The
Telecommunication Journal
of Australia

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VOL. 11, No. 1. JUNE, 1957

MR. E. SAWKINS, B.Sc., A.M.I.E.Aust., A.I.P.A.

In our last issue, congratulations were extended to Mr. R. E. Page on his appointment as Engineer-in-Chief, Australian Post Office, on 14th February, 1957. Mr. Page, shortly after his appointment, left Australia to take up an appointment at Geneva on the International Frequency Registration Board in the United Nations Organisation. The position he is occupying there was previously held by Mr. S. H. Witt, a former Post Office Engineer, who played an active part in the establishment of the Telecommunication Journal. We extend to Mr. Page our best wishes in his new sphere of activities.

Congratulations are extended to Mr. E. Sawkins, B.Sc., A.M.I.E. Aust., on his appointment to succeed Mr. Page as Engineer-in-Chief, on 10th April, 1957. Mr. Sawkins has had a varied and interesting career in the Post Office accompanied by rapid promotions, particularly in recent years. The fact that he is the youngest Engineer-in-Chief of the Australian Post Office highlights the confidence he has inspired in his superior officers during the successive stages of his career.

He commenced his Post Office career in Sydney when he was appointed as a Cadet Engineer in 1928. His cadetship was interrupted during the depression when he was transferred as Clerk due to the special measures taken on staffing and other matters during that period. However, he continued his studies, completed a university course in science and became a Bachelor of Science in 1932, afterwards for approximately 12 months carrying out various duties in the Materials Section of the Engineering Branch.

In January 1934 he resumed training as a Cadet Engineer and for a period of some 2½ years before being appointed as Engineer in August 1935, he was concerned with research in broadcasting matters in addition to work in the Telephone Equipment Section. After appointment as Engineer, his experience until 1941 included duties associated with substation and exchange maintenance in the metropolitan area, as well as P.A.B.X., substation and 2000 type exchange installations.

In January 1941 he was transferred to the General Works Section as Production Engineer handling Army signalling equipment, and radio physics equipment supplies for the U.S.A. Forces in Australia. Later, as Buildings Engineer, he was engaged in overseeing building proposals concerning the Engineering Branch. Mr. Sawkins returned to the Telephone Equipment Section in August, 1942, as Acting Divisional Engineer in charge of exchange, P.A.B.X., and substation installation operations. In 1945 he was selected as Divisional Engineer to establish the Telephone Planning Section, and in July, 1948, commenced to act as Assistant Supervising Engineer, Telephone Planning. He was promoted as Assistant Supervising Engineer, Equipment and Accommodation, Central Office, during this year but did not take up duty in Melbourne. His next promotion was to Supervising Engineer, Telephone Planning, New South Wales, to which he was appointed in 1950. Afterwards, he acted as Assistant Superintending Engineer, and in September 1955, he was appointed as Assistant Director (Engineering), N.S.W. During 1956, he acted as Director, Posts and Telegraphs, New South Wales, for some time.

During his career in New South Wales, Mr. Sawkins was responsible for the design and planning work associated with the implementation of several important projects, notable amongst which are:—

(a) Street lighting control for air-raid precaution purposes.
(b) Development of a post-war rehabilitation plan for telecommunication services in New South Wales.
(c) The development of a completely new phonogram system.
(d) Development of renumbering scheme for the Sydney metropolitan telephone network.

Mr. Sawkins was transferred to Headquarters in September, 1956, and was appointed Deputy Engineer-in-Chief, Central Staff, on 4th February, 1957, shortly afterwards being appointed Engineer-in-Chief.

Mr. Sawkins was for many years an active member of the Sydney Rowing Club. In addition, his activities have included bush-walking, canoeing and squash. As a canoe enthusiast he has been interested in river exploration.

Apart from the activities of an official and other nature mentioned above, the Post Electrical Society is very conscious of the work which Mr. Sawkins has put into Telecommunication Journal activities. He was a sub-editor of the Journal from 1947 until 1954 during which time he assisted very greatly by example and also by his drive in improving the standard of the Journal. He was indeed the first sub-editor appointed outside the Headquarters staff, and contributed several valuable and interesting articles. Since coming to Headquarters he has renewed his interest in the Telecommunication Journal and has been responsible for generating a new interest in its publication. We feel confident that, with his support, the Telecommunication Journal will continue to progress and become an even more valuable publication as far as the telecommunication activities of the Australian Post Office are concerned.

TELEVISION IN AUSTRALIA

*V. F. KENNA**

Introduction

The inauguration of the Australian television service in November, 1956, just prior to the Olympic Games, marked the culmination of activities on the part of Commonwealth instrumentalities which extended over many years. There were previous efforts to establish television in this country; indeed, history records that on two occasions plans had even advanced to the stage where tenders for the supply of equipment for national stations had been invited before the project was, for the time being, abandoned. It is well, perhaps, that these early efforts were unsuccessful, because Australia has now been able to enter the television field at a time when the art has achieved some measure of stability; consequently there is every reason to believe that the 625 line system that has now been adopted, will be adequate for a satisfactory service for many years to come.

Administration

The action that has resulted in the successful establishment of national and commercial services in Sydney and Melbourne was commenced with the appointment of the Royal Commission on Television on February 12, 1953. The Royal Commission was directed to examine and report upon the following matters:—

(a) The number of national and commercial television stations which can effectively be established and operated having regard to the financial and economic considerations involved and the availability of suitable programmes;
(b) the areas which might be served by television stations and the stages by which they should be established;
(c) the conditions which should apply to the establishment of television stations;
(d) the standards to be observed in the programmes of national and commercial television stations to ensure the best use of television broadcasting in the public interest;
(e) any conditions which may be considered desirable to apply to the television broadcasting of—
    (i) political and controversial matter and issues;
    (ii) religious services and other religious matter; and
    (iii) advertisements; and
(f) the conditions, if any, which should be imposed with respect to periods of broadcasting of television programmes.

Evidence was taken by six commissioners under the chairmanship of Professor G. W. Paton, Vice-Chancellor of the University of Melbourne. Thirty-four public sessions were held in the State capital cities and in all, 163 witnesses, expressing views either as private individuals or as representing organisations, were examined. In addition to the evidence tendered at the public sessions, certain evidence was received *in camera* and numerous written communications from Australia and overseas were examined. Thus every effort was made to obtain the views of a representative cross-section of the community.

The report of the Royal Commission was published on February 20, 1954. In a volume of 250 pages, the report summarises the evidence that was presented and the conclusions that were reached. The report, which is an extremely interesting document, concludes with 69 specific recommendations, and these form the basis upon which the structure of the Australian television service is being developed.

The recommendations concern the establishment of the initial stations at Sydney and Melbourne, the expansion of service to other centres of population, the manner in which the services should be controlled and administered, and the principles to be followed to ensure that programmes of satisfactory standard are produced. In particular, the report recommends that television should be introduced on a gradual basis, with a limit to the number of stations to be established in the early stages.

As far as the national stations are concerned, it is recommended that following the establishment of the first stations at Sydney and Melbourne the service should be expanded to other State capitals and centres of population as soon as practicable, the major portion of the expenditure being covered by revenue.

As regards the commercial service, the report recommends that, following the granting of two licences initially at each of the cities of Sydney and Melbourne, the subsequent expansion in those cities and to other centres of population should be effected as rapidly as circumstances permit, subject to the Minister being satisfied that the applicants for licences to operate the stations would be capable of providing a satisfactory service.

The Commissioners were of the opinion that the television service should

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* Mr. Kenna is Sectional Engineer, Television, In the Radio Section, Central Office.

be developed as far as possible by the use of frequency channels in the "very high frequency" band, without the need to utilize the "ultra high frequency" band. Also, that a complete frequency allocation plan, making adequate provision for future developments particularly in country areas, should be formulated by the Broadcasting Control Board. Other recommendations concern the responsibilities of the Australian Broadcasting Commission and the Broadcasting Control Board, the obligations of commercial stations and the standard and control of programme matter.

The Broadcasting and Television Act 1942-1956 gives effect to many of the Royal Commission's recommendations. In particular, this Act extends the functions of the Broadcasting Control Board, as the control and regulating authority, to include television and defines the functions of the Australian Broadcasting Commission and the Postmaster-General's Department in the television field.

The Commission is made responsible, not only for producing the national television programme, but also for providing and operating the technical equipment at the television studios. The Department's responsibilities include the provision and operation of the television transmitting stations, together with the radio links to connect these with the studios.

These functions represent an important change from those in respect to the national broadcasting service where the Department is responsible for all technical plant and the Commission is concerned with programme production only. However, the production of television programmes requires the integration of the programme production and technical functions to a much greater extent than does sound broadcasting and it is generally agreed that the change that has been made was necessary for the successful operation of the service.

Establishment of Service

In September, 1954, Cabinet decided that, as a preliminary step towards the introduction of television, the Post Office should proceed to invite tenders for the supply of equipment for national stations and studios at Sydney and Melbourne. Specifications for the equipment were prepared after discussions between the Control Board, the Commission and the Department, to ensure that the technical standards were satisfactory and that the facilities for the production of programmes would be adequate. The 22 tenders that were received offered a considerable range of equipment from the United Kingdom, the Continent and the United States. Eleven of the tenderers offered equipment for substantially complete installations.

In May, 1955, approval was given to place a contract with Amalgamated Wireless (A/sia) Ltd., for equipment for the transmitting stations, and for the studio-to-station programme transmission links for the Melbourne installation. Later in 1955 further contracts were placed for the supply and installation of equipment for the studios, as follows:—

Amalgamated Wireless (A/sia) Ltd:
  Studio equipment, cameras, telecine machines and standby engine alternator plant.

Pyrox Ltd:
  Telerecording and film editing equipment.

Television Engineering Pty. Ltd:
  Mobile radio links, mobile camera units for remote telecasts, test equipment.

E.M.I. Australasian Pty. Ltd:
  Cameras and test equipment.

Although the Australian Broadcasting Commission is responsible under the Act for providing the technical equipment at national television studios, in this instance the contracts for supply and installation of this equipment were placed, and are being administered, by the Post Office, mainly because of the Department's experience and existing organisation for the handling of major engineering projects.

Under the installation contracts the equipment is to be installed and adjusted for service by the contractors on a "cost plus" basis. The many indefinite factors that could affect the quantity and nature of the work to be performed made it clear that fixed price contracts for installation would not have been practicable and events have since proved this to be the case.

Planning by the Broadcasting Control Board

In the meantime, the Broadcasting Control Board, in accordance with its obligations under the Act, had issued a code of technical standards specifying the engineering requirements for the provision and operation of television installations, and had prepared a frequency allocation plan for the development of a television service throughout the Commonwealth. This plan is based upon the use of ten channels in the V.H.F. band, as follows:—

Channel 1. 49-56 Mc/s.
Channel 2. 63-70 Mc/s.
Channel 3. 85-92 Mc/s. (Inland areas only.)
Channel 4. 132-139 Mc/s. (Available from July 1, 1963.)
Channel 5. 139-146 Mc/s. (Available from July 1, 1963.)
Channel 6. 174-181 Mc/s.
Channel 7. 181-188 Mc/s.
Channel 8. 188-195 Mc/s.
Channel 9. 195-202 Mc/s.
Channel 10. 209-216 Mc/s.

The plan, which was published in the Board's Seventh and Eighth Annual Reports, provides frequency allocations for four stations to operate ultimately in each capital city and for two stations in every town throughout the Commonwealth with a population in excess of 5000. Provision is thus made for a total of 120 stations. This necessitates the use of each channel by a number of stations which have been spaced geographically to avoid interference. Although the radiation from the majority of stations will be horizontally polarised, co-channel operation is to be facilitated in certain cases by the use of vertical polarisation. The plan specifies an effective radiated power of 100 kilowatts for most of the stations although some allocations of 1 kilowatt and one of 14 kilowatts are included.

It is usual to rate television stations in terms of effective radiated power, or ERP, and some explanation of the term may be desirable. ERP is the product of the power output of the vision transmitter and the effective power gain of the aerial system, and is therefore equal to the power in kilowatts in a simple aerial of unity gain, that would provide the same signal intensity at a distant point. It is convenient to express the power of a station in ERP because stations of equal rating might quite usually secure the required output by different combinations of transmitter power and aerial gain. For example the national stations at Sydney and Melbourne will use 18 kilowatt transmitters with aerials giving a power gain in the horizontal plane of about 5.5 to secure the required 100kW ERP, whilst the commercial stations are using 10 Kilowatt transmitters with aerials having a power gain of 10 to secure a similar rating.

The Control Board also prepared recommendations to the manufacturers of television receivers concerning a number of important features of design, particularly in regard to the intermediate frequencies to be employed, and the desirable limits of radiation arising from the receiver circuits. The wide passband of the vision channel of a television receiver renders it very susceptible to interference from spurious signals generated by intermodulation, including those produced as sum and difference products of frequencies present or generated in the receiver itself. The problem of eliminating interference of this type is made more difficult by the requirement that the receiver should be capable of operation on any of the 10 channels that have been assigned for television services. After a very complete investigation of the problem, and discussions with representatives of the receiver manufacturing industry, the Board recommented that television receivers for use in Australia should be designed to employ intermediate frequencies of 30.5 Mc/s and 36 Mc/s for the sound and vision carriers respectively.

Commercial Licences

Early in 1955 licences were granted by the Government for the establishment of two commercial television stations in each of the cities of Sydney and Melbourne. The licences were issued subject to certain conditions designed to ensure that the licensee companies would operate with Australian capital and be controlled by Australian residents, and that the standards of technical equipment and programme production would be adequate for satisfactory service to the public.

The licences were issued at a time sufficiently in advance of the Olympic Games to allow transmitters and studios to be established and in operation for that important event. Although certain of the stations were not formally opened until after the Games, all were able to participate in the Olympic telecasts and to provide a very creditable service to the public.

National Stations

Towards the end of 1955 it became apparent that service from the national television stations at both Sydney and Melbourne would also be required before the commencement of the Olympic Games and arrangements were made with the contractors for sufficient equipment to be delivered and installed to enable programmes to be originated by that time. Essential equipment was set up in temporary buildings at the studio sites, whilst low powered transmitters. intended ultimately as standby units in the completed stations, were brought into operation on temporary aerial systems. Telecasts from the Olympic venues and other points of interest were made possible by the use of the mobile camera units and the mobile vision programme radio links which were delivered in good time by the contractor concerned.

The temporary facilities, provided for the Olympic Games, are now in process of being replaced as permanent plant is installed and brought into service. The transmitting stations should be completed and in full operation by mid-August whilst the greater portion of the studio plant should be installed by early 1958. In the meantime the temporary installations have afforded the operating personnel of the Commission and the Postmaster-General's Department, excellent opportunities for gaining experience with the new techniques of television.

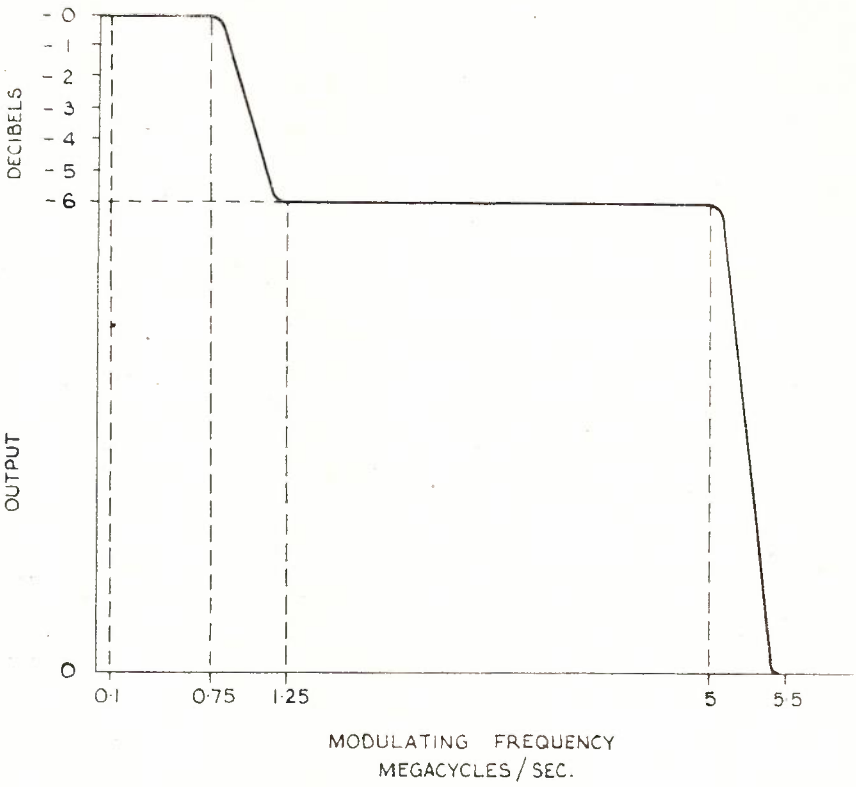

Fig. 2.—Output of Ideal Receiver.

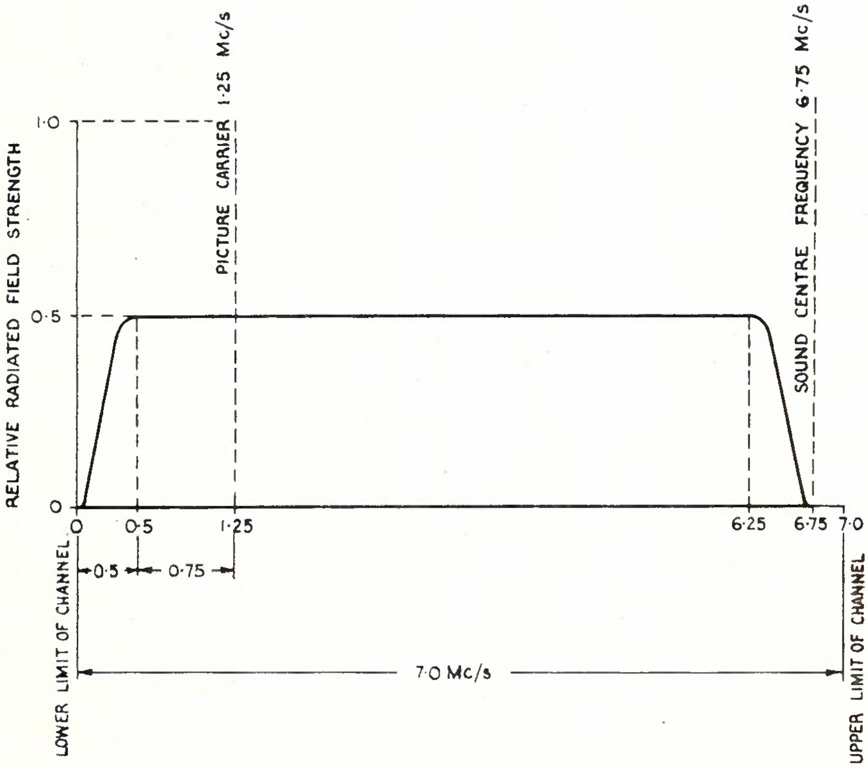

Fig. 1.—Utilisation of Channel. All Frequencies Shown are to be Added to the Lower Limit of the Channel.

Technical Standards

A very important detail in the specification for a television system concerns the basic standards upon which the system operates. The system standards are usually referred to in terms of the number of scanning lines used in a particular system to reproduce the picture detail, although it is to be noted that the several television systems in use in the world today, differ also in other important respects. In the United Kingdom, where high definition television was first demonstrated, a 405 line system is used. Twenty-five complete pictures are transmitted each second, using positive modulation—in other words the intensity of the radiated signal increases during the transmission of highlights. Amplitude modulation is used for the sound programme transmission channel.

A system using 525 lines and transmitting 30 complete pictures per second is used in the United States and in certain other countries. This system uses negative modulation—the intensity of the radiated signal decreases during the transmission of highlights—and frequency modulation is used for the sound channel.

Some of the Continental countries, including Germany, Italy, Switzerland and Holland use a 625 line system, transmitting 25 pictures per second, with negative modulation. The sound channel is frequency modulated. An 819 line system is in operation in France and Belgium.

The Australian System

After a close study of the various systems the Broadcasting Control Board has adopted the Continental 625 line system for use in the Australian television service and experience to the present time has shown that this was a wise decision. It may now be appropriate to discuss some of the main features of this system.

The complete television system requires the transmission and reproduction of both vision and sound programmes, and in practice equipment that is almost completely separate is provided for each function. The sound programme equipment is generally similar to that used in broadcasting practice, but the vision equipment is different in many ways and incorporates many new principles.

The transmitting station occupies a channel in the frequency spectrum which is 7 Mc/s wide, and this is utilised in the manner shown in Fig. 1. The sound programme information is transmitted by frequency modulation of a carrier located 6.75 Mc/s above the lower limit of the channel. The transmitted band extends from 30 to 15,000 c/s and at full modulation the carrier is deviated ± 50 kc/s. The vision carrier is located 1.25 Mc/s above the lower limit of the channel and is amplitude modulated by the signals necessary to transmit the picture information and to maintain the receiver scanning processes in synchronism with those at the transmitter.

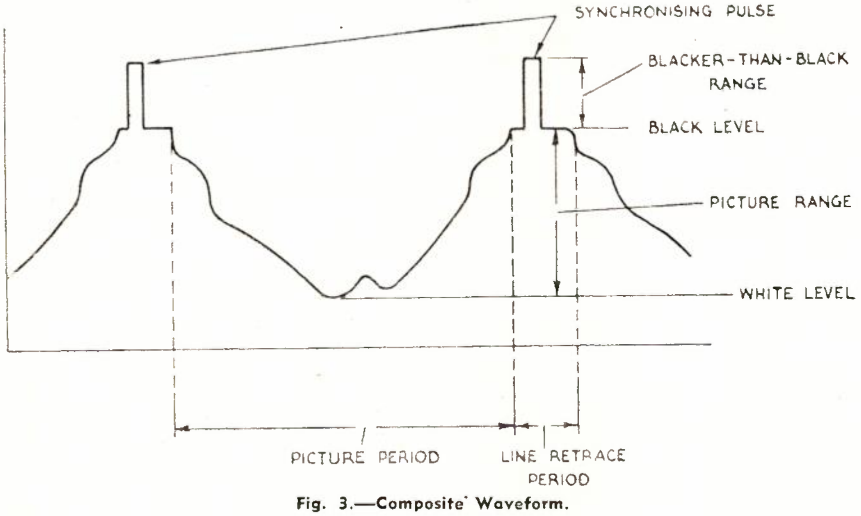

Fig. 3.—Composite Waveform.

The vision transmitter is capable of transmitting a band of frequencies extending to 5 Mc/s but it can be seen that double sideband operation would not be possible within the 7.0 Mc/s channel assigned to each station. The radiation of the 5 Mc/s bandwidth is made possible by the partial suppression of the lower sideband, a principle referred to as "vestigial sideband" operation.

Reference to Fig 1 will show that the upper sideband, extending to a full 5 Mc/s, is transmitted but the lower sideband is rapidly attenuated at modulating frequencies beyond 0.75 Mc/s. When the signals are rectified in a receiver having ideal characteristics, the response to modulating frequencies above about 0.75 Mc/s, in the region where only the upper sideband is transmitted, will be 6 db lower in level than in the case of frequencies below 0.75 Mc/s, and for which both sidebands are transmitted. The response of such a receiver would be as shown in Fig. 2, but practical television receivers incorporate an inverse correcting characteristic which provides an overall linear response for the transmitter and receiver combination.

Let us now examine the video signal that is used to modulate the vision carrier. This signal is generated at the studio, and is referred to as a "composite" signal because it contains both synchronising pulses and picture information. The picture signal is generated in a camera or in a telecine or film reproducing machine. An image of the scene to be televised is produced in the first instance by optical means and is analysed by a rather complex scanning process which translates the light and shade of the picture into varying electrical signals. The scanning process commences at the top of the image and traverses from left to right across the scene. On reaching the right hand side of the image, the operation is recommenced at the left hand edge, but displaced a little in the vertical direction. In this way successive scans analyse fresh areas of the image until after about 294 traverses the scan reaches the bottom of the scene. The process is now recommenced at the top of the image but each traverse is now arranged to fall exactly between those made previously, and after a further 294 traverses the bottom of the scene is again reached. At the completion of the second scan the picture will have been analysed in 588 separate traverses or lines each of which has examined, and converted to an equivalent electrical signal, the details of a narrow strip extending across the picture, and in width about one six-hundredth of its height. The scanning process is repeated at a rate such that 25 complete pictures are transmitted each second, each picture being scanned in two interlaced "fields" of about 294 lines. At the end of each line and at the end of each field, synchronising signals of distinctive character are inserted to make up the composite signal.

The picture signals and synchronising signals are diverted into separate circuits in the viewer's receivers, the former controlling the brightness of the spot in the cathode ray picture tube and the latter ensuring that the spot moves in synchronism with the scanning process or raster in the camera tube at the studio. Thus the picture is reconstructed on the screen of the picture tube, element by element and line by line. Because of the persistance of vision of the eye an image that is apparently continuous, is produced. The television picture is usually rather brighter than that produced on a motion picture screen and would therefore produce a greater sensation of flicker were it not for the interlaced system of scanning.

Fig. 3 shows a typical composite waveform comprising picture signals and line synchronising pulses as radiated from the transmitter. Whilst the picture portion of the signal is being transmitted the intensity varies in accordance with the light and shade of that particular line of the picture, white causing a reduction in the signal level and black, an increase. This sense of operation is identified by the term "negative modulation" and is contrary to the positive mode of modulation used in the 405 line system in the United Kingdom. The use of negative modulation has some advantage in that there is a tendency for certain types of interference to be reproduced as dark blemishes in the received picture. These are usually less conspicuous than the white pattern that is produced when positive modulation is used.

The signal level equivalent to black is established as at the base of the synchronising pulses. The signal is held at black level for a short period before and after the line synchronising pulse is transmitted, to allow time for the scanning spots in the camera and picture tubes to be returned to the left hand side of the picture before commencing the next line scan. This period is called the "line blanking period", or "line retrace period". During this phase the scan is ineffective in producing picture detail and the retrace is made at an increased velocity in order to allow the maximum time for the transmission of useful information. During the retrace movement of the scanning spot, and whilst synchronising pulses are being transmitted, the signals are not visible on the screen of the picture tube because the signal at this time is at black level or in the blacker-than-black region.

In addition to the line synchronising pulses which control the horizontal scanning movements, it is necessary to transmit field synchronising signals to ensure synchronism in the transmitting and receiving circuits of the vertical motion in the raster. Vertical synchronising information is transmitted after the bottom line of the image has been scanned and takes the place of the picture signals for about 18 of the 312½ line periods assigned to each field. The receiver circuits are able to distinguish these pulses from the line synchronising pulses and divert them into the appropriate circuits. During the transmission of these 18 line periods the scanning spot is returned to the top of the image to commence the scanning of the next field, but the return trace is not visible because, during the process, the signal is held at black level or higher. This phase of the cycle is called the "vertical blanking period".

Studio Equipment and Facilities

The principal features of a typical television studio group are shown in Fig. 4. It will be noted that equipment that is quite separate is provided for the sound and vision programme channels. The sound channel equipment is, in general, similar to that used for sound broadcasting, although certain additional features are incorporated to facilitate control during the production of live shows. The influence of the motion picture studio is also apparent in the use of elaborate booms to position the microphone as close to the artist as possible without appearing in the picture. Disc and tape reproducing equipment is available to provide musical accompaniments or sound effects when required for the programme.

Whilst films are being telecast, both sound and vision programmes are reproduced on the telecine machines, which are equipped to handle sound recordings made either optically or magnetically. Magnetic recordings may be on the parent film or on a separate or "unmarried" film run in synchronism with the parent film.

When the programme originates at a point remote from the studios the sound programme is usually conveyed to the studios by means of conventional wire circuits provided by the Department, although equipment to provide sound and communication channels by V.H.F. radio is also available. It is not proposed to enlarge further upon the sound programme equipment, the principal features of which will be familiar to the reader.

The vision programme equipment is extremely complex in design and operation and incorporates many features and principles that are not encountered in the field of sound broadcasting. Much of the complexity in the electrical design arises because of the requirement that the circuits be capable of transmitting frequencies in a band extending from about 25 cycles per second to 5 megacycles per second. This width of band is necessary because of the great rate at which information must be handled over a television system. The Australian system is capable of transmitting 25 complete pictures per second, each of which may contain some 400,000 individual picture elements. The significance of these figures may be realised when one considers that a picturegram service capable of producing a picture of comparable quality would require perhaps 8 minutes to transmit each picture.

A television studio is similar in many respects to a film studio, but there is one important difference. A motion picture film is produced by completing individual scenes which are later edited and joined up to give continuity to the production. Each scene is rehearsed until it is satisfactory in all respects; the scene is then filmed and the production of the next scene commenced. This procedure is not possible with a television production which, once commenced, must continue scene by scene without interruption until it is completed. Practical considerations limit the number of rehearsals that are possible for each performance and consequently the production of a live television show involves intense and concentrated effort on the part of both the production personnel and the artists. Therefore, as would be expected, highly developed control and production facilities are provided at television studios.

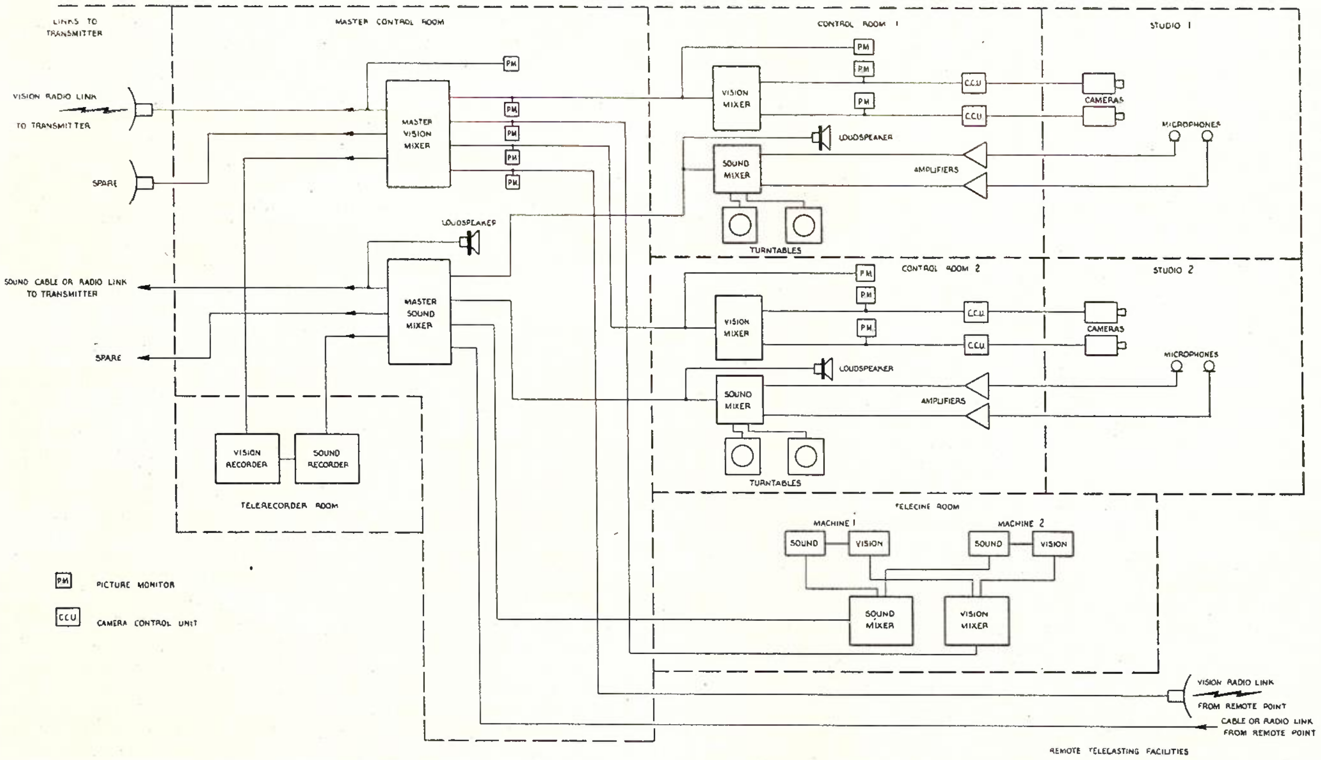

Fig. 4.—Block Diagram of Typical Studio Facilities.

Fig. 5.—Studio Control Room.

A studio group will normally comprise at least two studios, each of which is equipped with from two to four cameras. The camera operators are responsible for the artistic aspects of the pictures, whilst the technical operation of each camera is controlled by a technician stationed at the camera control unit. This may be located in the master control room or in the studio control room. The outputs from the camera control units are connected to the vision mixing panel and to picture monitors in the studio control room. Thus the producer is able to preview the picture produced by each camera before it is brought into operation, and to decide the switching sequence that is necessary for the desired continuity of the show that is being produced. The outputs of the several studios the telecine machines and the remote telecast unit, if in use, are controlled and switched in the master control room to provide the continuity from item to item and ensure the smooth flow of programme to the viewers. Here again picture monitors are connected permanently across each programme source so that the programme personnel may preview the scene about to be telecast. In addition, waveform monitors are used at appropriate points to examine the composite vision signal to ensure that the synchronising pulses are of correct shape and proportions with reference to the picture signal. The output of the master switching unit is conveyed to the transmitter, either by a coaxial cable or over a wide band radio link.

The telecine machines which contribute a large portion of the programme from a television station, embody some interesting features. A fundamental design difficulty arises because the television system allows a period of only about 1.5 milliseconds between the scanning of successive fields or pictures and this is insufficient for a normal film transport mechanism to move the succeeding frame into position in the gate. According to the manner in which this difficulty is solved, telecine machines may be classified broadly into two classes, namely, the vidicon and the flying spot types of machine. Both types are used in Australia and are capable of producing excellent results.

Vidicon machines use a special picture tube which is marketed under the name "Vidicon" or "Staticon" by various manufacturers. The machine consists essentially of a standard motion picture projector which produces an image on the signal electrode of a vidicon camera tube. The signal electrode has the property of retaining the optical image in the form of an electric charge pattern, until it has been scanned by an electron beam and converted to a standard vision picture signal. The action of scanning neutralises the electric charge image on the portion of the signal electrode that has been scanned, leaving it prepared to receive the next picture from the film projector. The storage property of the vidicon obviates the necessity for the film projector to run synchronously with the television scanning raster, or for the film pull-down to occur in the field blanking period. Vidicon machines have a great advantage in that they are relatively simple in construction and do not incorporate any very complex or critical mechanical or electrical feature.

In the flying spot type of telecine machine the image is scanned by a beam of light whilst the film is moved through a gate at a uniform velocity. After passing through the film the light is directed to a photocell which produces the picture signal. The light beam is generated from the spot on a cathode ray tube and can therefore be readily deflected as necessary for the scanning process. The motion of the scanning spot includes a factor to compensate for the continuous movement of the film and thus the need for the usual intermittent film motion is eliminated. All of the processes in a flying spot telecine machine must be very accurately synchronised and conse-

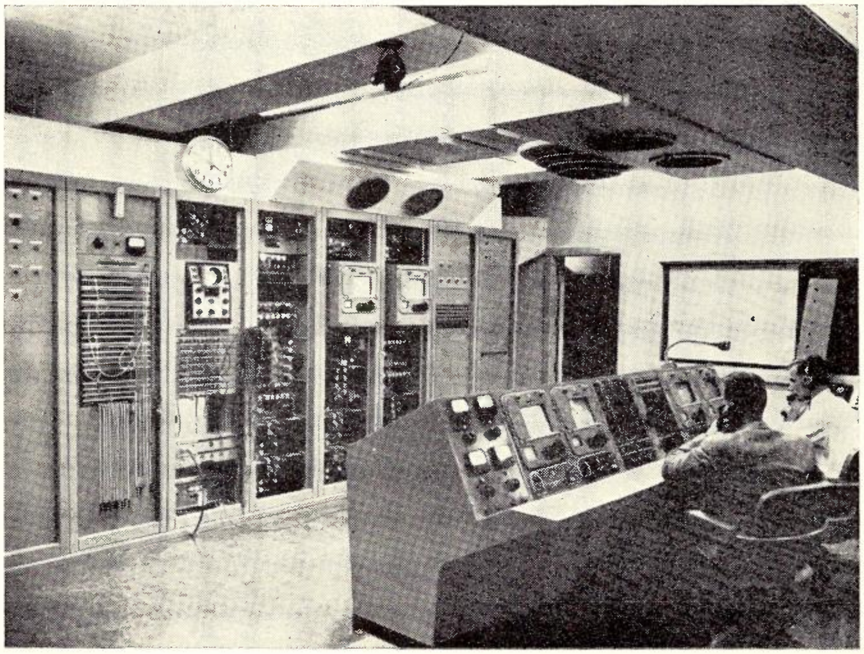

Fig. 6.—Master Control Room.

quently these units are highly complex in their electrical and mechanical detail. However, when used with well graded 35 mm film, flying spot machines are capable of producing pictures of exceptional quality.

Telecasts from places remote from the studio are made possible by the use of mobile camera units, which are fully equipped with the essential control room facilities for the production of vision and sound programme. Sound programme and communication links to the studios are usually provided by normal Departmental cable circuits. The vision programme is transmitted to the studios by radio equipment similar to that shown in Fig. 7. This equipment operates on a carrier frequency in the vicinity of 7000 Mc/s and is capable of providing a circuit over a distance of about 30 miles. Greater distances can be covered by the tandem operation of several links. A vision programme channel of about 5 Mc/s bandwidth is provided, but the equipment of certain manufacturers incorporates facilities for multiplexing a high quality sound channel over the system.

Telerecording equipment is provided at many studios to make permanent records of programme matter as telecast. Telerecording machines consist essentially of a means of producing a high quality television picture which is photographed by a motion picture camera running synchronously with the scanning process. Here again a difficulty arises because the field blanking period does not allow sufficient time for the film transport mechanism of a normal camera to draw a frame of unexposed film into the gate. However, several manufacturers are now producing fast pulldown cameras and it appears that these will come into general use for telerecording purposes. There are great difficulties to be overcome in the design of such a camera because of the enormous accelerations to which the film and certain of the moving parts must be subjected.

Prior to the advent of the fast pull down camera, all 625 line telerecorders worked on the "suppressed field" principle. Machines of this type record only the information in alternate fields and the film pull down is timed to occur during the lost fields. The pictures so produced retain full resolution in the horizontal direction but have a resolution equivalent to a 312½ line system in the vertical direction. Notwithstanding this deficiency, the reproduced pictures from a suppressed field recorder can be of quite acceptable quality.

Telerecorders usually incorporate a means of recording the sound programme on a magnetic track on a separate or "unmarried" 16 mm film, run in synchronism with the picture film. However, some machines record the sound by an optical method directly on the parent film. After the picture film has been processed, it is usual to dubb the sound on a magnetic stripe on each release print before it leaves the laboratory. This ensures the highest possible quality of reproduction without the inconvenience of handling a separate sound recording.

Transmitter Equipment

When the studios and transmitting stations are located on separate sites it is usual to provide the interconnecting vision programme links by microwave equipment, similar to that used with the mobile camera units and shown in Fig. 7, but with rigid mountings in place of tripods. The sound programme links may be by cable circuits, separate microwave or V.H.F. radio links or by multiplexed channels on the vision microwave systems.

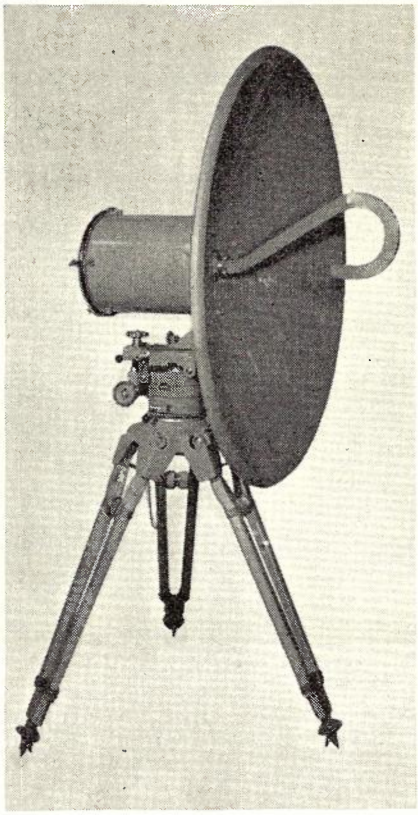

Fig. 7.—Vision Radio Link Terminal.

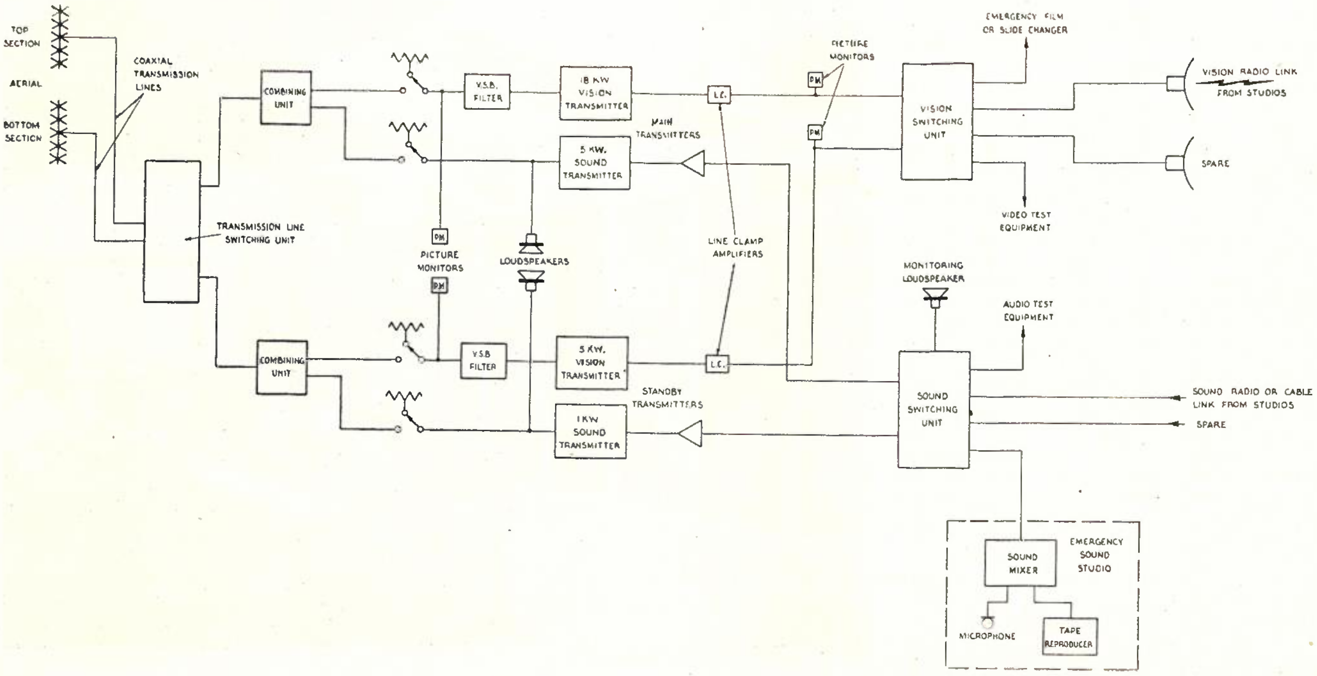

Fig. 8.—Block Diagram of Typical Transmitting Station Facilities.

Fig. 8 illustrates the principal items of plant at a typical national transmitting station such as is being installed at Melbourne. The equipment is completely duplicated as a precaution against lengthy interruption to service as a result of fault or breakdown. The complexity of television plant is such that faults on working equipment cannot always be investigated and cleared in a short time, and the total value of the installations at the transmitting stations and studios that would be immobilised by equipment failure is such as to justify the provision of comprehensive standby facilities.

It will be noted that although a common aerial system is used for both sound and vision transmissions, separate equipment is provided otherwise for the services. The aerial system is designed to concentrate the radiation in the horizontal plane and by so doing, an effective power gain of about 5.5 times is achieved. The aerial comprises 8 stacks, each of 4 dipoles arranged on the faces of the supporting tower. Reflecting screens are provided on the tower behind each dipole, to concentrate the radiation in an outward direction. The top and bottom sections of the aerial, each comprising 4 stacks, are fed by separate transmission lines from the station. Switching facilities are provided to enable either section of the aerial to be removed from service in the event of breakdown, such as might be caused by lightning.

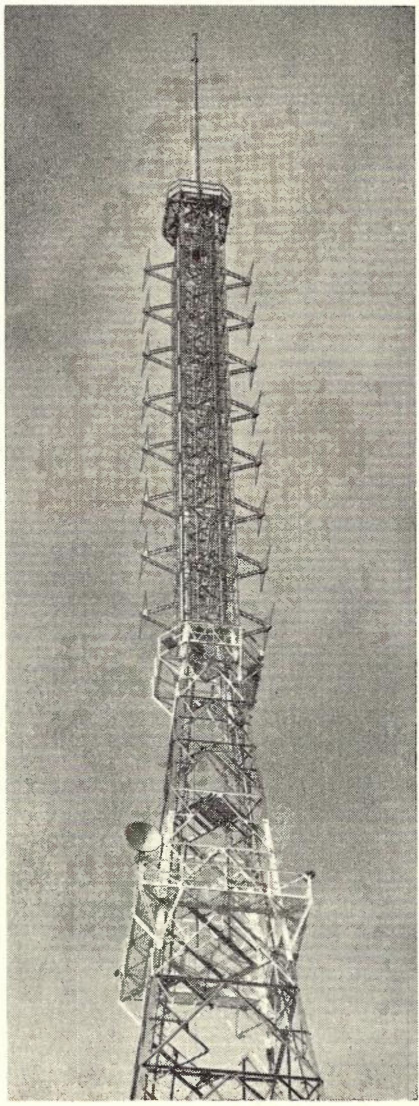

Fig. 9.—Aerial System.

The outputs of the sound and vision transmitters are connected to the aerial system by means of a combining network which prevents interaction between the two transmitters.

The sound transmitters are rated at output powers of 5kW and 1 kW respectively for the main and standby units. Air cooling is used except in the case of the dummy loads which must be water-cooled. The transmitters are frequency modulated and the frequency response extends to 15 kc/s. Monitoring, control and testing equipment is provided in accordance with broadcast station practice.

The vision transmitters are rated at output powers of 18kW and 5kW respectively. As in the case of the sound transmitters, air cooling is used throughout except for the dummy loads. Provision is made for re-circulating portion of the heated exhaust air in order to heat the transmitter building. This is a desirable feature as the Melbourne station is situated at a height of almost 2,000 feet above sea level. The main transmitter is modulated in the grid circuit of the final stage. The required sideband characteristics are secured by the use of an external network, shown in Fig. 8 as the vestigial sideband filter. The standby transmitter is of somewhat different design, being grid modulated in a low-level stage. Two linear amplifiers are provided to follow the modulated amplifier. The sideband characteristics are secured, partly by offsetting the tuning of the transmitter circuit, and partly by the external vestigial sideband filter. The frequency response of both transmitters extends to 5 Mc/s.

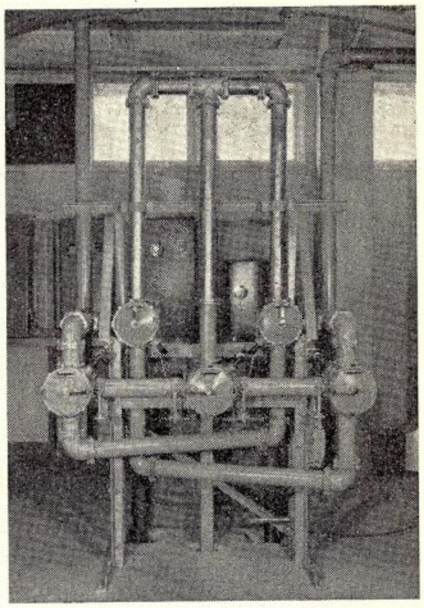

Fig. 10.—Transmission Line Switching Unit.

The composite vision signal, after arriving at the station over the radio link from the studio, is passed through a line-clamp amplifier which stabilizes the signal with regard to a fixed reference level equivalent to black level, and reshapes and proportions the synchronising pulse. One result of this operation is to

Fig. 11.—Transmitter Control Desk and 18 kW Transmitter.

reduce the effects of any low frequency interference, such as 50 cycle noise. The modulator circuits in the transmitter subject the signals to further stabilising or "clamping" processes to ensure that a fixed value of radiated power is maintained for black level.

Facilities are provided for picture monitors and testing equipment to be connected to the equipment at appropriate points.

Conclusion

Detailed descriptions of the studio and transmitter equipment are not within the scope of this article and the reader is referred to recent papers in overseas engineering journals for further particulars of plant of this type. The main transmitters at the Australian stations are very similar in design to the transmitter recently installed for the B.B.C. at the Crystal Palace station in London. A good description of this station appears in the Proceedings of the Institution of Electrical Engineers, Part B, September, 1956.

SPECIAL SERVICE AND OBSERVATION FACILITIES FOR THE LAUNCESTON TELEPHONE NETWORK

*K. R. RICHARDSON, B.E., Grad.I.E.Aust.**

Introduction

This article describes the line finder answering circuits of Interception, Trunk Enquiry, Information and Complaints, the answering circuit for the "Time of Day" service and the manual terminations of Local Service, Trunk and Telephonists' Observation Facilities installed at Launceston.

During October, 1955, the old combined trunk and central battery exchange at Launceston was replaced with a 25 position sleeve control trunk exchange, a 3,900 line automatic exchange and a 600 line portable automatic exchange. The suburban central battery exchanges of Mowbray and East Launceston, having capacities of 800 and 1,200 lines respectively, were modified to work into the new system. Launceston's C.B. exchange, together with much of its ancillary services, dated back to 1910, and the latter were entirely unsuited for use in the automatic network. It was, therefore, necessary to design and install a completely new system for the special service and observation facilities in time for the cut-over of the new exchanges.

In the designing of the special service answering circuits, considerable attention was given to the development of a simple key shelf on which operative effort would be reduced to a minimum. Also, as the positions were to be situated in the trunk exchange, it was necessary that their size be as small as practicable and that they match other items of furniture in the exchange. Standard drawings of selector and subscribers' observation circuits were used. These services were combined with facilities for trunk and telephonist observation on one manual position. Independent trunk and telephonist observation circuits were also provided on a second manual observation position and on the position of the Traffic Officer in charge. Both observation positions were built on 5 x 3 feet tables arranged side by side in a partitioned portion of the trunk exchange.

Special Services

As a means of obtaining a simple, compact key panel on the special service answering positions, line finders were selected, since their use enabled all lines to be terminated on the finder banks, while on the positions it was necessary to provide only one key for each type of circuit, namely Interception, Trunk Enquiry, Information and Complaints. One answering circuit for "Time of Day" is multipled over all special service positions, but is not incorporated in the line finder circuits. The three "time" trunks from the automatic exchange are arranged to be answered simultaneously from any position.

Four operators' positions, which are of the cordless type, are provided on two tables. From Fig. 1 it is seen that these are arranged between the switchboard suites of the trunk exchange. The table turrets were made opposite hands and

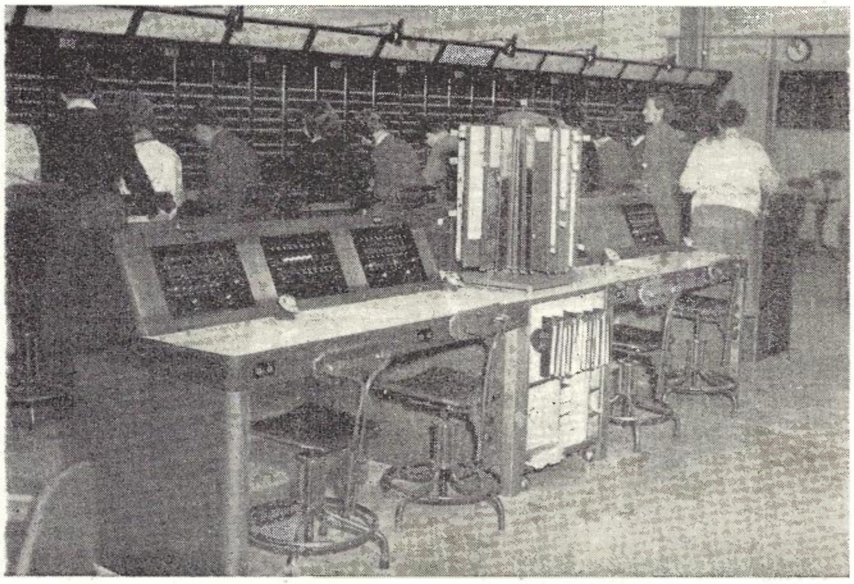

Fig. 1.—Layout of Special Service Positions.

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extend for a distance of twelve inches over one edge of the table. Thus, when placed together, the turrets are continuous and a space two feet wide exists between the tables. During the day, an information filing trolley is positioned in this space. At night, the trolley is wheeled adjacent to trunk position 16 where the circuits of special service position 4 are multipled on the end section of the trunk suite. Thus, when traffic is light, it is possible to control the whole exchange from the one trunk position.

Hold facilities are provided whereby the telephonist may hold one or more circuits and use her line finder to answer another call. Transfer facilities exist with which calls to Trunk Enquiry, Information and Complaints may be switched to the Traffic Officer, Supervisor, Pricing, Monitor or to another subscriber via an exchange circuit. Complaints are normally answered on positions in the automatic exchange from whence the circuits may be night switched to the special service positions.

A photograph of the key shelf is shown in Fig. 2. The answering, recall and hold keys are mounted in the upper row while the subsidiary keys such as time release, interception, through and transfer keys are mounted in the lower row. The supervisory lamp glows if a calling subscriber clears before the line finder is released by the restoration of the answer key.

Block Schematic and Facilities: A block schematic of the finder system is shown in Fig. 3. Two types of line circuits are utilised. One, incorporating transfer facilities, is used for Trunk Enquiry, Information and Complaints, while the other is used for Interception. These circuits are arranged in their four respective groups. Each group lights its appropriate call lamp on all positions, and prepares a start circuit for the line finders. A position relay set and a line finder is associated with each special service position and each position to which a call may be transferred. The operation of the appropriate answer key on any position will cause the associated line finder to find the calling line.

When from the special service positions a call is either "transferred" or "held", the line circuit assumes a lock-up condition which may only be released by the operation of the answer key on the position to which the call is transferred or, in the case of "hold", by the operation of the recover key on the position on which the call was held. Thus, since the line circuit locks, the finder circuit of the position effecting either the "transfer" or "hold" is immediately available for other use. The number of circuits being transferred or held simultaneously is limited only by the number of available line circuits. However, if after holding two calls simultaneously, the line finder is used again to answer another call, the circuits held may not necessarily be recovered in the same order in which they were stored. The common relay set is used to concentrate the call lamp feeds and to prepare and control the start circuits of the line finders.

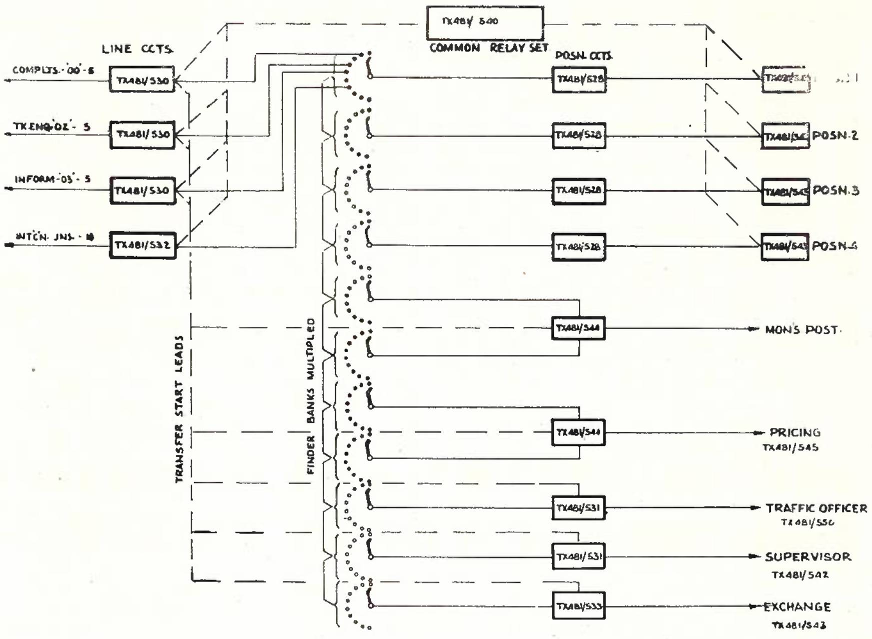

Fig. 3.—Block Schematic of Special Services Circuits.

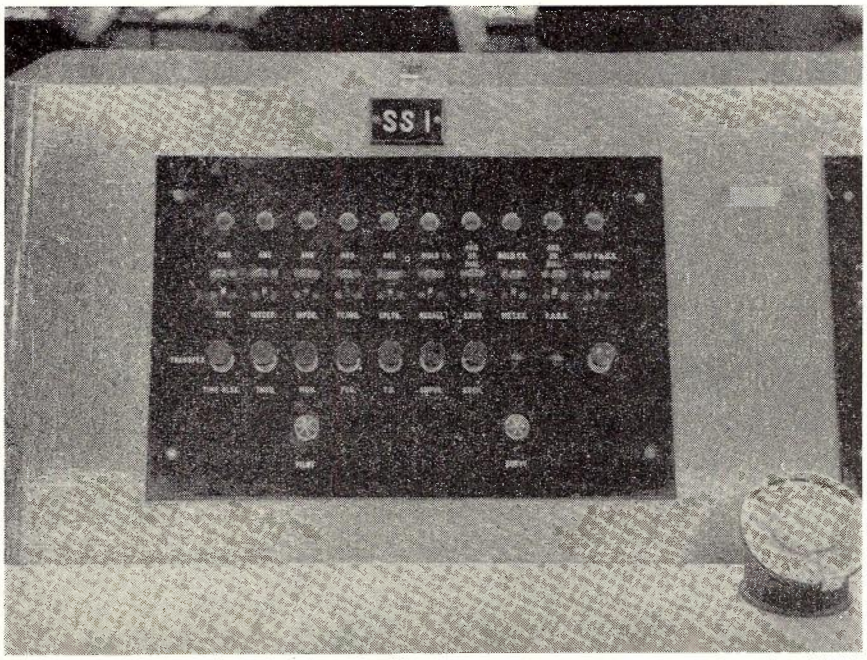

Fig. 2.—Special Service Key Shelf.

The Interception circuit automatically "locks off" when the telephonist leaves the line. If, however, she operates the "through" key before leaving the circuit, the interception junction will cause the call to be switched through to the called subscriber and, until the call is answered the terminating relay set is in the hold condition, but may still be monitored. If, by the restoration of the answer key, the telephonist leaves the circuit in this condition, it may once again be recovered by the use of the recover key until such time as the called subscriber answers.

Position Relay Set: Each special service position relay set (Fig. 4) is associated with a uniselector line finder. Leads ST and C are connected to the answer keys on the manual positions. Relay C operates over the ST lead via an answer key to an earth from contacts on the call relay in the common relay set. Therefore, unless a call condition exists on one circuit of the group corresponding to the operated answer key the line finder will not hunt. When the finder switches, relay C locks to earth at the answer key via the C lead.

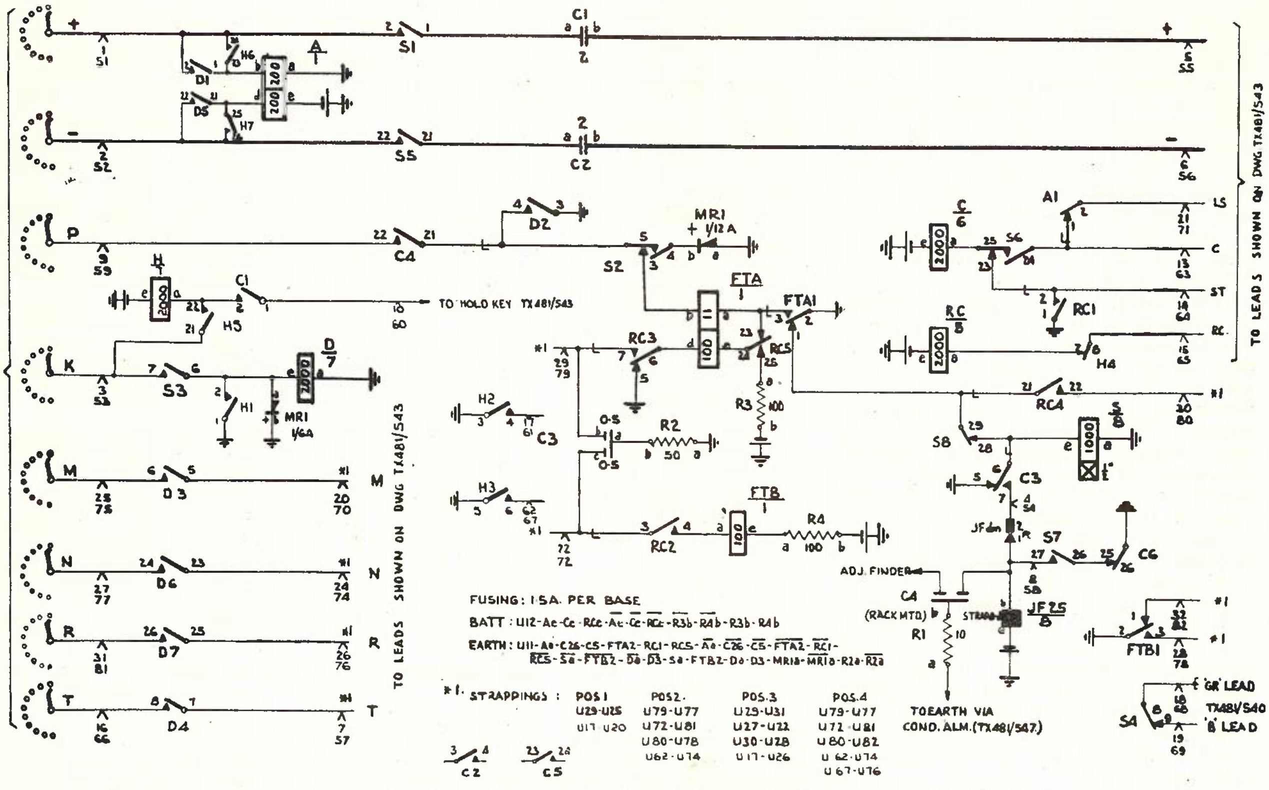

Fig. 4.—Position Circuit—Special Services Positions.

Relay C in operating causes the finder to drive. The calling line will be marked by 100 ohm battery on the P wire, which operates the FTA relay to cut the uniselector drive and to allow relay S to switch. Relay K in the line circuit operates in series with relay D and switches the line through to the telephonist. The restoration of the answer key releases relay C which in turn releases relay S. During this period, the drive magnet is energised to cause the uniselector to take one step, ensuring a forward searching action over all lines.

To "hold" a line, relay H is operated by the hold key and locks to relay S. Contacts of H extend an earth over one or two of the M, N and R leads to the line circuit. Relays in the line circuit operate to maintain this particular combination of earths, marking the circuit so that it can be subsequently found or recovered by the telephonist who held it. After operating the non-locking hold key the telephonist releases the answer key in order to deal with other business. The position circuit releases as previously described, but the line circuit remains locked until recovered.

To recover the line, relay RC operates to the recovery key and operates relay C which once again locks at S6. Contacts of RC connect the FTA and FTB relays to the M, N or R leads in order to search for the required combination of earths locked in the line circuit. Depending on the shelf strappings, either both FTA and FTB are required to operate before the finder will switch, or FTA must operate and not FTB.

To transfer a call, the transfer key places an earth on the T lead together with some combination of earths on the M, N or R leads. The circuit of relay D is opened in the line circuit and D releases to disconnect the M, N, R and T leads from the operators' position. The Telephonist then restores the answer key and the position circuit releases as previously described.

Line Circuit: Referring to Fig. 5, a call to the special service positions operates relay L which in turn operates LL. Ring tone is returned to the caller and the call lamps are lighted via the common relay set. Contact LI4 feeds the 100 ohm battery from the common relay set to the P wire on the bank of the finder to operate the FTA relay in the position circuit. When the finder circuit switches, relay K operates in series with relay D in the position circuit. Relay K extends the three wire circuit into the position circuit.

To hold a call, a combination of M, N and R relays are locked to earth at LL3. When the Telephonist leaves, the circuit relay K releases and allows L and LL to re-operate. Contact K3 replaces the locking circuit of the M, N and R relays before LL re-operates.

When the "recover" key is operated, the finder switches to the locked combination of M, N and R. Relay K re-operates in series with D to once again extend the three wire circuit. Relay K operating, opens the locking circuit of M, N and R allowing any that are operated to release. The circuit is now in the same condition, holding to the recover key as it previously was holding to the answer key.

The transfer circuit is similar to the hold circuit, excepting that the T relay is locked together with the combination of M, N and R. A call signal is given to the position to which the call is transferred and 100 ohm battery is connected to the marker bank wire of the associated line finder. The finder switches to the battery and operates relay K which releases the T, M, N and R relays.

Interception Line Circuit: Referring to Fig. 6, relay H operates over the B wire. H operates HA which returns ring tone to the caller and lights the positions' call lamps. When the finder switches, relay A operates followed by relay B which locks to HA and P. Should the operator now leave the circuit, relay A followed by H releases. Earth, via B1, A3 and P2, effects the lock off condition in the junction circuit in the Automatic Exchange. H releases HA which in turn releases B to clear the circuit. Should it be required to switch the circuit "through" to the called number, the relay set is locked in the hold condition. Earth is connected to the junction A wire by relay P to feed the through condition to the automatic exchange.

The telephonist may still monitor the circuit, or she may leave it with the hold lamp glowing. When the called subscriber answers the junction falls free. If the called subscriber does not answer, the circuit may be recovered by use of the recover key and should the telephonist now leave the circuit without again switching "through", the call will be locked off.

Exchange Line Circuit: This facility allows calls to Complaints, Trunk Enquiry and Information to be extended to

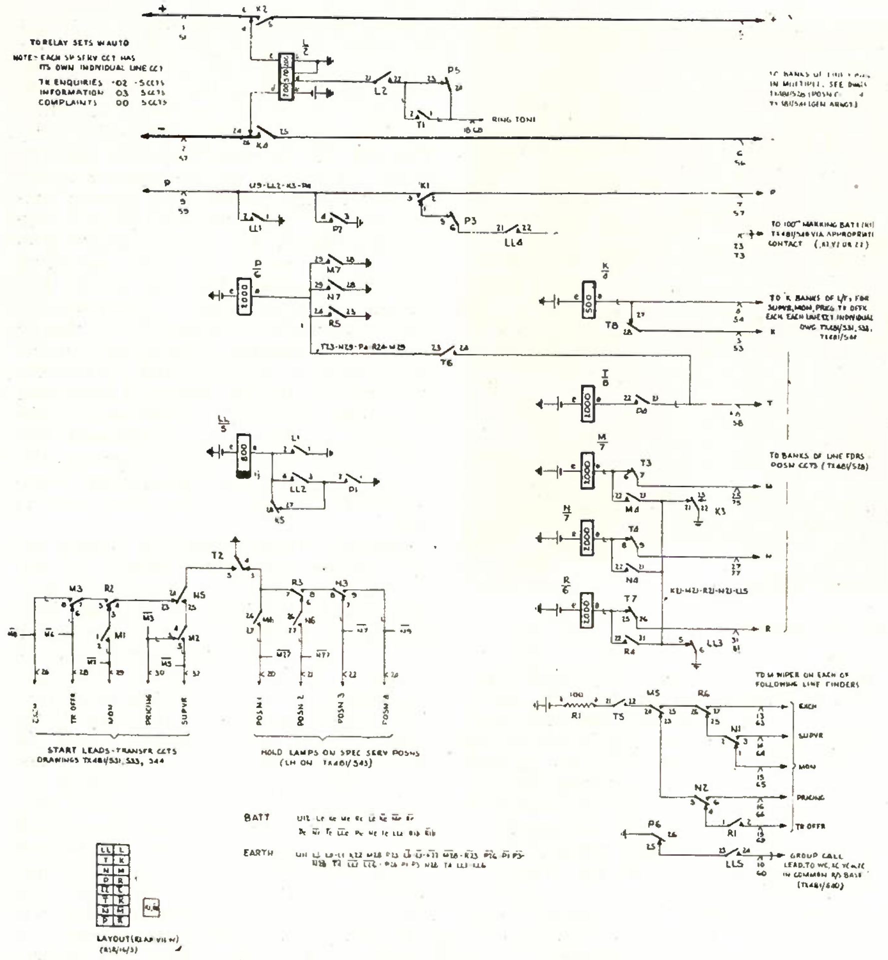

Fig. 5.—Line Circuit—Special Services Positions.

another subscriber. After answering the incoming circuit, the Telephonist operates the dial key on the exchange line circuit and dials the required number. On hearing ring tone, she operates the transfer key. The line finder associated with the exchange line circuit finds the calling line. The subscriber will hear the ring-tone and will enter into conversation when the called subscriber answers. Under these conditions, the exchange line relay set is held to the calling subscriber's loop. A meter key is provided to enable the call to be metered against the calling subscriber, if necessary.

Position Circuit — Traffic Officer, Supervisor, Pricing and Monitor: One transfer circuit is provided to the Traffic Officer's position, one to the Supervisors' and two each to the Pricing position and Monitors' turret. When an operator on a Special Service position transfers a call, the M, N and R relays of the line circuit lock in a combination depending on the position to which it is desired to switch the call. Under the control of the answer key, the associated uniselector finds the transferred line. Relay K in the line circuit operates to release the locked M, N and R relays and extends the three wire line circuit into the transferred position. The Special Service Telephonist who switched the call may continue to monitor it and, once the transfer is effected, may enter into a three-way conversation. However, once she releases the line from her position she cannot regain it.

Time of Day Circuit: Three similar circuits, each employing its own amplifier to produce unidirectional transmission at normal level, are provided. The telephonist simultaneously answers all calls that are waiting at the time she throws the answer key. Any subsequent

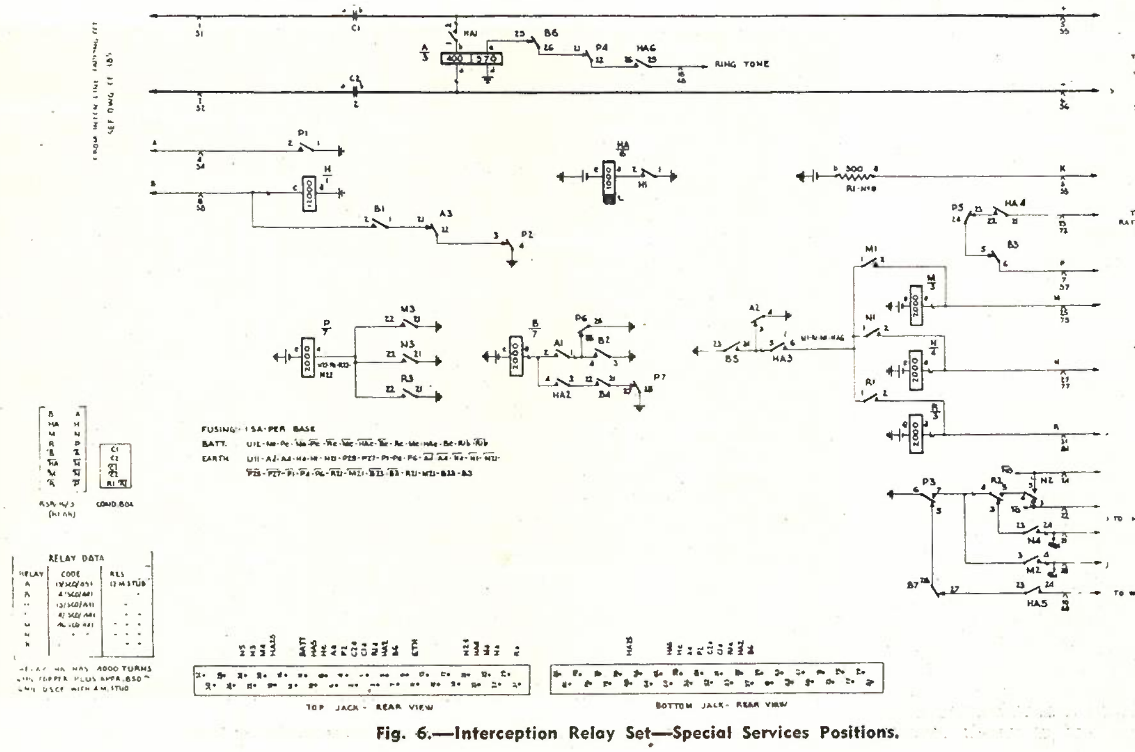

Fig. 6.—Interception Relay Set—Special Services Positions.

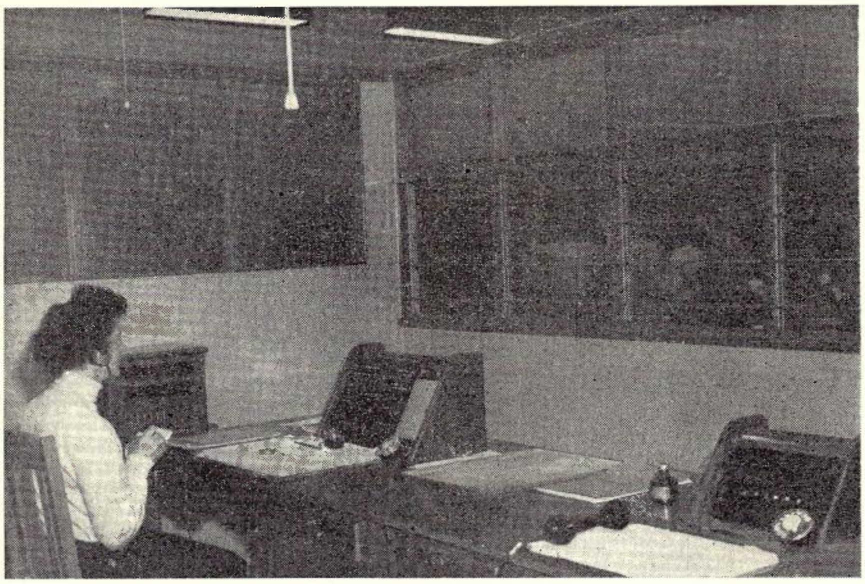

Fig. 7.—Layout of Observation Room.

caller receives ring-tone until such times as the telephonist once again operates the key.

Since all circuits are answered simultaneously, only one answering circuit is required. This circuit is multipled over all positions. To avoid double answering from two positions, the answer key extinguishes the call lamp. With the release of the answer key, the call lamp glows until the subscriber clears. If the caller does not clear, the operator, presuming the caller is not satisfied, repeats the announcement. A release key is provided to enable the call to be forcibly released, if, after several announcements, the subscriber does not clear.

P.A.B.X. Line: Four exchange lines which may ultimately become P.A.B.X. extensions are connected, one to each position. Experience has shown that a second multipled exchange line with transfer facilities could with advantage, have been used instead of these P.A.B.X. circuits.

Observation Facilities

Observation facilities provided at Launceston are as follows:—

(1) Local Service Observation (Selector Observation)
(2) Special Observation (Subscribers' Observation).
(3) Trunk Observation.
(4) Telephonist Observation.

The two observation manual positions were installed in a partitioned portion of the trunk exchange where louvre windows allow visual observation. The window louvres are of opaque glass which may be tilted to provide a controlled amount of vision into the exchange. All facilities exist on observation position 1, while position 2 has available only trunk and telephonist observation. A display panel for recording the dialling impulses is incorporated in the turret of position 1. It consists of a 10 x 6 group of lamps over which is placed a sand-blasted glass screen with letters and numerals reverse sign written in black. The photograph of Fig. 7 shows the layout of the observation room with the windows open, while Fig 8 indicates the layout of the lamps, display panel and keys of position 1. Under normal lighting, the letters and numerals of the display, although discernible, are not nearly as clear as the photographs would indicate. The block schematic of the scheme is as shown in Fig. 9.

Display Circuit: The display circuits were wired to a modified version of the standard Departmental drawings. The circuits are tapped by means of two valves, the control grid circuits of which are connected through a 5000 ohm resistance in each leg of the line. One valve repeats the dialled impulses, while the other marks the switching and other impulses which are received on the positive leg of the line. Impulses received in the valve relay set are repeated to the display circuits where they actuate uniselectors to light the appropriate lamp on the display. The display uniselectors may be returned to home by operating the display release key, the release key of selector observation, or automatically by a subscriber connected to special observation making an out call. In the latter case, a buzzer sounds to inform the operator that an observed subscriber is calling or being called and, if the former, to inform the telephonist that the display circuits have automatically switched away from the selector observation equipment, if the latter was in use.

Selector Observation: Ten tapping circuits in the automatic exchange are connected by a four-wire junction and keys on a patch panel to a terminating relay set in the trunk exchange. The patch keys are used to switch individually the junctions from the various automatic exchanges to the terminating relay sets. The dialled impulses are recorded on the display panel, and the operator may listen, but not speak on the circuit. The call lamp glows whenever a tapping circuit seizes the junction. The receipt of a meter pulse locks the meter lamp circuit to earth at reset key. If final selectors are being observed the odd hundred lamp indicates the odd hundred group of numbers. A release key is used to clear the junction and the display in readiness for another call, or the display may be separately cleared by a display release key.

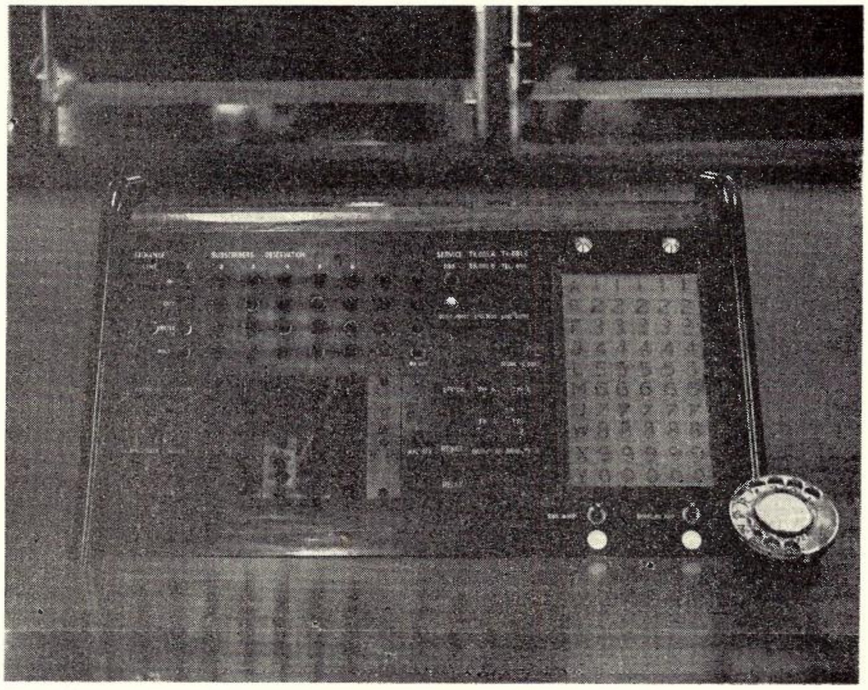

Fig. 8.—Layout of Key Panel on Observation Position 1.

If a call under observation is terminated by the subscriber or is "force" released from the observation junction by the telephonist, the tapping circuits are such that the next call to be originated on the tapped selectors will be observed.

Special Observation: Six observation circuits are wired from position 1 to plugs on the patch panel. The jacks on the patch panel are connected by three wire junctions to tapping circuits in the various exchanges. Five tapping circuits exist to Central Exchange and it is proposed to provide four or five junctions to each of the other exchanges as they are established. Lamps indicate "In call", "out call", "Hold" and "meter".

A night alarm circuit is wired so that when a call on an observed line is received or originated, the buzzer will be operated for a short period. If an out call is made, then the circuit automatically seizes and clears the display circuit and the dialled impulses are then displayed on the screen. Should two simultaneous calls be made, only the dialled impulses of the first line to be looped will be recorded, but both lines are available for monitoring.

Trunk Line Observation: Four modified final selectors mounted on routiner access banks are used to give double access to 400 circuits. The first 300 are used for trunk line observation and the latter 100 for telephonist observation. Selectors 1 and 2 are connected to position 1, while selectors 3 and 4 are shared by position 2, and the Traffic Officer. The wanted line is obtained by dialling two digits into the selector after selecting the required 100 group with a key. A three wire connection is used, the third wire extending the switchboard busy lamp to the observation desk. Monitoring is by means of an amplifier which is bypassed when the speak key is operated. The amplifier is wired to the same circuit drawing as is the amplifier in the telephonist's circuit of the trunk boards. The input impedance is 600 ohms, but resistors of 5000 ohms are wired in each leg of the tapping circuit to make the bridging loss negligible.

Telephonist Observation: The last 100 of the 400 selector numbers are used for telephonist observation. The control key on the position also places an earth on the third wire to operate the LT relay in the telephonist's circuit. All trunk and service operators' circuits and the pay station are connected, and all positions in Mowbray and East Launceston C.B. exchanges are wired via a special relay set using 4-wire junctions to each exchange.

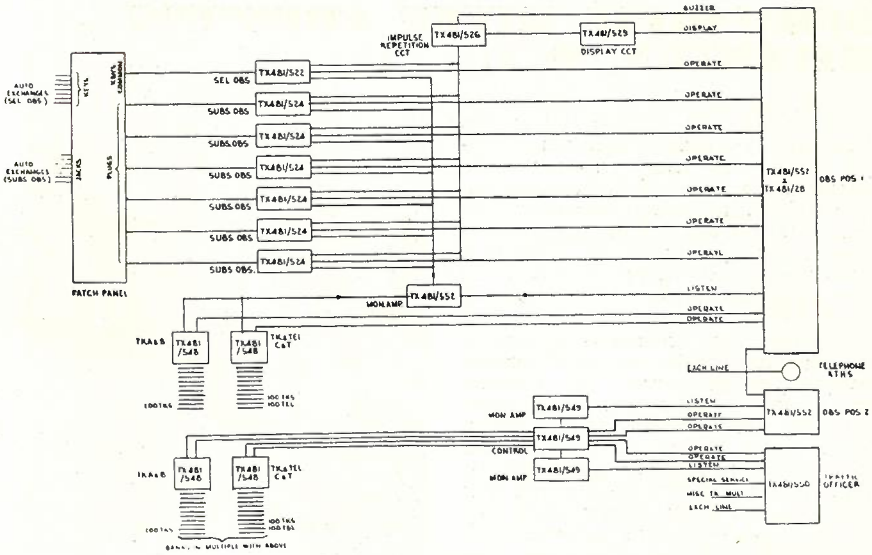

Fig. 9.—Block Schematic—Observation Circuits.

On telephonist observation, 4000 ohms of both the 5000 ohm series input resistors, are bridged out to compensate for the lower level received from the tapping across the telephonists' receiver. At Mowbray and East Launceston, the tapping is made across the position circuit commons, and not across the receiver as is usual. This allows a pad to be inserted in both suburban exchanges. The pad terminates the junction and avoids noise being introduced into the telephonists' circuit from the junction. The extension to the Traffic Officer allows him to listen or speak on any trunk line or to any telephonist in the Launceston network.

Exchange Line: At cutover, the exchange line was multipled over both positions. However, it was found such an arrangement interfered with observations. A normal telephone has since been installed between the two turrets, and the circuits arranged such, that the exchange line keys of either position, places the observation operator's circuit across the line in parallel with the telephone.

Conclusion

The facilities provided at Launceston have been very favourably received by all operating staff, and it is thought that the foregoing information may be of some value in the development of circuits for adoption in exchange networks similar to that of Launceston. It is of interest to note that the installation of the equipment at Launceston, involving cutover to automatic working and provision of a new trunk exchange, was effected by a staff including Technicians from N.S.W., Queensland and Victoria. The engineering control was from the Victorian Engineering establishment. The author wishes to acknowledge the valuable assistance rendered in the development and testing of these circuits by the installation staff concerned.

SUBMARINE RIVER CROSSING — RIVERTON, W.A.

D. SYNNOTT, B.Sc., Grad.I.E.Aust.

In the last few years several articles (1, 2 and 3) describing methods of laying cables at river crossings have appeared in the Telecommunication Journal. This article describes the principles followed for the first installation of this type carried out in Western Australia, namely the provision of a 150 pair armoured cable at Riverton in April, 1954.

Fig. 2.—View from eastern bank, showing old bridge and cable buoyed prior to plowing in.

The site of the crossing is adjacent to the Riverton Bridge, an aged wooden structure which crossed the Canning River some 5 miles from its junction with the Swan River. The Canning River is slow flowing and tidal, and at the crossing is about 105 yards wide. Its depth is less than five feet for over half its width, but at its deepest point in a channel near the eastern bank the maximum depth is 10 feet at high tide. The path followed by the cable in its crossing is shown in Fig. 1 and was determined by the position of some obstacles. For example, the State Electricity Commission "H" Pole and stay caused the approach on the eastern bank to be some 30 feet further from the road than otherwise necessary. The path decided upon was only a short distance north of the bridge, which was at that time being replaced. The Main Roads Department was constructing a new bridge upstream from the old, and on the average about 80 feet from the path of the cable. The plan of the site is shown on the sketch.

In the preliminary work, the Main Roads Department Engineers had taken soundings of the river bed and the knowledge so gained was used for the cable crossing. The soundings indicated that the bed of the river was free from snags, its surface consisting of sand with occasional patches of mud. The sand, however, was only a crust, with further layers of mud and sand under it. It was not desirable to place the departmental cable manhole on the edges of the banks and the approaches finally selected consisted of (i) a 90 yard run through a sand bank and a rushes bound swamp to the water from the manhole on the east bank, and (ii) a 76 yard run from the manhole on the west bank, which included a street crossing where 4 inch RI concrete pipes were laid, and a marshy bank with rushes and paper bark trees of up to 15 feet in height.

As the cable would be free from the liability of damage from rocks, snags and scour, it was decided to use steel tape armoured cable in lieu of steel wire armoured. The total length of the run without joints was 275 yards but the conditions on the west bank would not allow the cable to be plowed in. It was decided therefore to locate the drum of cable on the east bank and haul across the river by handwinch, sufficient cable for the crossing to the manhole on the west approach. The plow was placed near the water's edge on the west bank and the cable was to be fed through it and then buried in a trench. The remainder of the operation was to be carried out by plowing, the plow to be drawn by a power winch and the cable to be fed into the plow by hand. As a skid type of plow was not available and it was decided to use an ordinary mould board plow which gave a maximum depth of 2 feet 6 inches. Because an operation such as this had not been undertaken before by the staff concerned, and as there was some doubt whether a wheel plow would make the trip or bog down in the mud patches of the river bed a dummy run was arranged. This was completed without incident.

Some preliminary work was necessary before the actual laying of the cable took place. The west approach had to be cleared of snags and a trench dug in which to bury the cable, also pipes had to be laid under the road. Some clearing was required on the east approach also. A 12 feet length of galvanised iron pipe was fitted vertically at the rear of the plow to indicate the progress and stability of the plow when it was under water. A funnel mouth was fitted to the plow to make easier the job of feeding the cable without snagging. A number of 44 gallon drums had fittings attached so that they would serve as buoys for the cable when it was being hauled across the river. Finally a small dinghy was borrowed from a local resident and the operation was

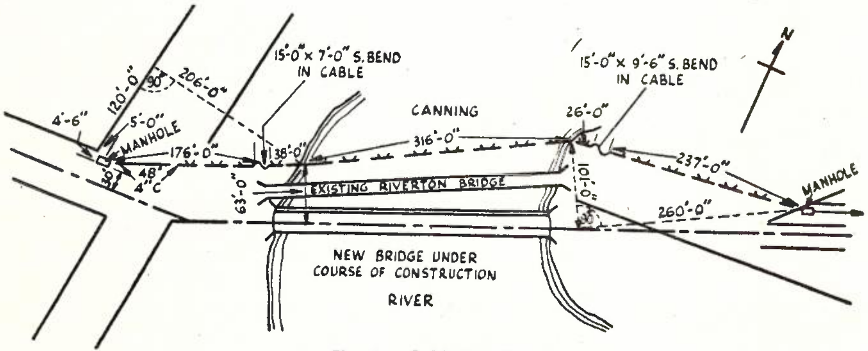

Fig. 1.—Cable location.

fully prepared. To haul the plow an Allis Chalmers HD7 Bulldozer was used with 400 feet of $\frac{7}{8}$ inch hawser.

The day chosen for the crossing was a warm sunny day which was appreciated by some of the men who were obliged to work in their bathing costumes. The first operation was to haul the towing hauser across the river and attach it to the plow. The hauling was done with manpower using the hand winch, one buoy being attached to the hawser at approximately the centre of its length. Next the cable was hauled across. This had buoys attached to it at approximately 20 yard intervals as seen in Fig. 2. Even so the weight of the cable was such that towards the end of the pull (which totalled 185 yards) the hand winch had to be anchored by parking a 30 cwt. truck against it, straddling the winch rope.

When sufficient cable had been hauled across, 80 yards was fed by hand through the plow and buried in the trench already prepared, a 15 x 7 feet 'S' bend being provided near the water's edge to anchor the cable. The plowing under the water then took place. Behind the plow was the small dinghy with three men in it. They had the jobs of unlashing the cable from the buoys and feeding it into the plow without the cable catching or bending. The whole operation proved to be relatively simple, taking only 25 minutes, and was under the control of one man situated on the vantage point of the bridge. A view of the plow emerging at the east bank is shown in Fig. 3. At the eastern bank more cable was pulled through the plow and buried in an 'S' bend while the bulldozer and cable jinker were moved to a place adjacent to the final manhole in Riverton Street. The final pulling operation through the marsh then took place with men walking beside the plow feeding the cable into it. Tests on the cable made at the completion of the installation and since, have shown no evidence of faults developing due to strain or damage.

Fig. 3.—Plow emerging at eastern bank.

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THE TYPE N-1 CABLE CARRIER TELEPHONE SYSTEM

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INTRODUCTION

The Type N-1 Carrier Telephone System is a 12-channel system which was developed by the Bell Telephone System, U.S.A., for application on existing single cables over distances of up to 200 miles. Details of the design have already been described fully in Bell System literature (Refs. 1 to 8). The Postmaster-General's Department purchased a number of Type N-1 systems from Canada during 1953/54, and these have been installed on various short-distance routes in New South Wales. This article presents a summary of the interesting features of the new system, and applications of the system will be described in a further article in the next issue of this Journal. Much of the material in this article has necessarily been drawn from the Bell System publications mentioned in the references, and acknowledgment is made to the editors of the Journals and the authors of the articles concerned.

GENERAL DESCRIPTION OF SYSTEM

A Type N-1 carrier system is designed to provide twelve channels of 250-3100 cycles per second bandwidth. Referring to the block schematics shown in Figs. 1 and 2, it will be seen that each channel has associated with it a carrier frequency which is derived from a quartz crystal oscillator. These channel carrier frequencies extend from 168 Kc/s to 256 Kc/s, and are spaced at intervals of 8 Kc/s. Modulation of the carrier frequencies by the respective voice frequency channels results in the production of a High Group (H G) band of frequencies lying in the frequency range 164-260 Kc/s. This group of frequencies is used in one direction of transmission, on one side of a cable quad. A Low Group (L G) band, extending from 44-140 Kc/s, and derived by selection of the inverted lower sideband produced by group modulation of the H G band with a 304 Kc/s carrier, is used for the other direction of transmission, on the other side of the same cable quad. In the repeaters, group modulators using 304 Kc/s carriers, also derived from crystal oscillators, interchange and invert the H G and L G bands between the input and output lines of each repeater. This process, referred to as "frequency frogging and inversion", tends to eliminate certain types of crosstalk, and provides a substantial degree of line attenuation equalization. Frequency frogging and inversion is described in greater detail later.

The modulation process employed in this system, involving the use of a single frequency group for initial modulation and final demodulation of the speech channels, yields the advantage that the number of channel band filters can be limited to twelve of different design, a factor of importance from an economic viewpoint. The employment of the frequency frogging and inversion technique also results in the normal 48 db repeater gain of this system being employed at the mean frequency of 152 Kc/s, and not at the maximum line frequency of 260 Kc/s, as would be the case if frequency frogging and inversion were not used. From the aspect of system planning, it will be appreciated that average repeater spacings in each direction of transmission are equal, which is not the case where frogging and inversion is not employed and different frequency bands are used in the two directions of transmission. The channel carriers are transmitted, and are used for automatic gain regulation and demodulation purposes, whilst the use of double side band transmission, taken in conjunction with the employment of compandors in the system, results in a marked relaxation in the discrimination requirements of the channel band filters, and permits application of the system to short distance routes where the noise level is in excess of the level due to cable thermal agitation and repeater shot noise contributions. The only filter required in the twelve-channel group of side-bands and carriers is a common filter, to suppress transmission of speech sidebands on channel carrier harmonics. Transmitting band filters are not required, as, for the H G band of frequencies, all harmonics fall outside the useful band. To permit flexibility, terminals are capable of transmitting and receiving either H G or L G frequency bands by installation of the appropriate group unit.

The economies achieved in the Type N-1 cable carrier system result from the employment of new system and circuit techniques, improved assembly techniques, and the use of miniaturised circuit elements, such as valves, resistors, paper, mica and electrolytic condensers, potentiometers, varistors, filters and transformers.

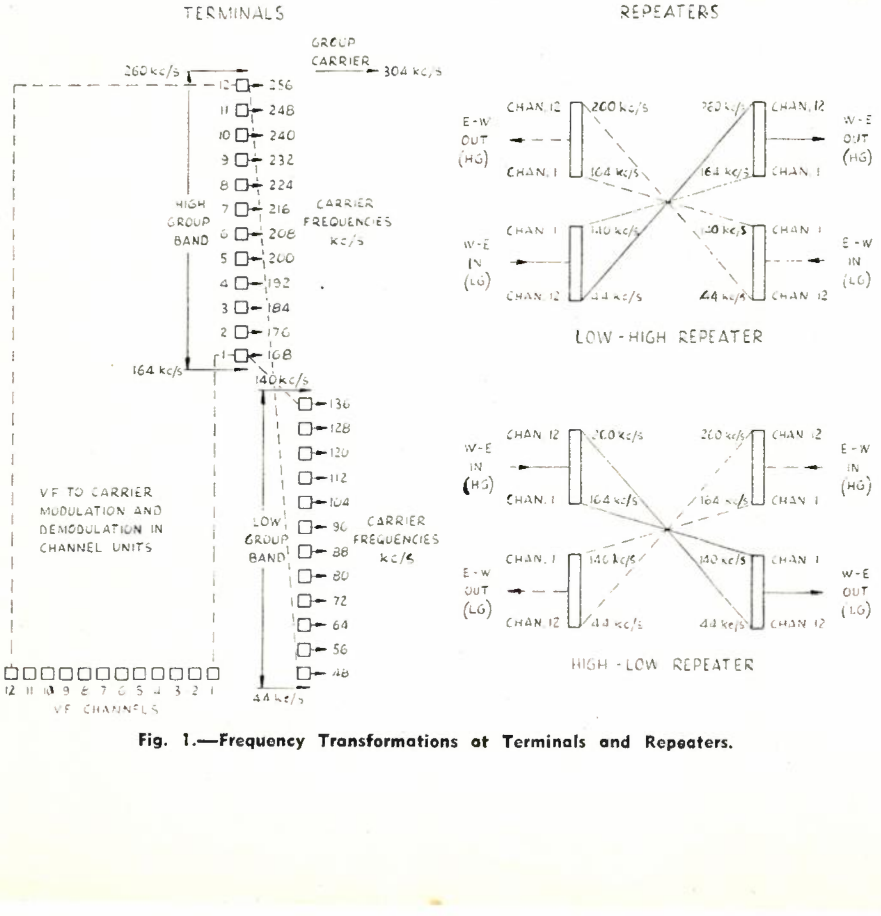

Fig. 1.—Frequency Transformations at Terminals and Repeaters.

THE USE OF COMPANDORS

Compandors, consisting of compressor units at the transmitting terminals, and corresponding expandor units at the receiving terminals, are used to raise the lower speech levels prior to transmission, and correspondingly restore them during the process of reception. In this manner the effects of undesirable noise and crosstalk signals are reduced on the line and at the terminals. A full discussion on the effect of compandors was given in the last issue of this Journal (Ref. 9). The usual degrees of compression and expansion are employed in the Type N-1 system, the input volume range of speech being halved by the action of the compressor and then restored to full volume range again by the action of the expandor. A signal to noise ratio improvement of some 20-25 db is thus obtained. In the absence of signal, the gain of the compressor is 28 db, and the loss of the expandor has the same value.

It was originally stated by the designers of this equipment that the use of compandors and other techniques described would, in all probability, enable Type N-1 carrier system to be used on every quad in a given cable

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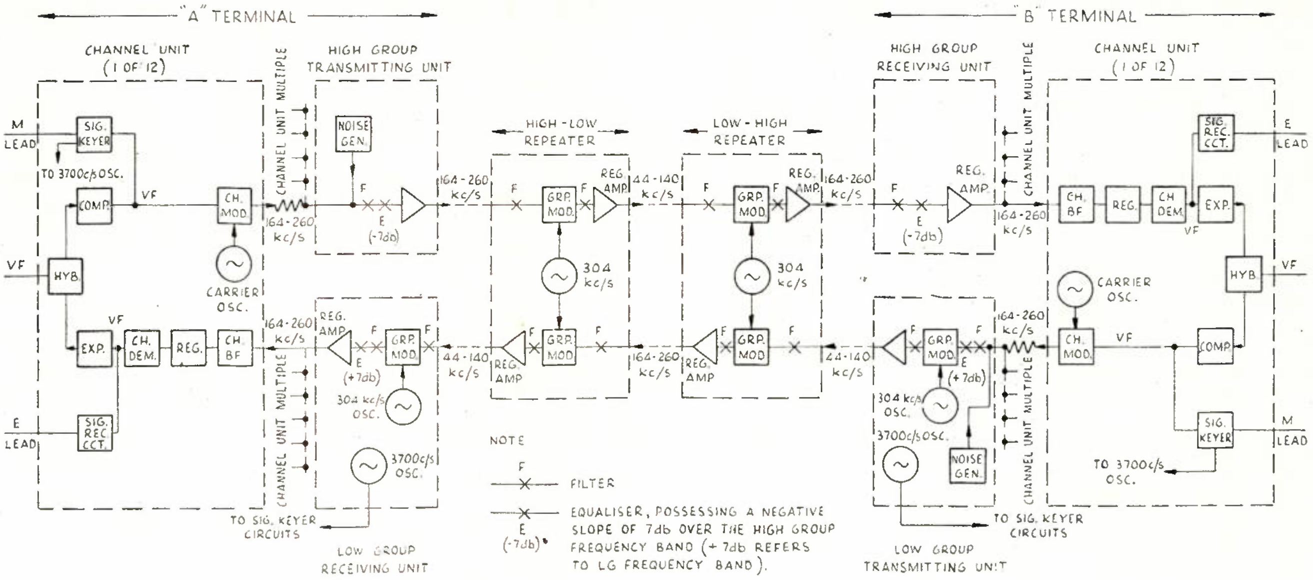


Fig. 2.—Simplified Block Schematic of Type N-1 Carrier System.

without special cable treatment, such as crosstalk balancing. It has been found subsequently, however, that it is not in general possible to load a cable to its maximum capacity with Type N-1 systems.

POWER SUPPLIES

Power supplies at terminals are obtained from + 130 volt and –48 volt batteries. Valve heaters of 20 volt rating are connected in series, and fed from a 40 volt supply derived from the 48 volt battery. Repeaters may be either supplied locally from the + 130 volt battery, or from a power-feeding repeater transmitting the required supplies over the cailhos or simplexes of the cable quads. Using the latter method, pole mounted repeaters (possessing no local power supply) on either side of the power-feeding repeater may be operated.

SIGNALLING

Signalling over the Type N-1 system may be achieved by several methods. Thus, ring down operation using 1000 c/s ringing signals may be employed over the voice channel in the normal way. Alternatively, ringing may be converted to DC and passed over the N system by switching a 3700 c/s tone (provided as an integral part of the system) on and off by operation of a suitable relay. The train of digits produced by dial operation can be carried by multifrequency key pulsing, or by dial make and break connections of single frequency tone. The 3700 c/s signal used in the system lies just outside the voice frequency channel bandwidth, but the carrier channel bandwidth is made wide enough to carry both the speech band of frequencies and the signal frequency of 3700 c/s.

DETAILS OF EQUIPMENT

Channel Unit

Each channel unit (Fig. 3) consists of three plug-in sub-assemblies:—

(i) Compressor sub-assembly.

(ii) Expandor and Signalling sub-assembly.

(iii) Carrier Frequency sub-assembly.

Sub-assemblies (i) and (ii) are identical for all channels. The three sub-assemblies are interconnected by plugs and jacks to form a single plug-in unit.

Compressor Sub-assembly: The voice frequency input to the compressor (Fig. 4) first passes through a germanium variable loss unit, or variolosser. This variolosser is constructed from germanium varistors (variable resistors), the variable impedance of which can be closely controlled by a DC bias. If this bias is a function of the level of the voice frequency input, the compressor, by virtue of the action of the variolosser, can be made to reduce its gain in decibels from input to output as the level of the voice frequency input rises. Examining this process in greater detail, the output of the variolosser is amplified by means of a 2-stage amplifier: a high proportion of this output signal is then fed through a control circuit comprised, mainly, of a bridge network consisting of germanium non-linear elements. The DC derived from the output signal in this manner is passed into an R-C filter located at the output of the germanium bridge. This R-C filter serves to discriminate against all components of the signal other than the rectified syllabic envelope of the voice frequency signal. The R-C filter time constants are chosen to provide fast attack and slow recovery of the compressor, the attack time con-

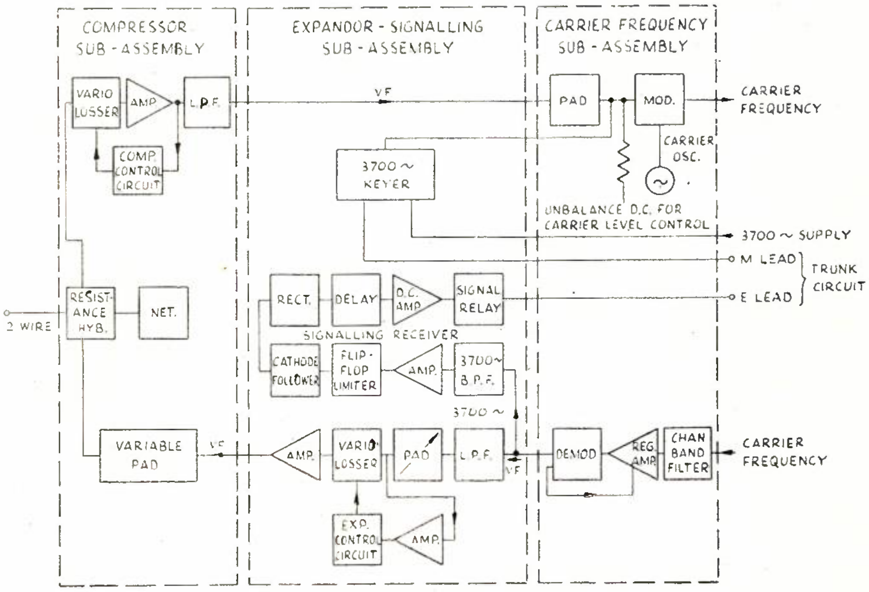


Fig. 3.—Block Schematic of Type N-1 Channel Unit.

stant lying in the range 3-5 milliseconds, while the recovery time constant lies in a range some ten times as large. The current output of the R-C filter is injected to the variolosser in such a manner as to produce the desired effect on the impedance values of the variolosser germanium varistor elements. A simplified analysis of a compressor is given in Part A of Appendix I.

As a consequence of the time constants chosen for the R-C filter, overloading of circuits following the compressor (resulting from the arrival of syllabic speech burst at the compressor input) is avoided, and fixed loss is introduced by the variolosser during a syllabic interval. The former attribute is associated with the shorter time constant, and the latter with the longer time constant.

Expandor and Signalling Sub-assembly: The expandor (Fig. 5) also consists of a variolosser, an amplifier, and a control circuit capable of amplifying and rectifying the compressed range of voice frequency signals, and applying them in a forward acting fashion to the variable loss network. For the expander, the D.C. control current is thus derived from amplified variolosser voice frequency input. This differs from the action of the compressor, in which the control current is derived from amplified variolosser voice frequency output, giving a backward acting arrangement. A simplified analysis of an expandor is given in Part B of Appendix I. The control current characteristics of the compressor and expandor are made to simulate one another as closely as possible, in order that the variable loss networks in the compressor and expandor will, in turn, "track" one another closely. This is essential if overall signal distortion of the type that may result from the inclusion of compandors in the system is to be reduced to an acceptable minimum.

The expandor sub-assembly also houses the signalling sending and receiving circuits, consisting of a keyer circuit and a signalling receiver circuit.

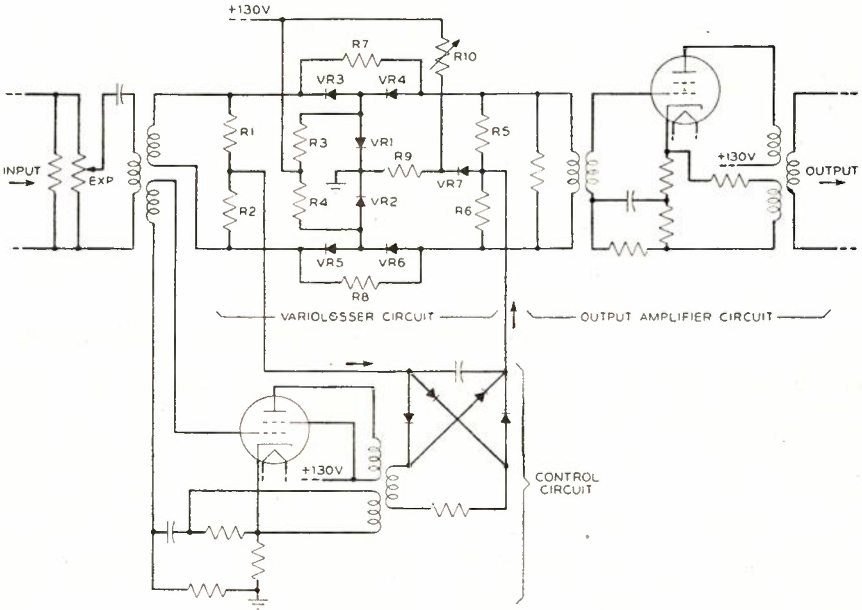


Fig. 5.—Expandor Schematic.

This is shown in block schematic form in Fig. 3. The signal input to the keyer circuit is derived from a signal oscillator common to the twelve channels of a system. This 3700 c/s. R-C oscillator, housed in the transmitting or receiving low-group sub-assembly of the group terminal unit (Fig. 2) is of the Wien bridge type, incorporating amplitude stabilization characteristics achieved by use of a thermistor (thermal resistor) suitably located in the bridge circuit. The operation of the keyer (or sending circuit) is not unlike that of the static modulator extensively used in multichannel VF Telegraph systems. Thus, the Type N-1 keyer circuit (Fig. 6) simply relies on the effective intermittent connection of the 3700 c/s. signal, derived from the common oscillator, to the input of the keyer transformer, following changes of bias on a pair of germanium varistors suitably arranged in a "loss/no-loss" circuit separating the 3700 c/s. oscillator signal from the keyer transformer. These changes of bias, received over the M lead from the trunk circuit, correspond to interchanges between the "on-hook" and "off-hook" conditions of a given subscriber's line. In the "off-hook" condition, tone is removed from the system, so that tones are not on the system during speech transmission. Interchange between these two conditions takes place at about 10 pulses per second when dialling occurs. The corresponding variations of bias on the pair of germanium varistors results in conversion from DC to AC without change of pulse length.

The signalling receiver (Fig. 7), which is connected to the output of the channel demodulator, consists of a 3700 c/s. band pass filter of some 150 c/s. bandwidth (chosen to reject noise but pass the significant sidebands of the dial impulse train in the interest of wave shape preservation), a stage of amplification, an amplitude limiter, a cathode follower stage for impedance conversion purposes, a voltage doubler rectifier circuit employing germanium varistors, a delay circuit, a DC amplifier and an output relay. The amplitude limiter is of the flip-flop type, providing a constant amplitude square wave output at 3700 c/s. in response to the sinusoidal 3700 c/s. input signal, which may vary in amplitude over a range of several decibels. The output of the limiter is fed to a cathode follower, which permits extremely stable operation of the voltage doubler rectifier circuit inserted between the low output impedance of the cathode follower and a low impedance termination. The delay circuit is included to mitigate the effect of noise bursts that may occur during the "off-hook" con-

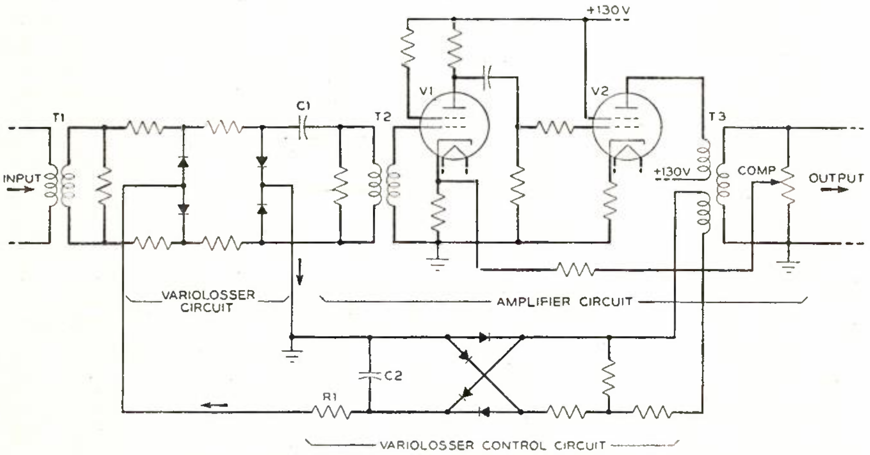
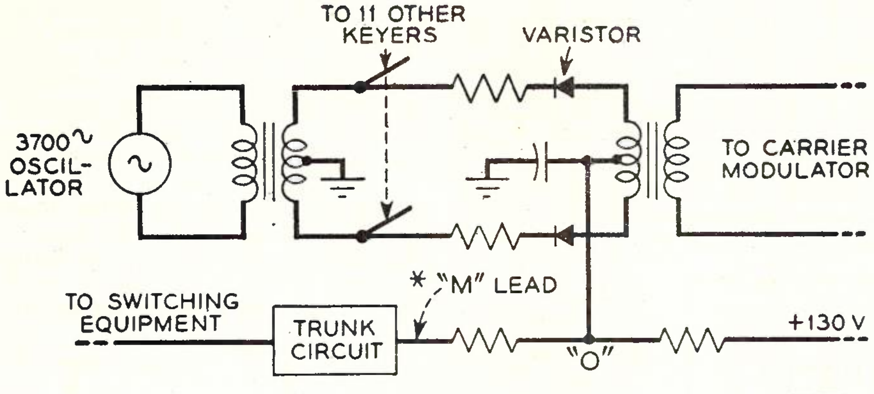


Fig. 4.—Compressor Schematic.



* ON HOOK: GROUND; TONE TRANSMITTED
OFF HOOK: −48V; TONE NOT TRANSMITTED

Fgi. 6.—Signalling Keyer Circuit.

dition. It has, however, an attendant disadvantage, in that it slows the build-up and decay of pulse edges, and so provides an additional contribution to pulse distortion. To prevent excessive pulse distortion from this cause, the amplitude limiter previously discussed has been included. The mercury contact output relay is fed from the DC amplifier: it has a split winding to permit percentage break and distortion adjustments. A compensating circuit, producing bias change on the varistor rectifiers of the voltage doubler circuit through the relay contacts, minimises first pulse distortion that would otherwise be introduced as a result of the high amount of delay introduced.

Carrier Frequency Sub-assembly: The carrier frequency sub-assembly consists, in the transmitting path (Fig. 8), of a modulator (composed of germanium varistors) associated with which is a channel carrier oscillator of the crystal controlled type. The units in the receiving path are shown in Fig. 9.

The output of the compressor low pass filter and the signal keyer are connected to the input of the transmitting path. The crystal oscillator circuit providing channel carrier utilizes a pentode valve strapped as a triode. The output derived from the oscillator is fed into the modulator.

Within the modulator circuit, carrier switching of the modulator non-linear elements takes place and arrangements are made for carrier transmission via the modulator output. Some advantages of double sideband transmitted carrier transmission were mentioned earlier in this article; there is, however, a difficulty that results when an attempt is made to reintroduce a carrier at the far-end of a system employing double sideband suppressed carrier transmission. In this case, apart from the usual considerations relating to the amplitude and frequency of reinsertion, the phase of reinsertion becomes of importance. The nature of this problem can be understood with reference to Fig. 10. Case (a) in this figure illustrates the desirable condition in which the sideband vectors combine in the direct line of the carrier vector. Case (b) illustrates an undesirable condition, in which the carrier vector is reinserted at 90° to the line on which the sideband vectors combine. In this second case, it may be seen that true reconstruction of the modulation envelope of the carrier is not achieved, and instead a rhythmic variation in the position of the carrier vector takes place about its mean position, and negligible variation of carrier amplitude occurs.

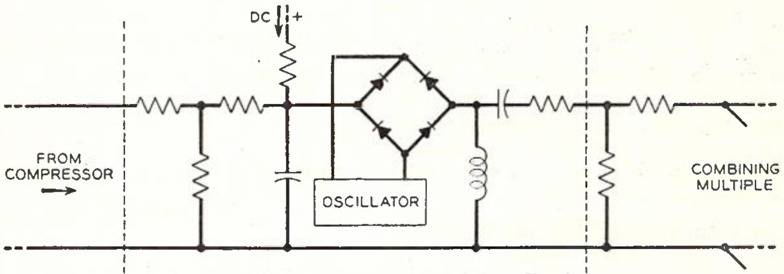


Fig. 8.—Carrier Frequency Transmitting Circuit.

Regarding carrier transmission via the modulator output, it will be appreciated that transmitted carrier leak of an uncontrolled nature would produce corresponding undesirable changes in the amplitude and phase of the transmitted carrier used for channel regulation and demodulation purposes. The method adopted in the Type N-1 carrier system to ensure stability of amplitude and phase of transmitted carrier involves, first, the selection of modulator non-linear elements to ensure a minimum of carrier leak, and, secondly, the introduction of a suitable flow of direct current through certain of the modulator elements to produce a controlled degree of unbalance in the modulator (Fig. 8).

Considering now the receiving path of the carrier frequency sub-assembly, channel selection is made from the output signal frequency spectrum of the receiving group unit (to be described later) by means of the band pass filter (Fig. 9). A potentiometer arrangement at the output of each channel band pass filter permits the overall level differences between channels of the system to be adjusted to a minimum. In each channel a two-stage double triode amplitude regulator operates to reduce level changes of the received channel signals.

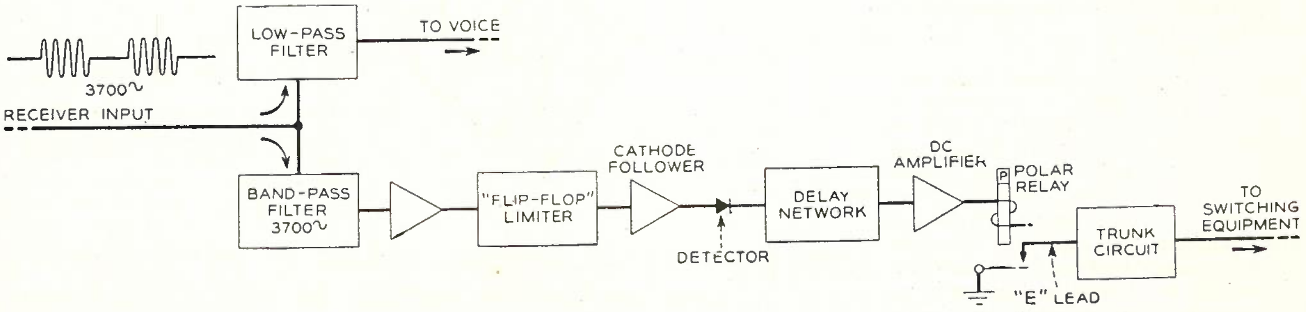


Fig. 7.—Signalling Receiver Circuit.

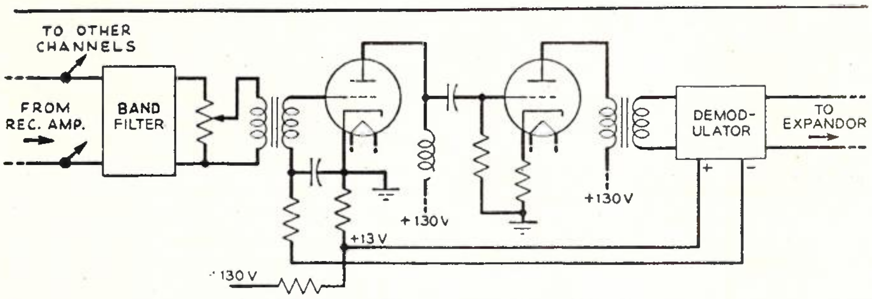


Fig. 9.—Carrier Frequency Receiving Circuit.

This regulator is effective to the extent that changes of xdb at its input are reduced to changes of x/10db at its output, but the effective regulation is only half this due to the subsequent expandor action. The well-known delayed AVC action encountered in modern radio receivers is employed in this regulator, the gain of which is controlled by DC obtained as a result of carrier rectification occurring in the demodulator, which is acting as a linear detector: an appropriate delay voltage, derived from the 130 volt supply, is used to oppose a proportion of the rectified carrier voltage. The regulator time constant is approximately five seconds. This time constant enables efficient regulating action to take place, at the same time preventing undesirable response to bursts of speech or similar signals of a transient character. The demodulator output is connected to both the expandor low pass filter and the 3700 c/s. signalling band pass filter (Fig. 3).

Terminal Transmitting and Receiving Group Units.

The transmitting and receiving group units (Fig. 2) may be regarded as the equivalents of the transmitting and receiving terminal repeaters used in other 12 channel cable carrier systems. Four types, necessary for the functioning of the Type N-1 system, are available. They are as follows:—

1 and 2:—Low Group Transmitting (LGT) and associated High Group Receiving (HGR) units, and

3 and 4:—High Group Transmitting (HGT) and associated Low Group Receiving (LGR) units.

A terminal utilises three assemblies of the plug-in type:—

(i) LG unit.

(ii) HG unit. An artificial noise generator is connected to the input terminals of the relevant transmitting unit (See Fig. 2 and section covering Type N-1 Special Facilities).

(iii) Oscillator unit, consisting of a 304 Kc/s carrier frequency oscillator and a 3700 c/s. signalling frequency oscillator. The oscillator unit is always associated with the LG unit.

This is easily remembered when it is recalled that the high group frequencies are the fundamental frequencies of the system, and that the low group frequencies are obtained from the high group frequencies by group modulation involving the use of a 304 Kc/s inverting carrier frequency.

The assemblage of the 12 individual channels into one group takes place in the resistance pads of the combining multiple, the output terminals of which are connected via a channel carrier har-

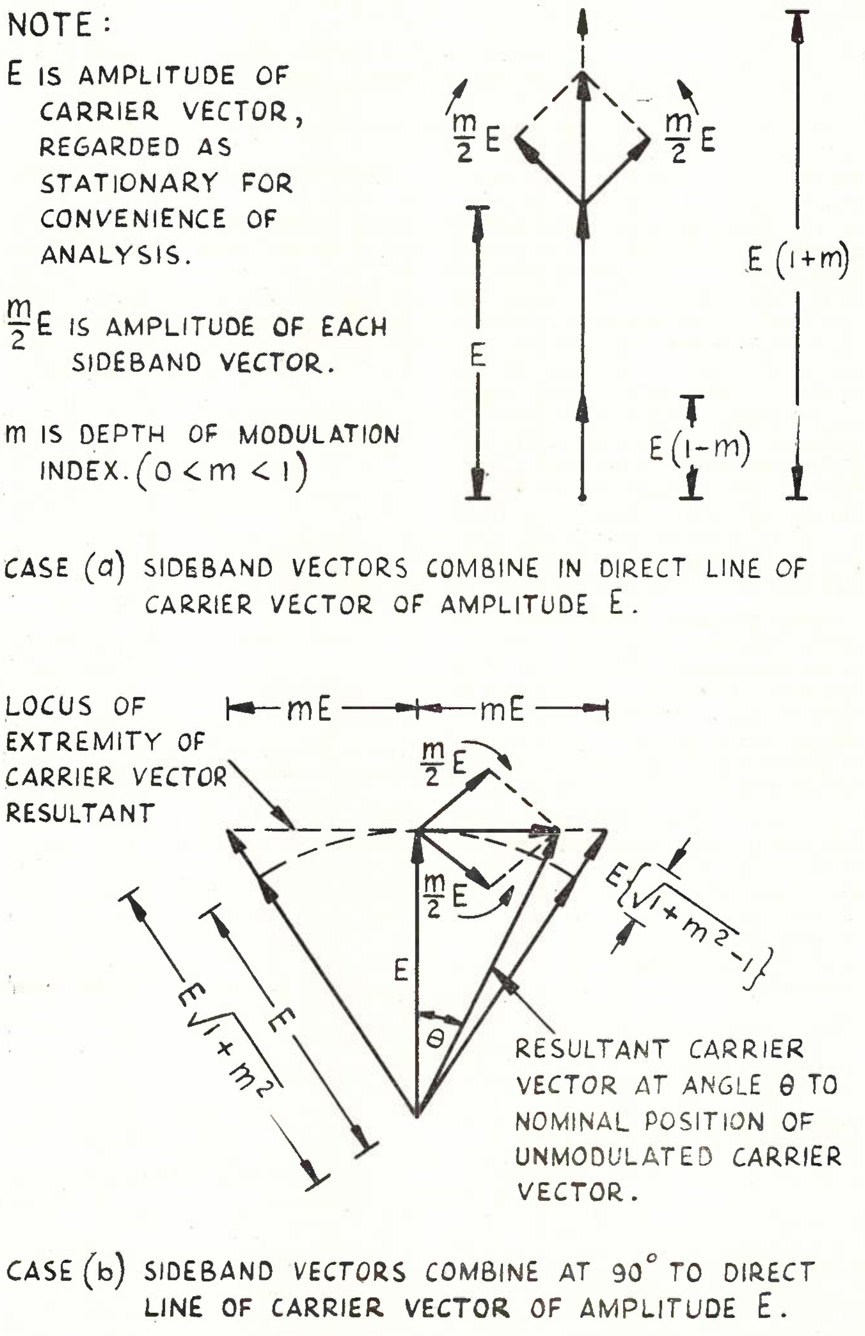


Fig. 10.—Illustrating Combination of Carrier and Sideband Vectors, Cases (a) and (b).

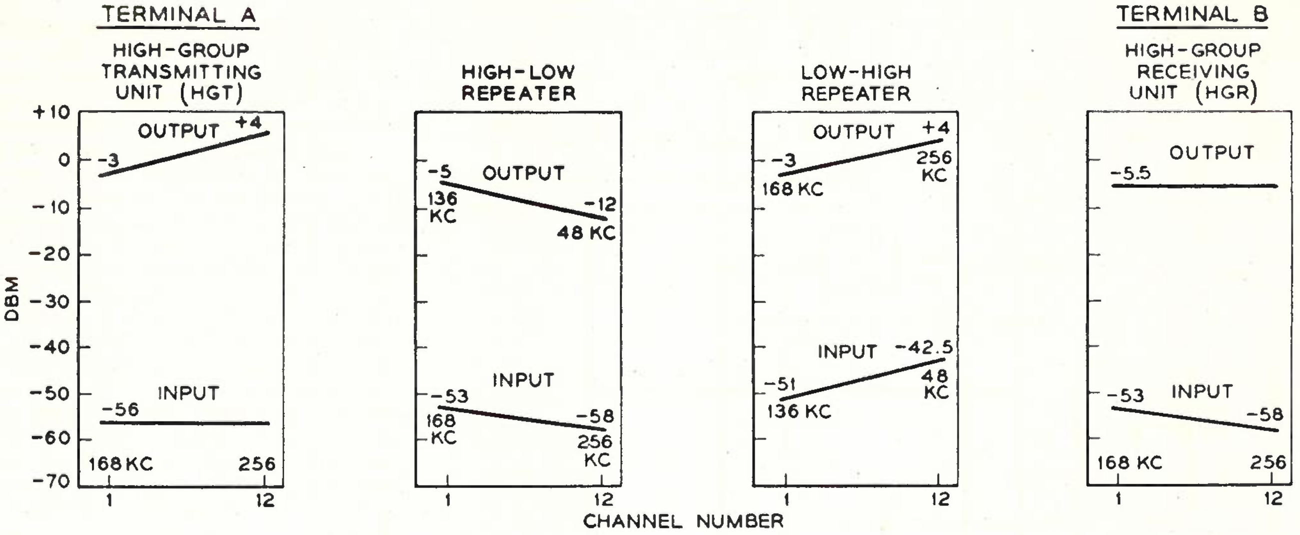


Fig. 11.—Repeater and Group Unit Level Diagrams.

monic suppression filter to the input of the transmitting group unit (Fig. 2). In this unit a slope equalizer, operating in the high band of frequencies, is used to provide a degree of pre-equalization. This pre-equalization, amounting to 7 db, is such that the highest output level of the transmitting group unit occurs at the highest frequency of 260 Kc/s. Upon arrival of the high group band at the first repeater input, the positive slope of 7 db has been converted, as a result of propagation over the cable, to a negative slope of the same order. Amplification and conversion of the high group band to the low group band by means of the repeater results in a low group band repeater output having a positive slope amounting to approximately 7 db, so that once again transmission over the next cable section takes place in such fashion that the highest carrier frequency in the band has, initially, a signal to noise ratio advantage over the lowest carrier frequency in the band, a desirable state of affairs not obtained under the conditions of "flat" transmission which prevail in the absence of pre-equalization. In the receiving group unit, a compensating slope equalizer restores the channel carriers to "flat" level throughout the band. Repeater and group unit level diagrams are given in Fig. 11.

The group modulator, a double balanced ring type employing copper oxide non-linear elements, and the 304 Kc/s. quartz crystal oscillator are similar in Type N-1 group units and repeaters. The two-stage feedback amplifiers in repeaters and group units are also very similar, and details will be given in the next section of this article.

Repeater.

The repeater (Fig. 2) is a plug-in unit which mounts, by means of a repeater shelf, repeater mounting bracket

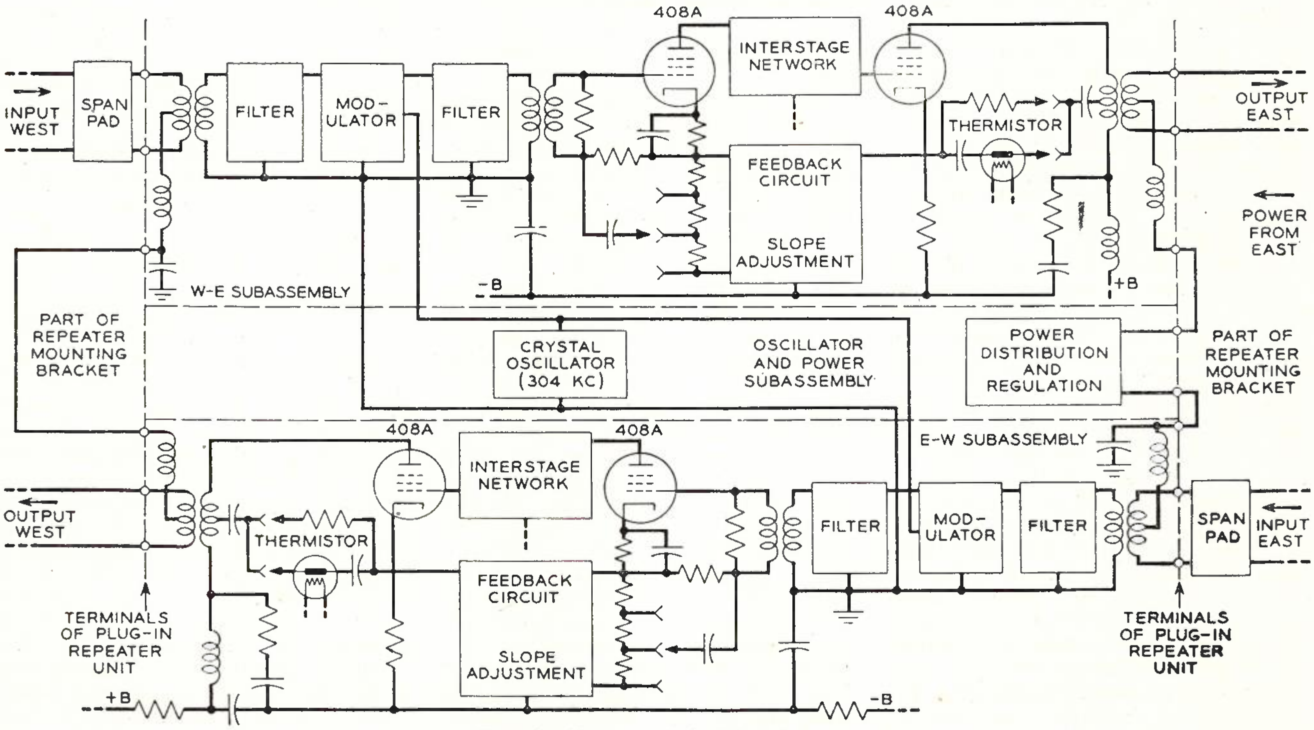


Fig. 12.—Repeater Block Schematic.

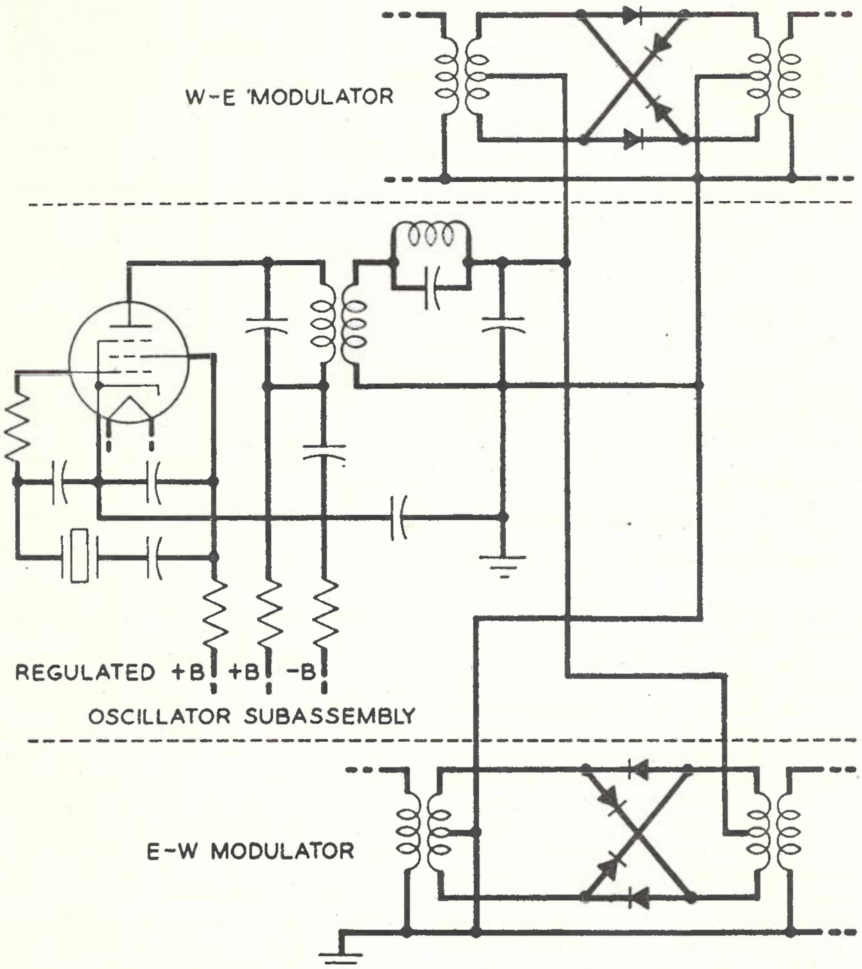


Fig. 13.—Repeater Modulator and Carrier Oscillator Circuits.

(a die cast frame) and repeater mounting top support, on to a rack framework. Also mounted on the rack framework are power panels, deviation equalizers, span pads, and artificial lines as required. Further reference is made to deviation equalizers, span pads and artificial lines in the section of this article dealing with transmission planning of Type N-1 systems. However, it may be noted here that deviation equalizers are used at the input or output of a repeater (whichever position locates it at a repeater station as distinct from a pole cabinet—when used) in the low group frequency range. Span pads are used to build out the line sections between repeaters to 48 db at the mean frequency of 152 Kc/s. To supplement loss so introduced in the case of very short repeater sections, artificial lines electrically equivalent to two or four mile cable lengths may be incorporated. Additional "slope", which may be required to allow for the span pad "flat" loss, and to compensate for the part of the cable characteristic not cancelled by "frogging", may be obtained by suitable adjustment of a three position repeater slope control. This results in suitable modification of the amplifier feedback path characteristic.

The repeater itself consists of three separate sub-assemblies, as shown in Fig. 12. Two of these sub-assemblies are the modulator-amplifier units, electrically similar, whilst the third is the oscillator-power sub-assembly. These sub-assemblies are alike in Low to High (LH) and High to Low (HL) repeaters. The modulation-amplifier circuits form the transmission paths through the repeater, and differ between LH and HL repeaters only insofar as frequency range of acceptance at the input and frequency range delivered at the output is concerned. A filter at the modulator input is chosen to block near-end crosstalk from line frequencies within the same quad or interaction crosstalk through tertiary pairs carrying other systems in the cable. At the modulator output, the filter suppresses the 304 Kc/s. carrier leak and the unwanted upper sideband. The HL and LH repeaters are designed to compensate for the frequency characteristic deviations of each other. A schematic of the modulators and 304 Kc/s. oscillator is shown in Fig. 13.

The amplifier gain can be adjusted to 48 db ± 1 db at the mean frequency of 152 Kc/s. This adjustment is carried out by suitable strapping of feedback circuit components. A further automatic adjustment of gain is obtained by means of a thermistor directly heated by a proportion of the total repeater output power, which is predominantly carrier power. The cycle of events associated with this automatic adjustment of gain is as follows. An ambient temperature change produces a change in line attenuation. This in turn results in either increased or decreased heating of the thermistor element. This element consists of a small pellet of semi-conducting oxides which is equipped with lead wires, a glass coating and an insulated heater. This assembly is covered with a gold coating and is enclosed in an evacuated glass tube to reduce heat losses to the surroundings. The device exhibits a marked negative temperature coefficient, and so in response to the changing carrier heating effect, can be made to modify the repeater feedback path characteristic in such a fashion as to effect compensation for the changes in line attenuation. The temperature at which the pellet would operate at the standard repeater output level would vary appreciably but for the inclusion of an ambient temperature compensating circuit. This circuit allows current to pass through the electrically insulated heater mentioned, under the control of a disc thermistor at repeater temperature. In this manner the thermistor pellet is maintained at a nominal temperature. The regulation action described is incorporated in each repeater and in the receiving group unit. The overall net channel loss can be limited to about ± 2 db in the worst case, and the operating time is of the order of 10 minutes.

REPEATER AND TERMINAL LEVELS, AND INTER-CHANNEL MODULATION.

Type N-1 repeater and group unit level diagrams are shown in Fig. 11. The normal LG repeater total output is + 3 dbm, and the normal HG repeater total output is + 12 dbm. In both LG and HG terminal units, the transmitting group input carrier levels are at —53 dbm and the receiving group output carrier levels are at —5.5 dbm. In each sideband spectrum, the frequency component corresponding to 1 mW audio frequency test signal at the transmitting switchboard is 12.5 db below the level of the associated carrier frequency. The signalling tone is 15 db below carrier level. Each channel of the system has, on a one-way basis, a gain of 26 db between 4-wire V.F. connections. The input transmission level (corresponding to zero level at the transmitting switchboard) is —16 db and the output transmission level is + 10 db. Built-in resistance hybrids for two-wire terminations are provided.

The Type N-1 system has been so designed that low level operation of the modulator and repeater amplifier takes place. These facts, taken in conjunction with the high level of switching carrier ultized in the modulator, and the degree of feedback employed in the amplifier, result in a low magnitude of interchannel modulation.

MAINTENANCE PROCEDURES AND TEST EQUIPMENT.

The suggested maintenance procedure for large installations of Type N-1 carrier systems involves the establishment of a central maintenance depot, at which location appropriate testing facilities are provided, and a stock of the various units and sub-assemblies employed in the system is held. The latter items are issued against corresponding faulty items received from the terminal and repeater stations of the system, the basis for restoration of a faulty system to service with a minimum of lost traffic time being that of rapid exchange of faulty units or sub-assemblies at the location concerned. Rapid exchange of equipment units and sub-assemblies is facilitated by the plug-in arrangements which are a feature of the system. The faulty units and sub-assemblies are restored to good order by a central maintenance team, and returned to stock in readiness for future issue. Corresponding stocks of the more specialised components used in the system must be held to permit satisfactory completion of this reconditioning work.

In-service switching of repeater and terminal circuits can be accomplished simply. This permits routine maintenance and fault location to occur without further interruption to service. To permit this type of work to be carried out, small lightweight transmission measuring equipment of portable type has been designed for use at repeater offices and pole cabinets, where the latter are employed. The following test equipment units are used:

(a) A 2A or 2B Signalling Test Set which provides supervisory signals or controlled pulses, and also provides means of measuring per cent. break of received pulse trains, or of observing received supervisory signals.

(b) A 2K Tube Test Set which enables a check of the cathode activity of the tubes in group terminal units to be made in service by effecting measurement of the percentage change in cathode activity when the heater voltage is reduced by 10%.

(c) A 2P Tube Test Set which permits measurement of cathode activity, heater current, and current through the voltage regulator tube for the tubes of the Type N-1 repeater; and also measurement of the DC voltage applied to the repeater.

(d) A Hickok Tube Tester which permits testing of most small sized amplifier and rectifier tubes of Western Electric and other manufacture.

(e) A 2J Repeater Test Set which is of small size, portable, and enables measurements of carrier power level at the repeater output to be effected. As a result of intermodulation of the Type N-1 system carriers, speech sidebands and signalling tones, it is also possible to provide an audio monitor of the 8 Kc/s. signal so produced. In a faulty system, noise may swamp the abovementioned audio signal. Where DC voltages are on the pairs of the cable, measurements may be taken. Except for this latter measurement, the 2J Repeater Test Set may be used for measurements on Type N-1 group units.

(f) A 2M Repeater Switching Set which enables system maintenance to proceed without interruption to service by substitution of a spare repeater for a working repeater.

(g) A 2N Group Unit Switching Set which enables system maintenance to proceed without interruption to service by substitution of a spare transmitting or receiving group unit for a working transmitting or receiving group unit.

(h) A 2T Maintenance Test Set which is used at the central maintenance depot to allow tests to be conducted on channel units, group units and repeaters. It also permits tests to be conducted on the 2M Repeater Switching Set, and the 2N Group Switching Set.

(i) An L1 Carrier Frequency Voltmeter which is a frequency selective voltmeter for measurement in the range 20 kc/s. to 500 kc/s. It has a high impedance input, and is direct reading in dbm when bridged across a balanced 135 ohm circuit or an unbalanced 600 ohm circuit. Use of a variable attenuator and a calibrated meter provides a sensitivity range of —70 dbm to +42 dbm. The lower part of the meter scale may be used for approximate readings to —85 dbm.

ALARM AND ORDER WIRE FACILITIES.

In a cable carrying Type N-1 carrier systems, two pairs are required for testing and maintenance purposes. One pair is used as an order wire, and the other pair is used to bring alarms from unattended repeater power points to attended points. Signalling over the order wire is achieved by use of either 1000/20 ringing or a 1900 c/s. tone, while tones of 700, 1100, 1500 and 1900 c/s are used to alarm four separate locations over the alarm pair. Operation is such that tone normally present on the line is removed by means of a relay under faulty condition. A delay of 5 seconds is incorporated in the alarm circuit to provide immunity against false operation.

TRANSMISSION PLANNING OF TYPE N-1 SYSTEMS.

In general repeaters are located in existing offices, and the maximum spacing of repeaters is determined by:—

(a) The repeater maximum gain at the mean frequency of 152 kc/s. (48 db ± 1 db).

(b) The desired output levels.

(c) The type of cable forming the transmission path.

As has been mentioned, Go and Return channels are operated on the two sides of the same quad in the cable; repeater sections shorter than the maximum can be built out by means of span adjusting pads (provided in 2 db steps from 2 db to 24 db) and artificial lines (available in 2 mile and 4 mile sections). To reduce to a minimum far-end/near-end interaction crosstalk at repeaters, input levels of the repeaters used in opposite directions of transmission at a repeater station must not differ too greatly. Equalisation is mainly achieved by the frequency frogging and inversion that occurs at each repeater. To minimise that part of the attenuation/frequency characteristic not cancelled by the tandem connection of two sections, and to allow for the span pad "flat" loss, where necessary, the repeater feedback transmission characteristics are adjustable in three distinct steps, A, B, and C, as has also been mentioned. Since the overall gain/frequency characteristics of the two types of repeater used in the Type N-1 system have also been designed to effect cancellation, the integrated effect of these various design features is to obtain substantially flat overall line transmission. Deviation equalisers are provided for operation in the frequency range 44 kc/s. to 140 kc/s. for the correction of systematic deviation of the gain/frequency characteristic of six repeaters. Should it be found impossible to restrict a repeater section to the theoretical maximum length, it is possible to increase the repeater gain 6 db by means of a simple circuit modification; this practice is not favoured, however, since the increased gain produced is associated with a deterioration in repeater performance in that the total noise output is increased.

SPECIAL FACILITIES.

It is of interest to note that special services, such as telegraph and telephoto, may be provided on the Type N-1 system by suitably arranging the standard channel equipment, while, utilizing special programme channel equipment, 3.5 kc/s. or 5.0 kc/s. programme channels can be provided.

Another feature of interest is the use of artificially generated noise (amplified valve noise) which can be injected with equal amplitude into each channel at the group stage of the transmitting terminal (Fig. 2) to mask intelligible cross-talk which may be experienced on exchange circuits of low noise.

A further novel feature is a small blower situated immediately below the bottom terminal on each terminal rack to ensure that the units of the terminal equipment are maintained at a safe working temperature. Air from this blower is force-fed via suitable flexible connections, through two vertical rectangular ducts, situated at the side of the rack, and discharged through slots in the form of streams directed towards regions below concentrations of valves. The 1/12 h.p. 115 volt A.C. blower motor is fed from a 240/115 volt 50 cycle per second transformer of suitable rating situated at the top of the terminal rack, and is switched on and off by a thermostat appropriately located in the upper terminal mounting.

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APPENDIX I

SIMPLIFIED COMPANDOR ANALYSIS

A. Compressor:

From Fig. 14(a) the following equations are obtained:—

Variolosser $V_1/\propto = V_2 \ (\propto > 1)$ 1

Amplifier $\mu V_2 = V_3$ 2

Control Circuit $K_1 V_3 = I_{dc}$ 3

where K_1 is a constant.

From equations 2 and 3 it is seen that I_{dc} is derived from amplified variolosser output signal. From equations 1 and 2,

Compressor gain (or loss)

$$= V_3/V_1 = \mu/\propto \qquad 4$$

Assuming $\propto = K_2 I_{dc}$, where K_2 is a constant, then from equations 3 and 4,

$$V_3 = \sqrt{\frac{\mu}{K_1 K_2}}\sqrt{V_1} \qquad 5$$

Using equations 2 and 5,

$$V_2 = \frac{1}{\sqrt{K_1 K_2 \mu}}\sqrt{V_1} \qquad 6$$

and using equations 3 and 5,

$$I_{dc} = \sqrt{\mu \frac{K_1}{K_2}}\sqrt{V_1} \qquad 7$$

If V_1' and V_1'' are input voltages such that $20 \log_{10} \left|\frac{V_1''}{V_1'}\right| = x$ db, then from equation 5,

$$\frac{x}{2}\ (\text{db}) = 20 \log_{10} \left|\frac{V_3''}{V_3'}\right| \qquad 8$$

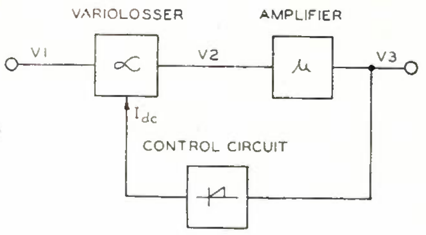
Equation 8 shows that for an input voltage change of x db, the corresponding output voltage change is $\frac{x}{2}$ db, so that 2 :1 compression has been achieved using the arrangement of Fig. 14(a) and the linear relationship assumed to link $\propto$ and I_{dc}.

B. Expandor.

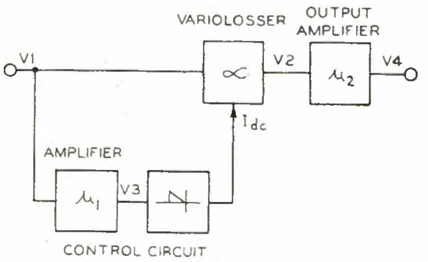
From Fig. 14(b) the following equations are obtained:—

Variolosser $V_1/\propto = V_2 \ (\propto > 1)$ 1

Control Circuit $\begin{cases} \mu_1 V_1 = V_3 & 2 \\ K_1 V_3 = I_{dc} & 3 \end{cases}$



(A) COMPRESSOR BLOCK SCHEMATIC



(B) EXPANDOR BLOCK SCHEMATIC

Fig. 14.—Compandor, Consisting of Compressor and Expandor.

Output Amplifier $\mu_2 V_2 = V_4$ 4

From equations 1 and 4,

Expandor Loss (or gain)

$$= \frac{V_4}{V_1} = \frac{\mu_2}{\propto} \qquad 5$$

Assuming in this case $\propto = K_2/I_{dc}$, then from equations 2, 3 and 5,

$$\sqrt{V_4} = \sqrt{\mu_1 \mu_2 \frac{K_1}{K_2} V_1} \qquad 6$$

Using equations 4 and 6,

$$\sqrt{V_2} = \sqrt{\mu_1 \frac{K_1}{K_2} V_1} \qquad 7$$

and using equations 2 and 3,

$$I_{dc} = K_1 \mu_1 V_1 \qquad 8$$

which shows that in this case I_{dc} is derived from amplified variolosser input signal.

If an input voltage change of x db $= 20 \log_{10} \left|\frac{V_1''}{V_1'}\right|$ occurs, then from equation 6,

$$2x\ (\text{db}) = 20 \log_{10} \left|\frac{V_4''}{V_4'}\right| \qquad 9$$

Equation 9 shows that for an expandor input voltage change of x db, the corresponding output voltage change is 2x db, so that 1 : 2 expansion has been achieved using the arrangement of Fig. 14(b) and the reciprocal relationship assumed to link $\propto$ and I_{dc}.

SPEECH LEVEL MEASUREMENTS AT MELBOURNE TRUNK EXCHANGE

D. G. TONKIN, B.E., A.M.I.R.E.Aust.*

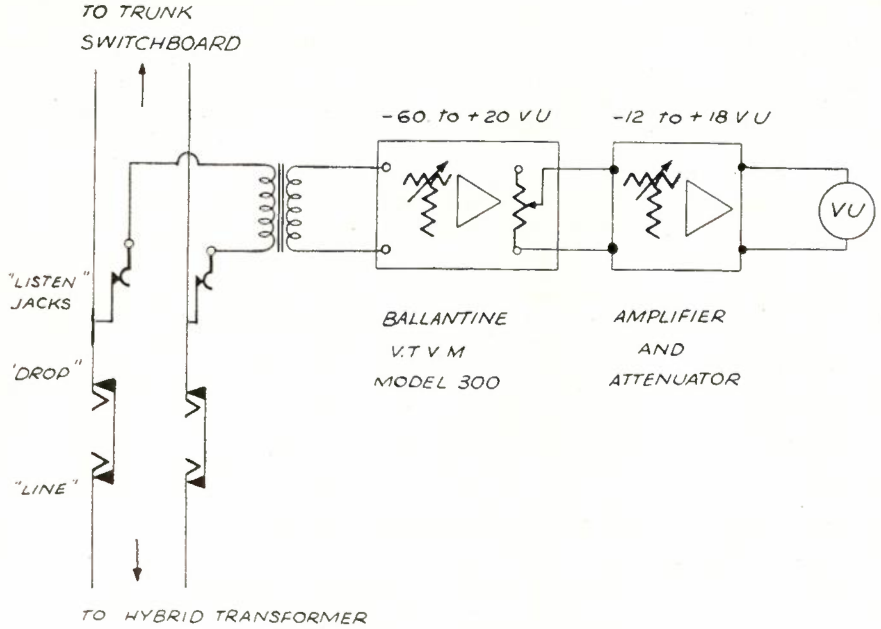


Fig. 1.—Set-up for Measuring Levels.

Introduction: A key factor in the design of telephone equipment is the distribution of speech levels likely to be encountered. These are usually measured at the transmitting trunk switchboard, or measured at some other point, and the level so obtained is then corrected to its value at the transmitting trunk switchboard.

Early measurements on long distance connections using an old type volume indicator (on which 0db was equivalent to a power of 6mW) were made in the U.S.A. about 1938 and yielded a mean volume of –16db (Ref. 2). This is roughly equivalent to –10 vu on a standard Volume Unit (vu) meter. Recent measurements, made in the U.S.A. in 1950/51, indicated that the mean near-end speaker volume was –15 vu on long distance calls (Ref. 3).

In the system design of the North Atlantic link of the first trans-atlantic telephone cable system (now in service), the "most probable U.S. volume distribution" was estimated to have an average value of –12.5 vu, with a standard deviation of ± 5. vu (Ref. 4).

This article describes the speech level measurements which were made at the Melbourne Trunk Exchange between November, 1954, and May, 1955, to determine the distribution of speech levels likely to be encountered in this country (Ref. 1).

The Method of Measurement: The channel under observation was bridged at the Trunk Test Board of the Melbourne Trunk Exchange. The difference in level between this Board and the Melbourne transmitting trunk switchboard is negligible during subscribers' conversation. The measuring set-up is shown in Fig. 1. The bridging transformer secondary was connected to the input terminals of a Ballantine Vacuum Tube Voltmeter (V.T. V.M.) Model 300, which has an input impedance of 0.5 megohms. The range switch of the V.T.V.M. input attenuator was remarked in Volume Units, the range being –60. vu to +20. vu. This allowed about 20 db overload margin for the V.T.V.M. amplifier in case of signals containing sharp peaks. The output jack of the V.T.V.M. was connected to a second amplifier and thence to a vu meter. The range of levels covered by the equipment was –78 dbm to +41 dbm, the lower limit being set by the internal noise level of the measuring equipment. The set-up was calibrated at a level of 0 dbm in 600 ohms at 1000 c/s, the attenuators in the V.T.V.M. and the amplifier being set to zero vu. The set-up was made direct-reading by adjustment of the output potentiometer of the V.T.V.M. Tests showed that the dynamic characteristics of the vu meter and associated equipment conformed with the requirements (Ref. 5). The vu meter was read in the prescribed manner, namely, "The reading is determined by

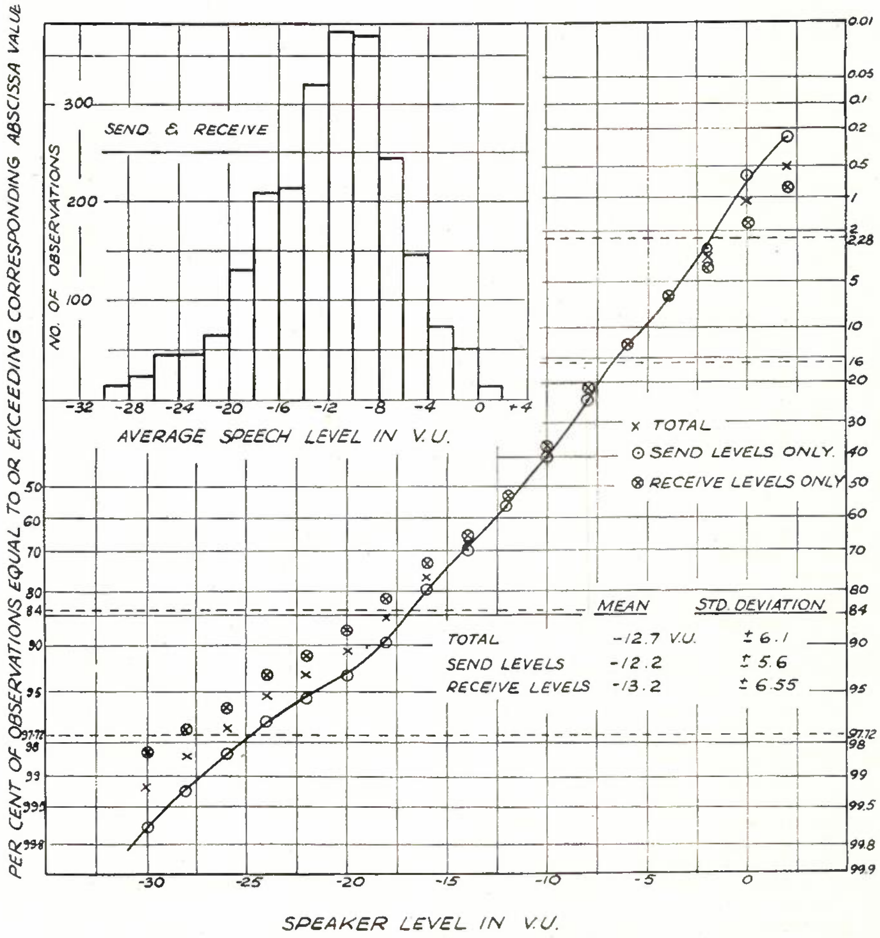


Fig. 2.—Summary of Nine Channels.

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* Mr. Tonkin is a Group Engineer in the Research Section, Central Administration.

the greatest deflections occurring in a period of 10 seconds (for message telephone speech waves) excluding not more than one or two occasional deflections of unusual magnitude". (Ref. 5). Provision was made for monitoring the channel under observation.

The Measurements: Measurements were made of speech, noise and V.F. signalling tone levels on each of 9 channels. All types of bearer circuits were included in the tests — cable carrier, open-wire carrier, and radio. Three of the channels measured employed compandors. One channel employed magneto-type signalling; the others used 2 V.F. signalling.

Approximately 100 conversations were observed on each channel, and for each conversation, a set of speech level readings was obtained for the sending speaker and also for the receiving speaker. The average value of speech level from a set of observations is called the "speaker level" of the speaker concerned. These speaker levels were used to calculate the mean speaker level, the mean sending speaker level and the mean received speaker level for each channel, together with the standard deviation from each mean. All of the circuits on which measurements were made were trunk circuits of nominally zero loss, so no correction to received speaker levels was made. From the speaker levels were calculated also the overall mean speaker level, the mean sending speaker level and the mean receiving speaker level for all the channels, together with standard deviations. These values are shown in Fig. 2, together with the plot of cumulative distribution points and the histogram for all channels. Similar calculations were made for groups of companded and non-companded channels, and these are shown in Figs. 3 and 4 respectively.

The mean sending speaker level was found to be –12.2 vu, with a standard deviation of ± 5.6 vu. The values obtained in comparable studies overseas are shown in Table I. While a combination of three companded channels and six non-companded channels is not representative of current Australian practice, the measurements showed no significant difference between the mean send speaker level for the two types of circuit. (see Figs. 3 and 4).

Send and Receive Averages: Several channels showed a difference of almost exactly 3db between the mean send level and the mean receive level, the send level being the higher. Only one channel showed an almost exact agreement between the mean send and the mean receive level. The difference between the mean send level and the mean receive level varied from +1.8 vu to –2.5 vu for the remaining channels. The reasons for these differences have not been investigated. The difference between the mean send level and the mean receive level, averaged over the nine channels, was +1 vu (Fig. 2).

TABLE I

VALUES OF MEAN SPEAKER LEVEL OBTAINED OVERSEAS

(From C.C.I.F. Green Book, XVIIth. Plenary Assembly, Geneva, 4-12 October, 1954—p. 198, Vol. I)

Date	Administration	Indicated	Reference Volume at 1000 c/s.	Equivalent with reference to 1 mW in 600 ohms vu	Standard deviation
1934	B.P.O.	–15db	6 mW in 600 ohms	–7db*†	7.8*
1939	Bell System (Holbrook & Dixon)	–16db	,,	–8db**	5.8
1947	A.T. & T. (U.S.)	–10vu	1 mW in 600 ohms	–10vu	6.0
1949	B.P.O.	–20db*	6 mW in 600 ohms	–12db†	6.2
1951	French	–12vu	1 mW in 600 ohms	–12vu	5.3
1950-51	Bell System (Subrizi)	–15vu	,,	–15vu	5.3

* This value has been calculated by C.C.I.F. Secretariat: original figures not quoted in this form.

** The vu meter gives for such a level of speech power, an indication of about –10 vu.

† In these tests, the indications on the voltmeter have been read according to the method recommended by the C.C.I.F. (Yellow Book Vol. IV, p. 183); the results are not, therefore, rigorously comparable with those which have been obtained with a vu meter used in the standard U.S. manner.

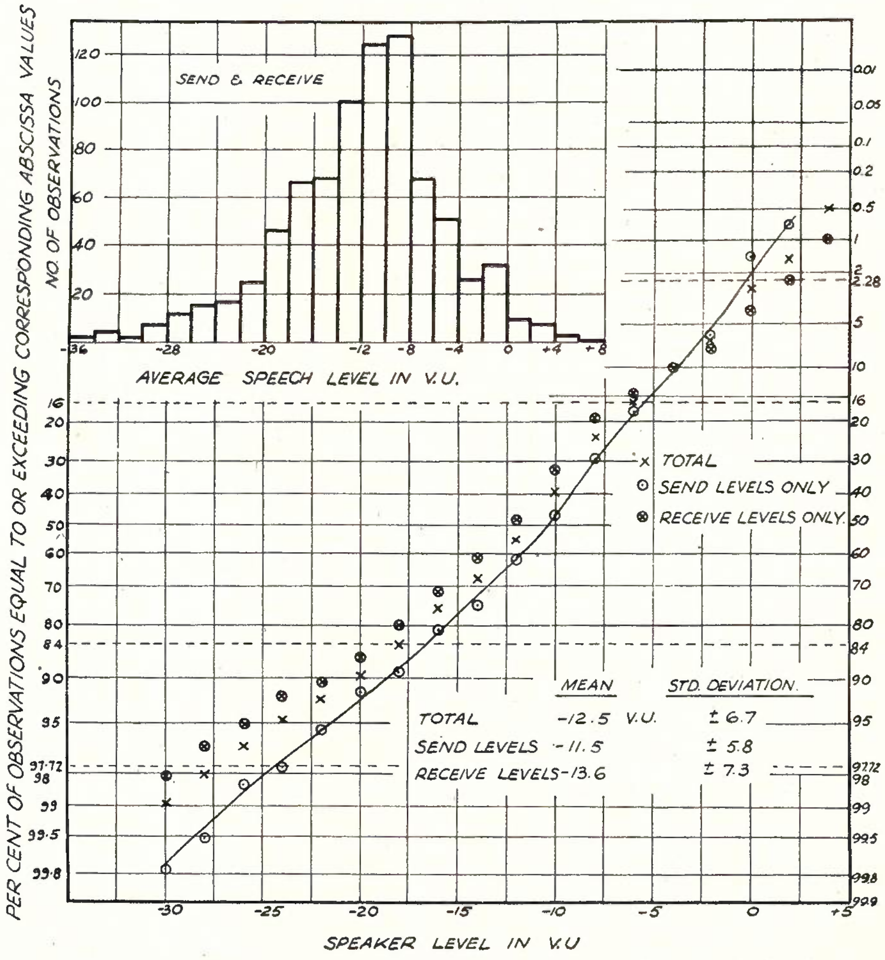

Fig. 3.—Summary of Three Companded Channels.

Effect of Noise: The average observed line and equipment noise level for each channel, during the period of measurement, was noted. The range of noise levels measured was not sufficient to determine the relation, if any, of noise level and speech levels, but the results seem to indicate that the average speech level tends to rise as the noise level falls below -40 dbm.

Signalling Tone Levels: Observations were made on the level of the signalling tones employed on the various systems. On systems employing 2 VF signalling, the range of sending levels varied between +2½ vu and -3 vu. It will be observed that these levels are higher than the bulk of speech levels encountered in practice (see Fig. 2).

Traffic Data: The observations taken also yielded information on some traffic details. The average length of a conversation on interstate trunk channels was found to be almost exactly six minutes (average = 5.94 minutes). The average length of a conversation is defined as the time elapsing between the beginning and the end of conversation between the two speakers.

According to recent figures from U.S.A., the average length of conversation, including local as well as trunk calls, is 5.35 minutes (Ref. 6). Figures provided by the various national bodies of the Commonwealth Telecommunications Board, yield an average for length of overseas trunk conversations of 6.8 minutes (Ref. 7).

The number of effective calls per hour per trunk channel has been calculated, from the observations, for each hour of the day from 9 a.m. to 5 p.m., and the results are tabulated below:—

	a.m.			Noon	p.m.			
Hour	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5
calls/hour	4.5	4.7	4.9	5.2	4.0	4.85	4.75	4.35

This indicates that "busy hour" rates of calling were maintained during the day on the channels observed.

The overall 9-5 average was 4.7 calls per hour. Practically no difference in the calling rate was observed between systems employing 2 V.F. signalling, and one system employing magneto signalling.

These results show that the portion of the busy hour for which the average channel is active is about 28 minutes (calculated from the average calling rate × the average length of conversation). Dividing this time equally between the two directions of transmission, it follows that each transmission channel is active, on the average, for about 25% of the busy hour. This is comparable with a conclusion reached elsewhere (Ref. 2).

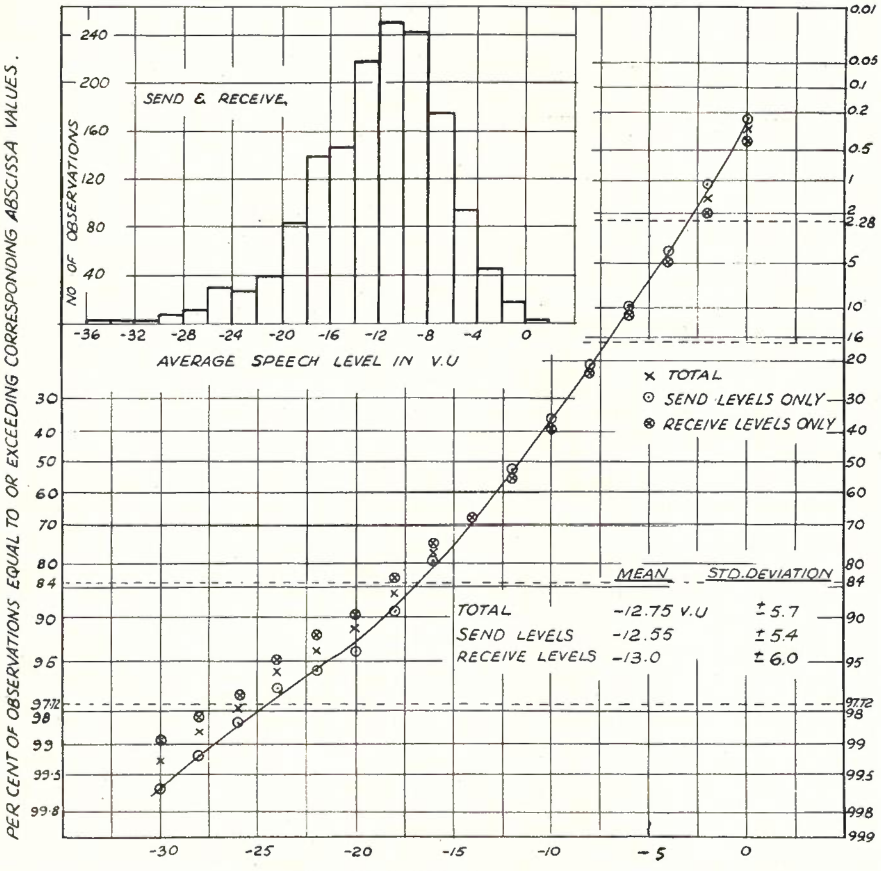

Fig. 4.—Summary of Six Non-Companded Channels.

Conclusion: From the observations made on a number of interstate telephone channels, the mean sending speaker level was found to be -12.2 vu with a standard deviation of ± 5.6 vu. The far higher levels of signalling power employed, however, indicate that in many cases speech levels are a secondary consideration in amplifier and equipment design.

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ANSWERS TO EXAMINATION PAPERS

EXAMINATION No. 3942: SENIOR TECHNICIAN.

Electrical Theory and Practice.

K. A. Neilson.

Q.8. What do you understand by the term "hysteresis. Sketch the hysteresis loops of typical samples of soft iron and hard steel, and explain the following terms with reference to your sketch.

(a) Retentivity

(b) Coercive Force

(c) Magnetic Saturation.

A.—8.

Hysteresis occurs in ferromagnetic materials and is an expression of the manner in which the flux density (B) in a material lags behind in changing magnetising force (H).

With reference to Fig. 1 diagrams (a) and (b), if a sample is subjected to a magnetising force (H) from zero to saturation, the results if plotted reproduce a curve O E.

On reduction of the magnetising force, the curve will not follow O E, as owing to the retentivity of the material there will be a remanent value of flux density present represented by OF.

To reduce this flux to zero the magnetising force must be applied in the opposite direction as represented by O G. The further increase of "H" to saturation and the subsequent decrease to zero, again results in a remanent value of flux which can be reduced to zero by the application of a reversed magnetising force of value O M.

The continued increase of H will complete graphically the typical closed loop indicating hysteresis, the area of which is indicative of energy loss expended in heat.

Retentivity: Is the quality of a material to retain magnetism after the removal of the magnetising force, and is graphically measured in (a) and (b) by the remanent values O F and O L.

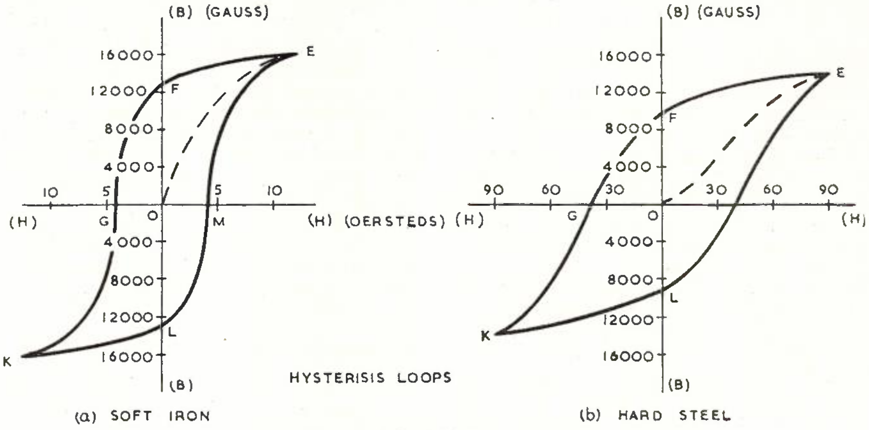
Coercive Force: Is the amount of reversed magnetising force necessary to reduce residual magnetism to zero and is represented graphically by O G and O M.

Since O G and O M measure the coercivity of the material the hysteresis loop of hard steel is much wider than soft iron as steel has a much higher coercivity.

Saturation: Magnetic saturation occurs in a material when changes in the applied magnetising force produce no changes in flux density attributable to realignment of the molecular structure of the material.

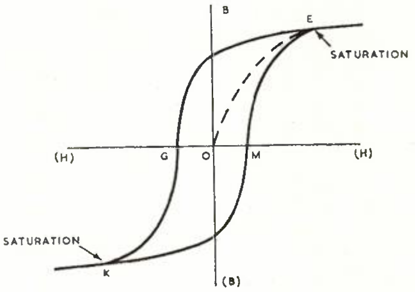
Any increase of flux density which may occur is due solely to the small increase in the number of lines produced by the increased magnetising force itself.

Saturation is represented graphically at points E and K of Fig. 2.



(a) SOFT IRON (b) HARD STEEL

Q.8—Fig. 1.



Q.8—Fig. 2.

Q.9. A 5 KW radiator is to be supplied at a pressure of 250V, at a distance of 100 metres from a generating station. If the voltage drop in the supply lead is to be 10V, what cross sectional area of copper in sq. cms. must be provided.

Specific resistance of copper = 1.7 microhms per cm. cube).

A. 9.

Power in watts = EI

5000 = 250 I radiator

∴ I radiator = 5000/250

= 20 amps

Allowable R of supply lead with 10 V drap = 10/20 = 0.5 ohm

Now R = pl/A

where R = resistance in ohms

p = specific resistance in ohms per cm. cube

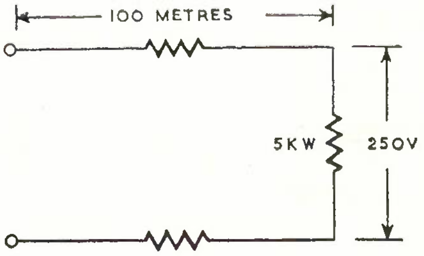
l = length in centimetres

A = cross sectional area in square cm

∴ A = pl/R

$$\text{and } A = \frac{(1.7 \times 200 \times 100)}{(10^6 \times 0.5)} \text{ sq. cm.}$$

Answer: 0.068 square centimetres.



Q.9—Fig. 1.

Q.10. The diagram below represents the circuit conditions in a main 2,000 type Line Finder Automatic Exchange during the application of a meter pulse. During metering a P.D. of 7V. is measured across the rectifier, the effective resistance of which is 140 ohms. Calculate

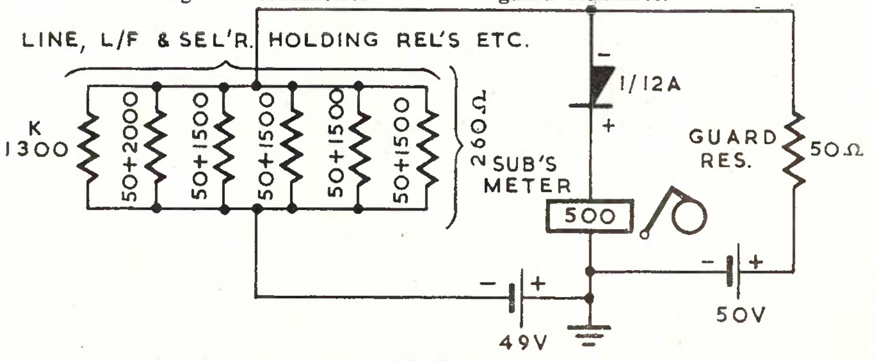
(a) the P.D. across the meter

(b) the current through the meter

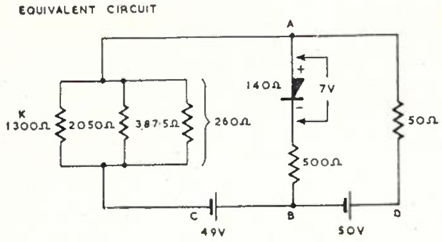
(c) the P.D. across the subscriber's line circuit K relay.

(d) the current through the subscriber's line circuit. K relay

(e) the current through the 50 ohm guard resistance.



Q.10—Fig. 1.



Q.10—Fig. 2.

A.10.

Given P.D. rectifier = 7V and R rectifier = 140 ohm.
Then **I** rectifier = 7/140 = 50mA
Then I meter = **50 m A**
∴ P.D. meter = (50 x 500)/1000
= **25 VOLTS**
P.D. across A B = 25+7 = 32 VOLTS
Now point A will be 49 + 32 = 81 VOLTS POSITIVE with respect to point C.
∴ **P.D. across K = 81 VOLTS**
∴ I through K = IK = 81/1300
= **62.3 mA**

If point D is 99 volts pos. with respect to C, and A is 81 volts pos. with respect to C, then the P.D. across the 50 ohm guard resistance = 18V.

∴ **I** 50 = 18/50 = **360 mA**

Answers:
(a) 25 VOLTS (b) 50 mA
(c) 81 VOLTS (d) 63.3 mA
(e) 360 mA

EXAMINATION No. 4445: SENIOR TECHNICIAN, TELEPHONE, JULY, 1956

Telephony II, Section II

Q. 4.—All channels of a three-channel system are reported as noisy simultaneously; discuss the possible causes and describe the means of locating and correcting the fault.

A.—Possible Causes. As the trouble affects all three channels, it would be in equipment common to all channels or in the bearer circuit. A bearer fault would be the most likely cause and would probably be an intermittent contact, a bad joint, or a severe unbalance of the line. The trouble could possibly be crosstalk from a system on the same route which is howling. The noise could also be due to a fault in the send or receive equipment between the modulator and demodulator band pass filters and the line, that is line filters, office wiring, line amplifiers and equalisers, or be due to a noisy power supply, for example, due to the failure of a floating rectifier filter capacitor. This could be in common equipment at any station, including repeater stations. Equipment troubles which could cause noise on the channels are dry joints, faulty valves, oscillating amplifiers, dirty jack contacts, contacts due to loose wires, faulty capacitors and disconnected earths.

Location and Correction. Considerable information as to the cause of the fault can be obtained by first listening on the channels and on the physical circuit on which the system is superimposed. This would immediately indicate whether the physical is also faulty or whether the trouble is due to crosstalk from a howling system on an adjacent bearer, or whether the system itself is howling. The technician at the adjacent station would also be asked to make similar listening tests, as sometimes bearer circuits used on some sections of the route are not extended to both terminal stations. In some long distance systems some bearer sections do not appear at either terminal station and it would be necessary to check with intermediate repeater stations as to whether the bearer is faulty in those sections.

If the bearer circuit is found to be faulty by listening tests, the system is patched to a spare bearer if available and the line fault located in the normal way. Long distance systems with repeaters are usually equipped with A.G.C. and most bearer troubles would be indicated by this equipment, the faulty physical sections being the one before the first station at which a received A.G.C. pilot is abnormal.

If the channels are much noisier in one direction than the other, the trouble is almost certainly due to equipment. It should be borne in mind, however, that noise can be transferred from one direction to the other through hybrids if not properly terminated, and also if the trouble is in equipment common to both directions, including the line, the noise can also be louder in one direction than in another due to the level difference in the two directions at the point of the fault.

If this preliminary work makes it doubtful whether the trouble is due to a bearer, the system is checked by terminating the hybrid at each end in turn and listening at the other, to see whether the noise does exist in only one direction. The faulty station (or bearer section if still in doubt) is located by opening the bearer at the line filter jacks successively at terminal and intermediate stations while listening on a channel at a terminal. Thus, if the noise disappears when the bearer is opened at the terminal station, it is not in the receive equipment at the station. If it is not present when opened at one intermediate point and is present when opened at the next point further distant from the listening station, the trouble is between these two points.

After localisation to a station the fault is passed to that station for attention and the panel of equipment is located in a similar manner, e.g., by listening to a channel at a receive terminal station and opening or short circuiting equipment items working away from the listening point until the noise appears. At a repeater station or sending terminal a T.M.S. set connected to system output in the direction concerned would be used as a detector instead of listening on a channel. Faulty jacks, wiring or dry joints found by this method would be repaired. If the trouble is in an amplifier panel plate currents would be checked to see if they are normal.

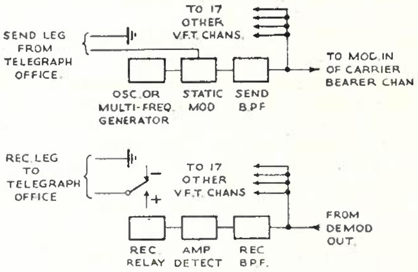
The valves would then be changed one by one to see whether this eliminates the trouble. If not, the trouble would be due to other faulty components, dry joints or loose connections. Wiring and joints would be inspected carefully and wires moved near the joints to see if this makes the noise vary in level. If the trouble is still not located and appears to be due to a dry joint, a test tone would be applied at the input to the amplifier and observed on the output meter and all components tapped, for example, with a pencil, and wiring moved until a variation is observed. If the trouble is due to the failure of components, the faulty item would be located in the normal way by observation of power supply voltages at valve sockets, across resistors and transformers, etc., and by testing individual components for open circuits or by substitution.

Q. 5(a).—Draw a block schematic circuit of one terminal of an 18-channel voice-frequency telegraph system for operation on a carrier telephone channel. Show the channel frequencies of the voice-frequency telegraph system.

Channel No.	Frequency c/s
1	420
2	540
3	660
4	780
5	900
6	1,020
7	1,140
8	1,260
9	1,380
10	1,500
11	1,620
12	1,740
13	1,860
14	1,980
15	2,100
16	2,220
17	2,340
18	2,460

Table 1.—Channel Frequency Allocations for 18 Channel V.F. Carrier Telegraph System.

A.—Refer to Fig. 1 and Table 1.

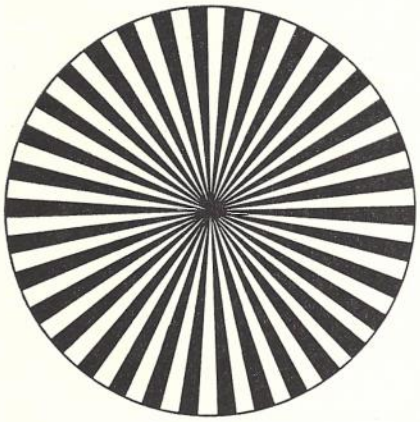


Q.5a—Fig. 1

Q.5(b).—On a multi-frequency generator installation for providing channel frequencies for such a system, describe briefly the means provided for checking the accuracy of the generated frequencies. State briefly the method of correcting the frequencies should they prove to be in error.

A.—The channel frequencies are generated by a motor alternator. The alternator shaft rotates 3,600 r.p.m. and carries a stroboscopic disc marked into 34 black and 34 white segments. To check the speed of the alternator (and hence the channel frequencies) the disc is observed with the flashes of a neon light driven by a 1020 c/s fixed frequency oscillator. if the speed is 3600 r.p.m., i.e., 60 r.p.s., the disc appears stationary because in the interval of 1/2040 sec. between flashes each segment moves 1/34 of a revolution, which makes it coincide with the next corresponding segment. If the speed is slow the disc appears to rotate backwards and if fast it appears to rotate forwards.

To correct the frequencies generated, the systems are switched to the spare motor alternator and the speed of the faulty generator is adjusted by means of its centrifugal governor. The governor has contacts which are controlled by the centrifugal forces produced by the speed of rotation and intermittently short circuit a shunt field resistance in the motor. The speed of the motor is thus held constant for the particular governor setting involved. A screw adjustment is provided on the governor contacts to enable the speed to be varied.



Q.5b.—Fig. 1.

Examination Nos. 4445, 4446 and 4465: Senior Technician, Telephone, Research and Radio and Broadcasting. July, 1956.

ELECTRICAL THEORY AND PRACTICE

Q.1.—(a) Describe the construction of an ordinary dry cell as used in a magneto telephone giving the functions of each component or ingredient.

(b) How would you measure the internal resistance of such a dry cell. Quote the formula you would use for your calculation.

A.—(a) A zinc can covered with a cardboard jacket forms the container, and the negative terminal is attached to it. The +ve terminal is attached to a carbon rod placed at the centre of the container and surrounded by a mixture of ground carbon, manganese dioxide and portion of the paste electrolyte, all contained in a sack. The balance of the electrolyte, which comprises a mixture of sal ammoniac, zinc chloride and some gelatinous material to form a paste, is placed between the sack and the zinc container. The top of the container is sealed with an expansion chamber immediately below the seal. The functions of each component are as follows:—

(i) The zinc container, which is the negative electrode, is attacked by the sal ammoniac in the electrolyte and an E.M.F. is developed between the zinc and carbon rod.

(ii) The carbon rod is the positive electrode.

(iii) The sal ammoniac is the active chemical in the electrolyte which attacks the zinc, converting it to zinc chloride. Zinc chloride is added to the paste when being prepared to reduce the corrosion of the zinc when the cell is not in use.

(iv) The manganese dioxide is the depolarising agent and releases oxygen to combine with the hydrogen gas which would form at the positive electrode—this reduces polarisation. The ground carbon is mixed with the manganese dioxide to reduce the internal resistance of the cell.

(v) The cardboard container insulates the cell from its mounting.

(b) The internal resistance "r" of a dry cell made be measured as follows:—

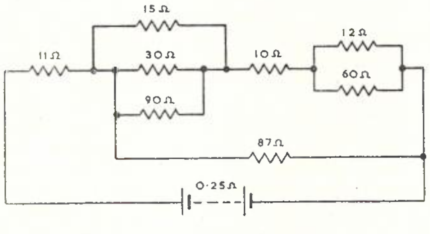
(i) Measure the open circuit voltage of the cell $= V_1$

(ii) Measure closed circuit voltage with a 2-ohm shunt "S" connected across the cell $= V_2$

Then the internal resistance of the cell

$$\text{"r"} = S\left(\frac{V_1 - V_2}{V_2}\right)$$

Q.2.—In the circuit shown hereunder the current flowing in the 87 ohms resistance is 500 mAs. Calculate the current flowing in the 12 ohms resistance and the open circuit voltage of the battery assuming that it has an internal resistance of 0.25 ohms.



Q.2—Fig. 1.

A.—First calculate the Joint Resistance of the two main parallel branches.

One branch has a single resistance of 87 ohms, the other branch has a total resistance of:—

$$\frac{1}{\frac{1}{15} + \frac{1}{30} + \frac{1}{90}} + 10 + \frac{1}{\frac{1}{12} + \frac{1}{60}}$$

$$= \frac{90}{10} + 10 + \frac{60}{6}$$

$$= 29 \text{ ohms}$$

Now 29 ohms in parallel with 87 ohms has a joint resistance of

$$\frac{1}{\frac{1}{29} + \frac{1}{87}} = 21.75 \text{ ohms}$$

∴ the total resistance in the circuit, including the internal resistance of the battery, = 0.25 + 11 + 21.75 = 33 ohms.

Now 500 milliamps flows through the 87 ohm resistance, therefore the current through the parallel 29 ohms resistance is

$$\frac{87}{29} \times \frac{0.5}{1} = 1.5 \text{ amps.}$$

The total current from the battery = 2 amps

The open circuit voltage of the battery = 2 × 33 = 66 volts

The current flowing through the 12 ohm resistance = $^5/_6 \times 1.5 = 1.25$ amps

Q.3.—(a) Explain in regard to an alternating current what is meant by—

(i) Average value of current.

(ii) Effective or R.M.S. value of current.

(iii) Form factor.

(b) State the form factor of an alternating current of pure sine wave and show very simply how this value is arrived at.

(c) Explain briefly why an alternating current of wave shape different from that of a pure sine wave of the same fundamental frequency causes heavier inductive interference than the pure sine wave.

A.—(a)

(i) Average value of an alternating current is the value obtained by taking the mean of a large number of instantaneous readings during a half-cycle.

(ii) The effective or R.M.S. value of an alternating current is that value of direct current which has the same heating effect as the alternating current.

(iii) The form factor of an alternating current is the ratio

$$\frac{\text{effective value}}{\text{average value}}$$

and indicates the deviation of any given wave from a pure sine wave.

(b) For a pure sine wave the ratio =

$$1.11, \text{ i.e. } \frac{0.707}{0.637}$$

(c) An A.C. current of wave shape which differs from a pure sine wave contains higher harmonics of the fundamental frequency and, as the amount of inductive interference between circuits increases as the frequency is increased, it follows that an alternating current of complex wave shape will cause greater inductive interference than if it were a pure sine wave of the same fundamental frequency.

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