suggestion received during the previous five years, and the papers relating to these earlier suggestions are attached when the new suggestion is being considered. This procedure serves a dual purpose: first, it obviates considerable duplication of effort in gathering data already available; secondly, it enables credit to be given to the original proponent of any idea which may, although previously rejected, be adopted upon subsequent investigation of a later suggestion on similar lines.

After being acknowledged, the suggestion is edited and the text of the suggestion is referred by the Secretary to the Head of the Branch responsible for the activity or service to which the proposal relates. The Branch concerned then initiates enquiries, examines the suggestion in detail and gives a complete report on its practicability or otherwise. If the adoption of a suggestion is likely to involve more than one State or more than one Branch, copies of the proposal may be forwarded to each State or Branch concerned for their comments. Similarly, suggestions affecting other Departments, or likely to be of advantage to other Departments, are forwarded to the Public Service Board for consideration and investigation by the Board and the Departments concerned.

In some cases it is not possible to assess the worth of a suggestion without lengthy investigation. In these cases, the proponent of the idea is kept informed of the progress of the investigation.

The final report from the Branch to the Improvements Board sets out the advantages and disadvantages of the suggestion and recommends whether it should be adopted or rejected wholly or in part. Where the report is favourable an indication is given in the report of the savings which will result, or of the additional revenue which is likely to accrue, or other less tangible benefits to be derived from its adoption. An idea is not rejected while any doubt exists as to its worth. If a Branch's rejection of a proposal appears to be based on uncertain grounds, or where the reasons given are subject to doubt, the papers may be referred back to the Branch for further details.

One of the most crucial features of a suggestion scheme is the way in which rejections are handled. A clumsy rejection will inevitably cause the author concerned discouragement and loss of interest. For this reason, the Board has always insisted that the unsuccessful suggestor should be given to understand clearly and completely why his suggestion could not be accepted. The Secretary's advice is phrased to explain fully why adoption of the proposal is not practicable whilst conveying appreciation for the interest shown and encouraging submission of further ideas.

AWARDS

Suggestions for which awards are made can be classified under three distinct categories, namely:—

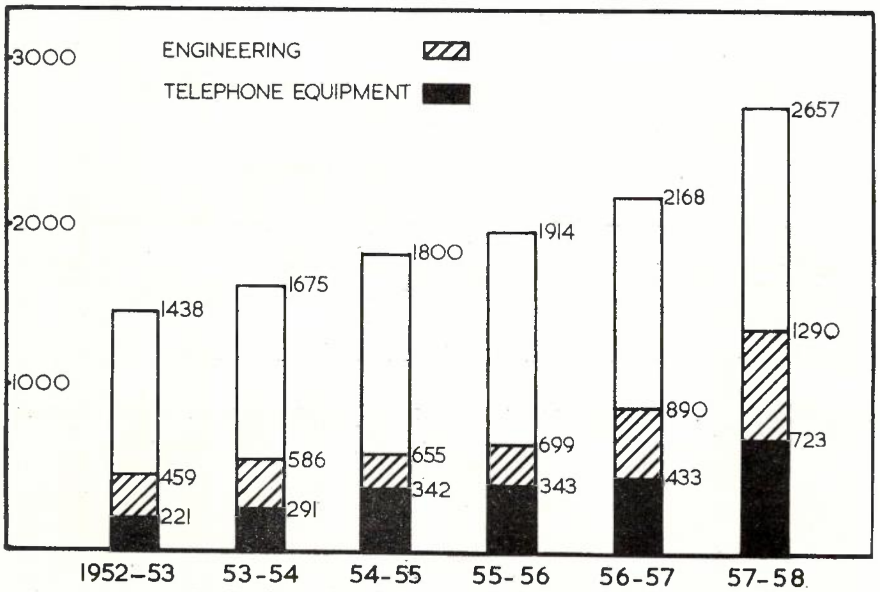

Fig. 2.—Suggestions Received by Improvements Board.

(a) Those which result in a definite financial saving or increased revenue to the Department or to the Service.

(b) Those which do not effect a saving but which effect improvements in service or procedure.

(c) Those which, although not suitable for adoption, merit tangible recognition—(i) by virtue of their ingenuity, evidence of constructive thought and research, and time and money expended by the suggestor, by the construction, for example, of working models; or (ii) for having brought about improvements which, although not suggested, become apparent as a result of the associated investigations.

For a suggestion resulting in a saving, assesment of an award is based on a percentage of the estimated savings for the first year after adoption of the suggestion. This basic award may be varied (either up or down) depending upon whether the suggestion relates to work of the suggestor's own Branch or any other Branch with which he is ordinarily associated, or to work of another branch entirely unrelated to his duties. The degree of originality displayed, the suggestor's status, the extent to which the basic idea has been developed, etc., are also factors bearing upon the amount of award. The higher the status of the suggestor the higher must be the quality of a suggestion to justify an award.

The minimum cash award paid for a suggestion which does not result in a saving but improves service or procedure is £2. This amount may be increased according to the degree of originality displayed, the extent of the application of the suggestion, and the benefit expected to be derived. Where there is evidence of considerable out-of-pocket expenses having been incurred by the suggestor, the Branch reporting on the suggestion may make an estimate of the amount, and this will be considered by the Board when assessing the award.

It should be noted that the submission of a suggestion results in a thorough and impartial investigation of an idea. It also ensures that the matter is brought to the notice of people in the various States who may be interested in the idea. Duplication of effort in two or more States often occurs because there is insufficient liaison between the States, but a suggestion which has Commonwealth-wide application will be brought to the notice of every State, thereby assisting co-ordination of effort.

No officer is barred from submitting a suggestion, but the amount of award is naturally dependent upon the status of the officer and the relation of his work to that of the suggestion. It may be of interest to know that suggestions have been received from a Supervising Engineer in one of the States. All staff employed by the Department are encouraged to ensure that ideas which will improve efficiency or contribute in any way to the efficiency of the Department should be made available to all officers concerned. This can be done through the Improvements Board or by the normal Departmental channels. However, it frequently happens that advice reaches Headquarters via the Improvements Board before the same information arrives via the normal channels.

The question of awards is one on which many people have fixed ideas and definite opinions. However, it should be stressed that the assessment of the value of a suggestion is no easy task. It is essential, before a full assessment can be made, that an overall picture of a scheme be kept in mind. For example, it is necessary to know whether the suggestion is applicable to the Commonwealth or only to one State, or even to one particular exchange or district. Then again, the type of suggestion has a large bearing on the award.

Many of the suggestions which are adopted are not really novel but, with the passage of time and the changing conditions of the Department, an idea which 10 or 15 years ago would not have been of value may now be acceptable. Quite often the Department will benefit from the earlier implementation of an idea in a suggestion although the idea is not novel, but in such a case, of course, an award is generally made. The assessment of this type of award is extremely difficult. Again, there must be consistency throughout the whole of the scheme. Every endeavour is made to keep a balance between recommended awards for suggestions of a similar nature and an overall balance between all suggestions which are adopted.

Encouragement awards are sometimes given in the Department. Encouragement awards can be very beneficial, particularly if a proponent has spent a great deal of time and effort in evolving, say, a circuit, and the only reason for its rejection is concurrent developmental work in Head Office or with one of the companies. This has occurred on several occasions. Quite often, however, the proponent's suggestion is not quite of the standard necessary for Departmental acceptance, not primarily through the proponent's fault but because he either has insufficient test equipment to try out his ideas or he is not in possession of all details required for the development. However, too free a use of encouragement awards can be detrimental to a suggestion scheme.

With an employment of approximately 83,000 people in the Department it is not surprising that duplication of ideas occurs due to "two great minds thinking alike," and thus quite often two or more suggestions on the one subject will come in to the Board within a matter of days. Also, it often happens that a suggestion proposed has already been thought of in the Head Office and the idea rejected on various economic or other grounds.

The Chairman of the Improvements Board has been delegated authority to approve payment of awards up to £5. All higher awards must be approved by the Public Service Board. All cash awards are accompanied by a notation on the officer's official history card. A notation on history cards may also be made in respect of suggestions which are adopted but which, by their limited scope, do not justify payment of a cash award. In addition, letters of commendation are often written to the authors of worthy suggestions.

Each month a list is published in the Monthly Circular in all States of the names of suggestors whose ideas have been adopted, with a brief description of the idea. They are also published in State Engineering Bulletins and other local publications. This publicity, however, is entirely dependent upon consent being given by the proponent to the publication of his name. Personal presentations are made by senior officers in the case of outstanding suggestions which are adopted.

STATISTICS

The large increase in the number of suggestions submitted to the Improvements Board in recent years is clearly shown in Fig. 2. It is apparent from a study of available figures that the increase in the number of suggestions submitted to the Improvements Board is largely due to the increase in Engineering suggestions. Whereas in 1952/53 the Engineering suggestions submitted to the Board represented 32% of the total received, this figure increased to 49% in 1957/58. During the same period the percentage of the Telephone Equipment Section's suggestions increased from 15.3 to 27.3.

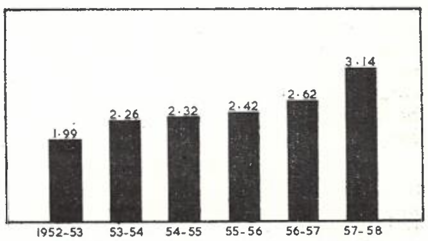

Fig. 3.—Suggestions Received per 100 Departmental Employees in Commonwealth.

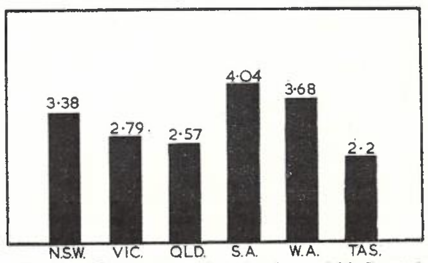

Fig. 4.—Suggestions Received per 100 Departmental Employees in various States, 1957-58.

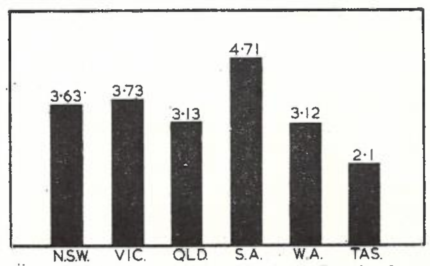

Fig. 5.—Engineering Suggestions Received per 100 Engineering Division Employees in various States, 1957-58.

It may be thought that the increases referred to above are due mainly to the increase in the number of staff employed in the Department. This is not so, as shown in Fig. 3. It will be seen that the number of suggestions from 100 employees (participation rate) has increased from 1.99 in 1952/53 to 3.14 in 1957/58. The participation rate for all Departmental employees in the various States is shown in Fig. 4 whilst Fig. 5 shows the participation rate for staff employed in the Engineering Division in the various States.

GENERAL SURVEY OF SUGGESTION SCHEMES

The importance of suggestion schemes in outside industry is apparently well recognised. In 1950, in the State of Victoria 46% of 75 companies included in a review had a suggestion scheme in operation. Of the total, 40% had never introduced a scheme and 14% had introduced schemes which had subsequently lapsed. A survey published in 1944 of 2,700 companies in U.S.A. showed that schemes were then operating in 25% of the manufacturing companies and in 20% of the non-manufacturing companies (1). The methods of operation of the various schemes employed elsewhere are basically similar. A committee is set up of three or more persons usually consisting of at least one member from top level management, a technical officer (often the Chief Engineer) and a representative of the Personnel Department, who is also the Secretary. In addition, there is often an employees' representative. Suggestions are investigated by suitable people and then forwarded to the committee for impartial consideration.

Suggestions are usually submitted on a printed form and placed in a suggestions box, these boxes being located at convenient points. The boxes are cleared regularly and the contents forwarded to the Secretary of the scheme who makes any necessary records, allots a number and forwards the suggestion to the appropriate person for investigation. Quite often several copies of the suggestion are made and forwarded to the heads of various sections who may be involved in the investigation and possible later implementation of the suggestion. In some schemes, the final decision whether the suggestion will be adopted or not is left entirely with the executive who will be responsible for its implementation. After investigation the suggestion is forwarded to the committee for assessment of the award. Usually, where the suggestion results in tangible savings the award is based on a proportion of the first year's estimated savings. Where an award is made not based on savings, that is, the improvement results in intangible savings, various factors are taken into account, such as the nature of the benefit, the distribution of the benefit, the ingenuity and initiative displayed by the proponent, the effort involved and the completeness of the proposal.

The question of anonymity appears to be of a contentious nature; some exponents of suggestions schemes insist on complete anonymity from beginning to end, even in the case where an award is made, others tend to the opposite extreme and require full knowledge of the proponent's name at all stages of investigation. However, the third school of thought to which this Department's scheme belongs believes in the middle course whereby the name of the proponent is published only when an award is made, and then only if he agrees. Although employees are required to show their names, designations and locations when submitting suggestions, that information is chiefly for determining and paying awards, and the principle of anonymity is observed as far as is practicable. However, where it is considered desirable, the name of the proponent is released to the investigating officer in order to facilitate investigation unless the proponent has specifically requested that his identity be kept confidential. In many circumstances, a suggestor desires his identity to be made known to the investigator as he has working models or ideas which are difficult to put down on paper or he is unable to express fully his ideas on paper. Such cases also give the proponent the satisfaction of knowing that his views have been correctly placed before the investigating officer.

In this regard, use is being made of retired officers for investigating suggestions submitted to the Improvements Board and, in particular, carrying out interviews with proponents where such are requested or warranted. The use of a retired officer for this type of work has a number of advantages as he can be quite impartial and independent and, having had many years of experience in the Department, possesses an intimate knowledge of its working and has a wide range of personal contacts. Furthermore, this is particularly important where design of equipment is concerned, as it has sometimes been found that a designer is reluctant to make changes to equipment he has assisted in designing. At present the Department employs one retired officer in Sydney, two in Melbourne and one in Adelaide. These men were senior responsible officers before their retirement and are proving of great assistance in the investigation of suggestions.

In considering the Departmental scheme in relation to other schemes in outside industry, it is very difficult to find one at all comparable. This is, partly, because of the large staff of approximately 83,000 employed by the P.M.G's Department and the fact that its activities are scattered so widely. In this regard, it is pertinent to mention that the P.M.G.'s Department is Australia's biggest business concern. One scheme at present operating in Australia is of interest as it involves a large staff throughout the Commonwealth. It is operated by the Vacuum Oil Company (4). This scheme is open to all staff except Directors, Branch General Managers and Branch Assistant Managers; awards for suggestions are not made to supervisors or senior officers if their suggestions could reasonably be considered as part of their ordinary duties. The suggestions are forwarded by company mail to the Branch Personnel Officer in the proponent's State who refers the suggestion to appropriate specialised officers for investigation and assessment. Each suggestion is usually sent also to the head of the Department concerned for his opinion on its suitability and of the savings likely to be effected. The suggestion and the investigation reports are then forwarded to the committee at the Head Office by the Personnel Officer who also adds his own recommendations for its acceptance or rejection. Subsequent to the final appraisal by the committee, the Personnel Officer informs the proponent of the result. If the suggestion is rejected the committee's reasons are given in detail.

Another scheme which bears comparison but which is not located in Australia, is the British Post Office Awards Suggestion Scheme referred to earlier. In 1935, the scheme was reviewed by a special committee (2) and a major change was introduced to make the scheme applicable to all Post Office staff instead of only factory employees. The scheme as it stands today is run on broadly similar lines to that of the Departmental suggestions scheme with the one outstanding difference that, where a suggestion is rejected, no reason is given for its rejection. This is in direct contrast to the practice of the A.P.O., as outlined earlier, and may be the cause, to some extent, of the relatively few suggestions submitted to the B.P.O. scheme, as shown in figures published by them (5). It is of interest to note that, even prior to 1935, the B.P.O. awards committee had power to authorise any individual award up to £20 without reference to any other authority (2).

THE EFFECTS AND BENEFITS OF A SUGGESTIONS SCHEME

The full effect and total benefits to be gained from a suggestions scheme are extremely difficult to assess. There are, of course, the immediate effects, such as the tangible savings obtained when a particular type of suggestion is adopted and implemented. But where a suggestion is adopted concerning safety measures or improvements to service, the gain cannot be readily assessed. However, there is no doubt that, taken from a long-term point of view, those types of suggestions ultimately benefit the enterprise from a monetary point of view.

Perhaps one of the greatest benefits of a suggestions scheme is the feeling it gives to the employee of participating in the operation of the enterprise. Furthermore, it provides a channel whereby an employee can obtain an impartial hearing for his ideas, particularly when he may have experienced opposition from his supervisory officers. The benefits gained in this way are intangible on the surface but the end effects can be a greater sense of security to the employee (in that if his idea is accepted he feels that he is wanted and he has a definite place in the enterprise) and an increased tendency to greater work output and production of more ideas due to quickened interest and the sense of participation. Management is also assisted greatly in that the submission of ideas and the subsequent replies to proponents provides a direct line of communication between the two.

As stated earlier, many firms in outside industry have installed suggestions schemes, but not in all cases. Where there is no suggestions scheme there is often an incentive award system which takes the place of the suggestions scheme to a large degree. Thus, the proponent of an idea in such a business receives an award commensurate with the idea in that his incentive pay is increased because the adoption of his idea leads to increased output. In the Public Service there is no direct incentive award scheme based on work output, and a suggestions scheme has a very vital part to play in the operation of a Department in the Service. The Improvements Board of a Department provides the only direct financial incentive for additional effort in the Public Service.

ATTITUDES TO SUGGESTIONS

The attitude of management to suggestions can be either positive or negative. If the approach is negative little value may be obtained from a suggestions scheme, and suggestions can be considered mainly of a nuisance value or even a slur on the management. However, if a positive attitude is taken much good can result from suggestions, even those that are rejected initially. In more than one case it has happened that over a period of, say, several years numerous suggestions on the one subject are submitted. With some suggestions schemes, an instruction is issued that suggestions on this subject are barred. However, in so far as the P.M.G.'s Department is concerned no suggestions are barred and, as mentioned previously, where a number of suggestions on the one subject are submitted, this is taken as an indication that trouble is being experienced in the field and that more extensive investigation is necessary.

An example of this type has been the marking of equipment. Quite a large number of suggestions have been submitted proposing the marking on equipment of the drawing number in addition to the schedule number and the year of manufacture and manufacturer's code. Some of these suggestions were rejected initially as investigations had shown that, in the case of relay sets and certain other pieces of equipment, the specification lays down that the drawing number must be included on the equipment. However, in the case of some switchboards and racks, and many pieces of equipment manufactured in the Postal Workshops, such was not the case and no drawing number is marked. As a result of the submission of these suggestions, action is in hand to have this rectified.

Another example is that of remote testing at R.A.X.'s. Over a period of several years, a number of suggestions have been received proposing that remote testing or allied remotely-controlled functions should be provided at R.A.X.'s

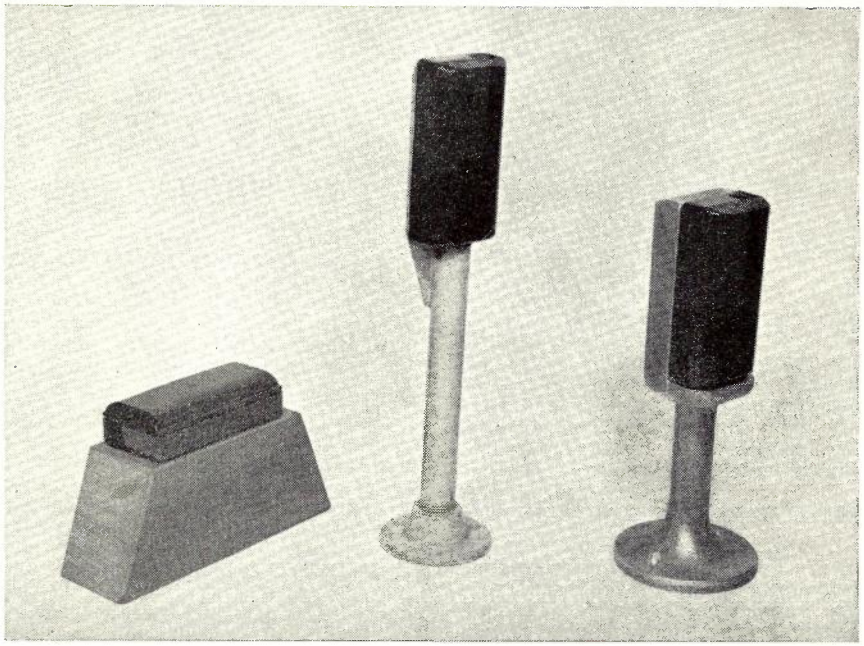

Fig. 6.—Wooden Pyramid Block, Conduit Pedestal and Suggested Aluminium Pedestal.

Early company-designed R.A.X.'s were provided with remote-testing facilities, but when the A.P.O. types B and C R.A.X.'s were evolved just at the end of the Second World War, simplicity was the keynote and it was decided not to include any remote-testing facilities. However, with the advent of qualitative maintenance and the large increases in labour and transport costs, it was decided that a revision of this policy was desirable. Furthermore, as country technicians have become familiar with automatic principles, and with the overall rise in the standard of training given to country technicians, the original necessity for simplicity of equipment has decreased. Consequently, as a result of the submission of the suggestions, the favourable reports from the engineering staff in the States and the considerable savings to be gained by its introduction, it has been decided to reverse the original policy and install remote-testing equipment.

Another fact to be borne in mind concerning suggestions is that the Department pays for ideas and not always for a complete design. A particular example of this is the newly-designed floor standard to Drawing CE.60029 for mounting the two-pair 20/4 terminal block in offices. Up until the time of the submission of a suggestion different States used various methods of attaching these blocks, particularly where desks at which telephones were required were situated in the centre of a room. Wooden pyramid blocks to Drawing CE.409 were used in some States. In one State a rather crude unit was fabricated from conduit and pipe fittings and sheet iron, and the costly overall result was lack of uniformity and often unsightly installations (see Fig. 6). The suggestion resulted from the desire of the management of the Commonwealth Bank in Hobart to have an installation of improved appearance over the standard one offered by the Department at that time, and the proponent of this suggestion in his own time developed a cast aluminium pedestal which formed the basis of his suggestion. This type of standard was installed in the Commonwealth Bank in Hobart. When the suggestion was first submitted to the Telephone Equipment Section for appraisal the design, as submitted, was

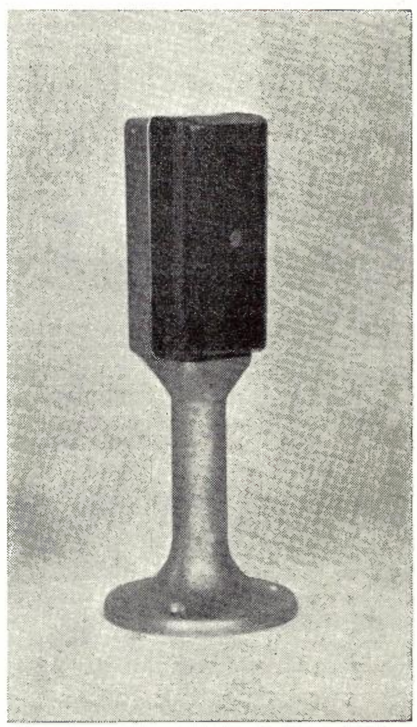

Fig. 7.—Aluminium Pedestal Mounting Developed from Suggestion.

not considered to be suitable for general Commonwealth wide use, due, mainly, to its high cost. However, it was decided that the submitted design would form a good basis for the development of a standard pedestal for use throughout the Commonwealth. Initially, it was decided to remove as much metal as possible to save material costs. Besides the savings in material costs, the standard was improved from an aesthetic point of view. The basic idea of the design is that it should be mounted near a table leg, and should be of such a size and proportion that objects such as floor polishers, brooms, etc., should not damage the somewhat fragile terminal blocks. Sections of the base were made so that they could be taken out readily in order to lead wires to the base without damaging the floor surface or cables. The pedestal as now purchased is shown in Fig. 7.

SOME INTERESTING SUGGESTIONS

One interesting suggestion was that by Mr. G. O'Mullane for the control and recording of automatic routiners in automatic exchanges. By the use of this suggestion a considerable number of man-hours can be saved in that it is not necessary that a routiner be attended whilst it is performing routine tests. Each switch is tested and, if faulty, is tested a second time, following which a printed record is made on a telegraph machine such as a Morkrum printer or teleprinter. At a convenient time the results are removed and the faulty switches are individually tested and the faults cleared. The suggestion has been developed further in that only one recording apparatus is required in each exchange, even if there are a number of routiners installed. Each routiner waits until the recording equipment is clear and then records its own particulars as required. In addition, the suggestion proposed a particular type of short routine to be applied to switches, and this can be of a selective nature in that of, say, the ten switches on a shelf, switch number one is routined fully, the other nine switches being short routined on the first day, and on the second day switch number two is routined fully, the other nine being short routined, and so on. Thus, over a period each switch will be fully routined, whilst every day every switch has a functional test applied to it. Whilst Mr. O'Mullane's suggestion was not completely original, as the B.P.O. were already developing such equipment, the method of application proposed by Mr. O'Mullane was more applicable to Australian conditions and has resulted in the earlier installation of this type of equipment than would have occurred if the suggestion had not been submitted and advice regarding developmental work by the B.P.O. had been awaited before application was made in Australia. Mr. O'Mullane's suggestion was more fully described in a previous issue of this Journal.[6]

Another suggestion, for which a substantial award was paid, was for the design of the 40-line B type R.A.X. by Mr. R. Nelder.[7] Five hundred of these units have been bought, and they are giving excellent service throughout the Commonwealth.

A fairly recent suggestion of note was to use 50-cycle current for the ring supply at small P.B.X.'s Investigation showed that this method has been in use by the B.P.O. for over 20 years, but had never been brought to the notice of the Department. Units are now being purchased which combine the 50-volt battery eliminator with the 50-cycle ring current in a neat and compact piece of equipment. This suggestion was submitted by Mr. R. W. Burlock.

It is anticipated that much time will be saved with the installation of automatic call-tracing and holding equipment at the Melbourne Trunk Exchange. This equipment will enable faulty trunk lines to be held and the call traced through each switching stage. A significant reduction in lost time on trunk lines should result. This suggestion was submitted by Mr. B. M. Worden.

Mr. E. L. Pearce suggested modificastions to test set No. 25, many of which will be adopted for use in future purchases. The inclusion of these alterations will enable a wider range of tests to be made with less fault liability.

There are still in use many thousands of pre-3000 type relays which were installed many years ago. The contacts on many of these relays have been worn down considerably. Mr. T. Martin devised a pair of re-contacting pliers for quickly and easily replacing these contacts. Full scale field trials are at present being conducted throughout the Commonwealth.

CONCLUSION

What of the future? As has been mentioned earlier, the number of suggestions submitted to the Board is continually increasing. This is, of course, a sign of a healthy attitude towards the suggestions scheme as a whole, and should be encouraged. The suggestions scheme is a very good way in which the field staff can bring to the notice of Headquarters the difficulties being experienced, particularly in minor things which are sometimes overlooked. It is readily admitted that there is still plenty of scope for the improvement of the service provided by the Department to the public. It is obvious from the recent Raise Our Sights forums that many of the manipulative staff have ideas to improve the efficiency of the Department and its workings in all aspects. It is these suggestions which we require to continually improve our service. Only by close co-operation between management and staff can improvements be effected, and the suggestions scheme is one of the most efficient ways of obtaining this co-operation.

No doubt the number of suggestions received will continue to rise, particularly if the speed of answer can be improved, and this will result in better human relations as well as greater safety and efficiency, together with improved service to the public.

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[7] "The Development of the Standard A.P.O. 40-Line "B" Type R.A.X." — R. Nelder, Telecommunications Journal of Australia, Vol. 7, No. 5.

CHANGE IN BOARD OF EDITORS

It is with regret that the Postal Electrical Society has accepted the resignation of Mr. A. N. Hoggart from the Editorial Board. Mr. Hoggart who was promoted some time ago as a Supervising Engineer in the Lines Section of the Victorian Administration, recently took up duty in the State Office. In recording appreciation for the valuable work Mr. Hoggart has rendered as Editor for the past two years, it is noteworthy that during this period considerable improvements have been made in the publishing aspects of the Journal and in the submission of articles. The Society joins with the Board of Editors in thanking Mr. Hoggart for his efforts in the past and wishing him success in his new sphere.

Mr. V. J. White has kindly agreed to undertake the editorial duties in place of Mr. Hoggart and has been appointed to the Board of Editors. Mr. White is a Sectional Engineer in the Lines Section at Headquarters who has had many years of engineering experience in the West Australian and Central Office Administrations, and has contributed to the Journal. His editorial experience in the publishing of the Departmental Publication "On the Line", apart from other qualifications, will be of value in the future work on the Board of Editors.

SHORT HAUL CABLE CARRIER SYSTEMS—PART 1

M. W. GUNN, B.Sc., A.M.I.E.Aust.*

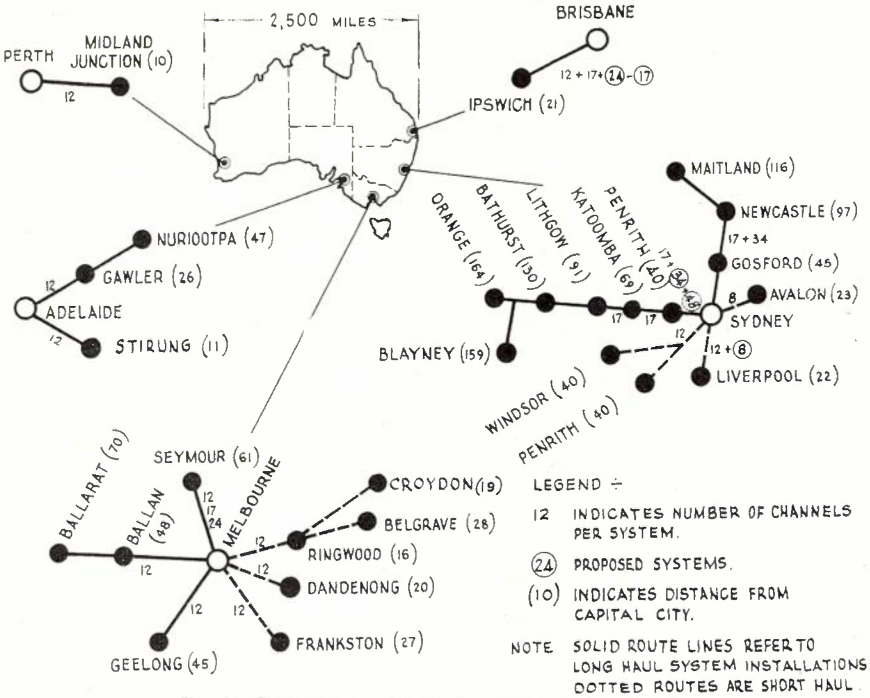

Fig. 1—Cable Carrier Routes Providing Trunk Circuits.

INTRODUCTION

Until recent years the application of cable carrier systems in Australia has been confined mostly to the installation of long haul systems such as the Type K system and the 17-channel system. Some installations of junction carrier equipment have been made in the metropolitan areas of Sydney and Melbourne, but the justification for these installations has been influenced considerably by the necessity for the early provision of the circuits required and very few systems of this type have been provided in the last few years. Compared with the distances for which the long haul systems were designed, their application in Australia has been over relatively short distances. The longest main route circuit at present in use is Sydney-Orange (164 miles), and the shortest is Perth-Midland Junction (10 miles). The trunk routes on which cable carrier equipment is at present installed are shown in Fig. 1.

Since World War II there has been considerable design effort on the part of telecommunication administrations and equipment manufacturers to develop cable carrier systems which are economical for short haul operation. This development was encouraged by the rise in the price of cables, and the increase in demand for circuits together with the expansion of toll dialling. This programme has led within the last ten years to the development of short haul systems such as the Western Electric Type N, the Siemens & Halske Type Z 12 N, the Philips Type STR.113, and to the further development of the T. S. Skillman junction carrier system. These short haul systems give more economical channel provision than the systems available previously and consequently enable carrier channels to be justified for shorter distances. They are designed to have a wide application and are used on existing cables (deloaded) as well as new cables.

This article reviews the characteristics and application of the T. S. Skillman System Type RY432, the Philips System Type STR.113, and the Siemens &

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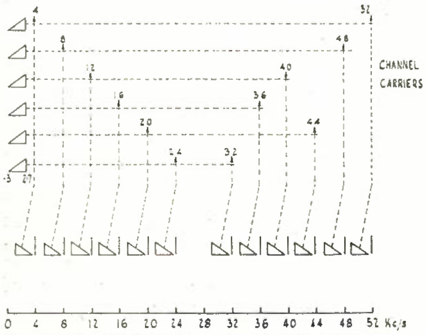


Fig. 2—Frequency Allocations and Modulation Plan—Type RY 432 System.

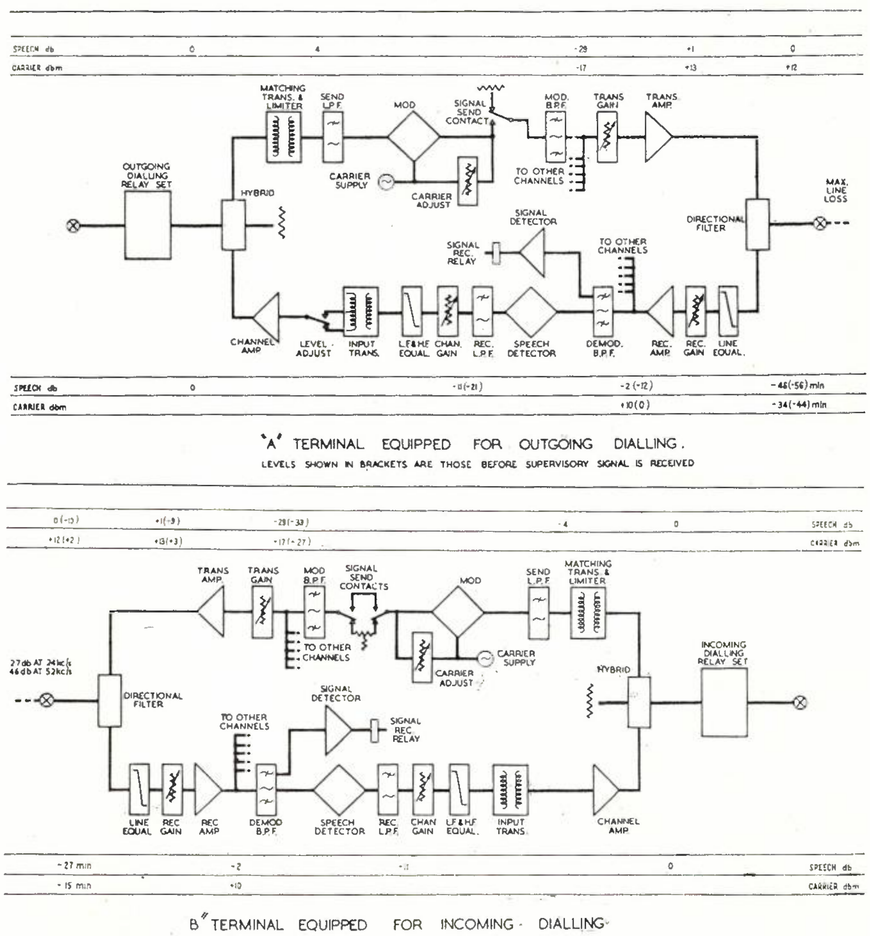


Fig. 3—Block Diagram of A & B Terminals of Type RY 432 System.

Halske System Type Z 12 N, which have been purchased for installation in the New South Wales and Victorian networks. The Western Electric Type N1 System has been covered by other articles in this Journal. (1,2).

T. S. SKILLMAN SYSTEM TYPE RY.432

General

This system provides 6 channels per bearer on unloaded cables, and was originally designed to give junction relief in city networks. It is electrically similar to the 6 channel junction cable carrier equipment described in this Journal (3), but physically it is very much smaller. In practice, upwards of 30% of the pairs of a junction cable, after deloading, will give satisfactory crosstalk figures up to 52 kc/s without special balancing, and thus the capacity of a cable can be doubled by the use of these systems. Carrier frequencies spaced at 4 kc/s intervals are used and provide 6 channels on a grouped frequency basis using the range 0-24 kc/s for A-B transmission and 28-52 kc/s for B-A transmission. The system uses transmitted carrier and derives its signalling facilities from this transmitted carrier.

Up to the present time the application of these systems has been to derive extra circuits from existing cables which are fully occupied, although as indicated previously the justification for provision has depended in all cases on the necessity for quick provision of the circuits concerned, rather than on economic grounds. In recent years the application has been on short trunk routes as well as on junction routes.

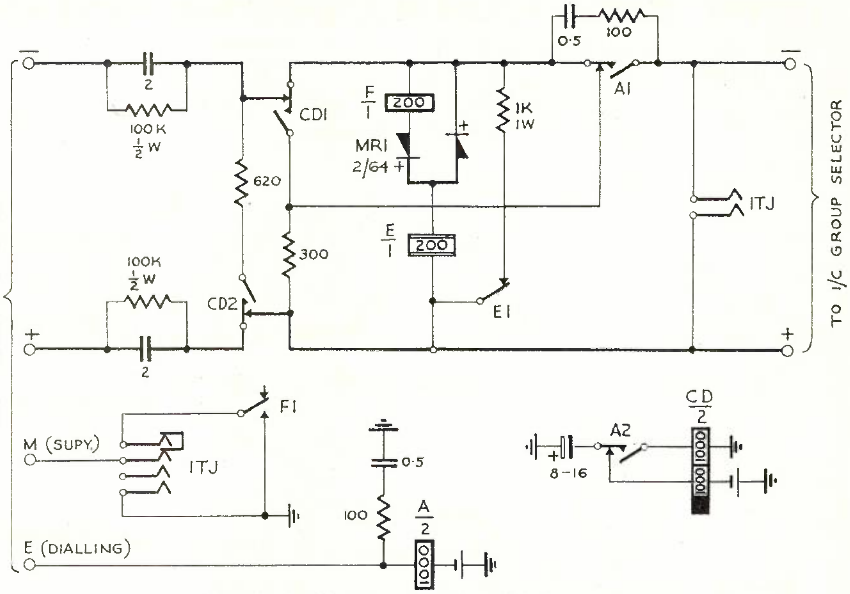


Fig. 4—Junction Carrier Relay Set—Incoming.

The system transmits lower sidebands in both A-B and B-A directions, together with the carrier which is used for demodulation and signalling purposes. The frequency allocation is shown in Fig. 2 and the channels derived have an effective bandwidth of 300-2700 c/s.

Terminal Equipment

Electrical Functions: A block schematic diagram of an A terminal equipped for outgoing dialling and the corresponding incoming B terminal is given in Fig. 3. The relative sending level per channel is 0 db and the corresponding carrier goes to line at +12 dbm. Individual channel units are readily converted to "outgoing" or "incoming" conditions, as required, by small plug in relay sets. High speed relays are used for the sending and receiving dialling functions. Supervision is normally given from the "incoming" terminal back to the "outgoing" terminal by initially using a low level carrier condition and then increasing this carrier by 10 db when the metering signal is required. The gain of the channel amplifier at the "outgoing" terminal is reduced accordingly when this occurs. However this method of supervision causes crosstalk to be degraded by 10 db in the period before the supervisory pulse is obtained, and a number of systems have been modified to use a pulse type of supervision. This is described later in this article.

The maximum line attenuation over which the system can operate without repeaters is 46 db at 52 kc/s. This is equivalent to a little over 10 miles of 20 lb. star quad cable or a little under 7 miles of 10 lb. cable. Fixed equalisers appropriate to the route concerned have been used but a variable equaliser has now been developed. This has the disadvantage at present of requiring a separate small panel for mounting but offers considerable advantages during installation and for subsequent transfers. No repeatered installation of this type of system is planned for the present.

A moveable link on the front panel of each channel unit allows the transmission

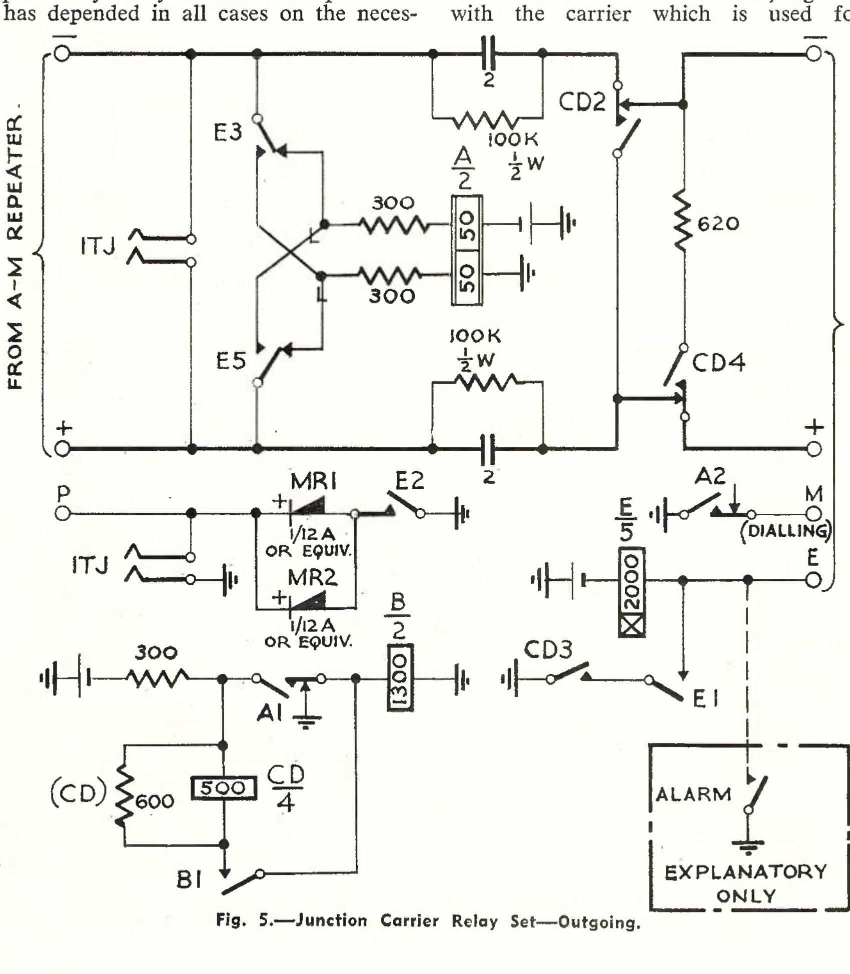


Fig. 5.—Junction Carrier Relay Set—Outgoing.

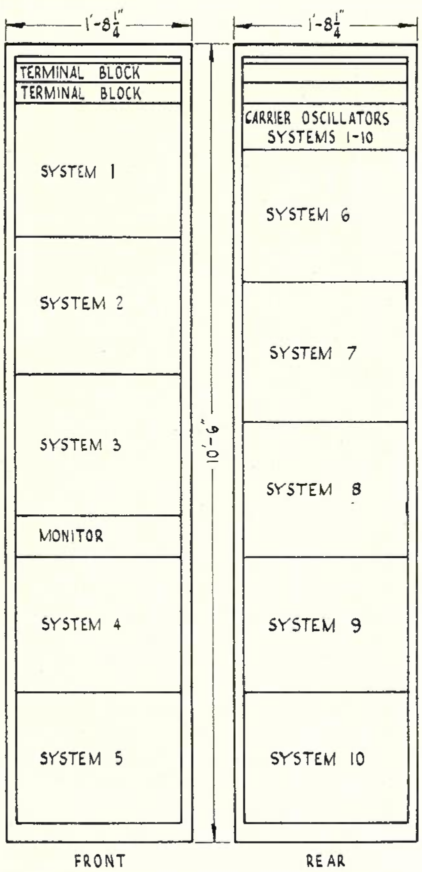


Fig. 6—Terminal Layout of Type RY 432 Systems on 10 ft. 6 inch Rack.

of high level carrier to be stopped for a sideband level measurement, or alternatively for the channel transmission to be stopped completely.

Signalling: The system uses transmitted carrier for signalling, the carrier being continuously transmitted and then broken by dialling or other signalling impulses as required. This carrier is transmitted at a level of +12 dbm under normal conditions. The supervisory signal from the called subscriber when answering is given normally by an increase in carrier level from the "incoming" terminal from + 2dbm to + 12 dbm. The low level of carrier transmitted continuously in this backward direction permits transmission of the tones and speech which occur prior to the called subscriber answering. A separate valve is used for the signalling detector and the design is simple and effective.

Conversion relay sets are provided in accordance with Figs. 4 and 5. These sets are designed to work from auto/auto or auto-manual repeaters, and thus as far as the exchange equipment is concerned, a junction carrier circuit is completely equivalent to a cable pair. The sets are normally mounted single-sided on a 10′ 6″ rack, 20¼″ wide, each rack mounting 60 sets. This capacity corresponds to a completely equipped 10′ 6″ rack of terminals (10 terminals) so that installations take the form of an equal number of terminal racks and relay set racks.

Carrier Supply: A carrier supply comprises six plug-in oscillators of frequency 4, 8, 12, 16, 20 and 24 kc/s for an A terminal and 32, 36, 40, 44, 48 and 52 kc/s for a B terminal. Each oscillator will supply a maximum of 10 terminals, and has an output of +8 dbm. A spare oscillator, which can be readily adjusted to give any particular channel frequency, is provided with each supply. Coil condenser oscillators are used, and do not vary more than ± 30 c/s for all practical applications. Particularly stable oscillators are not required as the transmitted carrier is used for demodulation purposes.

Physical Layout and Construction: This system is representative of the redesign work which has been carried out by T. S. Skillman over the past few years. Its physical size has been reduced to approximately one-fifth of that of the non-miniaturised system, without any impairment of its electrical performance. A 10′ 6″ rack will carry 10 terminals with associated carrier supply and monitor panel, whilst an 8′ 6″ rack will carry 5 terminals with carrier supply and monitor panel. The physical layout of a 10′ 6″ rack is illustrated in Fig. 6. The reduction in physical size has been made with standard components or their readily obtainable miniature equivalents. The reduction in size has been made possible primarily by the miniaturised coils developed by the Company, and by the physical layout of the equipment which effectively uses the full volume available.

In accordance with modern practice the system uses plug-in working units, for example, channel units, carrier supply oscillators and transmitting amplifiers.

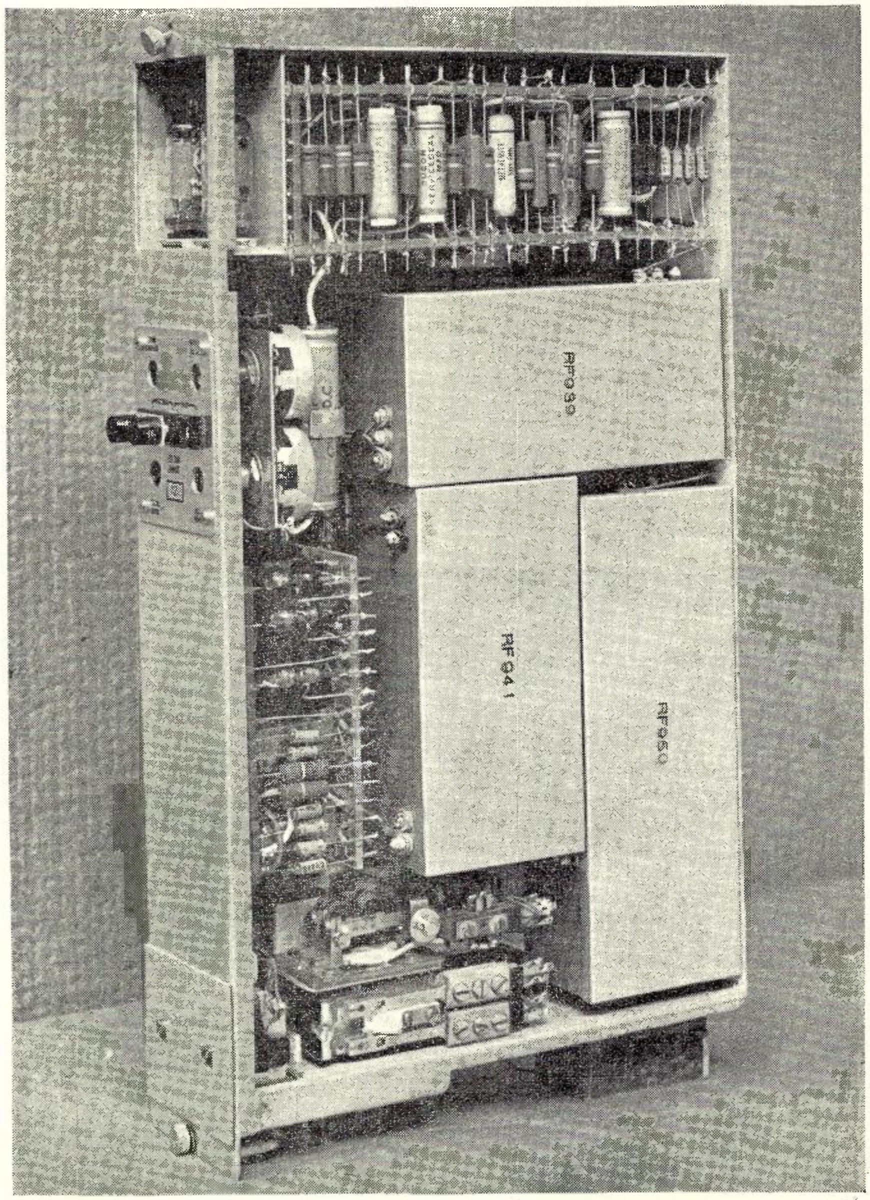


Fig. 7—Channel Unit of Type RY 432 System.

The plugs and sockets used are B.P.O. 2000 type switch jacks which are gold-plated for satisfactory service in low level circuits. They are located so as to avoid accidental short circuits and dust entry, and have readily removable cover plates to allow inspection in situ if necessary. The base frame, into which these units plug, screws directly to a standard 20¼" wide rack. This frame carries the terminal strips which connect to the rack wiring which in turn terminates on the strips at the top of the rack.

The constructional techniques used are illustrated in Fig. 7, which shows the details of a channel unit, and Fig. 8 which shows the channel unit jacking arrangements. Fig. 9 illustrates four complete terminal units mounted on an 8′ 6″ rack.

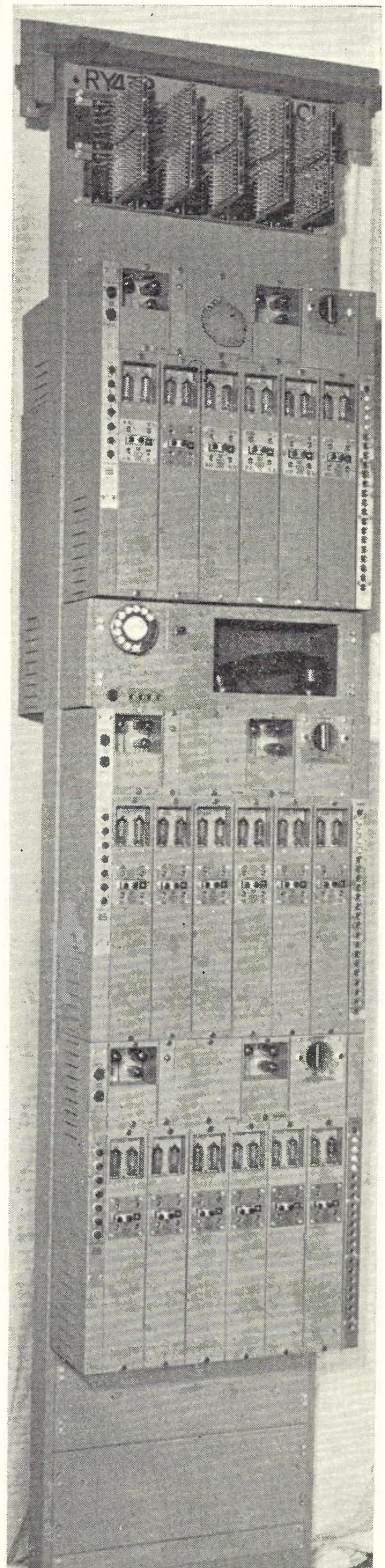
Valves Used: The valves used throughout the system are limited to two types, 6AQ5 and 6AU6, which are on the Department's list of preferred types.

Alarm Facilities: Comprehensive alarm facilities are provided by this system to cater for the specialised junction working it offers. Voltage supply failures, common equipment failures, and removal of common equipment from the terminal rack are catered for and earth the private wires to prevent switching to faulty circuits. A far end alarm is also provided, which indicates to a terminal that a "failure other end" exists.

Power Supply: The system as supplied to the Department is designed for operation from 48V and 130V D.C. supplies which are provided from the normal exchange supply and a small 130V rectifier plus battery installation. Typical figures for power consumption are as follows:

	48V. D.C.	130V. D.C.
Terminal	1.4 amps.	0.22 amps.
Carrier Supply (6 oscillators)	3.0 amps.	0.22 amps.
Relay sets for 6 channels	0.35 amps	—

Fig. 9—Four Type RY 432 Terminals on an 8 ft. 6 inch Rack.



Measuring Facilities: A portable meter which is used in conjunction with a rotary switch on the terminal to measure percentage deviations from normal, is provided for each terminal location. Jacked equipment can be removed on extension leads for measurements under working conditions, and a bay trunk is provided on each rack to extend measuring equipment to either side of the rack if required. To give complete measuring facilities, an Australian Post Office Transmission Measuring Set is also provided at each terminal location. This T.M.S. provides facilities giving 800 c/s at levels 0, –3, –13, –40 dbm, and is capable of measuring levels and losses from –35 dbm to +33 dbm in the frequency range 30 c/s – 50 kc/s.

Dimensions and Weights: A 6-channel terminal occupies 21″ of rack space and weighs 70 lb. The corresponding figures for a carrier supply are 7″ and 35 lb. and for a monitor panel 7″ and 15 lb. Equipment units project 7″ from the rack.

PHILIPS 6-CHANNEL SYSTEM TYPE STR.113

General:

This system (4) has been designed to provide an economical means of increasing the number of speech circuits obtainable from an existing V.F. or carrier cable. The channel carrier frequencies are spaced at 6 kc/s intervals, and are of the single side-band suppressed carrier type. Eight carrier circuits per cable pair are produced on a group frequency basis using 6 to 54 kc/s for one direction of transmission, and 60-108 kc/s in reverse direction.

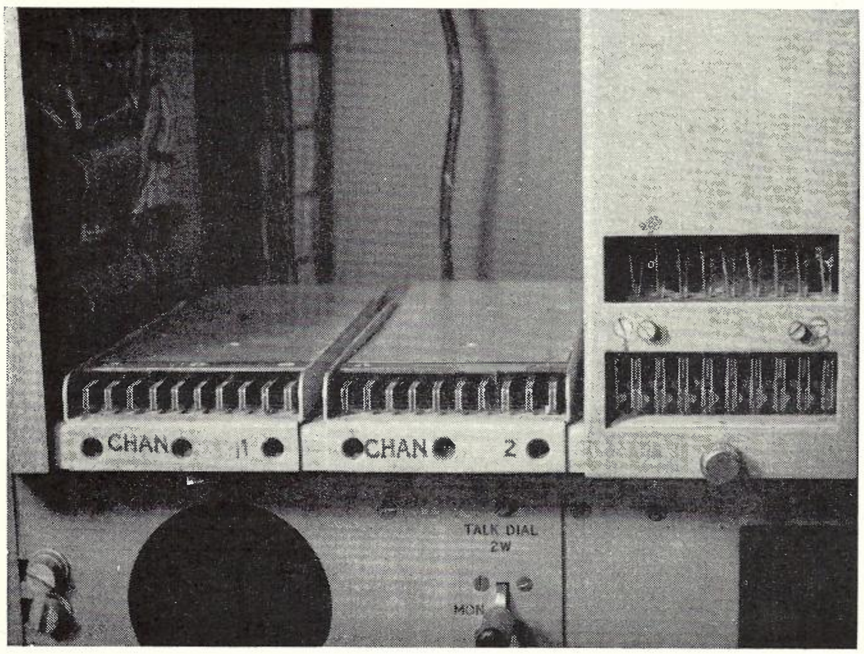


Fig. 8—Channel Unit Jacking Arrangements Type RY 432.

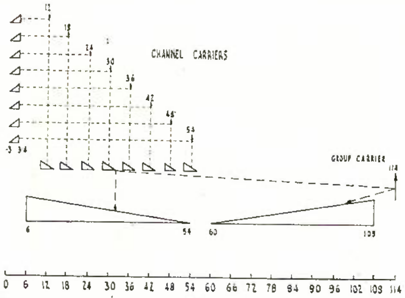


Fig. 10—Frequency Allocation and Modulation Plan—Type STR 113/13 System.

The frequency band of a speech channel is 300-3400 c/s, and each channel is provided with an in-built signalling circuit, which uses a frequency of 4300 c/s. Pre-equalisation is provided at the terminals and has a slope equivalent to approximately half the length of the maximum repeater section spacing. The remaining equalisation required is obtained in the repeaters and the distant terminal receiving amplifier. The intermediate repeaters use frequency frogging, involving the inter-changing of the high and low groups in each direction.

The pairs on which the systems are to be used must be de-loaded, and have suitable crosstalk characteristics. The latter are obtained by selection of pairs, or by balancing.

Fig. 10 shows the frequency plan of the system terminals. The eight V.F. channels, 300-3,400 c/s, are modulated with carriers of 12, 18, 24, 30, 36, 42, 48 and 54 kc/s respectively. The lower side-bands are selected, and the carriers suppressed. The resulting 6-54 kc/s band goes directly to line, or is translated to 60-108 kc/s using a carrier of 114 kc/s before transmission, according to the overall circuit requirements.

Terminal Equipment

Electrical Functions: A block diagram of a terminal station and one repeater is given in Fig. 12, which also includes a typical level diagram, but omits the carrier supply circuits. Provision is made for working with either 2-wire or 4-wire V.F. circuits. In the 2-wire condition, the relative line-up level is 0db at hybrid line. Under 4-wire conditions the pads provided are of a semi-fixed type, which are supplied from the factory in accordance with requirements, and which can be obtained with a sufficient range to almost meet the standard levels of –13 db and + 4db, at the transmitting and receiving terminals respectively. Pre-

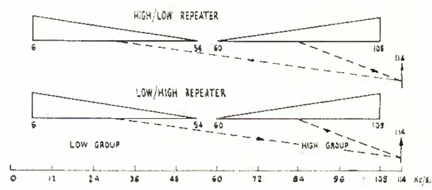


Fig. 11—Repeater Frequency Allocations—Type STR 113/13 System.

equalisation equal to one half of the maximum repeater section is provided in the transmit equipment, and the repeater lengths are built out to this length by means of a positive or negative artificial line which is incorporated in the negative feed-back circuits of the line amplifiers. Pre-equalisation has the advantage that the low frequencies, which are most likely to cause intermodulation effects in the directional filters, are transmitted at a relatively low level, while the higher level of the high frequency channels improves the signal-to-noise ratio. Variable equalisation is provided which corrects for cable sections having attenuations of between 26 and 65 db at 108 kc/s.

Signalling: A frequency of 4300 c/s is used for the transmission of the signal-

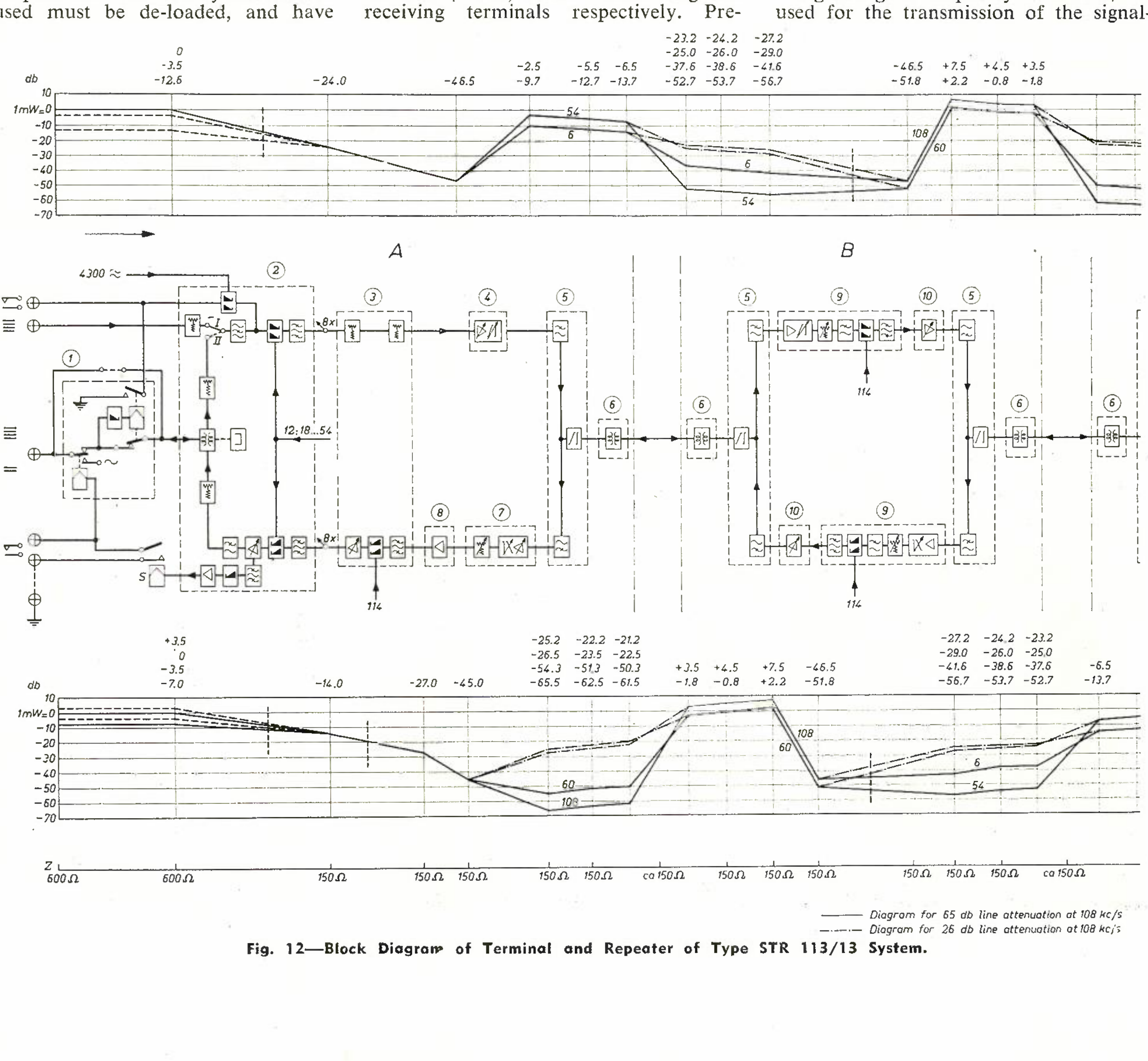


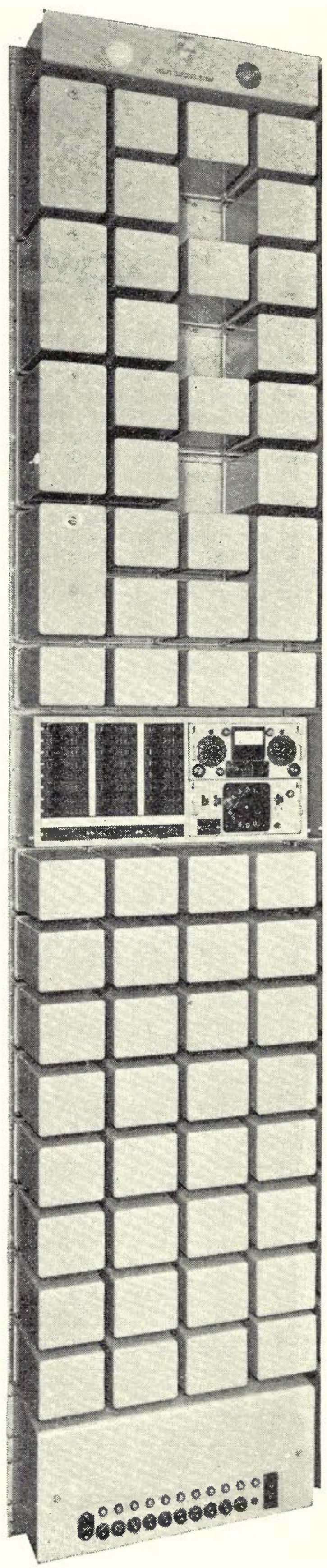
Fig. 12—Block Diagram of Terminal and Repeater of Type STR 113/13 System.

ling impulses associated with each channel. The signalling level is -6db at a point of zero reference level. Since this signalling frequency lies outside the speech band of the system, a large measure of speech immunity is provided, without auxiliary guard circuits. At the transmitting end a static relay is used to modulate the signalling carrier with the impulses from the associated relay set. At the receiving end, the signalling frequency is separated, and the impulses are rectified and used to operate the high speed signalling relay after amplification by a D.C. amplifier. The receive signalling relays may be mounted either on the bay panels or in the associated exchange relay sets. A separate oscillator, with a standby oscillator and changeover facilities, provides the 4300 c/s signalling tone. The system is not suitable for use on a continuous tone signalling basis, because of possible intermodulation effects in the common path, and the fact that the signalling tone causes interference in its associated channel of the order of -35db weighted. For this reason it has been necessary to produce special pulse type relay sets, which cause transmission of signalling tone only during impulses and supervisory periods. In the case of multi-metered circuits, the multimetering timing pulses can be heard quite distinctly, but are not undesirable.

Carrier Supply: All frequencies are derived from a master frequency of 114 kc/s generated by a thermostatically controlled crystal oscillator. Part of the 114 kc/s output is used to synchronise a 6 kc/s oscillator, the output of which is amplified to drive a magnetic multivibrator. The required carrier frequencies are filtered from the multi-vibrator output. The 4300 c/s signalling frequency is obtained from a separate oscillator. The carrier supply provides for up to 96 channels, that is 4 racks of equipment. Normal procedure for a 4 rack installation is to have carrier supplies on racks 1 and 2 only, with automatic changeover in the case of failure. The design of the carrier supply is based on the assumption that the harmonic generator will not become faulty and thus only one rack in a 4 rack installation is provided with this equipment. Provision is made for the checking of the synchronisation between oscillators.

Physical Layout and Construction: The mechanical design of this system is dominated by the requirement that the component units must be standardised and must be readily interchangeable. Reduction in component size as compared with pre-war components makes it possible to combine electrical units into easily mountable equipment. This system uses Philips "conclave construction" by which parts of electrical units previously built in separate sealed cans are enclosed as one complete electrical unit in one airtight container. Thus a channel unit is enclosed in one die-cast aluminium alloy air-tight container which can be readily dismantled for maintenance purposes, and which jacks into the terminal bay

Fig. 14.—Terminal Bayside with Three Complete Type STR 113/13 Terminals.



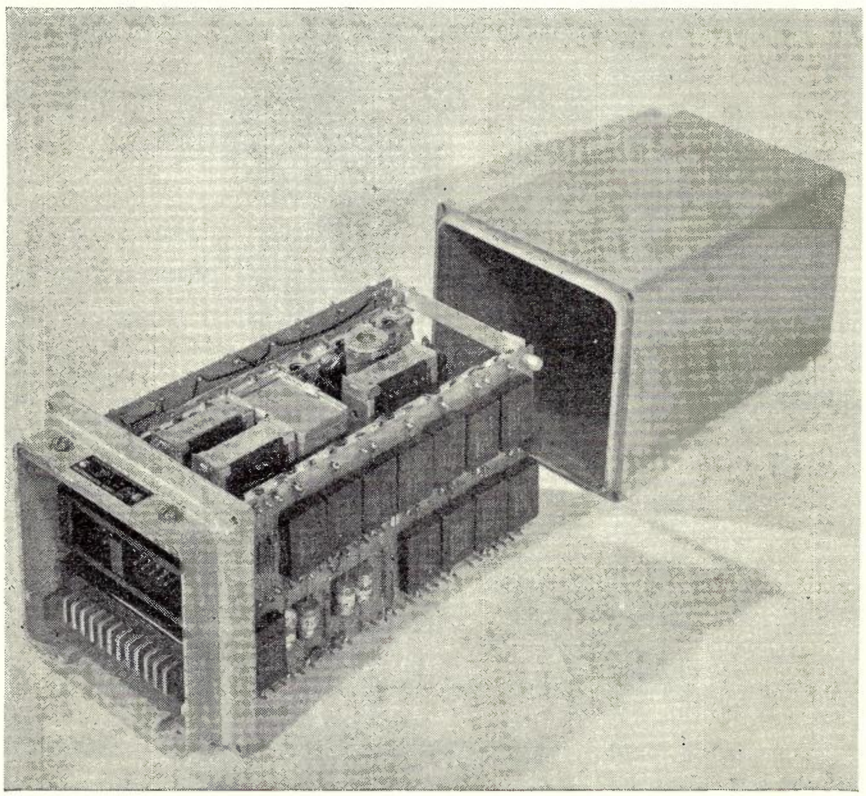


Fig. 13—Channel Unit of Type STR 113/13 System.

assembly. Silica gel desiccators are provided in each conclave unit, to keep the moisture content at a low figure. It is important that this silica gel cartridge be re-generated whenever the conclave unit is opened to the air for more than a few minutes. If the unit is open for a considerable period there is a tendency for an amount of moisture to be absorbed in the various components and mechanical structure, which is greater than the capabilities of absorption of the silica gel cartridge. Under these circumstances, it is necessary for the conclave unit to be re-opened about 24 hours after the initial closing, and the silica gel cartridge again dried. It is most important when drying the silica gel that an excessive amount of heat is not used, as this causes powdering of the desicant, with consequent loss of efficiency.

A channel unit is illustrated in Fig. 13, and the channel bay assembly in Fig. 14. Fig. 15 illustrates the central section of a terminal bay containing the telephone test panel, "U" link panel and monitoring set, and has one channel unit removed which shows details of the jacking, and mounting of the receiver signalling relay. Each plug-in unit is provided with a 24-way plug, and a separate strip of pin terminals is also provided which enables various adjustments (such as amplifier gain) to be made from the outside of the unit by means of pin strapping. The components are mounted on bakelite sheets which are in turn supported on the unit framework.

The physical layout of a terminal rack of the STR. 113/13 system is shown in Fig. 16. This arrangement provides three complete 8-channel systems including relay sets, plus carrier supply and power supply. Standard rack dimensions are 9′ high x 21″ wide and 11½″ deep. Their construction is such that they can be placed back to back, but installations of this nature are not suited to the Department's standard row spacing of 4′, as it results in an inconveniently narrow aisle space of 2′ 1″. Each rack consists of a rectangular frame of aluminium alloy channel sections, which carries the mounting plates, each plate providing four jack receptacles side by side. The fittings for each conclave unit consist of a fulcrum plate and a 24-way socket, and may also make provision for a fuse and a channel unit signalling relay. The units are plugged in by engaging with the fulcrum plate and pressing downwards. This hinge construction makes it possible to use contacts with high contact pressure, since considerable force may readily be applied for making and breaking the contacts. It also provides automatic line-up of the contacts, and prevents incorrect insertion. The position of the contacts protects them to a large extent against dust. The magnetic coupling between circuit pairs is kept low by arranging the contacts in pairs with each pair separated by only a thin sheet of insulating material. The form of panel mounting used in this system, in which the units are individually suspended, allows the free circulation of air, which is required for heat dissipation from the totally closed units, to be obtained.

A later version of this system, coded STR. 113/11, uses separately mounted relay sets. This enables the bay layout to be changed to provide accommodation for four complete 8-channel systems plus carrier and power supplies.

Valves Used: Amplifiers, oscillators, supervisory and synchronising units use only two types of long life pentode valve, E83F and E81L.

Power Supply: The systems include power packs enabling operation from 220V 50-60 c/s A.C. supplies, with a maximum permissible fluctuation of ± 5%. Power consumption for a terminal bay is about 465 V.A. (P.F. 0.8) and for a repeater bay about 390 V.A. (P.F. 0.8).

Test Panel and Alarms: The test panel provides facilities for measurement of the important currents and voltages by means of a meter and two 12 position switches. These switches facilitate routine measurements and enable rapid locations of faulty units to be made. Urgent and non-urgent alarm lamps are mounted at the top of the bay. Individual channel unit failures do not give an alarm, but conditions which cause the failure of an 8-channel group are brought to immediate attention.

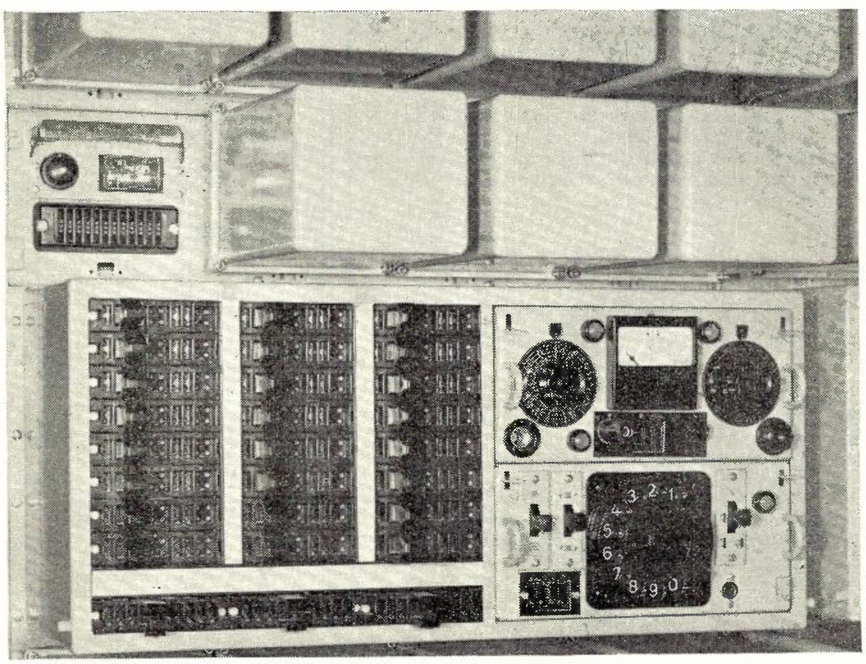


Fig. 15.—Channel Unit Jacking and Test Panel.

Repeater Equipment

Electrical Functions: As mentioned previously, Fig. 12 gives the block diagram and level diagram for a typical repeater station. The frequency modulation plan is illustrated in Fig. 11. Frequency frogging is applied at repeater stations to interchange the frequency bands for the two directions of transmission, so that for both directions a repeater receives the lower band and transmits the higher band or vice versa. A frequency of 114 kc/s is used to effect the modulation required. The use of frequency frogging complicates the line amplifier equipment required at terminal and repeater stations but gives considerable advantages in working which can be summarised as follows:—

(i) Third circuit effects are reduced so that non-repeated circuits can pass through a repeater station without the installation of low pass filters to block the crosstalk paths.

(ii) As the sums of the losses in two repeater sections for all channels are approximately the same, it is possible to have repeaters with an almost flat frequency response. In practice this is usually obtained by pre-equalising at the transmitting terminal for half of the designed repeater length, thus giving each terminal and repeater a specified slope and level for the high and low groups.

(iii) The gain provided by the line amplifiers can be the same for both directions of transmission and can be less than that which would be necessary for the amplifier in the high group if no frogging were used. The usual application is with the pre-equalisation discussed under (ii), and results in a repeater gain approximating that corresponding to the loss of the cable at the mean line frequency of the bands in use. In the Philips STR.113 system this frequency is 60 kc/s.

(iv) Variations in cable losses due to temperature changes are compensated to some extent. With temperature change, the significant cable changes for short haul systems are expressed as a flat loss change and a slope change, and if successive repeater sections are at approximately the same temperature, the slope changes due to temperature variations will be nearly compensated.

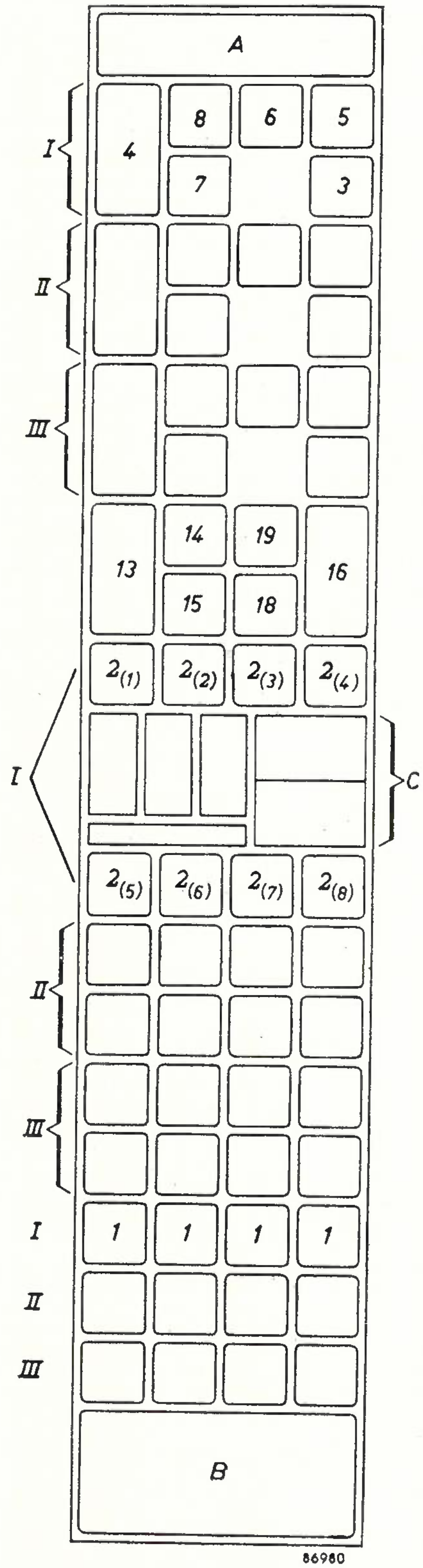


Fig. 16.—Layout of Terminal Rack of STR 113 System, When Arranged for Transmission in the 6-54 kc/s Band. A = terminal blocks; B = power unit; C = telephone and test panel. Roman numerals refer to systems; arabic numerals refer to Fig. 12; index numbers refer to channels.

(v) Some reduction in inter-system crosstalk can be effected as two channels will run in parallel in the high frequency position, where crosstalk interference is greater, for only half the distance as compared with a system without fiequency frogging.

The system will work over 70 db sections with a maximum of 4 sections. A maximum of 10 repeater sections may be used if the loss is smaller than 70 db. Two limiting factors of the total terminal to terminal line loss exist. They are:

(a) The accumulating frequency deviations brought about by frogging, and

(b) The effect on level stability caused by variations in cable attenuation with temperature changes.

In practice, however, neither of these limitations will be decisive in the spacing and number of repeaters, since in most installed cables interference and noise (such as dialling interference) will limit the repeater section insertion loss to a lower figure than might be expected from the previous paragraph in order to maintain an adequate signal-to-noise ratio on the channels.

Physical Layout and Construction: Physically the repeater equipment is of similar construction to the terminal equipment and the bay layout is illustrated in Fig. 17. A bay provides for 6 repeaters, with associated carrier supply and power supply. The 114 kc/s carrier supply provides for the 6 repeaters and is provided in duplicate with automatic change over facilities. The test panel provides patching facilities to enable repeaters to be replaced without circuit interruption.

High Frequency Line Adjustment: The overall adjustments for equalising the carrier line characteristics consist of flat and slope networks at each repeater station and in the terminal receiver amplifiers. In addition, a mid-section equaliser is provided at the repeater station nearest to the middle of the route when a number of repeater stations are employed. The purpose of this equaliser is to compensate for the systematic differences between the line loss and the individual gain characteristics of the repeaters.

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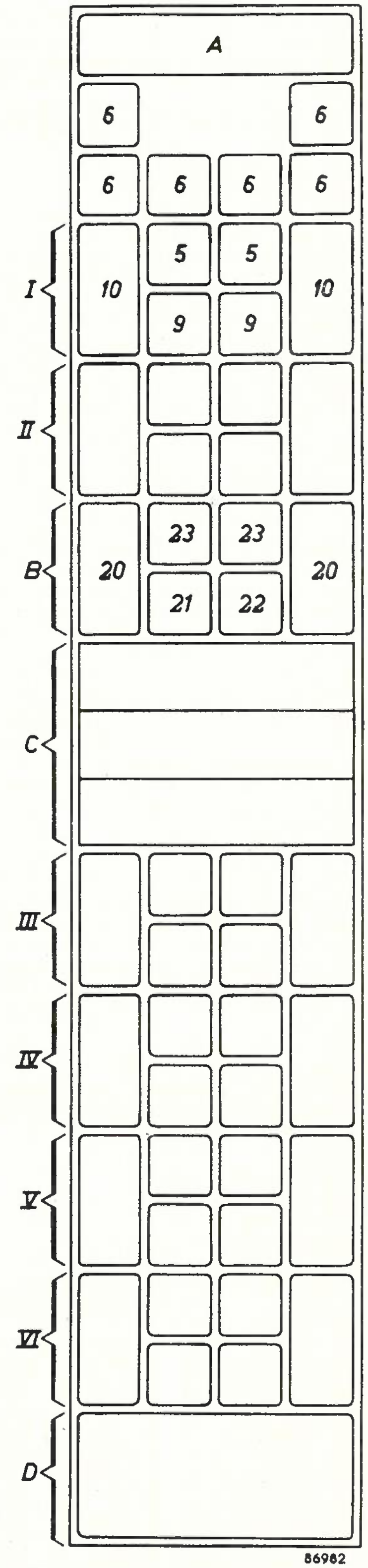

Fig. 17.—Layout of Units on Repeater Rack. A = terminal blocks; B = carrier supply and alarm units; C = test and alarm panel; D = power unit. 5 = directional filter unit; 6 = matching transformers; 9 = frogging unit for low-to-high band conversion; 10 = transmitting amplifier; 20 = 114 kc/s oscillator unit; 21 = alarm unit; 22 = optional unit for relaying alarms to attended station; 23 = spare units.

DETERIORATION OF THE PHYSICAL TERMINATIONS OF THE BASS STRAIT TELEPHONE CABLE

*P. R. BRETT, B.Sc., A.Inst.P.**

INTRODUCTION

During the 1957 repair operations on the Bass Strait Cable it was found that the last few feet of cable at three of the four cable terminals was in poor condition, having low insulation resistance. The faulty portions were cut away and the cable resealed. Full details of the history, location and repair of the faults were given in a recent article in this Journal (1). The recovered cable with the old seals (called "terminations") was examined in the P.M.G. Research Laboratories with a view to finding the cause of the deterioration and to devising an improved method of sealing the cable ends.

EXAMINATION OF FAULTY TERMINATIONS

The samples examined were:

(i) Northern Cable Termination from Naracoopa, King Island. this termination was made in 1935 using the method shown in Fig. 1.

(ii) Southern Cable Termination from Naracoopa, King Island. this termination was made in 1949 in accordance with Fig. 1.

(iii) Southern Cable Termination from Stanley, Tasmania. This termination was made in 1950 in accordance with Fig. 2.

Basically the three are the same, the main difference being in the method of bringing out the return conductor. In the method shown in Fig. 1 the return conductors are insulated from the lead sheath and are laid back and brought out through the sealing tapes and terminated on a copper ring. The sealing of the termination depends on a layer of rubber tape overlaid by a layer of varnished fabric tape. This method is only partly effective and it is not possible to seal the points where the return conductors are brought out through the wrapping tapes. In the method illustrated in Fig. 2 the return conductors are bonded to the lead sheath and the external connection is made to the sheath below the main sealing wrappings. This method overcomes the difficulty of sealing the return conductors and if carefully carried out will give a more reliable seal than the former method. Some apprehension was felt that this method would cause galvanic corrosion between the copper tapes and the lead sheath but the termination made this way in 1950 showed no evidence of trouble.

Examination of the cable terminations and adjoining lengths of cable showed that deterioration of the insulation extended for some feet along the cable from the termination and that the worst points were several feet from the end. Values as low as 30,000 ohms were obtained for the insulation of a length of 4 feet of cable cut from immediately below the termination of the southern section at Naracoopa. A further 5 fete along the cable the insulation of a 12 inch length was of the order of 5×10^6 Megohms. Similar observations, varying only in detail, showed that the insulation of the cable ends had deteriorated badly and the deterioration extended for 6 or 7 feet along the cable.

Several of the faulty lengths of cable were opened up. The lead sheath was found to be corroded on the inside with a pitting type of corrosion and a brownish white corrosion product was evident. This was found to be lead carbonate and traces of acetic acid were found in the textile beneath the sheath. The teredo tape and the return conductors were vividly coloured with a bluish green corrosion product but the extent of the corrosion was very superficial.

The paragutta core of the cable was found to be severely resinified and cracked easily on bending. Numbers of cracks of long standing were detected, these being on the outside of bends in the cable. In some cases the cracks extended to the cable core and obviously had been points of low insulation resistance. The positive potential applied to the core of the cable had caused leakage

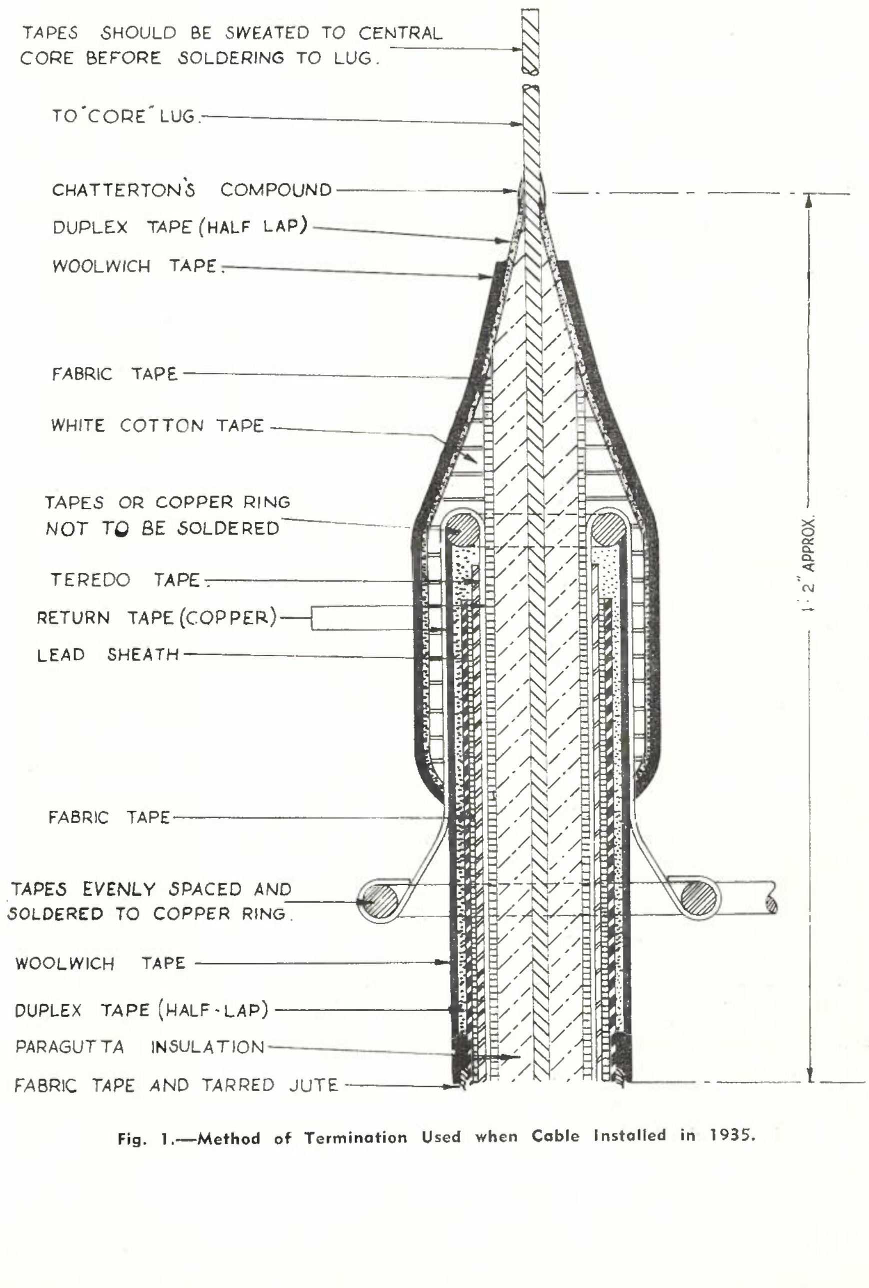

Fig. 1.—Method of Termination Used when Cable Installed in 1935.

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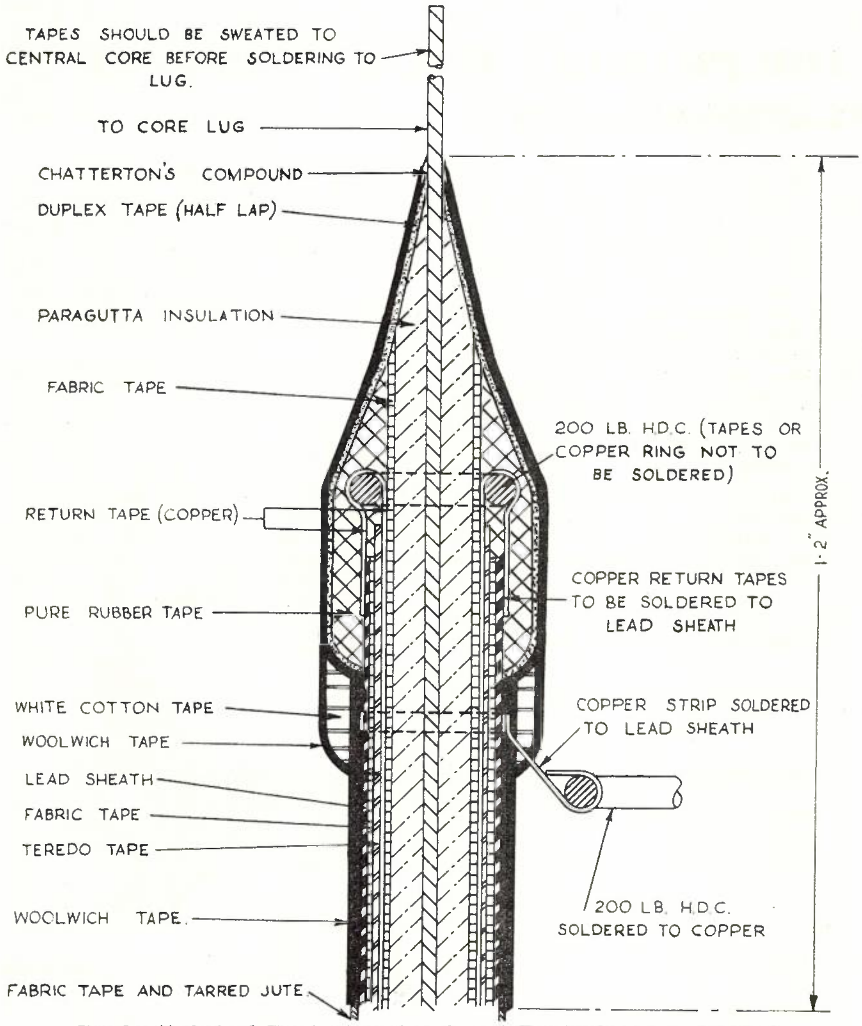

Fig. 2.—Method of Terminating when Several Terminations were Replaced.

through these cracks and discoloration due to copper corrosion was evident on the walls of the cracks. When the cracks were opened up it was found that slight electrolytic corrosion of the central conductor had taken place and in one case, one of the copper tapes around the central conductor had corroded through. The general appearance of the cracks is illustrated in Figs. 3 and 4. The deterioration extended along the cable for a distance of up to about 7 feet from the end after which the condition of the paragutta and of the lead was comparatively good.

It was apparent, from the examination, that air and moisture had penetrated into the cable beneath the lead sheath due to breathing through the taped seal. The action of the air had caused resinification and embrittlement of the paragutta resulting in cracking where the insulant was under tension at bends. The penetration of moisture along with the air resulted in low insulation when the insulant finally cracked through. The moisture and air had also caused degradation of the textile wrappings beneath the lead sheath and minute quantities of acetic acid had been developed. The acetic acid promoted the pitting corrosion found on the inside of the lead sheath. In the case of the Stanley termination, the lead sheath had been damaged at floor level and moisture and air had gained access in this way also.

Inspection of the cable entry pits at the various cable stations showed that, in the case of Stanley and Naracoopa, the cable was coiled around in a 2 x 2 feet pit immediately below the terminal rack. This meant that within three feet of the seal the cable was coiled in a circle of about 10½ inch radius. It was

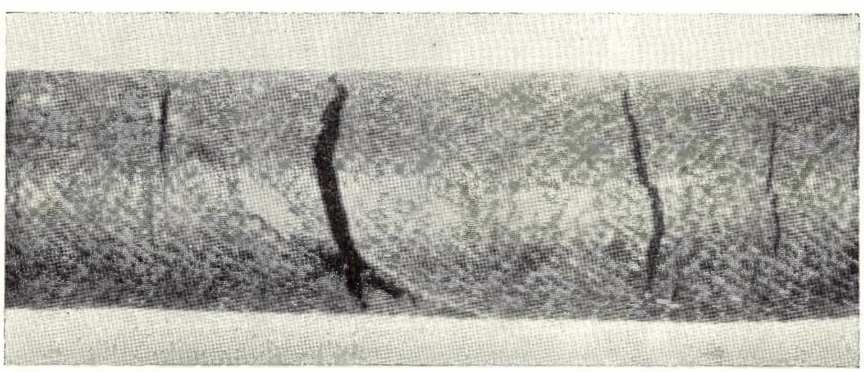
Fig. 3.—Cracks in Resinified Cable Core from King Island Termination.

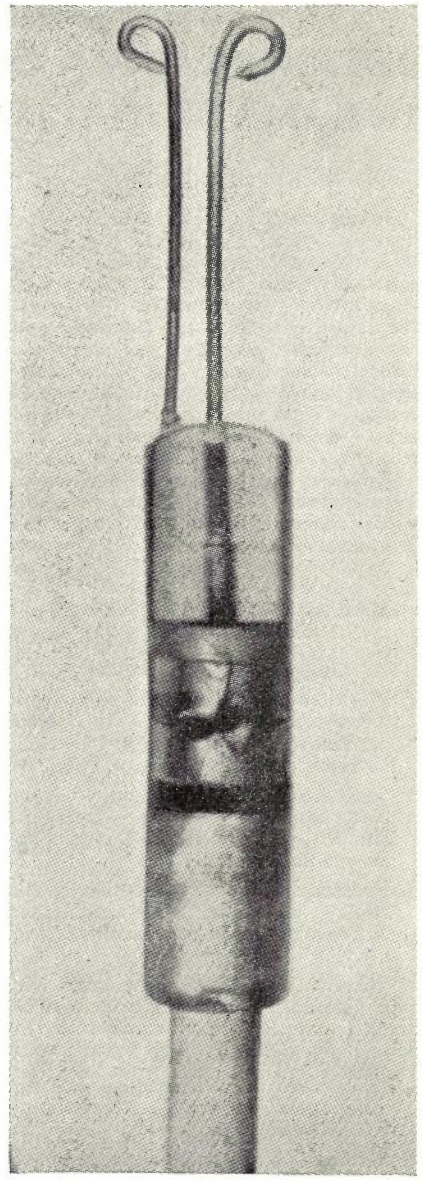
Fig. 5.—Cast Epoxy Resin Termination for Bass Strait Telephone Cable.

in this severely bent section of cable that the cracks in the insulant occurred. At Apollo Bay the cable follows an easy sweep for about 10 feet and then enters a pit where slack cable is stored. The minimum radius in the pit is about 10 inches until a point about 30 feet from the cable end where it is bent with a 7 inch radius to enter the duct leading to the beach. The absence of any significant bends until about 10 feet from the end explains why the Apollo Bay termination is still satisfactory despite its age of over 20 years. Evidence from the other termination would suggest that resinification of the paragutta at the Apollo Bay end will extend up to about 7 feet from the end. However, there are no sharp bends in this length and the insulation, although embrittled, will be still intact.

IMPROVED METHODS OF TERMINATION

The deterioration of the termination has been due to imperfect sealing by the tape wrapping. The new terminations made during the 1957 repair operation agree substantially with Fig. 2 except that self bonding plastic tape and pressure sensitive P.V.C. tape have been been used instead of Duplex tape and Woolwich tape as was used in the earlier terminations. The use of these modern plastic sealing tapes will result, probably, in an improvement and it may be that the action that has been taken already to cut the ends back to sound cable and to reterminate using modern plastic sealing tapes will give terminations that will cause no further trouble. However, in case improved reliability is considered necessary, a method of producing a cast epoxy resin termination that is completely and permanently sealed has been developed. A sample termination sealed in this way is illustrated in Fig. 5.

To make this termination, the tapes of the return conductor are brought a short distance past the end of the paragutta and are soldered to a ring about ¾ inch in diameter. An external connection of 200 lb. H.D. copper line wire is soldered to this ring and is taken forward parallel to the central conductor. The various wrappings on the cable are cut back and tied and the lead sheath bared and cleaned for distance of about 2 inches. A mould is then clamped around the termination and is filled with a cold setting epoxy resin. In this way a seal is obtained to the sheath and also to both conductors. The whole is compact and tidy and the cable could be restored to service during the period when the resin was setting.

REFERENCE

(1) S. Dossing, "Bass Strait Telephone Cables, 1957 Repair: Fault Conditions and Testing." Telecommunication Journal of Australia, Volume 11, No. 3, Page 82.

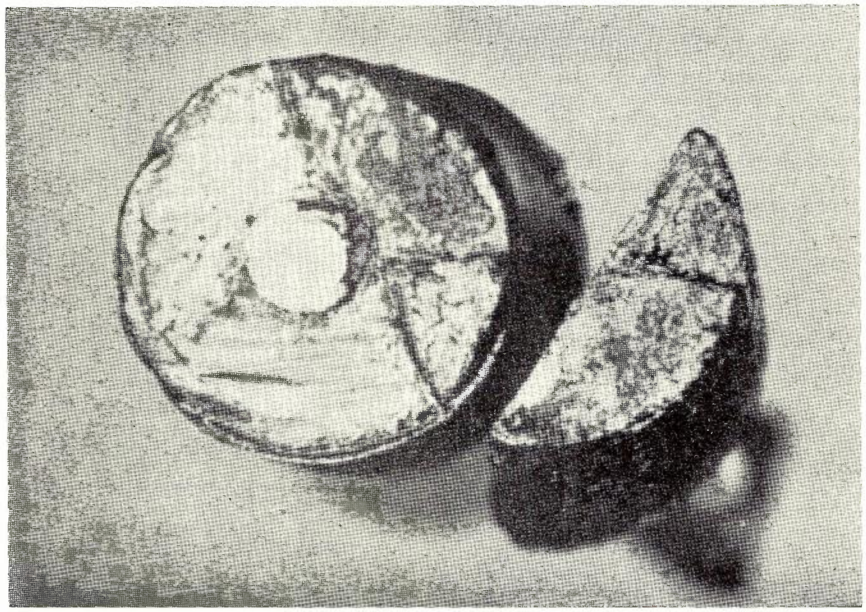

Fig. 4.—Section Through Crack Shown in Fig. 3. Note Crack Extends to Conductor and Several of Tapes Around Conductor have been Corroded Through.

CIRCUIT PROVISION FOR SMALL QUANTITIES OF TRAFFIC AND THE E.M.U. TRAFFIC TABLES

*B. MARROWS, M.Sc., B.A.**

INTRODUCTION

The number of circuits provided at any switching stage of a telephone system is governed by two major considerations. Firstly, in order to provide good service to the telephone users sufficient circuits should be installed to reduce to small proportions the probability that a subscriber will not find a free circuit at any time. Secondly, in order to reduce the cost to the communication authority, circuits should not be provided so liberally that large numbers of them are seldom used. Clearly, these considerations are opposed to each other; while one demands a large number of circuits, the other demands a small number, and a compromise solution is always necessary.

EQUAL GRADE OF SERVICE

In a busy signal system, that is one in which busy tone is transmitted to the calling subscribers if at any switching stage encountered there is no free circuit, the compromise to these two considerations is usually expressed in terms of the probability that a call would be lost due to a shortage of circuits. More commonly, this is called the 'grade of service' and may be separately specified for each link used in establishing a connection between a calling and a called subscriber. In specifying a grade of service it is necessary to adopt some assumption regarding the behaviour of subscribers who receive busy tone. Since it is usual in Australia and Europe to adopt the assumption of 'lost calls cleared' rather than 'lost calls held', work in this paper will also be based on this assumption.

Theoretically, it would be possible to arrange for the distribution of loss throughout the switching system so as to reduce to an absolute minimum the total traffic loss for, say, a given capital expenditure on circuits. The solution would depend on such factors as the cost of the various circuits in the system and the amounts of traffic expected on the various links. Such a solution would provide quite a range of probability of loss on the various switching stages — poorer service on the more expensive circuits and better on the cheaper circuits — poorer on the small groups of traffic which are inefficient in traffic carrying capacity and the better on the large groups which produce high traffic carrying capacity. However, such a solution would be difficult to compute and would require constant recalculations as the cost of circuits and amounts of traffic vary.

A simple approach is to specify the worst grade of service which can be tolerated at any switching stage regardless of cost and regardless of the traffic efficiency of any circuit group. Part of a typical full availability traffic table for a fixed grade of service of 0.01 is given in Table 1.

Table 1

Grade of Service 0.01 at All Points of Table

No. of Circuits	Traffic Offered (in erlangs)	Group Traffic Efficiency	Grade of Service
N	A	A/N	B
1	0.01	0.010	0.01
2	0.15	0.075	0.01
3	0.46	0.153	0.01
4	0.87	0.218	0.01
5	1.36	0.272	0.01
6	1.91	0.318	0.01
7	2.50	0.357	0.01
8	3.12	0.390	0.01
9	3.78	0.420	0.01
10	4.46	0.446	0.01

'Group Traffic Efficiency' is the traffic offered divided by the number of circuits. The term is introduced in this paper to make concepts easier to follow and to simplify graphical illustrations.

It is customary to use equal grade of service traffic tables in such a way as to ensure that the grade of service is no worse than that specified by the table. Consequently for traffic values intermediate between those shown on the table, the number of circuits required is the number corresponding to the next highest traffic value shown on the table. For example, a traffic of 2.0 erlangs would require seven circuits in order to ensure that the grade of service would be no worse than 0.01. The group traffic efficiency would then be 0.286.

The disadvantage of such a system is evident from the third column of the table, which shows that the traffic loading on small groups of circuits is very low. The last circuit in a very small group contributes little towards the general increase in traffic carried and the consequent revenue derived. It might be used to advantage elsewhere to effect an improvement in the total traffic carried and the average grade of service provided to subscribers.

This will be illustrated with an example in which, for simplicity of treatment, it is assumed that all circuits cost the same and contribute equally to the grade of service experienced by the subscribers. Consider two separate traffics of 0.50 and 2.50 erlangs to which the above traffic table is applied. Four and seven circuits respectively would be required and grades of service of .0016 and .0101 would result. The total traffic lost on these two groups of circuits would be 0.0257 erlang. This is simply the addition of .0016 x 0.50 and .0101 x 2.50. The average grade of service is therefore 0.0257/3.0 = 0.0086.

Eleven circuits could also be provided in groups of three and eight respectively for these two quantities of traffic. The grades of service would then be .0127 and .0031, the traffic lost 0.0141 erlangs, and the average grade of service .0047. By such a simple change in allocation of circuits, more traffic may be carried, more revenue derived and the quantity of traffic lost reduced to about half, without any change in cost.

That part of the traffic table where these effects are most pronounced has been deliberately selected in order to illustrate the point. Beyond 10 circuits the variation in traffic carrying capacity is less pronounced. Consequently the improvement which may be effected by subtracting a circuit from one group and adding it to another, is relatively small.

EQUAL MARGINAL UTILITY

It has been shown that if traffic tables based on equal grade of service at all points on the table are used, more traffic can be carried with the same number of circuits by taking circuits from the small end of the scale and providing more at the upper end of the scale. On the other hand, if traffic tables based on an equal group traffic efficiency at all points of the table are used, the same effect is achieved by transferring a circuit from the upper end of the scale to the lower end of the scale. Consider a traffic table with a group traffic efficiency of, say 0.45 erlangs per circuit. Then one circuit may be offered up to 0.45 erlangs, two circuits up to 0.90 erlangs and so on. Using such a table for traffic of 0.80 and 3.20 erlangs, two and eight circuits respectively would be provided, a total of 0.157 erlangs would be lost and an average grade of service of .039 would result. However, by re-grouping these same 10 circuits to provide three circuits for the smaller and seven circuits for the larger amount of traffic, the total traffic lost is reduced to 0.122 erlangs and an average grade of service of 0.30 obtained.

Clearly there must be a traffic table lying somewhere between these two in character, which maximises the total traffic carried. It follows that it would also minimise the total calls lost, and maximise the return on invested capital.

To maximise the total traffic carried by several groups of circuits, it is necessary that the marginal utility at any point on a traffic table is equal to the marginal utility at any other point on the table. More specifically, the traffic which would be carried by an additional circuit (if provided), must be the same at all points of the table.

A set of figures which meets these requirements is indicated in Table 2.

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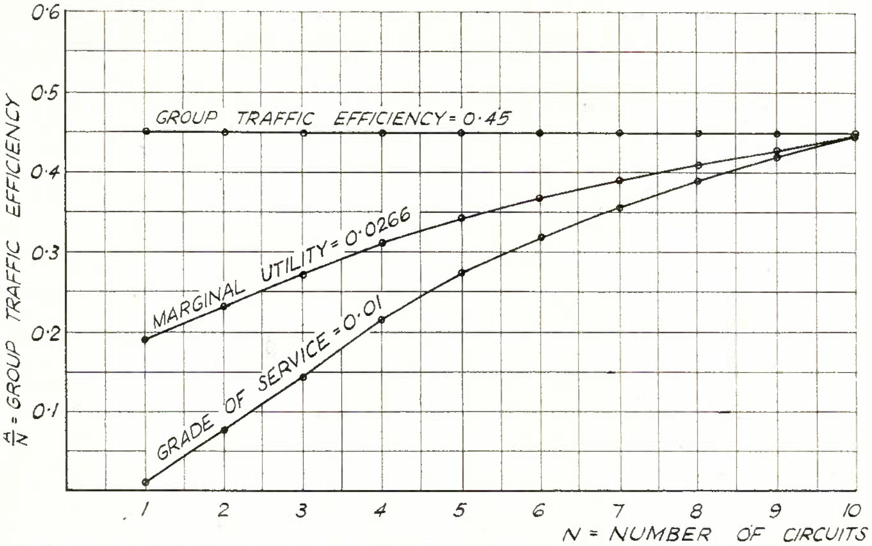


Fig. 1.—Comparison of the Number of Circuits required for Constant Grade of Service, Constant Group Traffic Efficiency and Constant Marginal Utility.

Table 2.
Marginal Utility 0.0266 at all Points of Table

No. of Circuits N	Traffic Offered (in erlangs) A	Group Traffic Efficiency A/N	Grade of Service B
1	0.19	0.190	0.146
2	0.46	0.230	0.068
3	0.82	0.273	0.041
4	1.25	0.312	0.029
5	1.71	0.342	0.022
6	2.20	0.367	0.018
7	2.73	0.390	0.014
8	3.28	0.410	0.012
9	3.86	0.429	0.011
10	4.46	0.446	0.010

A comparison of this table with the examples of equal grade of service and equal group traffic efficiency previously mentioned, is given in Fig. 1. For simplicity of graphical illustration, consecutive points of the graph corresponding to consecutive points on the table are joined by a straight line.

It will be seen that compared with the equal grade of service graph, this graph produces less variation in the group traffic efficiency, while compared with the fixed group traffic efficiency graph, there is less variation in the grade of service. A positive slope ensures that a concentration of two or more quantities of traffic into a single quantity in general reduces the total circuit requirements, and never increases it.

Use of the table will ensure minimum traffic lost, maximum revenue earned, and best overall grade of service; or expressed in other words, having used this table for two or more different quantities of traffic, no possible re-arrangement of the same total number of circuits can improve the average grade of service. This can be illustrated by two marginal cases.

Consider firstly two traffics of 0.20 and 2.20 erlangs. Application of Table 2 indicates that two and six circuits respectively should be provided with individual grades of service of .016 and .018, a total traffic loss of .042 erlangs and average grade of service .0175. The traffic values were chosen near the limiting values for the number of circuits, 0.20 erlangs barely justified the second circuit, while 2.20 almost justify the seventh circuit. If, howerver, we allot one and seven circuits respectively to the two quantities of traffic, the resulting grades of service are .1667 and .0055 respectively with a total of 0.0454 erlangs lost and average grade of service .0189.

A second example is taken in which the smaller traffic almost justifies an additional circuit while the larger traffic barely requires the last circuit. Traffics of 0.80 and 2.70 erlangs require three and seven circuits respectively if Table 2 is used. The total traffic lost from this arrangement is .0688 erlangs. The allocation of four and six circuits respectively to these traffics, results in a total traffic loss of 0.1067 erlangs.

Clearly there is a whole family of tables of this type, even as there is a whole family of tables of equal grade of service or equal group traffic efficiency. As with the equal grade of service curves, the particular one to be used will depend upon the compromise reached, between the desire to give subscribers a good grade of service, and the limitation of capital for providing circuits and funds for subsequently maintaining them.

Again as with equal grade of service tables, a table for a poorer grade of service may be used for trunk circuits than for local and junction circuits in order to give a better average service for the same capital costs. It is of interest to note, however, that for a subscriber's trunk dialling system in which the trunk and local rates are proportional to the cost of circuits, there would be no justification for this differential if it were desired to maximise the total traffic carried and the return on invested capital. In other words, the same traffic table would be used for both local and trunk circuits.

THE UPPER AND LOWER BOUNDS

This study places upper and lower bounds on the slope of traffic tables suitable for use with busy signal systems. The slope may be defined either in terms of the increment in traffic capacity for an additional circuit, or, as is illustrated in the figures of this paper, the increase in group traffic efficiency for one circuit. Since both traffic and group traffic efficiency are monotonically increasing functions, any reference to slope will apply equally well to the increment in traffic capacity and the increment in group traffic efficiency.

At no point should the slope of a traffic table be steeper than the equal grade of service table which goes through that point, nor flatter than the equal marginal utility curve which passes through that point. For if so, it would be possible to improve both the worst

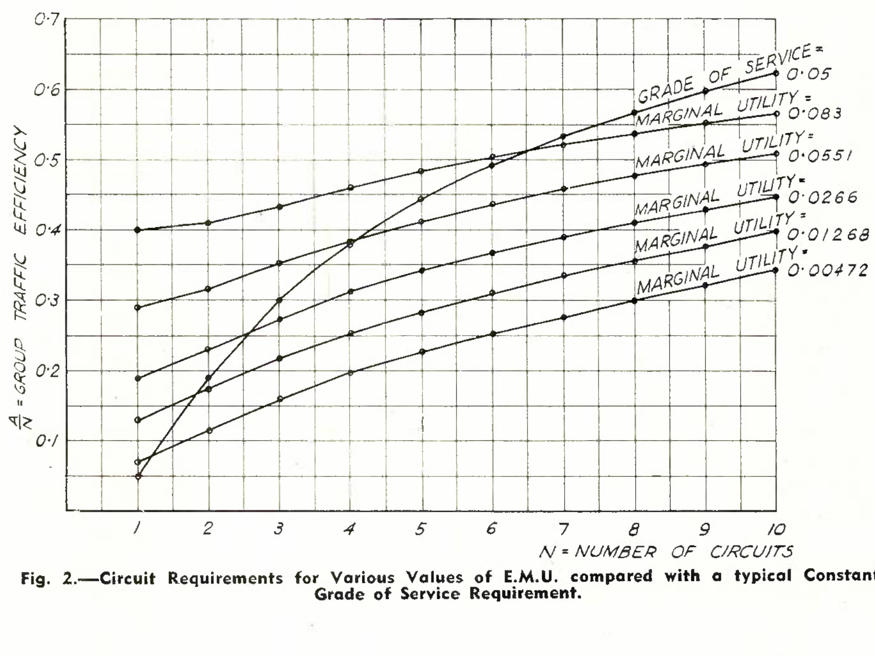


Fig. 2.—Circuit Requirements for Various Values of E.M.U. compared with a typical Constant Grade of Service Requirement.

grade of service encountered, as well as the average grade of service provided, without increasing the total circuit requirement. Any table whose slope lies between that of the equal grade of service table and the equal marginal utility table, can be improved with respect to the worst grade of service encountered by increasing the slope until it equals that of the equal grade of service table, but this can only be done at the expense of the average grade of service provided. Alternatively by reducing the slope of any such table until it reaches that of the equal marginal utility table, the average grade of service may be improved at the expense of the worst grade of service encountered.

The level or height of the table will be determined by such factors as the capital available, and the general standard of service provided to the public by the Administration concerned.

A COMPROMISE

The upper and lower bounds of the slope of a suitable traffic table still leave considerable latitude in choosing a table for practical use. For large quantities of traffic the problem of low traffic carrying capacity does not arise. There is reasonable justification for adhering to the principle that, at least for the larger values of traffic, the grade of service should not be worse than a certain design figure and hence equal grade of service tables may be applied.

It could also be argued that an Administration cannot afford the luxury of this design grade of service, unless each circuit installed adds a certain minimum figure to the traffic carrying capacity of the system. Such an argument demands that for small quantities of traffic equal marginal utility traffic tables should be used, the marginal utility co-inciding with the minimum figure which justifies an additional circuit.

Beyond 10 circuits the traffic efficiency of equal grade of service tables is reasonably high. Also the two sets of tables become progressively closer in slope as the number of circuits increases and at 10 circuits there is very little difference. A suitable compromise is to consider the lowest permissible grade of service only when the number of circuits exceeds 10 by using equal grade of service tables, and to consider only the minimum increase in traffic carrying capacity in the region of 10 circuits or less by using equal marginal utility tables. Traffic tables may be made continuous by selecting those equal marginal utility tables which give the more commonly used grades of service at 10 circuits. These might then be regarded as the extension to the equal grade of service tables.

By fixing a point of concurrence in this matter, then for traffic values below this figure, the graph which is the upper bound in slope becomes the lower bound for traffic values and vice versa. Table 3 gives figures based on this compromise. The marginal utility, that is the traffic which would be carried by the (N + 1) th. circuit, is shown in the first column. For example, if a traffic of 1.84 erlangs were offered to a full availability group of circuits, the fifth circuit would carry 0.083 erlang. These tables are also illustrated in Fig. 2.

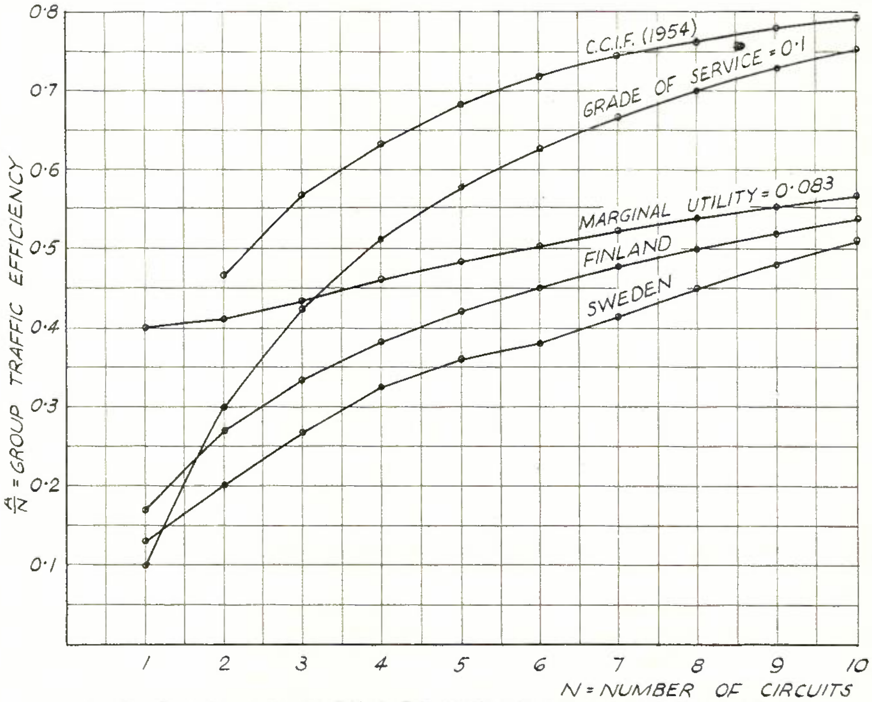


Fig. 3.—Comparison of the E.M.U. Curve with other Typical Requirement Curves.

Table 3

Further E.M.U. Traffic Tables

M.U		CIRCUITS N 1	2	3	4	5	6	7	8	9	10	10 or more
	A	0.40	0.82	1.30	1.84	2.42	3.02	3.65	4.30	4.97	5.66	
0.083	A/N	.400	.410	.433	.460	.484	.503	.521	.538	.552	.566	
	B	.286	.156	.104	.079	.064	.053	.046	.041	.037	.033	1/30
	A	0.29	0.63	1.06	1.54	2.06	2.62	3.21	3.81	4.44	5.08	
0.0551	A/N	.290	.315	.353	.385	.412	.437	.459	.477	.495	.508	
	B	.225	.108	.070	.051	.039	.033	.029	.025	.022	.020	1/50
	A	0.19	0.46	0.82	1.25	1.71	2.20	2.73	3.28	3.86	4.46	
0.0266	A/N	.190	.230	.273	.312	.342	.367	.390	.410	.429	.446	
	B	.146	.068	.041	.029	.022	.018	.014	.012	.011	.010	1/100
	A	0.13	0.35	0.65	1.01	1.41	1.86	2.34	2.85	3.39	3.96	
0.01268	A/N	.130	.175	.217	.252	.282	.310	.334	.356	.377	.396	
	B	.115	.043	.024	.016	.011	.009	.007	.006	.006	.005	1/200
	A	0.07	0.23	0.48	0.79	1.13	1.51	1.93	2.39	2.89	3.43	
0.00472	A/N	.070	.115	.160	.198	.226	.252	.276	.299	.321	.343	
	B	.065	.019	.011	.008	.005	.004	.003	.002	.002	.002	1/500

M.U denotes marginal utility
N. denotes number of circuits.
A. denotes traffic offered in erlangs.
A/N denotes group traffic efficiency.
B. denotes grade of service.

EXAMPLES FROM OTHER ADMINISTRATIONS

It is interesting to note that other telephone administrations have developed traffic tables which provide poorer grades of service for lower traffic quantities in order to improve the traffic efficiency at the lower end of the scale. Examples from the C.C.I.F., Sweden and Finland are illustrated in Table 4:—

Table 4

Examples from Other Administrations

Number of Circuits N	Traffic Offered (in Erlangs) C.C.I.F. (Oct. 1954) reference Vol. VI (Operating and Tariffs) Recommendation No. 63.	Finland	Sweden
1	—	0.17	0.13
2	0.93	0.54	0.40
3	1.70	1.00	0.80
4	2.53	1.53	1.30
5	3.41	2.10	1.80
6	4.31	2.71	2.30
7	5.21	3.34	2.90
8	6.11	4.00	3.60
9	7.01	4.67	4.30
10	7.91	5.37	5.10

These tables are also illustrated in Fig. 3, from which it will be seen that each has a slope intermediate between equal grade of service and equal marginal utility tables.

SUMMARY

This paper discusses the conflict between what might be called the 'service' approach and the 'economic' approach to the provision of circuits for small quantities of traffic. While the 'service' approach puts emphasis on the worst grade of service encountered, the 'economic' approach puts emphasis on the average grade of service provided. Upper and lower bounds to the slopes of any acceptable compromises are established. The slope of the tables adopted would be somewhere between these limits depending upon the relative emphasis wanted on these two approaches. Tables are developed for the simple compromise in which the 'service' approach involving equal grade of service traffic tables, is adopted for traffic requiring ten circuits or more, while the 'economic' approach involving equal marginal utilities tables, is adopted for smaller quantities of traffic.

Although tables have only been developed for busy signal systems using the assumption of lost calls cleared, the same principles may be applied to delay systems or busy signal systems using the assumption of lost calls held.

ACKNOWLEDGMENTS

The above article is substantially the text of a paper which was presented at the Second International Teletraffic Congress held in July, 1958 at The Hague. Thanks are due to Mr. I. A. Newstead who read the paper at the Congress. A tribute is paid to Mr. N. M. H. Smith who not only did most of the hard work of calculating and preparing traffic tables, but also made substantial contributions during discussions on the problem.

ANSWERS TO EXAMINATION QUESTIONS

EXAMINATION No. 4641 PROMOTION OR TRANSFER AS ENGINEER, P.M.G. DEPARTMENT

Comments by Examiners on the way questions in the following papers were answered.

NATURAL SCIENCE
TELEPHONE EQUIPMENT
TELEGRAPH EQUIPMENT

NATURAL SCIENCE

Question 1a.

The formal general solutions of equations of the third and fourth degree are outside the scope of this examination; when such equations are set, there will generally be some artifice by which they can be reduced to quadratics. In the present case, the factors on the left form an arithmetical progression; hence the sum of the second and third constants equals the sum of the first and fourth. On multiplying the corresponding pairs of factors, we have

$$(x^2 - 7x + 12)(x^2 - 7x + 10) = 80 \quad \text{(i)}$$

By substituting

$$y = x^2 - 7x \quad \text{(ii)}$$

the equation may first be solved as a quadratic in y, and each result in turn then entered in (ii) which is solved for the final results. One value of y will give a pair of real roots and the other a pair of complex roots.

No candidate gave this or any equivalent solution. Those who arrived at a reasonably correct root by trial received credit for it.

Question 1b.

Many candidates solved this successfully. The key equation is

$$(r - 8)^2 + (r - 9)^2 = r^2$$

Question 2.

This is a standard type of problem solved by integrations—one integration to give the total pressure on the area, one for the moment of pressure, conveniently about the side lying in the surface, and one for the moment about some convenient vertical axis.

Few candidates attempted this, none successfully.

Question 3.

This question contained a misprint, for which the examiner apologises to any who were misled by it. The brackets and index in the expression for the radius should have enclosed only the numerator of the fraction, not the whole fraction as printed.

One candidate solved this, obtaining the correct expression for the radius.

Question 4.

The majority of candidates who attempted this question failed to observe the significance of the rolling motion, but generally gave an answer which would have been correct for frictionless sliding motion. The radius of gyration of the cylinder is in the present case equal to its geometrical radius; in consequence, its energy of rotation is equal to its energy of translation.

The correct answer is equal to 2 times that given by most candidates; 1.91 seconds.

Question 5.

This is a standard problem, fundamental in the theory of strength of materials. Its solution is fairly straightforward.

Question 6.

This question was generally well answered. Candidates were evidently on familiar ground.

Question 7.

This question broke some new ground; designedly so, as transistors and related devices are acquiring great importance in the telecommunication field.

Question 8.

This could be solved by elementary means, starting from the formula for the reflection coefficient.

Maximum and minimum line currents are 1.33 and 0.75 amps respectively.

Question 9a.

Primary colours are generally defined as those three colours which correspond most nearly to what are believed to be the basic sensations originating in the three sets of colour-perceiving elements of the eye—red, yellow or green, and blue. Many candidates referred the term to the whole range of colours of the spectrum. Secondary colours are those derived by combining two primary colours.

Question 9b.

This is a standard text-book subject.

Question 10.

This is again a standard text-book subject.

Question 11.

The general standard of answers to this question was good; basic principles were generally well set out.

Question 12.

Again here, candidates were for the greater part on familiar ground. "Methods of Extraction" was perhaps the point on which answers were weakest.

A very good survey of the mathematical subjects in the syllabus of the examinations is given in "Basic Mathematics for Radio and Electronics," by F. M. Colebrook and J. W. Head (Iliffe & Sons Ltd.).

TELEPHONE EQUIPMENT

General Comments

The standard of answer submitted was generally equal to that dealt with in the past few years. Exceptions to the rule were observed in two States, namely New South Wales and South Australia. The standard of answer submitted in New South Wales was much lower than average and lower than has been experienced in previous years. In the case of South Australia the standard of answer was exceptionally good. It is presumed that these results are reflected to some extent on the availability of classes dealing with this subject.

Question 1: Traffic

On the whole this question was answered fairly well. However, there was considerable doubt amongst some of the candidates on the real need for grading.

Question 2: Traffic Recordings

This question again was reasonably well answered. The main doubt appeared here to be connected with how the traffic recorder results were interpreted into traffic units.

Question 3: Bimotional Versus Other Systems

The answers on this question were somewhat patchy, although the Victorian candidates appeared to have a reasonable knowledge of the crossbar system, whereas the South Australian candidates knew more about the motor uniselector system. The latter was, of course, covered in an article published in the Telecommunication Journal, October 1951.

Question 4: R.A.X. 40 Line

This question was fairly well answered, especially by candidates from country districts.

Question 5: SE.50 Type Selector

This question was fairly well dealt with, it being evident that many candidates had studied the recent Telecommunications Journal article on the subject.

Question 6: Qualitative Maintenance

This question was the one most often attempted and also the one where the best answers were submitted. The main weakness in the answers was the lack of knowledge on the Artificial Traffic Equipment.

Question 7: Building Design

The answers to this question were fair. Candidates had many different ideas of the best way to place the various services of an exchange building.

Question 8: Service Observations

This question was very poorly answered. The details of service observation equipment is set out fairly fully in Telephony 4, and there is a fairly reecnt article in the P.O.E.E. Journal concerning recent improvements made in that country.

Question 9: Rectifiers

This question was fairly well answered, although some candidates did not appreciate how the transductors operated in relation to the main transformers of the rectifier.

TELEGRAPH EQUIPMENT

(1) **By Questions:—**

Question 1:

Part (a) is "straight book work" and the usual wide variety of answers to this type of question was received. Part (b) calls for some thought based on the previous part and only a few candidates showed an appreciation of the question.

Question 2:

Both parts of this question are "straight book work" but generally answers are poor.

Question 3:

In general, this question being on the lines of Long Line Equipment practice, was answered fairly well. However, it is interesting to note that a lot of candidates have only very hazy ideas of the fundamental principles of A.M. and F.M. transmissions.

Question 4:

Relatively few candidates attempted this question and answers were poor, although the question is quite straightforward.

Question 5:

Fair answers were received to part (a) of this question but very few candidates completed answers to part (b) successfully, although the subject matter is covered in Engineering Instructions.

Question 6:

Again, relatively few candidates attempted this question and answers were poor, although the question is quite straight-forward.

Question 7:

This question touches on the fundamentals of Communication Theory, and although only five candidates attempted to answer it, only one failed to get more than half marks.

Question 8:

This is a quite straight-forward question and was generally well answered.

Question 9:

The recent dissemination of informative matter about TRESS appears to have achieved a fair measure of success as answers to this question were generally fairly good.

(2) **By States:—**

The following table indicates the relative performance of the candidates from various States:—

No. of Candidates	N.S.W.	Vic.	Qld.	W.A.	Tas.
Total	12	13	6	1	2
Successful	2	6	4	0	1

As usual, New South Wales displays the widest variety of candidate from the best to a considerable tail of the unprepared and ignorant. The success of the Victorians is, once more, a tribute to the efforts made in organising unofficial classes for prospective candidates, although the standard is rather lower than that noted in former years. An interesting feature of this examination has been the high quality of Queensland answers. Candidates from the other States are so small in number as to make comment impracticable.

(3) **General Comments**

The answers to this examination tend to repeat the pattern noted in former years. The large number of successful attempts at Question 3 reflects the "Long Line Equipment" background of so many candidates, while it is disappointing to see the continued lack of knowledge displayed in the fields of teleprinter mechanisms (Questions 1 and 2), telegraph transmission (Questions 4 and 5) and telegraph circuits (Question 6), particularly when the amount of telegraph plant is increasing so rapidly in our system, and by implication, should call for some thought on the part of every district engineer in the field. Virtually all can now expect to have considerable telegraph installations in their territory and should, reasonably, be expected to have some idea of the "whys and wherefores" even though details may be left to technical staff and telegraph engineering specialists. On the other hand it is interesting to note that the new development of TRESS has so stimulated interest as to produce a good standard of answer to Question 9.

TELEGRAPH ANSWERS

SAMPLE ANSWERS

EXAMINATIONS Nos. 4668 AND 4669. 22nd NOVEMBER, 1958, AND SUBSEQUENT DATES

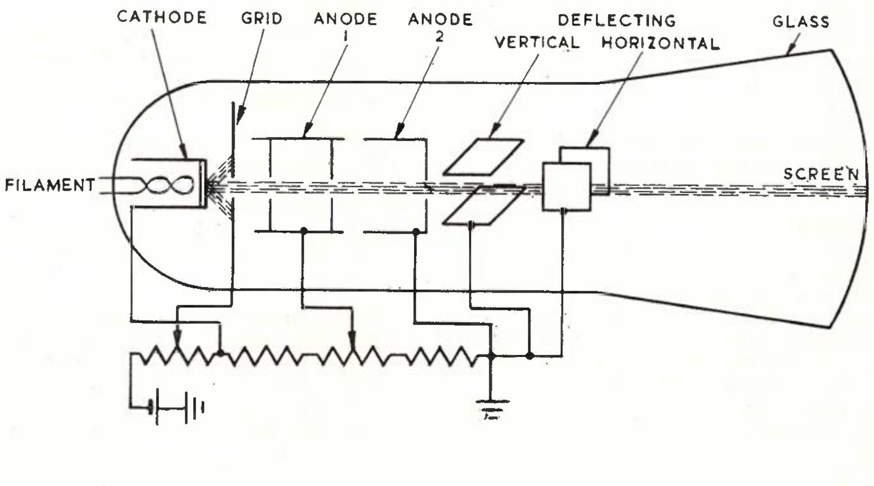
For appointment, transfer or promotion as Technician, Telecommunications (Telegraphs), Postmaster - General's Department, (All States).

THEORY.

WRITTEN TESTS.

PAPER No. 1.

Q.8.—Draw a simple diagram showing the elements of a cathode-ray tube and briefly describe its operation. Draw diagrams showing the display you would expect to see on a B.A.T.E. type 6 Transmission Distortion Measuring set adjusted for 50 baud operation, using the start-stop time base to measure telegraph distortion on random passing signals which—



(a) Are undistorted but slightly faster than 50 bauds!

(b) Exhibit 20 per cent. marking bias distortion, but are of correct speed;

(c) Exhibit contact bounce on M-S transistors but are otherwise undistorted, and are of correct speed.

A.—A cathode ray tube is essentially a thermionic valve having cathode, grid, and anodes, as shown in sketch. The components are so constructed as to cause the electrons emitted from the cathode to be formed into a beam, and bombard a fluorescent screen, producing a spot of light on the screen.

The beam of electrons, or spot on the screen, can be deflected across the screen either electrostatically or electromagnetically. A pair of horizontal and vertical deflection plates or coils are provided in order that the beam can be moved in any direction across the screen face, according to the polarity of the potentials applied to the plates.

When an alternating voltage is applied to either set of deflection plates the spot will move backwards or forwards in a straight line across the screen face, and the moving spot appears as a line of light on the screen of the tube.

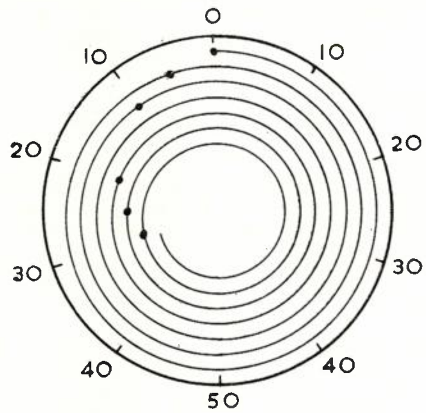
When alternating voltages are applied simultaneously to both sets of deflection plates, a series of patterns of set form, is produced. If both voltages have the same frequency and are in phase a diagonal line will appear on the screen. As the phase angle between the two voltages changes, then this line will become a loop until at 90° phase difference, there will be a circle produced on the screen.

Thus, by variation of the frequencies of voltages applied to each pair of deflection plates, patterns of any required shape or form can be produced for display purposes.

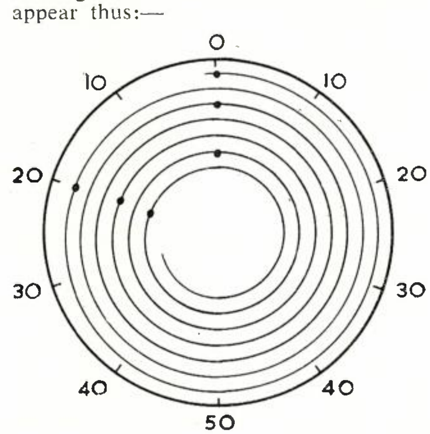
Conversely, by the application of unknown current or voltage variations to one set of deflection plates, with a known and suitable "time base" or "sweep frequency" voltage which moves the spot in a linear manner, (equal distance in equal time), applied to the other set of deflection plates, a pictorial representation of the unknown circuit variations can be obtained.

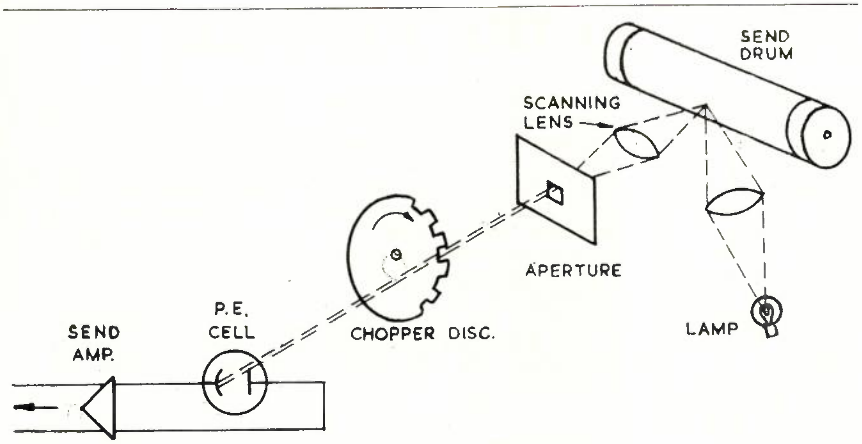
The B.A.T.E. Type 6 Transmission Distortion Measuring Set, when adjusted for 50 baud operation, using the start-stop time base to measure telegraph distortion on random passing signals, exhibits a triggered spiral trace on a calibrated screen. Mark to Space and Space to Mark transitions are observed, as they occur, as spots of light on the spiral trace, each 360° of which constitutes one signal element, commencing with the start signal which triggers the display, and ceasing after the fifth code element.

(a) Undistorted signals slightly faster than 50 bauds would appear thus:—

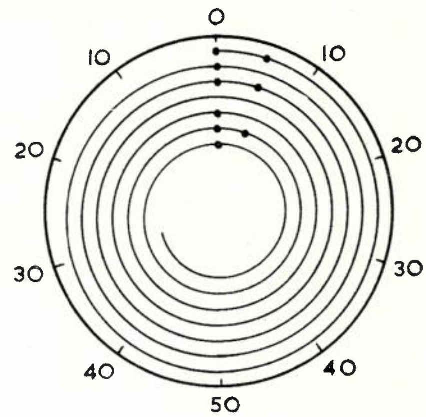


(b) Signals of correct speed, but exhibiting 20% mark bias distortion would appear thus:—





(c) Undistorted signals of correct speed exhibiting contact bounce on M-S transitions would appear thus:—



Q.10.—In a picturegram transmitter variations in light and shade in a picture (i.e., the variations in picture density between black and white on the picture) are converted into electrical variations. Describe in general terms how this process is accomplished.

A.—In picturegram transmission, the picture to be transmitted is clipped to a drum, which is rotated at constant speed and moved axially each revolution. Projection lamps, focussed by optical lenses, illuminate a small area of the picture to be transmitted. Emissive type photo-electric cells, that is, those in which the cathode emits electrons when exposed to light, are used to convert the light reflected from the picture to electrical current. Reflected light from a small rectangular section or scanning spot in the illuminated area of the picture is focussed by an objective lens, through an aperture on to the cathode of the photo-cell.

The current in the photo-cell varies with the light reflected from the scanning spot, which in turn, is controlled by the shade or tone of the small scanned spot, a greater current flowing for a white spot and less for the darker spots.

As the drum rotates, a narrow strip of the picture is scanned, and as the axial movement of the drum per revolution is equal in width to the scanned line, the picture is scanned in successive strips each the width of the scanning spot.

The picture signals, that is, the current variations in the photo-electric cell, produced by the changes in picture density, are superimposed on a carrier wave for amplification and transmission to line.

The modulation of picture signals is done primarily to overcome the difficulty in amplifying and transmitting the slightly varying currents frequently encountered when pictures of almost unchanging shade are being scanned.

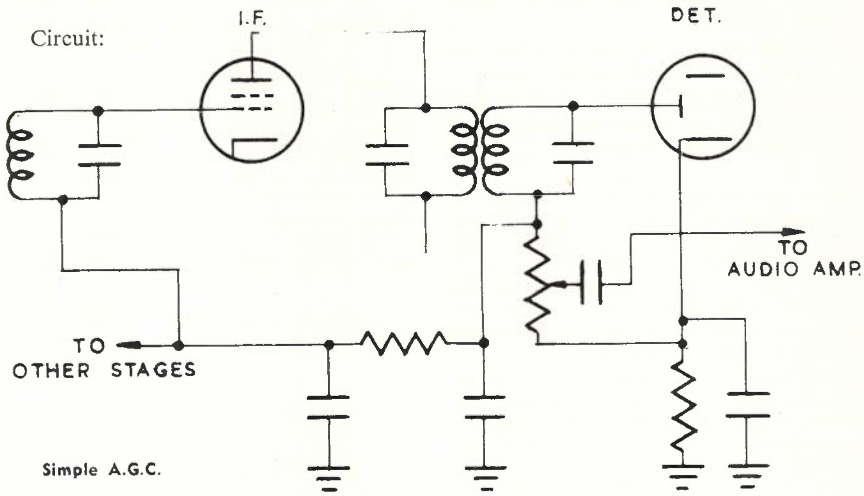
Modulation is effected by means of a rotating square-toothed wheel, called a "chopper-disc" which is interposed in the light beam between the send scanning spot and the photo-electric cell as shown in sketch.

As the light beam is continually "chopped" by the toothed wheel, the resulting signal produced is a pulsating current of frequency corresponding to the number of teeth in the wheel and its rate of rotation, the amplitude being determined by the picture density.

The carrier wave of chopping frequency, modulated by the picture signal, is then amplified and transmitted to line over telephone channels to the receiving equipment.

The "chopper-disc" method of producing a carrier wave requires precise speed control and close maintenance of the mechanism driving the disc, and because of this, an alternative method is used in some portable transmitters, where a suitable carrier frequency is generated by means of an oscillator whose signal is modulated electronically by the light beam, amplified and sent to line.

Circuit:



Simple A.G.C.

RADIO AND BROADCASTING

Technicians' Examination Nos. 4670, 4671. Paper No. 1, Section B.

Q. 7.—Why is automatic gain control used on radio receivers? How is it achieved? What is the purpose of delayed automatic gain control? How is it achieved?

A.—1. Automatic gain control is used on radio receivers for the following reasons:—

(a) To present a relatively constant R.F. voltage to the detector over a wide range of signal inputs thus preventing undue distortion.

(b) To prevent overloading of the R.F. and I.F. and converter amplifiers when the receiver is close to the transmitting station.

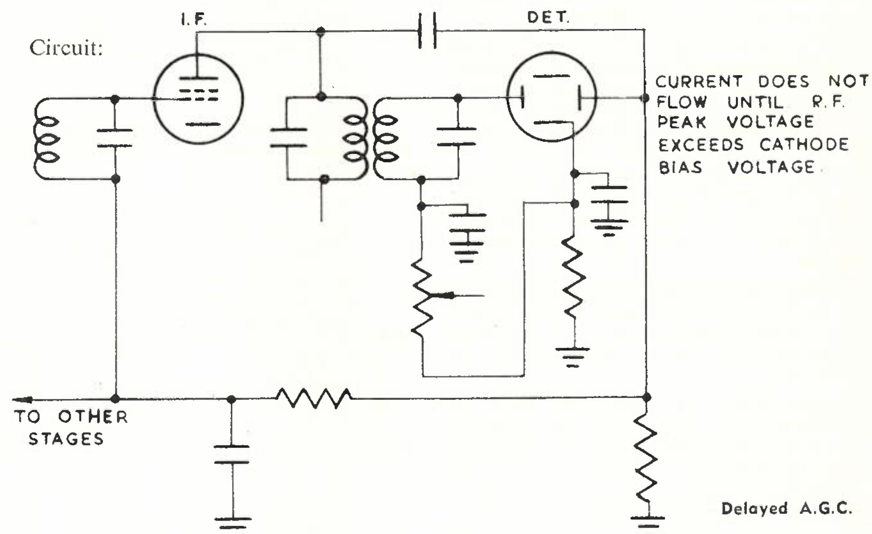
(c) To reduce the amount of audio volume control adjustment necessary as the receiver is tuned from station to station.

(ii) A.G.C. is achieved by rectifying part of the R.F. energy at the detector stage and feeding the resultant negative D.C. voltage to the grids of variable mu. R.F. and I.F. amplifier valves. Thus the greater the R.F. input, the more the gain of these valves is reduced.

(iii) Delayed A.G.C. is used so that the maximum gain of the receiver is used when the incoming signal is below a predetermined level.

(iv) Delayed A.G.C. is achieved by bucking the A.G.C. diode detector such that no rectification occurs until the R.F. level exceeeds the bucking voltage. The bucking voltage is generally obtained from the cathode of an audio tube.

Circuit:



Delayed A.G.C.

IMPROVEMENTS TO THE JOURNAL

During the past twelve months, the number of articles submitted for publication in the Journal has shown an appreciable increase and the lag in publication which has existed for many years has largely been overtaken. The opportunity has also been taken to increase the number of pages in the last few issues. The Board of Editors is confident that future issues will appear on time and will contain a greater number of articles than in the past. To assist in ensuring that the Journal will include the type of articles of greatest interest to readers, a short questionnaire has been added to the subscription slip for Volume 12, Nos. 1 to 3, in this issue. All readers are urged to fill in this questionnaire.

The larger size of the Journal naturally results in greater publication costs, but it is felt that these additional costs can be met without increasing the annual subscription if the number of subscriptions continues to rise as it has recently. To further increase the popularity of the Journal and assist sales, a new cover will appear with the next Volume. It is hoped also to include a limited number of advertisements in future issues to help offset the increased costs. Any subscribers who are interested in advertising in the Journal, which incidentally is read by most telecommunications interests throughout the world, should contact the publishers, Ruskin Publishing Pty. Ltd., 39 Leveson Street, North Melbourne, who will supply information on rates and conditions.

INDEX - VOLUME II

KEY TO NUMBERS

No.	Month	Year	Pages	No.	Month	Year	Pages
1	June	1957	1-32	4	June	1958	97-132
2	October	1957	33-64	5	October	1958	133-172
3	February	1958	65-96	6	February	1959	173-216

ANSWERS TO EXAMINATION PAPERS

SENIOR TECHNICIAN

Commencing with No. 3 of Volume 11 complete answers to all questions in examination papers are not given. Instead the Journal now includes answers to a few questions only from a number of recent papers. The questions selected for inclusion are those answered poorly, or of special interest, or of a type not covered in recent issues of the Journal.

SENIOR TECHNICIAN

The Ruskin Press Pty. Ltd.
39 Leveson Street,
North Melbourne