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C.B. NON-MULTIPLE SWITCHBOARD — COMBINED "A" AND TRUNK POSITION

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R. W. Turnbull, A.S.T.C.

Introduction

In pursuance of the intention to utilise C.B. equipment where practicable in lieu of magneto equipment in country centres (1) where automatic facilities cannot be provided within a reasonable time, it was decided in 1947 that a C.B. floor pattern non-multiple switchboard should be developed as speedily as possible for use as a combined "A" and trunk position in small country exchanges.

The primary intention is for this switchboard to replace as a standard the obsolescent floor pattern magneto switchboards of 100- and 200-line capacities. In view of the precarious supply situation throughout the world on telephone equipment at that time, it was necessary that the C.B. non-multiple board should be kept as simple as possible because any additional facility or requirement added to meet traffic needs causes a corresponding delay in delivery and the use of a greater quantity of raw materials. Whilst it is intended that such switchboards shall be confined to locations where not more than two positions will be required during the life of the manual exchange, or for a shorter period if replacement of the equipment can be foreseen within that time, it is recognised that in some cases there may be justification for the installation of three positions.

This article describes the development and design of the new standard C.B. non-multiple switchboard.

Prototype Installation

A prototype switchboard was developed by the Superintending Engineer, Sydney, and installed at Berry, N.S.W., for field trials early in 1948.

For simplicity in design and manufacture and also to conserve materials, the subscribers' line circuits were designed without line and cut-off relays. This arrangement had already proved successful on the standard lamp signalling P.B.X. (2). Since it is not possible to accommodate all

Fig. 1.—C.B. Exchange, Berry, N.S.W.

of the necessary relay equipment in the rear of the switchboard without causing serious congestion, the design caters for a relay rack to be associated with the switchboard on each installation. In general one relay rack will be sufficient to accommodate the equipment for two or three switchboard positions.

The original installation at Berry is shown in Fig. 1, and initially 187 subscribers, 7 trunks and 1 public telephone were connected. The relay rack and M.D.F. are shown in the background. In order to save time in the manufacture of the prototype, which was installed primarily to test the circuits and prove the general arrangement under field conditions, a single panel magneto switchboard was obtained from stock and reconstructed for the purpose. The arrangement does not give the desired face layout, but it served the purpose for which it was intended. From the experience gained at Berry, a set of standard circuits was developed for the purchase of a large quantity of switchboards for use in all States of the Commonwealth. Drawing C.E.522 refers. These circuits will be described at a later stage.

Development of Standard Design

Capacity: The 100-line and 200-line boards are identical in physical construction and wiring, and differ only in the amount of equipment installed initially. The 200-line board consists of:—

Subscribers' line circuits	200
Trunk line circuits	18
Cord circuits	16
Network cord circuit	1

The full 18 trunk line circuits are all available on a 2-wire basis but provision is made for up to four 4-wire circuits by utilising the wiring and space occupied by eight of the 2-wire circuits. Thus with the maximum number of 4-wire circuits in use, the total capacity would be ten 2-wire and four 4-wire circuits. If only three 4-wire circuits are required then up to twelve 2-wire circuits could be used and so on.

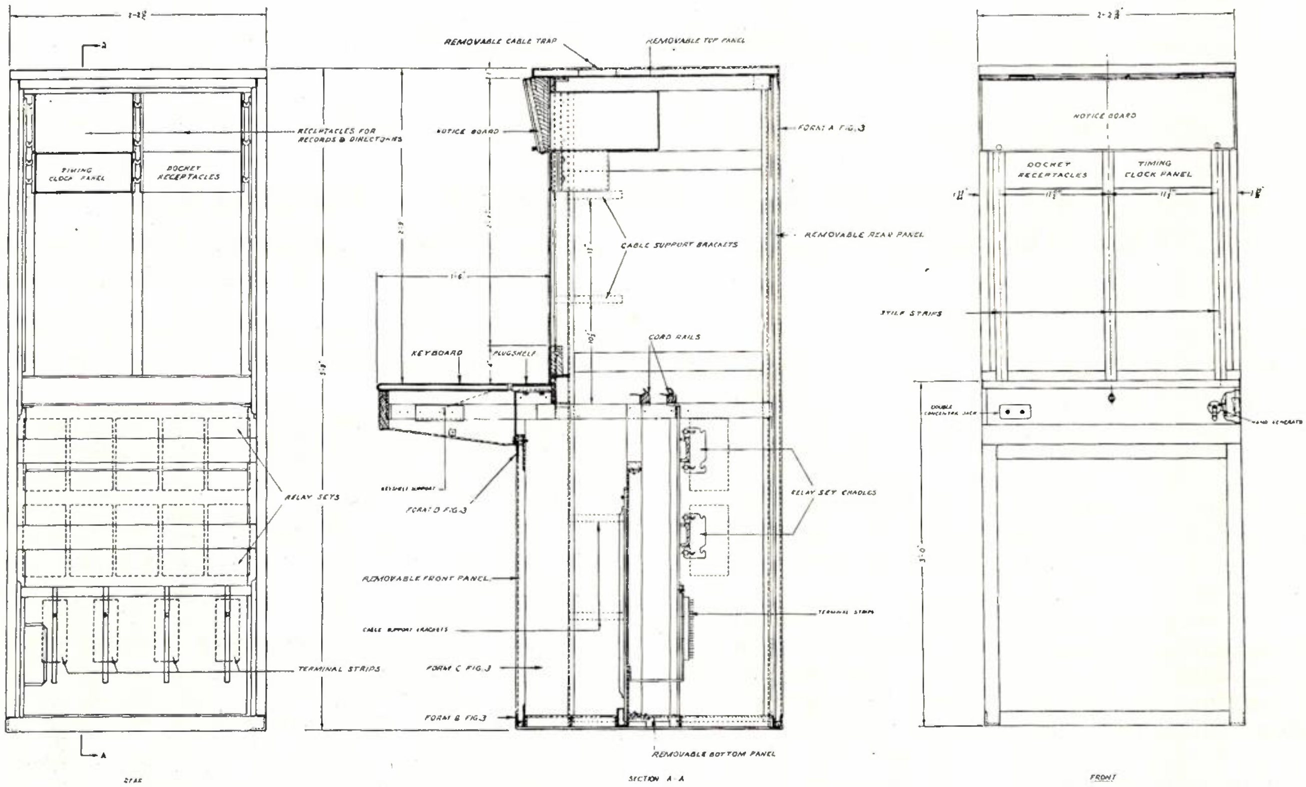


Fig. 2.—Switchboard Framework.

The 100-line board is fully wired for the ultimate capacity of the switchboard but with equipment for the following circuits initially:—

Subscribers' lines	100
2-wire trunks	10

In all other respects, including terminal strips and cord circuits, this board is the equivalent of the 200-line size and may thus be readily extended in situ to its full capacity.

Physical Design (Drawing C.E.523): In determining a suitable standard physical design for the switchboard, factors such as the following were considered:—

(1) General standardisation.

(2) Determination of face lay-out of equipment, and provision of operating facilities based on conventional usage.

(3) Provision of jacked-in equipment at the rear of the switchboard.
(4) Accessibility for installation and maintenance.
(5) Facilities for external cable connections.
(6) Provision for docket and directory receptacles.
(7) Incorporation of notice board.
(8) Ease of manufacture.
(9) Appearance.

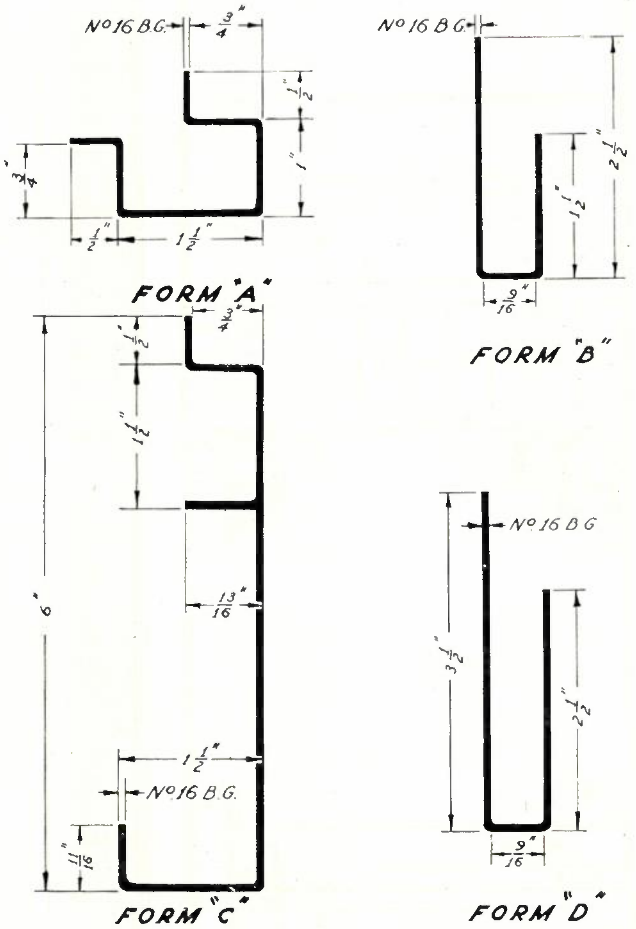


Fig. 3.—Folded Metal Sections.

Fig. 2 shows the front, side and rear views of the switchboard framework. The essential dimensions are shown and it will be noted that these have been made similar to a single multiple switchboard position (3). The main structural members of the framework are folded metal sections as shown in Fig. 3. These sections were all actually shaped prior to incorporation in the design to prove that they could be handled during manufacture without difficulty.

Face Lay-out: This is shown in Fig. 4. The jack and lamp fields follow conventional lines, and the method of numbering, i.e., from top to bottom, is consistent with the arrangement used within each group of 100 on a standard multiple installation. The reasons for four groups of subscribers' pilot lamps as well as a common position pilot is explained later during a discussion on the subscribers' line circuit. The trunk line ring keys are used to simplify the trunk line circuits. The docket receptacles and panel for the mounting of the timing clocks of the minuter type are within easy reach of the telephonist. The provision of receptacles for records and directories fills an important need in small country exchanges. These receptacles are normally hidden by the notice board which is hinged and held by a spring type catch, thus facilitating the raising of the notice board at will to gain access to the receptacles.

A feature of the face lay-out of this switchboard is that all mounting is done by means of jack fasteners of the conventional "butterfly" type. All receptacles, clock panel, and the keys, are in separate units and detachable from the switchboard merely by releasing the relevant jack fasteners in the same manner as is done for the release of a jack strip. This not only simplifies manufacture, but makes it very easy to modify the upper layout at any time.

Again, for simplicity in manufacture, all the upper accessories are made of welded sheet steel sections. This introduced the possibility of shocks to the telephonist by having the docket receptacles, etc., at earth potential. The normal coating of paint is not regarded as adequate protection. The difficulty was overcome by using "Prespahn" insulating material 1/32" thick between the face equipment and the frame. This applies to all receptacles, the clock panel and the key strip. The stile strips are made of clear methyl methacrylate (perspex) for the same reason, and wooden fillers have been interposed between outer stiles and the outer edge of the switchboard.

Plug Shelf and Keyboard: The lay-out of the equipment is shown in Fig. 5. The use of a universal cord circuit suitable for subscriber to subscriber, subscriber to trunk, and trunk to trunk switching connections would have involved additional relays, and, therefore, again with the object of conserving as much equipment as possible, it was decided to use separate cord circuits for trunk to trunk connections. Thus cord circuits 1-14 are provided to cater for the majority of connections, i.e., subscriber to subscriber and subscriber to trunk. Two cord circuits, viz., T1 and T2, cater for through trunk connections. It was considered advisable also to cater for a four-wire trunk connection. The network switching cords give this facility.

Provision has been made for two transfer circuits by including drillings as shown. The location selected at each end of the cord circuits was done for the purpose of providing a balanced arrangement. However, since the switchboard is designed for locations where not more than two positions are envisaged, the transfer circuits will not normally be required. The provision is made merely as a precautionary measure to facilitate installa-

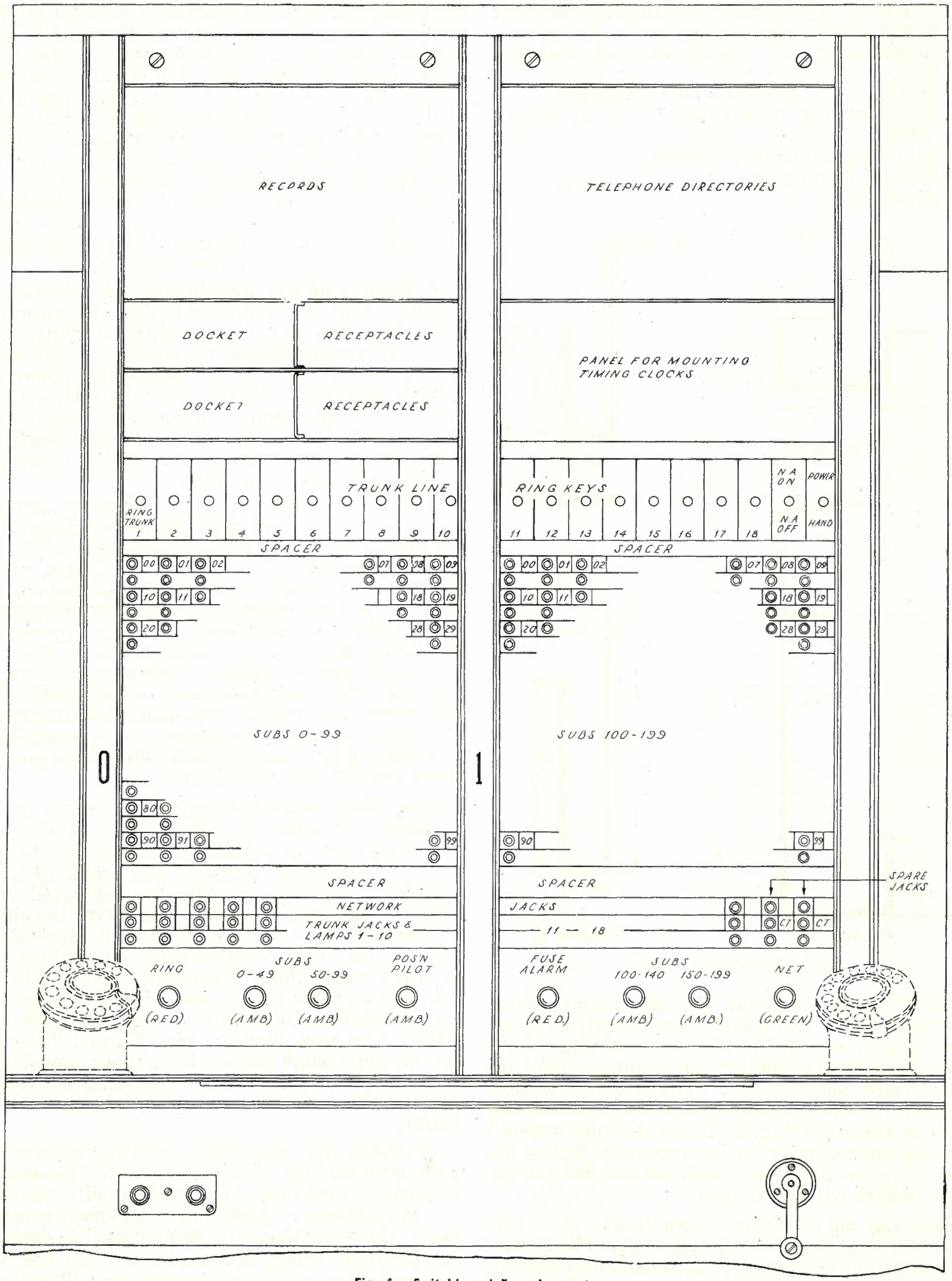


Fig. 4.—Switchboard Face Lay-out.

tion in the exceptional case where more than two positions are unavoidable and transfer working is inescapable.

The dotted holes for the meter keys are shown merely to illustrate that the keyboard is practically identical with the keyboard on a standard multiple switchboard position (3). Provision is made for the mounting of a dial, spare dial and dial changeover key.

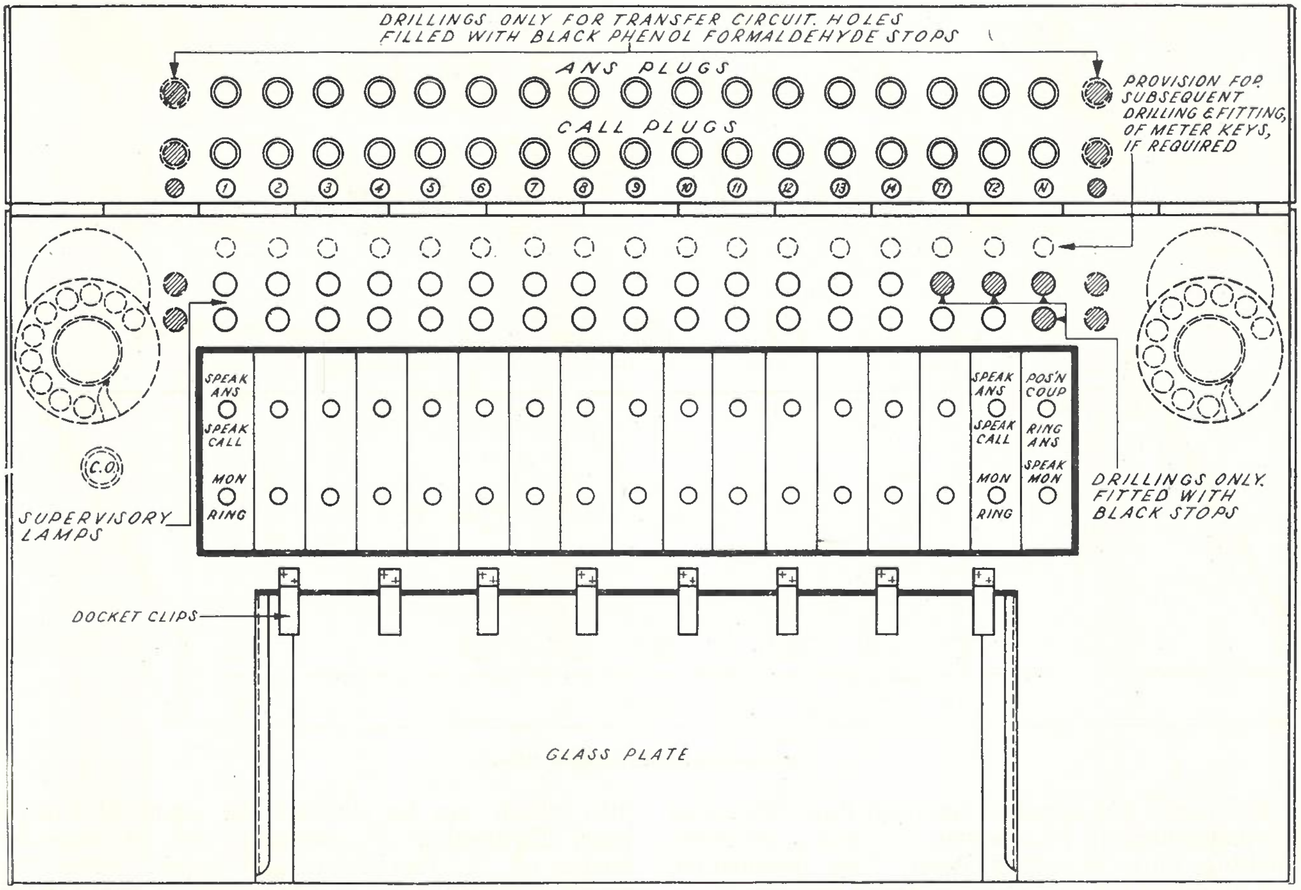


Fig. 5.—Plug Shelf and Keyboard.

The keyboard is fibre faced in the conventional way, but an innovation introduced by the Superintending Engineer, Sydney, and tried successfully at Berry, is incorporated on the plug shelf. The normal thickness of the wooden portion of the plug shelf would be 1" plus fibre facing of thickness $\frac{1}{8}$" to match an equivalent arrangement on the keyboard. However, in this case the fibre facing has been dispensed with, and the main wood base, which is finished matt black on the top, is $\frac{7}{8}$" in thickness. On top of this is a $\frac{1}{4}$" panel of clear methyl methacrylate. The arrangement which is shown in exploded form in Fig. 6 allows for the top portion of the plug shelf to be removed and changed or reversed if necessary at any time when the cord holes exhibit excessive wear. The change can be made in the matter of a few minutes. The designation discs are inserted in the wooden base and show clearly through the transparent panel. These designations are thus protected from defacement.

Provision for Cabling. The external cables may be brought in from overhead or from under the floor, whichever is the more convenient for a particular installation. For the floor entry a plate in the bottom of the board may be removed for the purpose. The overhead entry is catered for by the provision of a removable trap 6" x 3" on the top of the switchboard through which the cable may enter. The position of the trap is shown in Fig. 2. Brackets are provided on the right-hand side of the switchboard at appropriate intervals for use as a cable runway.

Removable Panels: To give full accessibility for installation and maintenance, the front, side and rear panels are all removable. The top of the switchboard is designed with one side of the cable trap forming part of the outer edge of the top so that the latter can be removed and replaced readily without fouling the cable.

Relay Set Rack: The physical dimensions of the rack are 8' $6\frac{1}{2}$" high and 2' 9" wide. The rack is generally in accordance with the requirements of the relevant B.P.O. specifications for 2000 type racks, and is fitted with nine shelves, each shelf arranged to accommodate five relay sets of ten relays. Each shelf is complete with cradles and 32-point switch jacks.

In the past it has been the usual practice to provide screw terminals to which the forked cord tags are connected. This involves the use of two cord rails. The new connecting link, which is shown in Fig. 11, consists of a terminal assembly

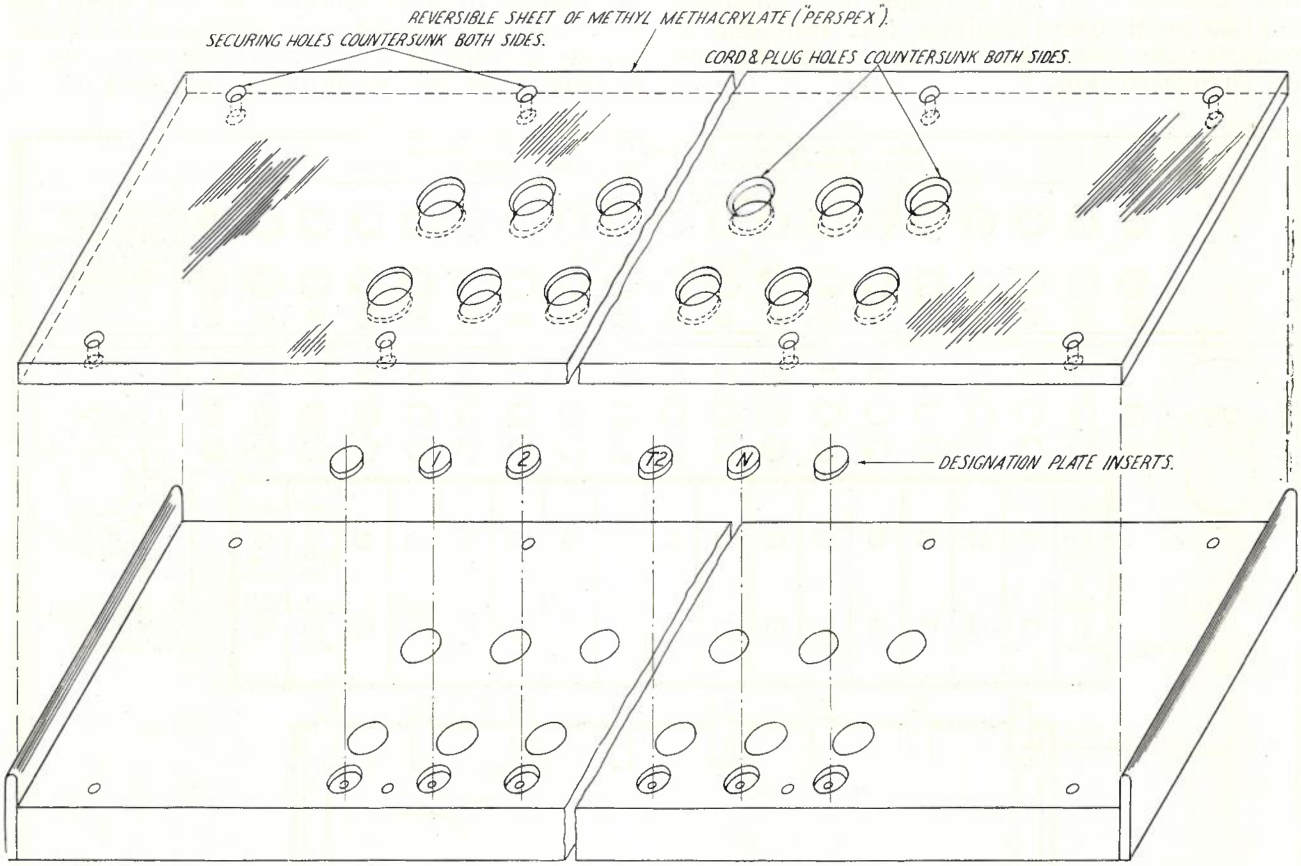


Fig. 6.—Plug Shelf, Exploded View.

The racks are supplied unwired, but otherwise complete with all accessories to make a complete working unit, including fuses, fuse mountings, and facilities for providing common services.

As it is intended to fuse the switchboard from the relay rack, individual fuses are provided on the rack on the basis of four groups of ten 1.5 amp fuses and one group of six 1.5 amp fuses as well as the main rack fuse.

A rack delivered recently is shown in Fig. 7. Eight 2-wire trunk circuit relay bases are mounted for the purpose of illustration.

Complete switchboard: Photographs of a switchboard position delivered recently by the Telephone Manufacturing Company, England, are shown in Figs 8, 9 and 10. In Figs. 8 and 9 the directory receptables are hidden by the notice board. This switchboard contains a new type of cord terminal developed recently for the British Post Office and fitted at the request of the Department.

into which can be pressed six standard forked tags. Tightening or loosening can be done by means of the knurled thumb screw. When the screw is released for the insertion or withdrawal of tags, the entire assembly is held by light tension from the spiral spring thus rendering it unnecessary to hold the tags by hand until the screw is tightened.

The four insulating blocks forming the housing for the assembly are made from phenol formaldehyde. One cord rail only is required because each terminal assembly will accommodate the tip, ring and sleeve connections from both the calling and answering cords, in the same space previously occupied by one set only of these three connections.

Although the new cord terminal is an extremely simple device, it marks a most important milestone in the development of manual switchboards, and emphasises the usefulness of plastics in the telephone industry.

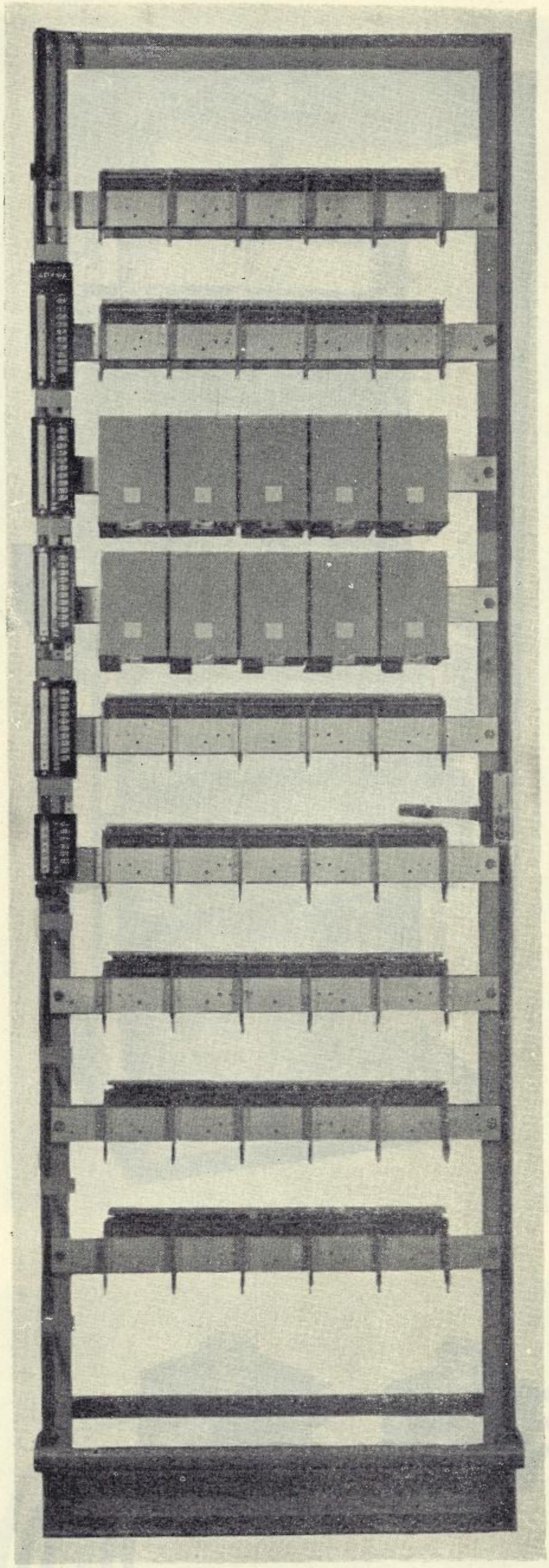


Fig. 7.—Relay Set Rack.

Figs. 12 and 13 show the layout of the relay sets and the arrangement of the connections to the terminal strips at the rear of the switchboard. On future switchboards purchased all trunk circuits will be convertible from two-wire to four-wire and to do this an additional terminal strip will be provided and a re-arrangement of connections will be made.

Circuits

It is not proposed to describe the circuits in detail because they are largely self-explanatory.

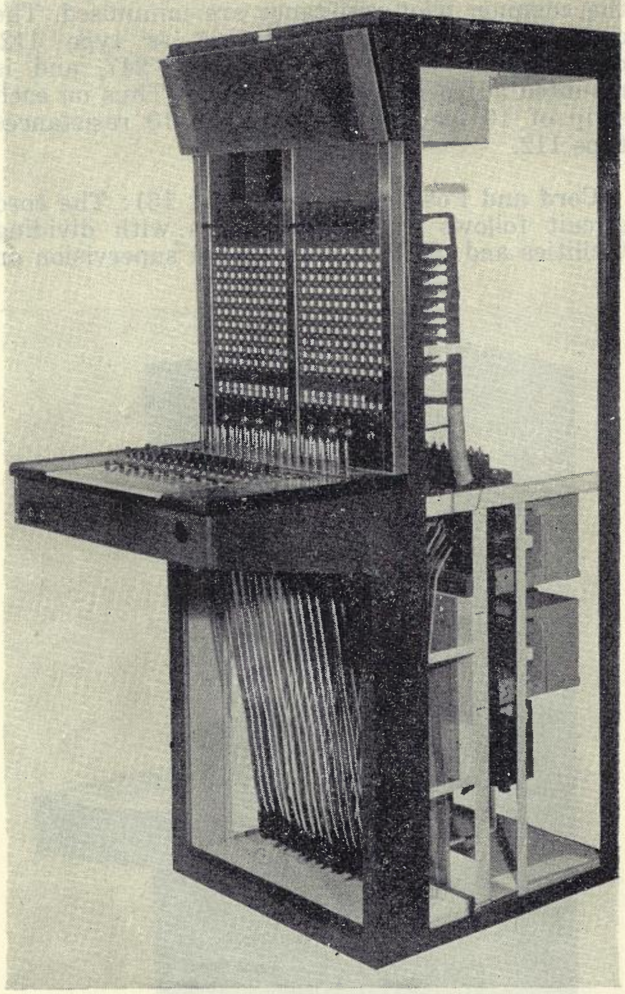


Fig. 8.—Switchboard, less front, side and rear panels.

However, the main points of interest will be discussed.

Subscribers' Line and Night Alarm Circuit (Fig. 14.) : The most interesting feature of this circuit is that a line pilot, LP, is used for every 50 lines with a common position pilot relay, PP, for each position. The provision of four line pilot relays is necessary because of the large values of cumulative line leakance on open wire lines. At Berry, which is close to the coast, measurements as high as 19 mA were experienced. This rendered it impracticable to design a single relay which would give the necessary operate and release characteristics with a proper factor of safety under fault conditions. Each line pilot operates a sectional pilot lamp as well as the position pilot lamp. The sectional pilot lamps are on the front panels of the switchboard, and thus facilitate the isolation of faults. The condenser, QA, is of high capacitance to shunt voice frequency currents so that crosstalk effects due to the common pilot resistance are minimised. The current limiting resistance YA is type 112, described in Vol. 6, No. 4, page 247, and is mounted adjacent to the call lamp. Thus on each strip of 10 lamps there are also 10 resistances type 112.

Cord and Position Circuit (Fig. 15): The cord circuit follows conventional lines with dividing facilities and positive switch hook supervision on

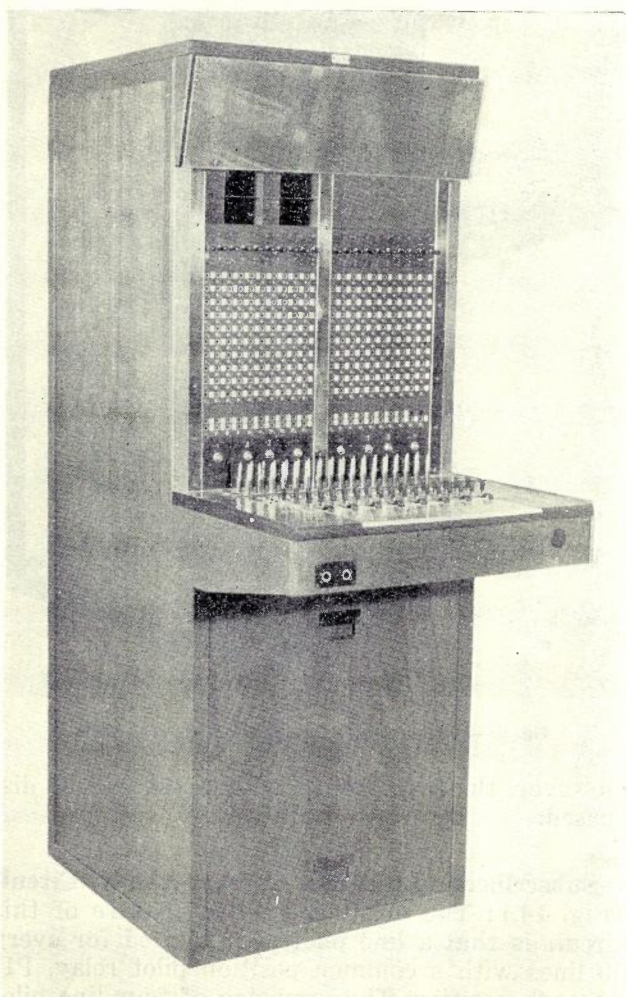


Fig. 9.—Switchboard, Complete.

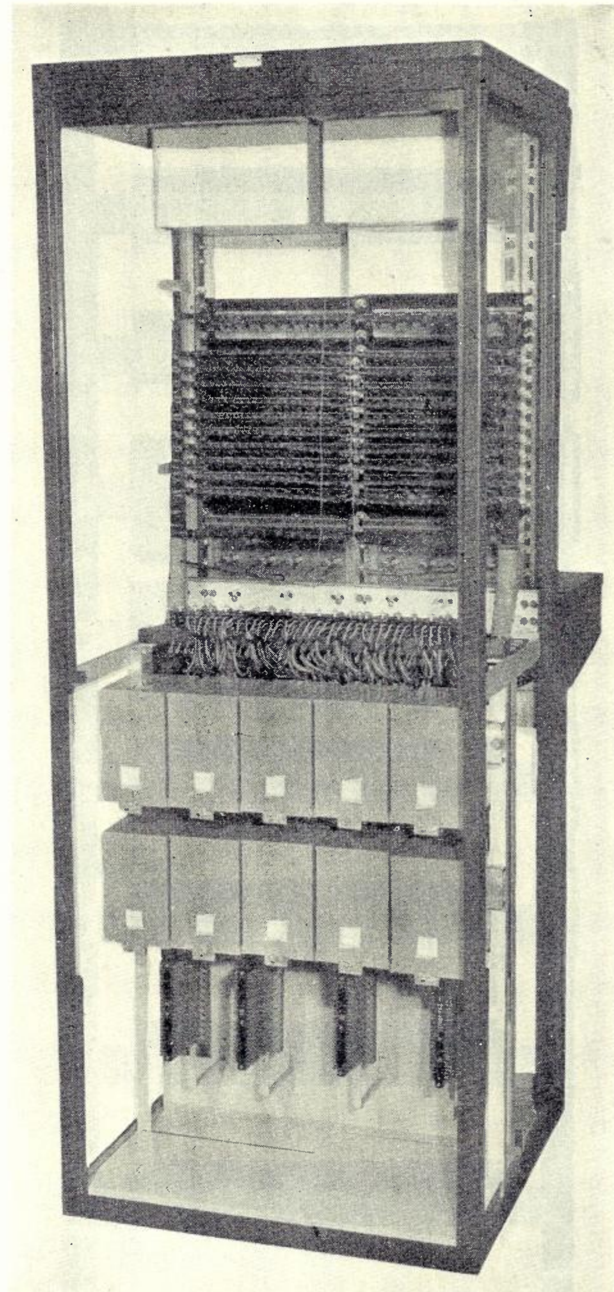


Fig. 10.—Switchboard, Rear View, with panels removed.

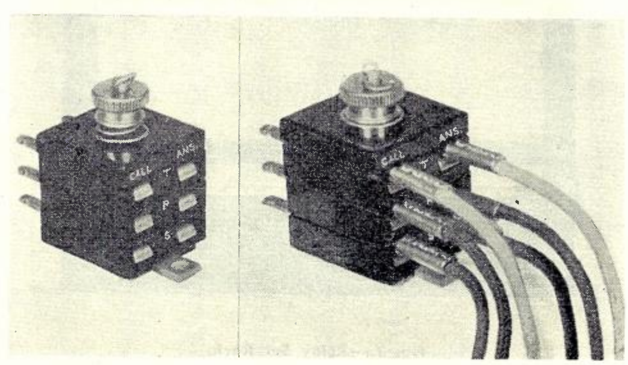


Fig. 11.—Cord Fastener, Terminal Assembly.

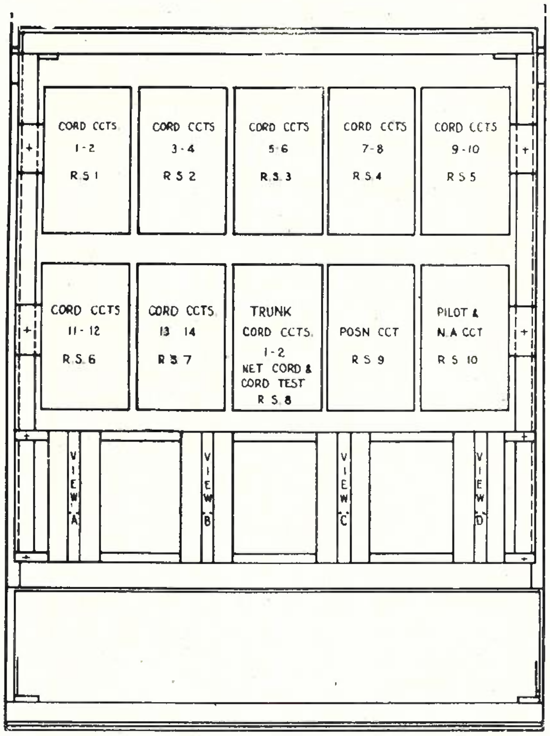


Fig. 12.—Layout of Relay Sets and Terminal Strip at rear of Switchboard.

current limiting resistance YA is type 112, subscriber to subscriber connections. A supervisory night alarm is provided by means of rectifiers MRA and MRB connected to the position pilot relay PP, Fig. 14. On subscriber to trunk connections, positive supervision is given on the subscriber's side, but on the trunk side a fleeting

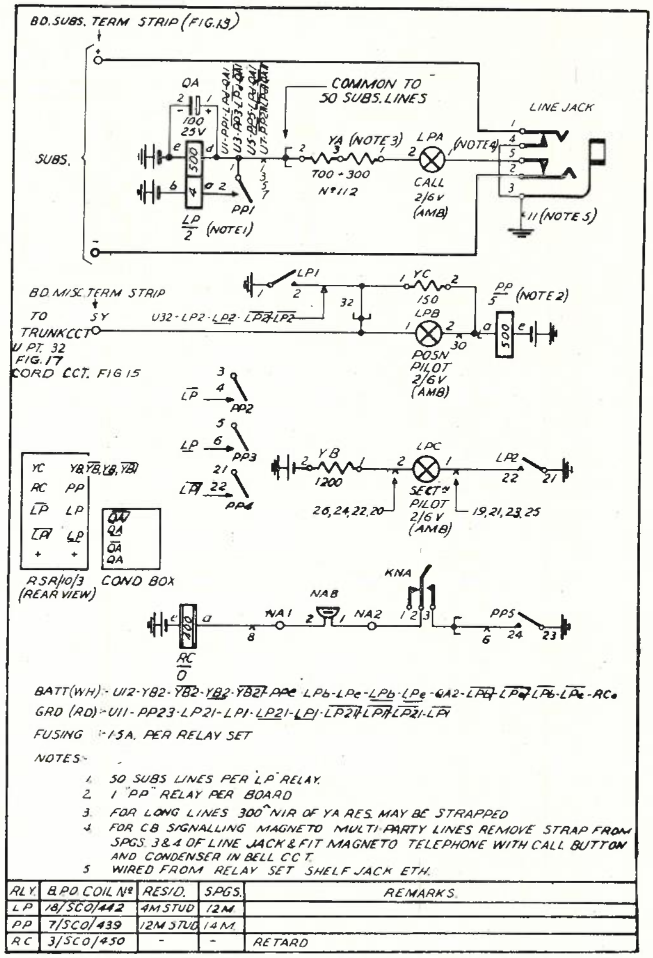


Fig. 14.—Subscriber's Line Circuit.

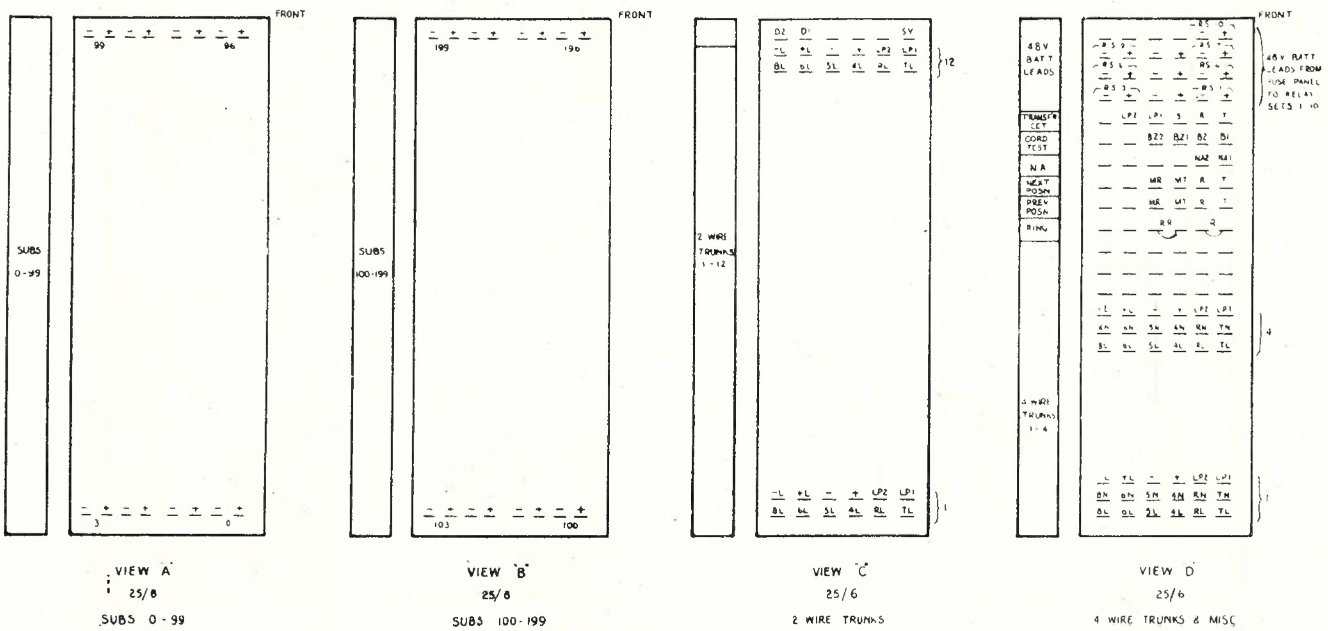


Fig. 13.—Terminal Strip Appropriation.

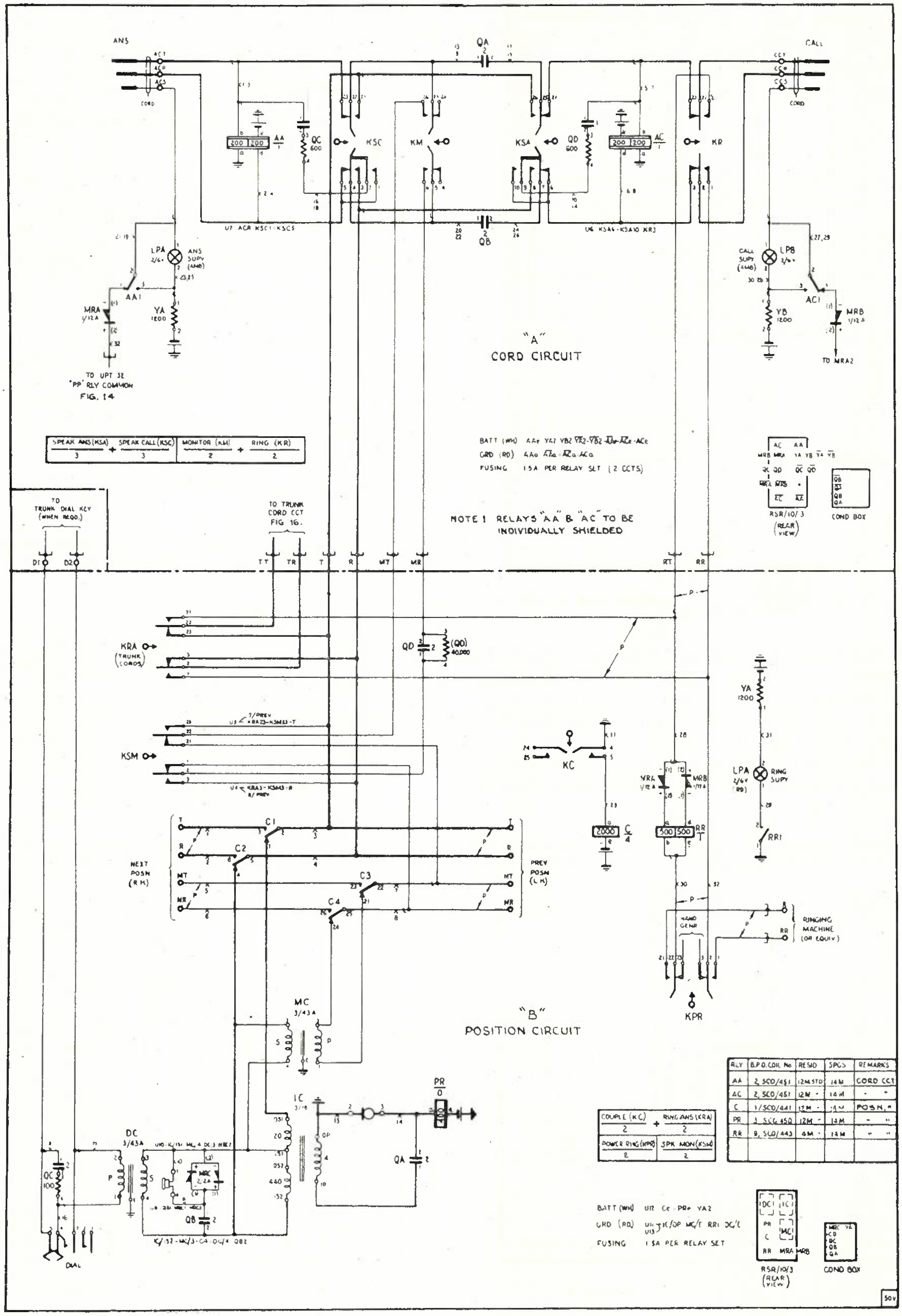
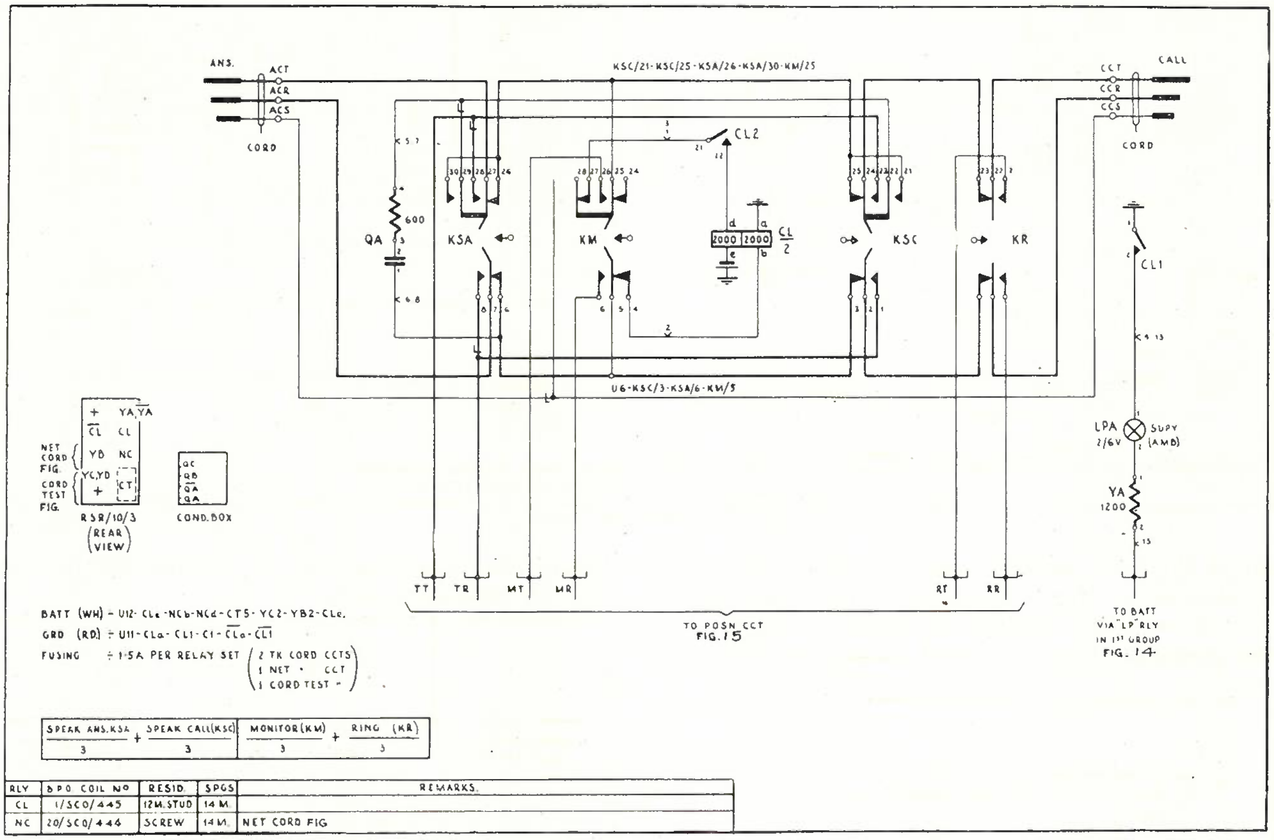


Fig. 15.—Cord and Position Circuit.

supervisory signal is received for the duration of the ring off via contact L2 in Fig. 17. Resistor-capacitor units QC and QD provide the usual voice frequency terminations for certain switching conditions.

On the position circuit provision is made for a dial if required. High impedance monitoring facilities are included via transformer MC. Position coupling is catered for by relay C under the concontrol of key KC. The 40,000 ohm resistor across inserted in jack. The rectifier bridge arrangement gives maximum potential to operate relay L from rectified A.C. The outgoing ring is transmitted clear of all equipment via ringing key KR. This is done for simplicity. Relay L transmits supervisory signals to the cord circuits via contact L2. The circuit may be provided for 2-wire or 4-wire switching as required.

Cord Test Circuit (Fig. 18): Supervisory signals and continuity of cords are tested on jack A.



RLY	B.P.O. COIL No	RESID.	SPGS	REMARKS.
CL	1/SCO/445	12M. STUD	14 M.	
NC	20/SCO/444	SCREW	14 M.	NET CORD FIG

Fig. 16.—Trunk Cord Circuit.

QD is a conventional arrangement for contact wetting purposes.

Trunk Cord Circuit (Fig. 16): This circuit is designed for "through" trunk switching connections to give minimum insertion loss, maximum ringing efficiency, and supervision at least equivalent to that given by a clearing indicator in a magneto switchboard. When the ring off is received from either trunk circuit, relay CL operates from battery via L2 of Fig. 17 and locks up at CL2. The supervisory lamp thus glows until the telephonist intercepts or clears the connection. The supervisory lamp circuit is wired through the first group LP relay, Fig. 14, which operates the position pilot and N.A. circuit.

Trunk Line Circuit. 2-wire Convertible to 4-wire (Fig. 17): When an incoming ring is received, relay L operates and locks until plug is Jack B permits the testing of the outgoing ring by a bell. The transformer and buzzer associated with jack B provide a tone for the purpose of checking the transmission, e.g., cord circuit condensers.

Network Cord Circuit (Fig. 19): Relay NC operating to the sleeve of the jack causes a network pilot lamp to glow if the 4-wire connection is incomplete. This relay also provides a proper V.F. termination until both cords are inserted into jacks at which time differentially connected relay NC releases because of opposing currents.

Transfer Circuit (Fig. 20): This circuit is a conventional type of transfer circuit providing for plug ending at the "A" position and jack ending with lamp signalling at the trunk position. The interaction of relays X and Y provide a flicker earth for operation of a flashing supervisory sig-

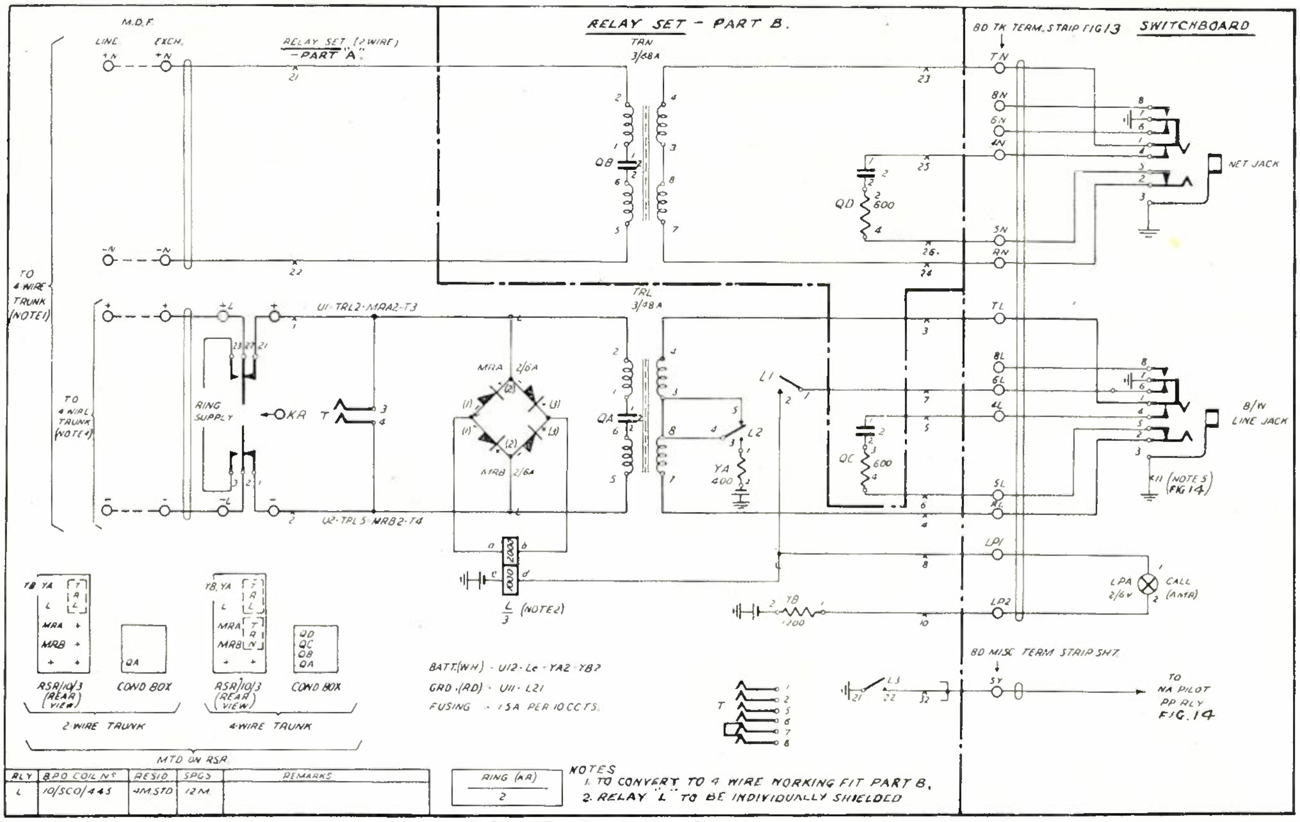


Fig. 17.—Trunk Line Circuit.

nal at the "A" position when the transfer circuit is released by the trunk telephonist, who has full control over the connection. Since not more than two positions are envisaged in the general case, the provision of the transfer circuit will be made only in isolated instances.

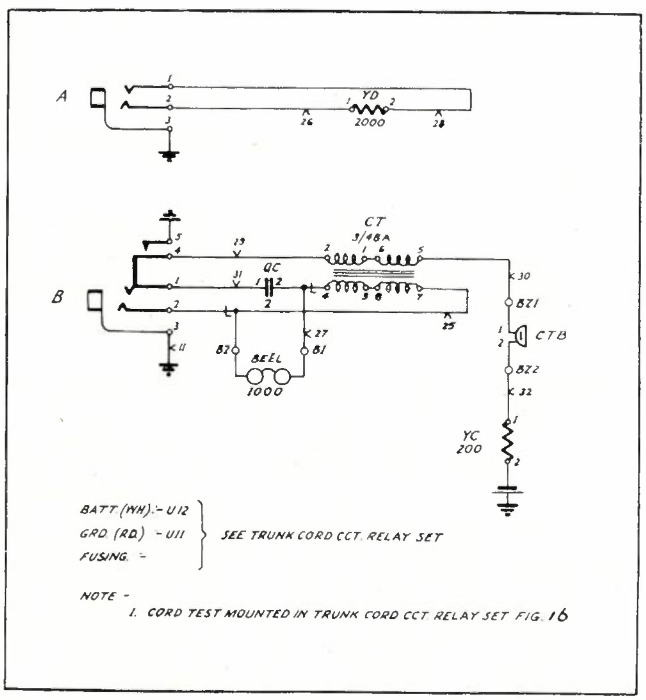


Fig. 18.—Cord Test Circuit.

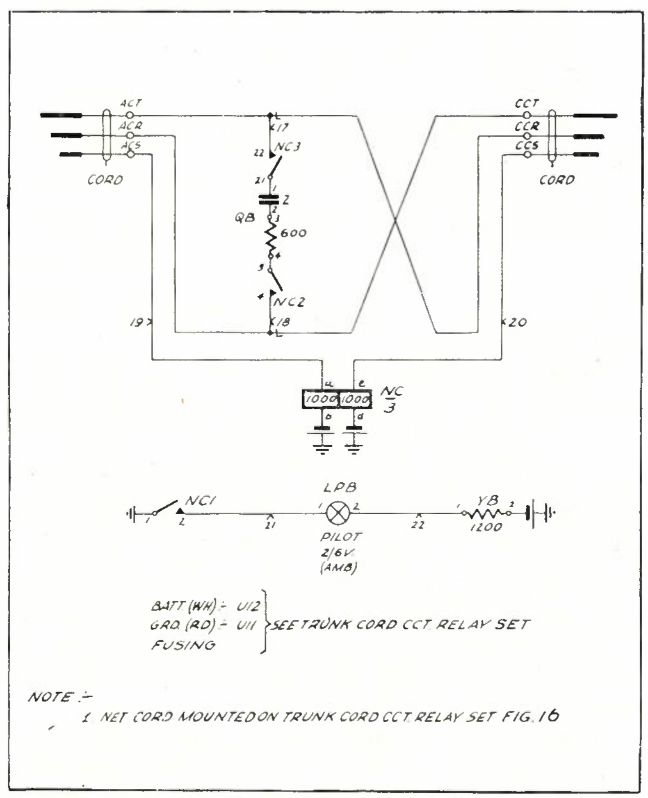


Fig. 19.—Network Cord Circuit.

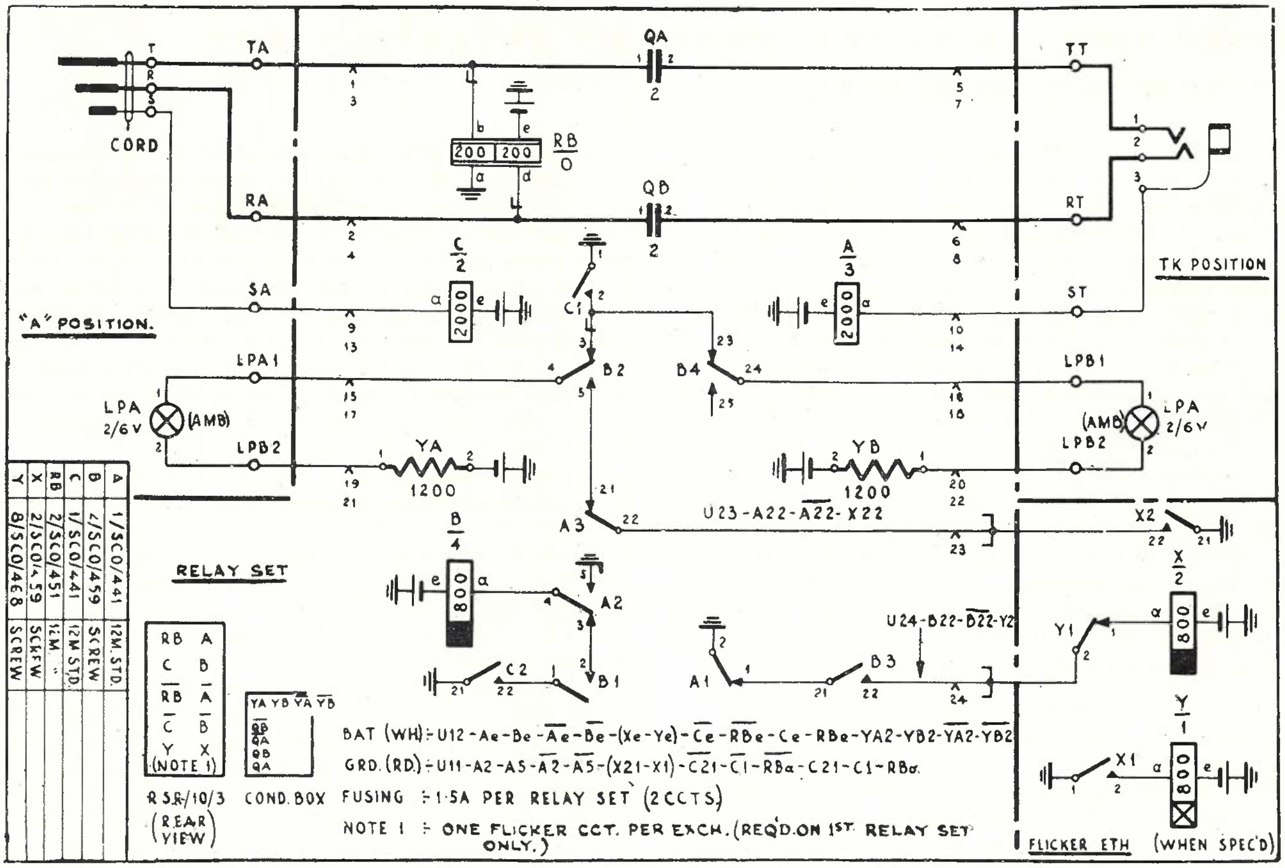


Fig. 20.—Transfer Circuit.

Acknowledgments

The authors desire to pay a tribute to all concerned in the Engineering Branch and Telephone Branch in New South Wales for an excellent co-operative effort in producing and installing the prototype switchboard at Berry within a comparatively short space of time. In the Central Administration credit is due to all engineering officers and draftsmen associated with the project in further developing the circuits, and developing and finalising the physical design. Acknowledgement is due to the Telephone Branch personnel for their co-operation, and also to the manufacturers for helpful contributions.

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Errata

Vol. 8, No. 1, Manual C.B. Exchanges for Country Centres—Page 34—delete reference to Drawing C.E.336 and insert C.E. 366.

Vol. 8, No. 1—Manual C.B. Multiple Exchanges and Sleeve Control trunk Switchboards. Page 39, Fig. 5. The locations of the "Subs. Plugs" and "Trunk Plugs" on the plug shelf should be reversed.

SOME ASPECTS OF ELECTROLYSIS INVESTIGATION IN NEW SOUTH WALES

T. W. Crams e

Introduction

The theory of electrolysis and other forms of corrosion has been covered comprehensively in various publications, and statistical details of faults which have occurred on Departmental cables throughout the Commonwealth due to corrosion and other causes were given previously by C. J. Griffiths in this Journal, vol. 3, No. 6. In the present paper it is proposed to describe the practice followed in New South Wales in investigating conditions giving rise to cable failures due to stray current electrolysis and the application of drainage bonds as remedial measures. An outline is given of the method of carrying out electrolysis surveys, including a description of the recording meters, the selection of test points, and the interpretation of results. This is followed by an examination of the design principles involved in the installation of a drainage bond and a description of the equipment used.

Routine Surveys

There are two methods of approach to the problem of electrolysis testing:—

(i) The routine survey, in which a defined area is comprehensively surveyed at specified periods and appropriate steps taken to correct any unsatisfactory conditions which may be disclosed.

(ii) The investigation of conditions in the immediate vicinity of a cable fault if visual examination of the faulty cable suggests electrolysis as the probable cause of failure.

In the initial stages of electrolysis investigation tests were almost exclusively carried out in areas where actual faults had occurred. Routine surveys were commenced later. As remedial measures are applied, generally in the form of drainage bonds, which reduce the number of actual or potential corrosion areas, the routine survey becomes the normal method of attack. Conditions never become stable over long periods in traction areas as loading on the traction systems changes with development, tramway and electric railway services are extended, curtailed or eliminated, additional telephone cables, water and gas pipes are laid, and tram tracks which may not have carried rolling stock for years, but have still formed a part of the electrical system, are ultimately removed.

The present aim is to survey each area once every two years, with small supplementary surveys when any local major change in the traction systems takes place. In this connection it is of interest to note that five of the six drainage bonds now under construction were found necessary by routine investigation, and only one as the result of tests following a cable fault.

A telephone exchange area is the unit area of survey, and an electrolysis plan is prepared for

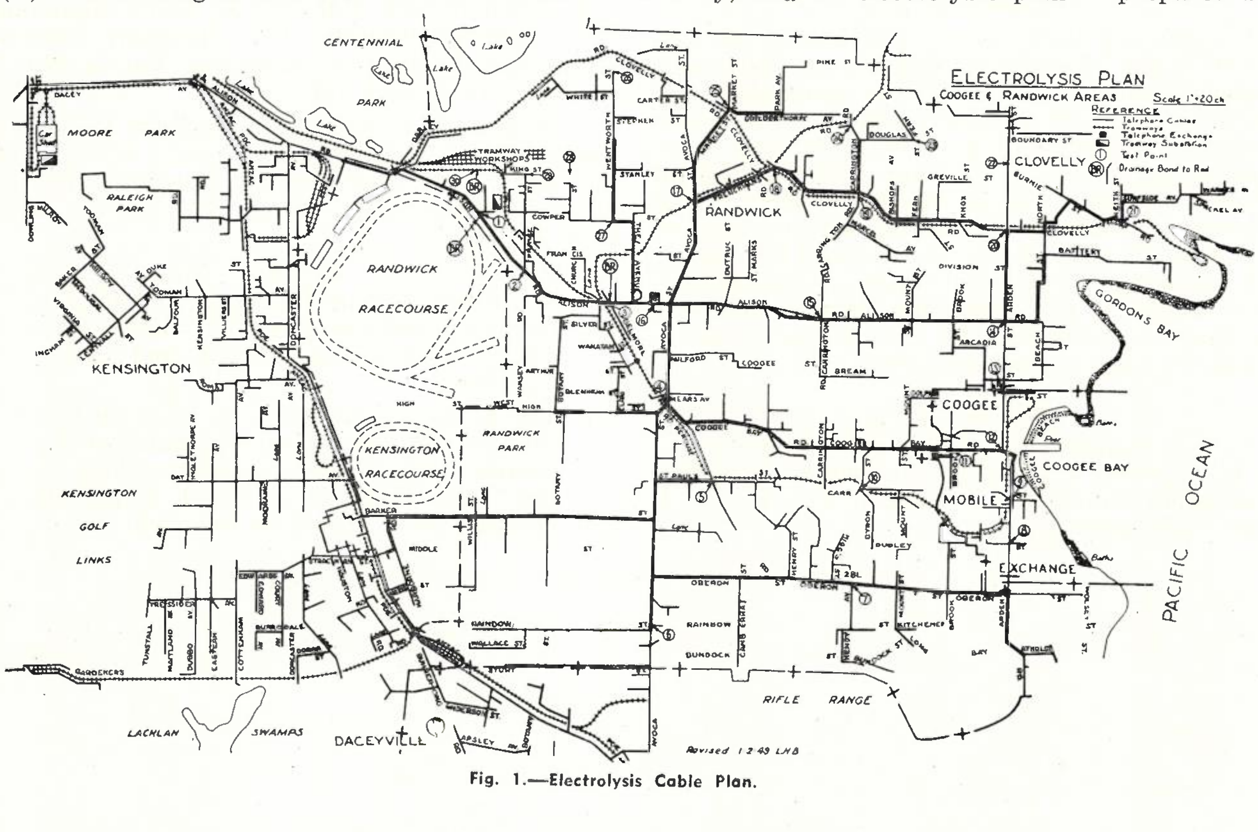

Fig. 1.—Electrolysis Cable Plan.

each such area, showing all cables from 28 pairs in size upwards. Fig. 1 is a typical electrolysis plan. Cables of 200 pairs and larger are drawn with a thicker line to indicate the more important routes.

Location of railway and/or tramway sub-stations and tracks, installed drainage bonds and points at which tests are usually made are included. Test points are numbered in a sequence so that minimum distances are travelled in installing and recovering the recorders if the positions are followed in order. These plans also form an index to recordings which are filed in numerical order in accordance with the test point number.

Conditions tending to result in anodic electrolysis in traction areas.

Fig. 2 (a) represents the conditions existing in the simplest case of an evenly loaded traction system, MN, with a sub-station connected at one end and paralleled throughout its length by a cable PQ. AA^1 represents the potential of the rails with respect to a remote earth, and BB^1 that of the ground surrounding the cable. CC^1 represents the potential of the cable sheath. At point O conditions are neutral. The cable will tend to pick

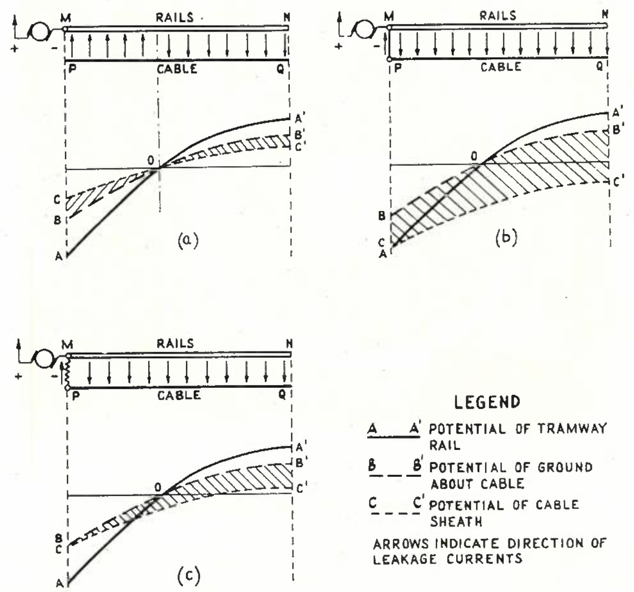

Fig. 2.—Graphical Pepresentation of Relations between Tramway, Rail Cable Sheath and Soil Potentials.

up current in the section to the right of this point in accordance with the potential differences represented by the area B^1OC^1. Similarly, the cable will tend to discharge in the section to the left of point O.

Fig. 2 (b) represents conditions when a connection of negligible resistance (ie., uncontrolled "drainage" bond) is established between cable and rails at a point near the sub-station (or to a negative feeder). The cable potential approaches that of the rails at this point, but may be lowered throughout if the length of the system is not great. The area BB^1C^1A represents increased potentials tending to cause greater pick-up of current. The cable under these conditions constitutes a danger to other underground structures in the vicinity, and may itself be liable to cathodic corrosion, more particularly in the section remote from the sub-station.

Fig. 2 (c) represents conditions of controlled drainage, whereby the resistance of the cable to

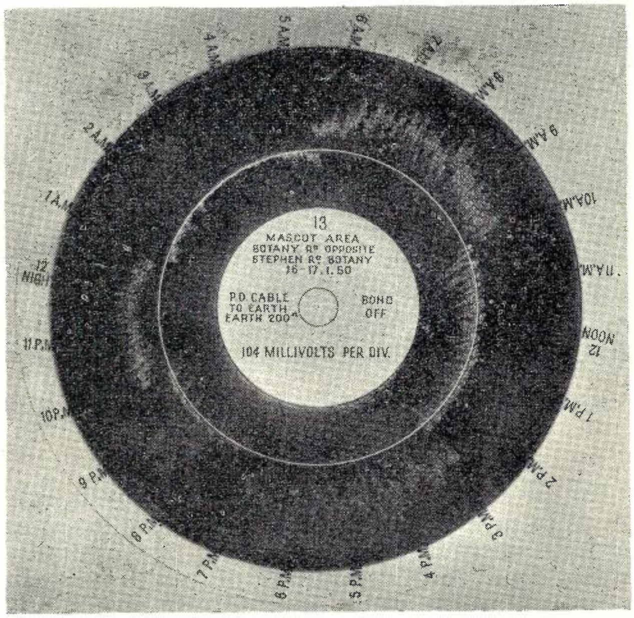

Fig. 3.—Test Chart, showing effect of Substation Operation.

rail connection is such that the cable and soil potentials are approximately equal. The desired adjustment of the drainage connection is that which makes the cable 0.05 volt negative to earth, but drainage to this value may be opposed by other bodies if actual tests indicate an adverse effect on their systems. In some cases a compromise on a bond resulting in a value less than that quoted may be necessary.

Referring again to Fig. 2 (a), similar conditions to those at P and Q can exist at the same point at different periods of the day (under more complex conditions) when an additional sub-station may be put into service during periods of heavy traffic. This is illustrated in Fig. 3. There is a sub-station in the immediate vicinity of the test point, and when in operation (from 5.15 a.m.-9.45 a.m., 3 p.m.-7 p.m. and 9.45 p.m.-12.30 a.m.) the cable would be positive to earth P. However, current passes in the drainage connection at these periods, see Figs. 4 and 5, and the condition 2 (c) obtains. During other periods of the day the bond does not pass current and the condition at Q exists. For the bond to be completely effective (when operating) the recording should be entirely within the "soil line." The conductance of this bond is apparently insufficiently large and, therefore, requires adjustment.

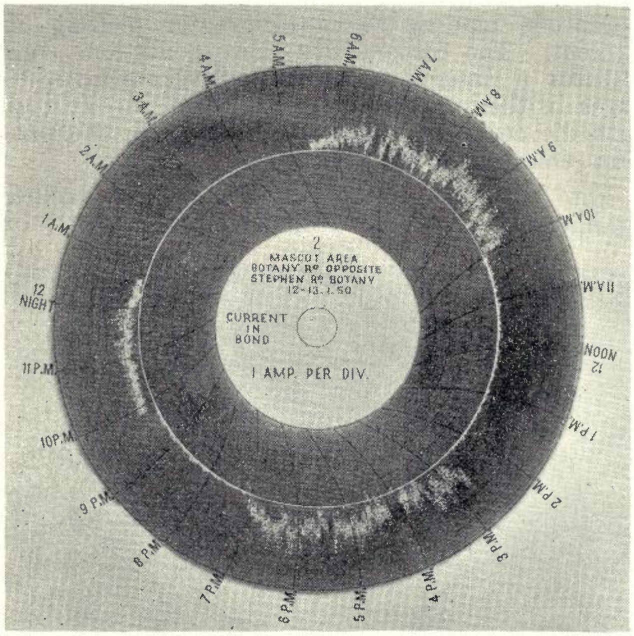

Fig. 4.—Test Chart, showing Current passed by Drainage Bond.

Recording Instruments

The principal objective of an electrolysis survey is to determine the areas in which the cables tend to discharge current. For this purpose twenty-four hour recordings of cable to earth potentials are taken at selected test points, and the results analysed in terms of cable "positive" and cable "negative" areas.

The instrument used by the Department for making the twenty-four hour tests is the "Bristol" recording voltmeter, the latest type of which is

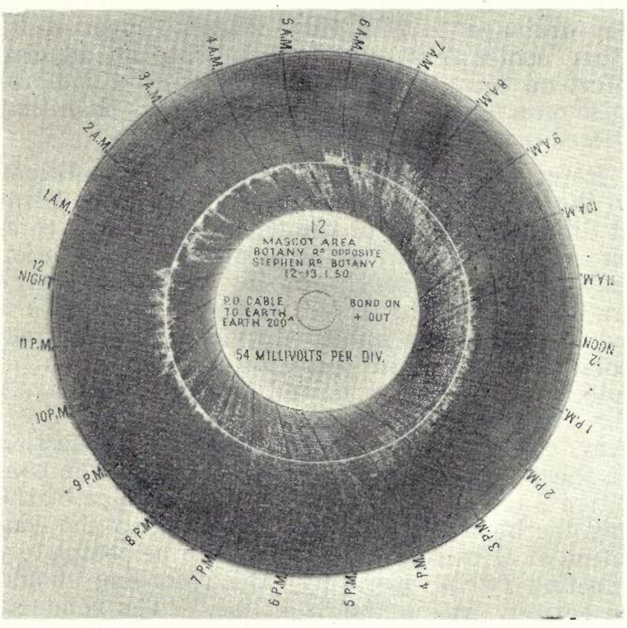

Fig. 5.—Test Chart, showing effect of Substation Operation—Drainage Bond connected (meter resistance 10,000 ohms/volt.)

shown in Fig. 6. These instruments are actuated by clockwork and record on circular "smoked" charts for a maximum period of 24 hours. The chart provides the scale of the instrument, and has a centre zero line. A zero adjustment for the voltmeter is provided. The charts are read in conjunction with the setting of an eight-position range switch and the value of the resistance of the earth connection. Fig. 7 is a chart from which the carbon deposit has been removed for clarity and shows the main divisions and sub-divisions.

The voltmeter needle is free to move, except during the actual period of recording, which

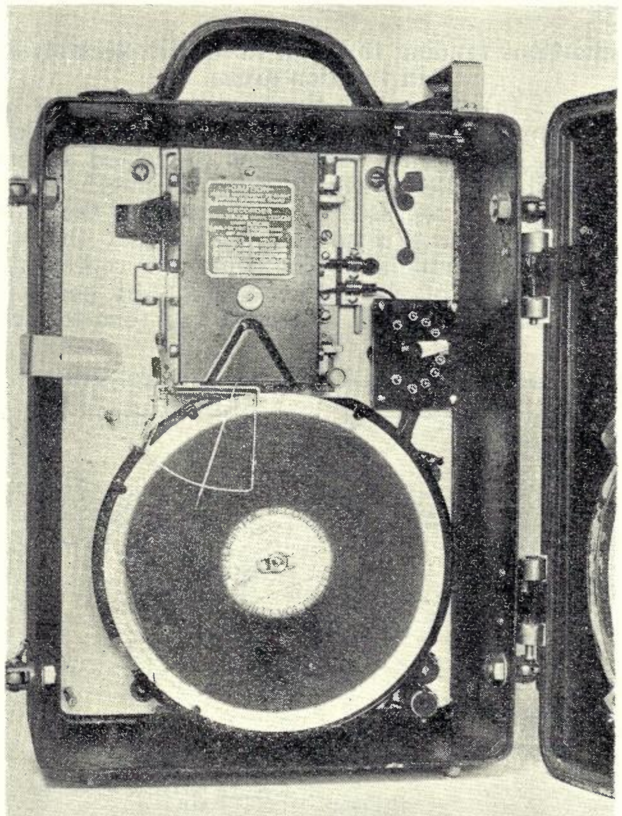

Fig. 6.—Bristol Recording Millivoltmeter.

occurs at intervals of approximately six seconds. Recording is effected when a chopper bar causes the point of the needle of the voltmeter to impinge on the smoked surface of the chart removing a small portion of the carbon deposit and indicating the value of the potential at that particular instant. Connections of the instrument are such that positive potentials are recorded outwards from the centre zero line.

The more recent types of instrument have been modified locally to give ranges of 10, 50, 100, 250, 500, 750, 1000 and 5000 millivolts each side of the centre zero. Voltages greater than five are likely to be experienced only when cable to rail measurements are required. The inclusion of a one megohm resistor in series with the instrument is satisfactory in most cases to extend the range for this purpose.

In soils of high resistivity the earth resistance at a test point may be large and reduce the sensitivity of the instrument. In such locations it is often not possible to take a satisfactory recording with the older Bristol recorders (300-500 ohms per volt) as the earth plate resistance "swamps" the instrument resistance and, unless the potentials to be measured are large, the result is little more than a straight line. The later meters (10,000 ohms per volt) in such locations are capable, in general, of giving a satisfactory recording. Figs. 5 and 8 are examples of recordings taken at the same location with the more recent and the older meters respectively.

Earth plate resistances are measured with a Megger earth tester, and, unless very small, need to be considered when determining the range of the meter for any particular recording. A recorder having a characteristic of from 50,000 to 100,000 ohms per volt is desirable, as earth resistances could be ignored and a comparison of conditions at different locations could be more readily determined by inspection of relevant charts.

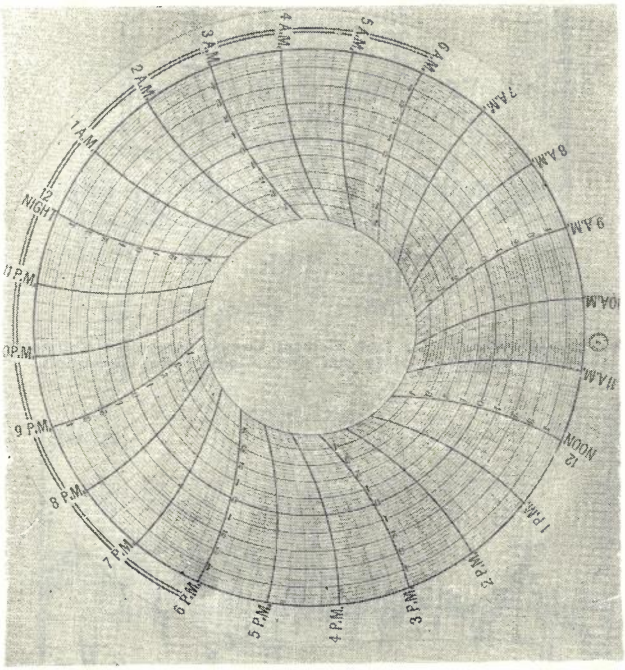

Fig. 7.—Bristol Recording Millivoltmeter Chart—Carbon deposit removed to show scale divisions.

Charts are supplied in boxes of 25, and are separated from each other by spacers at the centre and outside edges. The boxes require careful handling or damage to the chart surface is likely. After the recording has been made the charts are "fixed" by immersion in a solution of shellac in methylated spirits and can then be handled with safety.

Orders have recently been placed for recorders using paper rolls in lieu of circular charts. These will permit continuous records to be taken, and thus enable week-end conditions to be compared with those of normal periods. It will be possible

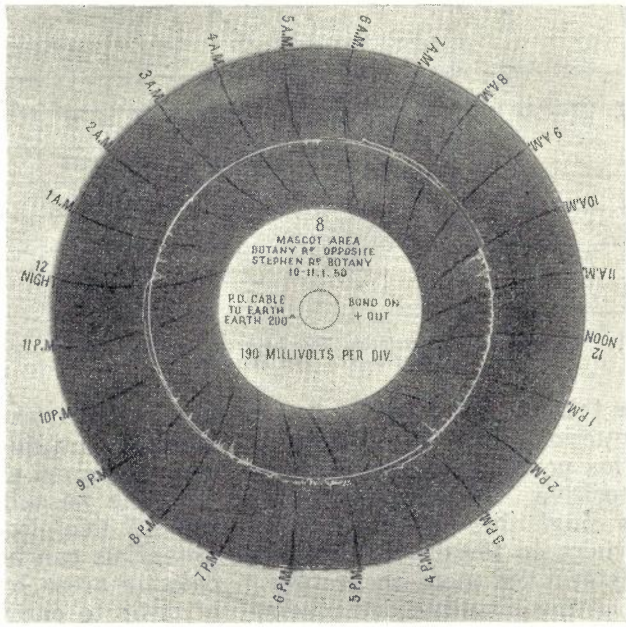

Fig. 8.—Test Chart, showing effect of Substation Operation—Drainage Bond connected (meter resistance 400 ohms/volt.)

also to leave the instruments in isolated localities to take recordings over several days, without the necessity for a 24-hour time limit to be fixed for their recovery. The lack of this facility has resulted in much valuable information not becoming available during recent months when tramway services were withdrawn at week ends as the result of coal shortages.

Earth Stakes or Plates

The earth connection normally consists of a cylindrical lead tube approximately 12 inches long and 1 inch in diameter, to which is attached a lead tail. The cylinder is buried or inserted under the floor of a manhole or pit through which the "tail" protrudes. The use of any other metal than lead for an earth connection results in the formation of a crude primary cell, the voltage of which may result in misleading readings. Even with lead plates considerable differences of potential are recorded, some being positive, others negative, and allowance must be made accordingly.

It is possible to determine approximately the value of electrode potentials when measuring traction and other artificial effects if the activity due to these causes ceases for some period of the day. With traction systems there is usually an interval of an hour or more between 1 a.m. and 4 a.m. in which there is a "dead" condition. This

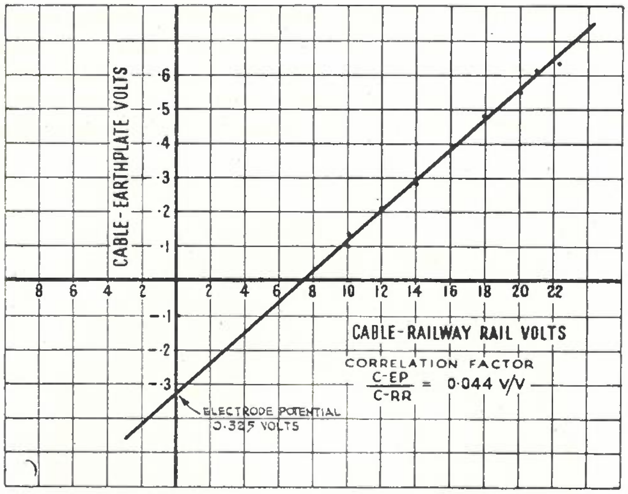

Fig. 9.—Analysis of Correlation Test between Cable/Earth Plate and Cable/Railway Rail Potentials.

is taken as the "soil line" or zero, in so far as the traction effect is concerned, recordings outside this position on Bristol charts being regarded as positive. The circumference of a circle passing through this position indicates the soil line elsewhere on the chart. Electrode potentials can be determined more accurately in traction areas by plotting simultaneous readings of cable to earth and cable to rail potentials. As shown in Fig. 9, the electrode potential is a constant and the amount of shift of the C-EP/C-RR curve from the origin determines its value.

Testing Procedure

At normal routine survey test points cable to earth potential recordings only are taken, but at drainage bond test positions as many as three meters may be installed simultaneously, to record the usual cable to earth potential, the cable to rail potential, and the value of current in the bond. It is necessary in this latter case to install a portable shunt of appropriate value in the drainage bond conductor circuit. Figs. 4, 5 and 10 are examples of such recordings.

Charts are averaged over the period recorded, and the values of cable potential to soil plotted against the various test points on a copy of the electrolysis plan. It is thus possible to determine readily the worst danger areas which are indicated by the highest positive cable to soil potentials.

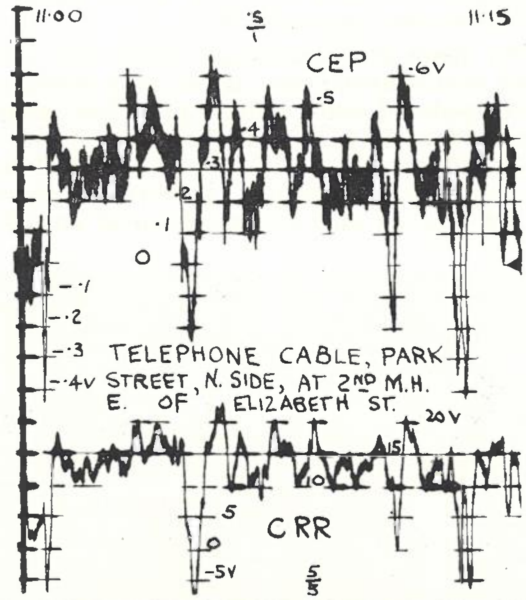

Fig. 11.—Test Chart from Twin Element Camera Recording Voltmeter, showing Cable/Earth plate and Cable/Railway Rail potentials.

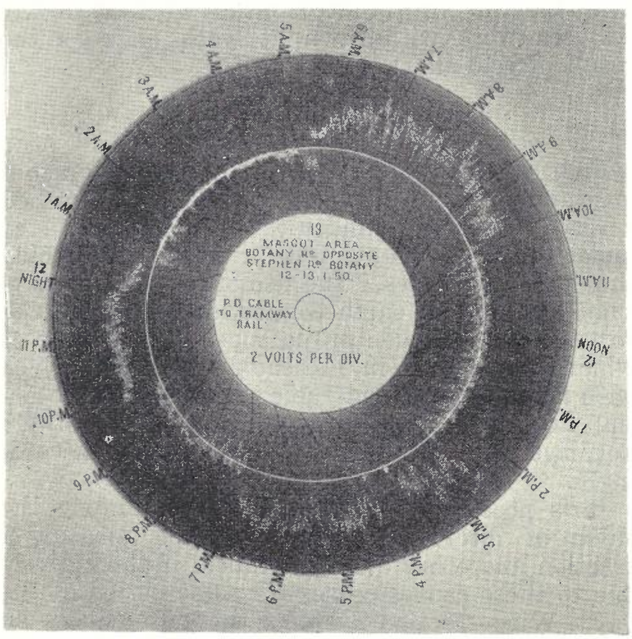

Fig. 10.—Test Chart, showing potential difference between Cable and Tramway Rail.

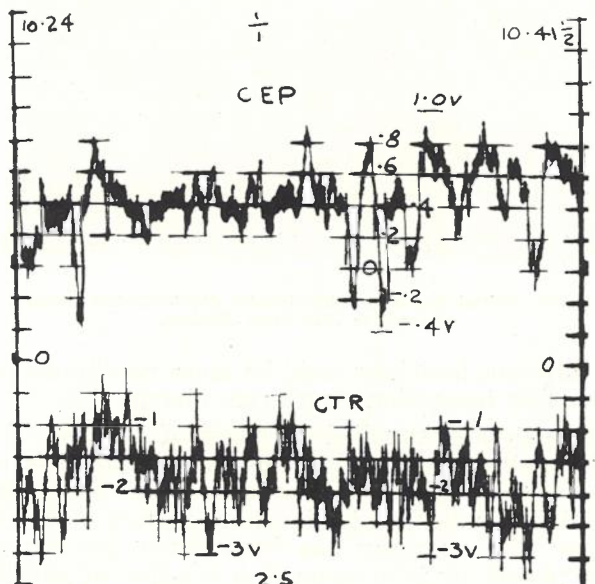

Fig. 12.—Test Chart from Twin Element Camera Recording Voltmeter, showing Cable/Earth plate and Cable/Tramway rail potentials.

Having determined the danger areas, the next step is to check the correlation that exists between the cable to earth potential and the cable to railway or tramway rail. This is done by taking simultaneous short period readings of the two potentials on a twin element camera type recording voltmeter, the property of the Sydney Electrolysis Committee, which co-ordinates the activities of the various authorities concerned in Sydney. Where both railways and tramways operate in the area concerned, tests may be taken to both systems. Figs. 11 and 12 are potential recordings of cable to earth plate and cable to railway rail, and of cable to earth plate and cable to tramway rail, respectively, at the same location in Park Street, Sydney. The railway is underground and it was necessary to arrange the testing circuit via pairs in telephone cables. The subsequent trial bond test lead, and the lead for the bond finally installed, were run down a ventilator shaft to the railway rail. The bond panel was installed in the head of the ventilator shaft. It will be noted from Fig. 11 that correlation to the railway rail is good, but to the tramway rail (Fig. 12) indefinite.

An analysis of the test to the railway system is indicated in Fig. 9, which shows points selected on the cable to earth recording plotted against simultaneous cable to rail potentials. The average of the C-EP curve for the 15 minutes of the test is +0.29 volt, from which the electrode potential of —0.325 volt is subtracted. This latter value is the amount the C-EP/C-RR curve is displaced from the origin. The high positive potential of the cable with respect to earth, namely, +0.615 volt, established a case for trial bond test and the percentage of time in which the cable is positive to rail was an indication that almost continuous drainage could be expected from such a bond.

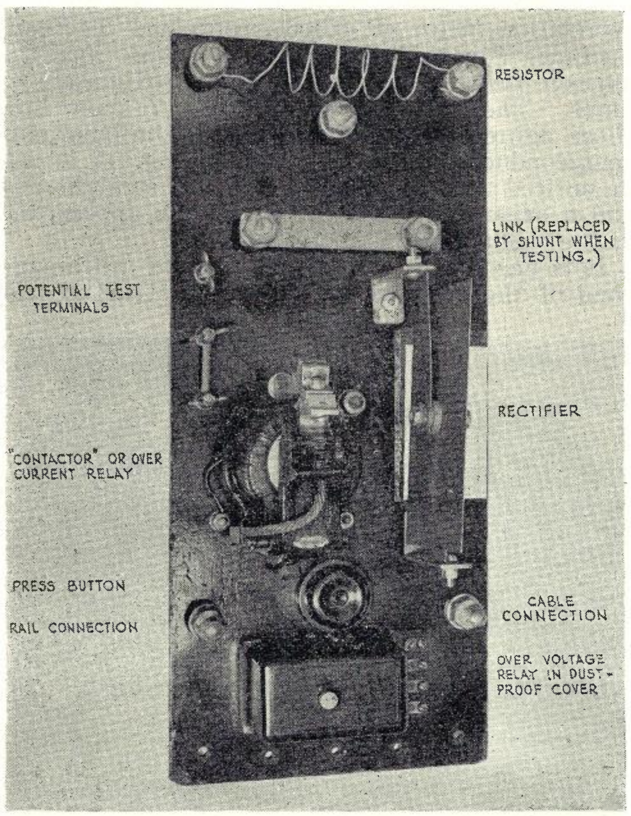

Fig. 13.—Portable Drainage Bond Panel used for Field Tests.

Trial Drainage Bond Tests

These are made by connecting a heavy conductor between cable and rail with a rectifier and variable control resistor in series. The rectifier may be dispensed with if cable is not likely to become negative to rail. A portable bond panel used in trial bond tests to simulate working conditions of the final installation is shown in Fig. 13. The layout of equipment on the portable bond panel is similar to that provided in the permanent installation. The press button, however, is an additional feature provided only on the portable panel. Operating the button completes the circuit through the contactor (but short circuiting the rectifier) to enable current to flow from rail to cable. This allows conductance tests of the bond to be carried out without waiting for the cable to rail voltages to become positive, and thus saves time spent on testing. In slack periods, at some locations, the cable may be negative to rail for a considerable time. A circuit of the drainage bond and method of operation are given later.

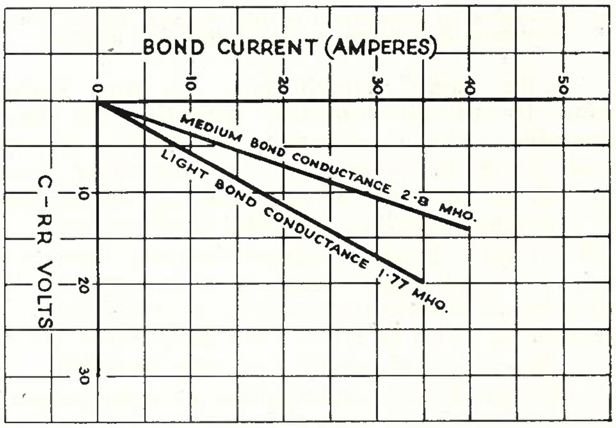

Fig. 14.—Analysis of Conductance of Trial Drainage Bond—"Light" and "Medium" Conductance. Bond Current v. Cable/Railway Rail potential.

The usual procedure is to apply a bond of such conductance that an overdrained condition will be readily apparent by an inversion of the correlation between cable to earth and cable to rail potentials. The light rays from the reflecting galvanometers in the twin element camera recorder are observed through an inspection aperture, and the conductance of the bond adjusted accordingly. This becomes the "heavy" bond condition and its effect is recorded for

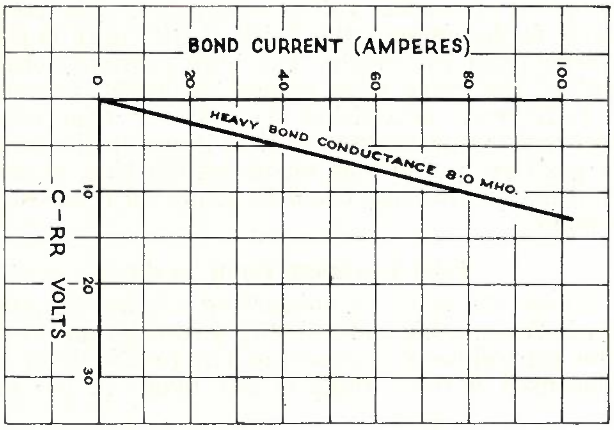

Fig. 15.—Analysis of Conductance of Trial Drainage Bond—"Heavy" Conductance Bond Current v. Cable/Railway Rail potential.

a "traffic cycle" which may be any period from 10 to 30 minutes according to local timetable. The conductance, in mhos, of this bond value is determined by recording bond current on one element and cable to rail voltage on the other and later plotting these values.

A "light" bond of approximately half the "heavy" bond conductance is then applied, its value being determined roughly by indicating instruments. The effect of this bond for a traffic cycle and its conductance are also recorded.

Analyses of the conductances of a subsequent trial drainage bond test in Park Street are shown in Figs. 14 and 15. Three conditions were taken in this test, that is, light, medium and heavy conductances. The effects of these three drainage bond conditions and the "bond off" condition are illustrated in Fig. 16.

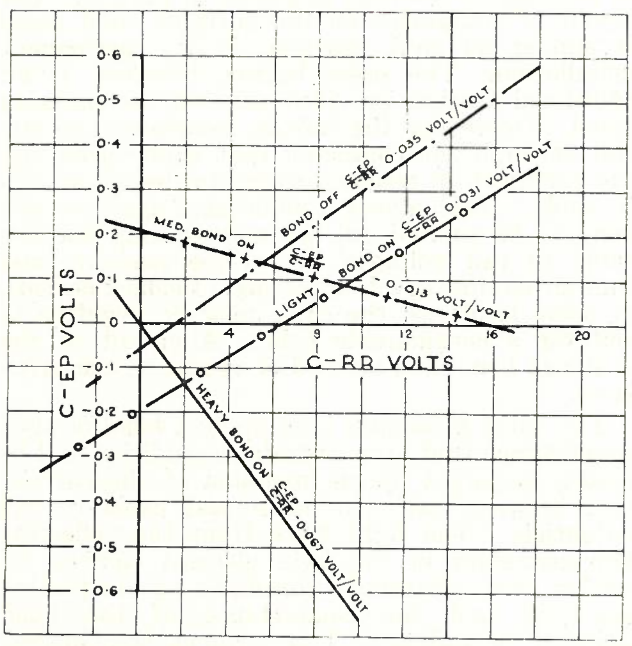

Fig. 16.—Analysis of Conductance of Trial Drainage Bond. Cable/Earth v. Cable/Railway Rail potential.

Drainage Bond Design

The next step is to plot the correlation factors against conductance, Fig. 17. Having determined the average cable to rail potential from the recording taken during the trial bond test, the correlation factor for average cable to earth potential of -0.05 volt is then calculated by dividing this arbitrary figure by average cable

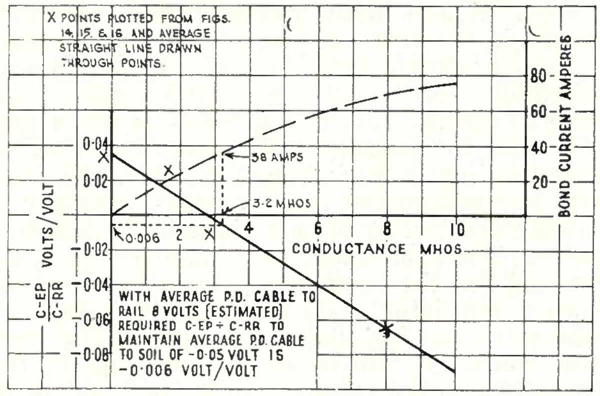

Fig. 17.—Graph showing method of calculating Conductance of Drainage Bond.

to rail voltage. The method of calculating the design bond conductance and average current in the bond with this conductance is shown in Fig. 17. The average cable to rail potential was 8 volts and when the design figure of -0.05 volt for cable to earth potential is divided by 8 a correlation factor of -0.006 is obtained. The conductance for this figure is 3.2 mhos. and the average bond current would be approximately 38 amps. The dotted lines on Fig. 17 show how these figures were derived. From the bond current/conductance curve shown in Fig. 17 it will be noticed that the relation is not a straight line and a saturation value of current is approached as the conductance is increased.

It is necessary to test the effect of a drainage bond of the designed value on the structures of

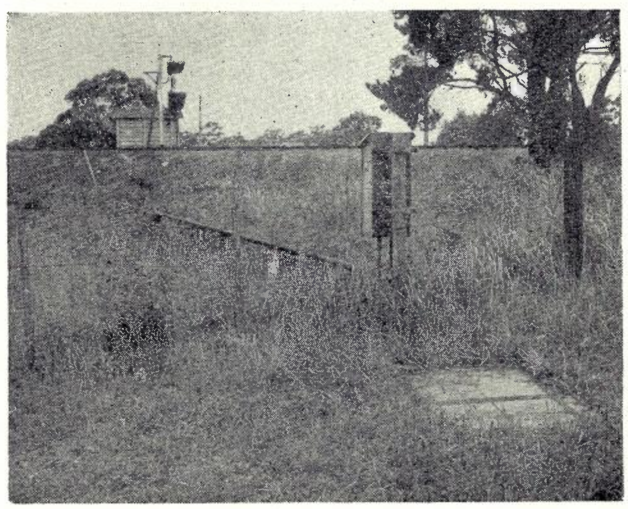

Fig. 18.—Typical Drainage Bond from Cable to Railway Rail.

other authorities and their representatives on the Committee may seek a modification of the conductance if adverse effects are observed. The results of these tests are considered by the Electrolysis Committee and if the proposed installa-

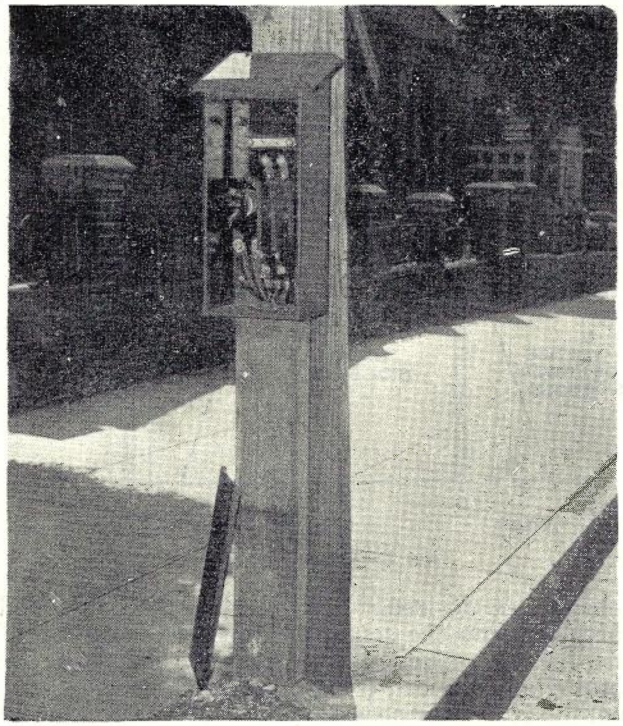

Fig. 19.—Typical Bond Box on Drain to Tramway Rail. Box contains two drains, one from telephone cable and other from water main.

tion is agreed to the appropriate traction authority is requested to install a bond. After installation, 24 hour tests are made to check the effectiveness of the installation. Short period camera-recordings

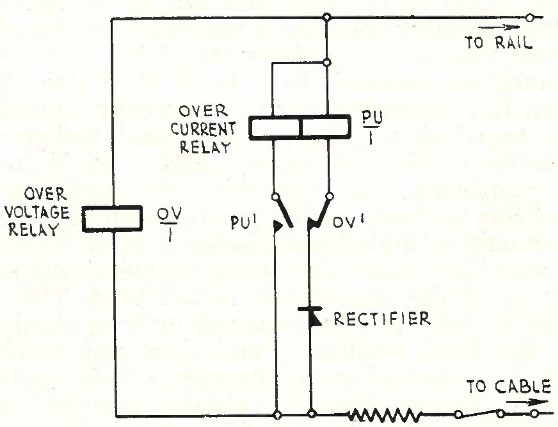

Fig. 20.—Schematic Circuit illustrating Operation of Drainage Bond.

are also taken and analyses circulated to Committee members for record purposes.

Figs. 18 and 19 are examples of railway and tramway drainage bond installations respectively. The latter is a dual bond draining the telephone and the power cables. Separate rectifiers, resistors and heavy conductors will be noted. The smaller leads terminating at the bottom of the panel render cable, earth and rail readily available for potential testing purposes.

Fig. 20 is a schematic circuit demonstrating the operation of a drainage bond. When the cable is positive to rail, current flows through the rectifier and the pick up coil of the "contactor" or over-current relay, which will operate on currents of the order of 2 amperes, to close contacts PU1, thus short circuiting and protecting the rectifier and over-voltage relay contacts. When the cable is negative to rail the normal short circuit on the over-voltage relay OV is ineffective and OV open circuits the bond at OV1 to prevent damage to the rectifier. The resistor is set to give the complete bond circuit the designed value of conductance.

Conclusion

The foregoing description of the method of investigation and application of remedial measures deals essentially with the electrical drainage bond as applied to a traction system. There are, of course, other types of electrical drainage, the description of which could well form the subject of a separate paper. In non-traction areas and traction areas beyond the scope of connection between the cable and the traction negative system, extensive use is made of "boosted" drainage bonds. The general principle is similar to the normal drainage bond but negative potential is applied to the cable and positive potential to an earth plate system by means of D.C. supply obtained normally via a rectifier from the commercial A.C. supply. Similar conditions, but involving currents much smaller in magnitude, are obtained by using zinc plates which, with the lead cable sheath, form a galvanic cell in which the zinc is eaten away and the lead protected. Investigations are now being made into the use of magnesium and aluminium compounds for this purpose.

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OUTLINE OF TELEVISION — PART 2: RECEIVERS

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Introduction

In the previous issue of this Journal, the general principles of the production and transmission of television signals were reviewed briefly. This present article is concerned with the general operation of television receivers.

General

A block diagram showing the essential parts of a superheterodyne television receiver is given in Fig. 1. Both sound and vision signals are amplified together as far as the output of the frequency changer, the same local oscillator being used to provide the separate intermediate frequencies.

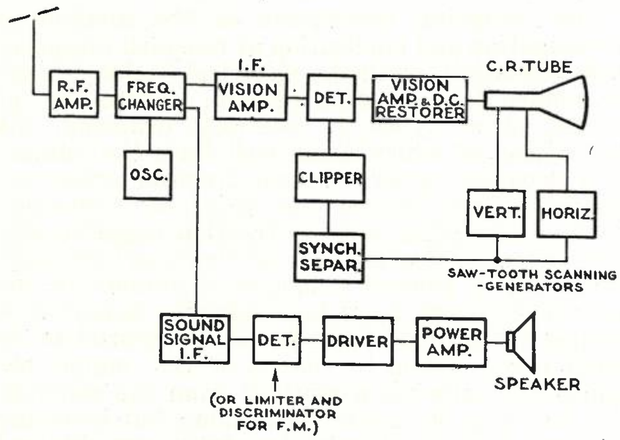

Fig. 1.—Superheterodyne Receiver Block Schematic.

The anode of the frequency changer contains a special filter for separating these intermediate frequencies, and from there on the sound and vision channels are treated individually. Fig. 2 shows a typical receiver chassis.

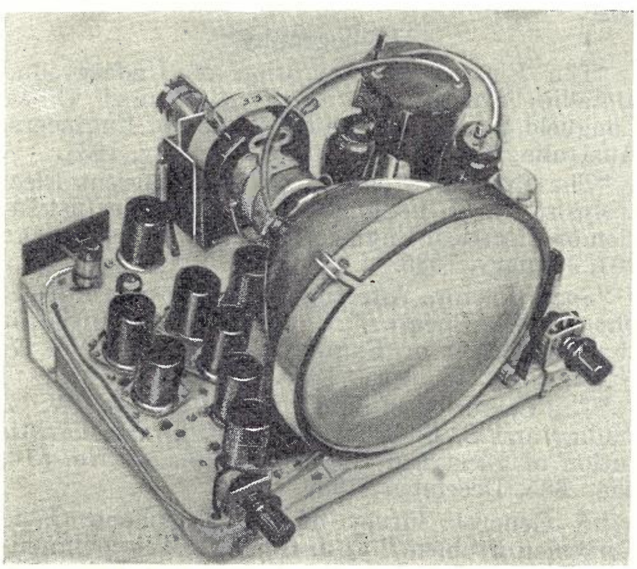

Fig. 2.—Typical Television Receiver Chassis.

To ensure proper reproduction of the vision signal, it is essential that the carrier be correctly tuned in relation to the pass band of the I.F. amplifier. This is not necessarily the centre of the band, since it is common practice to utilise only one sideband for the vision signal, as shown in Fig. 3. The upper or lower sideband may be

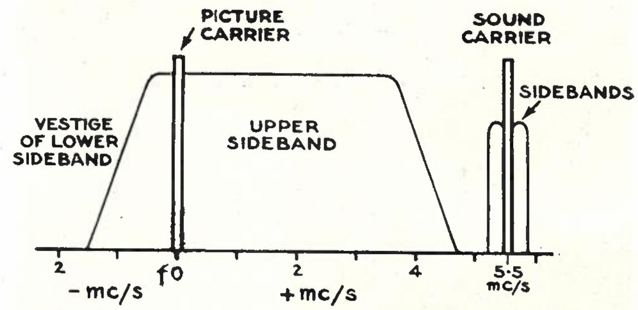

Fig. 3.—Channel Spectrum.

selected as desired. By selecting the sideband farthest from the sound channel, the rejection of the latter frequency is improved, although the total channel width is increased. When using this method it is thus necessary to tune to the edge of the sideband to ensure full coverage. Correct tuning may be achieved by using the sound signal as a tuning indication. The I.F. amplifier for the audio signal usually has a pass range of about 100 kc/s wide to allow for frequency drift of the I.F. oscillator. The vision I.F. passband may be 5 mc/s or more in width. Correct tuning of the audio signal within this pass range, by variation of the oscillator frequency, automatically involves correct tuning of the vision signal if the two I.F. channels are correctly lined in the first place. The vision I.F. frequency must be carefully chosen to give an adequate pass band without serious attenuation or phase-distortion, and to avoid spurious responses, which produce chequerboard or wavy line patterns across the reproduced picture. When only a single transmission is to be received, the amplifier before the vision frequency detector may be of the fixed-tuned T.R.F. type. This reduces the tendency to frequency drift by eliminating the local oscillator, and does not produce spurious interfering frequencies. This system, however, makes clean separation of the sound and vision channels more difficult as it has to be carried out at the relatively high transmitted frequencies, and not after conversion to lower frequencies. Some improvement may be obtained by dividing the feeder line from the aerial into two channels and inserting appropriate rejection filters in each channel. Another possibility with double side-band transmission is to use single sideband reception, the sideband on the opposite side of the carrier to the audio signal being accepted. The chief difficulty with this method, in a T.R.F. receiver, is that satisfactory operation depends on the R.F. circuits being, and remaining, correctly tuned.

The vision frequency detector is generally a diode, but a triode functioning as an anode bend detector may be used. The diode load resistance must be low, about 5,000 ohms, in order to prevent attenuation of the higher frequencies by the stray capacitance across it. The same is true of the vision frequency amplifier following the detector, and special methods are adopted to neutralise the reactance of the stray capacitance. The vision frequency amplifier is not usually a D.C. amplifier, and a diode or similar device is used to restore the D.C. component at the output.

The vision frequency amplifier is connected to the voltage-light converter. The latter function is successfully performed by the cathode-ray tube, the beam of which is capable of intensity modulation by the application of a voltage to its grid. The grid voltage varies the density of the electrons in the beam, and hence the brightness of the spot formed on the screen, a positive direction of voltage increasing brightness. The most common diameters of the screen are 12 and 9 inches. The colour of the light depends on the screen material, a popular colour being bluish-white.

A deflecting system is necessary to synthesize the D.C. light pulses into an intelligible picture, and arrangements must be made to deflect the beam horizontally and vertically in a manner identical to, and in step with, the scanning beam of the pick-up camera. As mentioned in the previous article, deflection may be achieved by applying saw-tooth voltages to the cathode-ray tube deflection plates, or saw-tooth currents to coils for magnetic deflection.

The saw-tooth generator consists usually of a resistance-capacitance charge circuit operating in conjunction with a triggering device. The free frequency of the triggering circuit is set to a value slightly below the fundamental of the frame or line saw-tooth frequency, and is pulled into step by means of synchronising pulses sent from the transmitter. The synchronising pulses are separated from the vision signals by means of a special synchronising separator stage, and the line pulses are separated from the frame pulses by a filter. Line pulses control the line-by-line horizontal scanning action, and the frame synchronising pulses lock the frame-scanning generator so that each picture or frame starts at the right instant. Obviously, if the receiver picture did not start at the same time as the transmitted picture, severe distortion would result.

Distortion: The order of importance of the four types of distortion in television reception is harmonic, attenuation (frequency), phase and transient, this being different from that for audio reception. Harmonic distortion has relatively little effect, but both attenuation and phase distortion have a large influence on the picture. High frequency cut-off attenuation distortion leads to a picture with blurred outlines, whilst high-frequency intensification in the vision-frequency amplifier may result in transient distortion, evidenced by a rippled effect. Low frequency cut-off in the vision frequency amplifier causes uneven reproduction of large surfaces. Phase distortion leads to a plastic relief type of image.

Tuned R.F. Receivers

The R.F. amplifier of this type of receiver should be designed with the following points in mind:—

(i) Maximum amplification requires the tuning capacitance of all tuned circuits to be as small as possible to reduce grid input and anode output capacitances to as small a value as possible.

(ii) Input resistance is relatively less important than in narrow band receivers, because the greater band-width calls for heavy damping.

(iii) Mutual conductance should be as high as possible.

(iv) For minimum shot-noise resistance, total cathode current at minimum must be as small as possible.

A typical circuit, showing the first R.F. amplifier of a television receiver is shown in Fig. 4; one

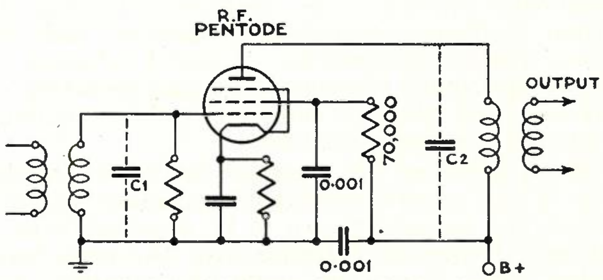

Fig. 4.—First R.F. Stage of a Television Receiver.

or two similar stages could follow this to give desired amplification and selectivity. The residual capacitances C_1, and C_2 may be kept to a low value (approximately 15$\mu\mu$F) by careful design and layout, and really act as the tuning capacity of their respective coils so that no additional capacity is required.

Superheterodyne Receivers

The chief advantage of this type of receiver over the T.R.F. is that it can more conveniently select any one of a number of different carrier frequency transmissions. The disadvantages are a poorer signal-to-noise ratio, particularly when no R.F. stage is used ahead of frequency changer, a tuning stability dependent on the characteristics of a local oscillator, and the production of spurious frequencies, which may be fed back to the input of the receiver to cause interference with the picture. The signal-to-noise ratio in a superheterodyne receiver having no R.F. amplifier is lower because the frequency changer generally produces more noise and gives less amplification to the signal than an R.F. amplifier. The local oscillator, too, adds its own quota to the total noise.

In the superheterodyne it is normal to accept audio and vision signals up to the frequency changer output and to provide two separate I.F. channels. The frequency stability of the local oscillator is, therefore, more important from the point of view of the audio channel than of the vision, because the tuned circuits in the audio I.F. amplifier have much sharper selectivity. They may, however, be given a pass band of up to ± 100 kc/s compared with ± 20 kc/s normally required for high-fidelity amplitude-modulated reception. This results in a slightly reduced signal-to-noise ratio which is usually not serious. The chief cause of interference with the television signal is I.F. harmonic feed-back into the signal circuits. These harmonics can be produced in the I.F. amplifier, and are normally present across the detector load resistance in the form of an R.F. ripple. If these fall within the television signal pass band and are fed back into the signal circuits they may cause chequer-board patterns or alternate streaks of light and shade to appear across the picture. Troubles of this nature may be reduced materially by careful shielding of components and decoupling of all circuits, including the frequency changer, I.F. amplifier, detector to vision frequency amplifier connection, and the vision frequency amplifier. Careful selection of the intermediate frequency and the reduction of the I.F. band width by employing single side-band reception are also important.

Single sideband I.F. reception is almost a necessity in the superheterodyne if adequate amplification and selectivity are to be obtained with a uniform frequency response over the pass band range. The vision and audio I.F. amplifiers are lined up together, so that when the audio signal is correctly tuned the vision carrier is correctly located on the side of the I.F. curve, that is, the output from the audio receiver acts as a tuning indication.

R.F. Amplifier: The design of an R.F. stage preceding the frequency changer of a superheterodyne receiver is identical with that of an R.F. stage in a T.R.F. receiver, as described earlier and shown in Fig. 4.

Frequency Changer

Whether or not the frequency changer is preceded by one or more R.F. stages depends on the type of frequency changer. If it is a heptode or hexode, an R.F. stage is essential. On the other hand, if a pentode of high mutual conductance is used with oscillator application to the grid-cathode circuit, the equivalent noise voltage is not so much greater than that of a T.R.F. receiver.

The use of a heptode or hexode without a preceding R.F. stage may increase the noise by as much as eight times as compared with a T.R.F. receiver, but the provision of an R.F. stage ahead of the hexode or heptode will materially reduce this. A typical circuit using a separate oscillator valve is shown in Fig. 5. A separate oscillator

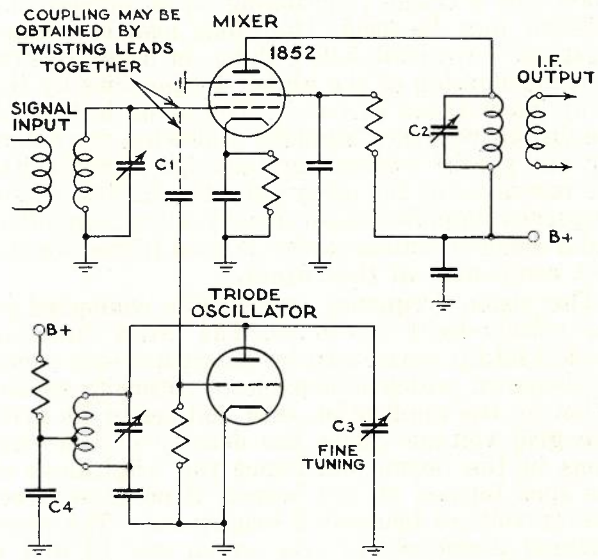

FIG. 5 FREQUENCY CHANGER WITH SEPARATE OSCILLATOR

valve is almost an essential requirement for the television frequency bands, because it is not possible to obtain a high enough mutual conductance and low enough plate resistance for satisfactory operation from a triode and frequency changer combined in the same envelope. Hartley and Colpitts circuits, or modification of these, are in common use, a modified Hartley circuit being used in Fig. 5. Fine tuning is carried out by means of the small trimmer capacitance C_3, which is usually about 2 to 5 $\mu\mu$F. Careful design and the use of negative temperature coefficient capacitors will minimise frequency drift.

The condenser C_4 is intended to decouple the oscillator from any low-frequency components present in the H.F. source.

I.F. Amplifier

Fig. 6 shows a typical I.F. amplifier section, and includes audio signal rejector circuits. The rejection filter generally consists of a series or parallel circuit, tuned to the frequency it is desired to reject. Referring to Fig. 6, one type is a series resonant circuit, L_{13} C_{23}, included in parallel with the primary or secondary to act as a shunt to the rejection frequency. Another type is the series parallel circuit, C_{31} and L_{16} C_{32}. The parallel section L_{15} C_{32} is tuned to the mid-frequency of the vision pass band, and C_{31} is adjusted for resonance with the inductive reactance of L_{16} C_{32} at the lower audio carrier frequency. It can only

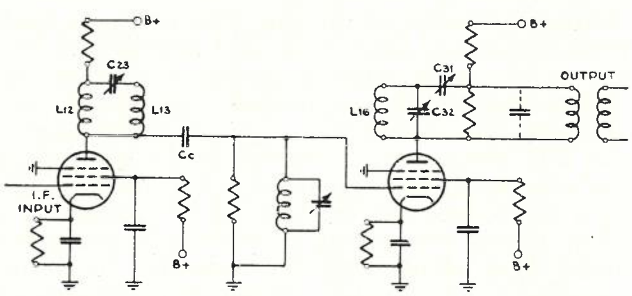

FIG. 6 I F. AMPLIFIER WITH REJECTOR CIRCUITS

be used to reject frequencies lower than the vision frequencies.

Detectors

Of the several methods of detection normally used in sound receivers only two are conveniently applicable to television, namely the diode and the anode-bend detectors. Considering first the half-wave diode detector, the capacitance across the diode load resistance determines the highest value of load resistance consistent with the video frequency band to be passed. Provided the phase angle of the load resistor with its capacitance shunt does not exceed about 0.3 radian, the load may be made nearly constant and non-reactive by the inclusion of inductances as shown in Fig. 7.

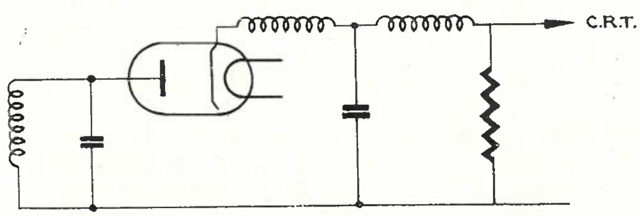

Fig. 7.—Diagram of Half-Wave Diode Detector.

The permissible load is about 5,000 ohms for a video band of 4.5 mc/s. Such a value produces poor rectification efficiency with normal types of diode and special diodes have been designed for this function.

A detector of the voltage-doubling type was used in early television receiving apparatus, its main object being to increase the overall gain of the receiver by the voltage-doubling action as shown in Fig. 8. However, the efficiency of this detector is not as high as may be expected, since

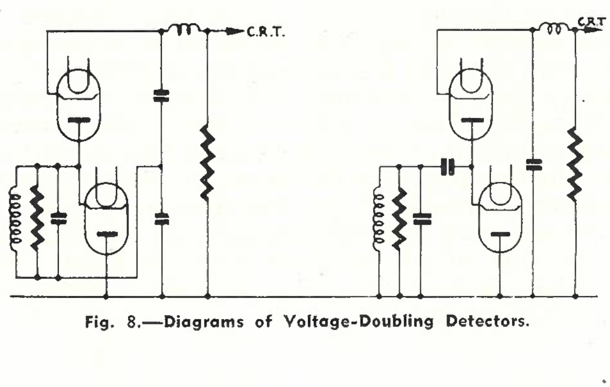

Fig. 8.—Diagrams of Voltage-Doubling Detectors.

the two diodes are effectively in series and their impedance is comparable with the load. A better form of full-wave detector for operation with low values of load resistance is the familiar push-pull type shown in Fig. 9. The diodes are then, from a D.C. point of view, effectively in parallel. Furthermore, the radio-frequency component present across the load is considerably less than for the voltage-doubler or the half-wave type. This point

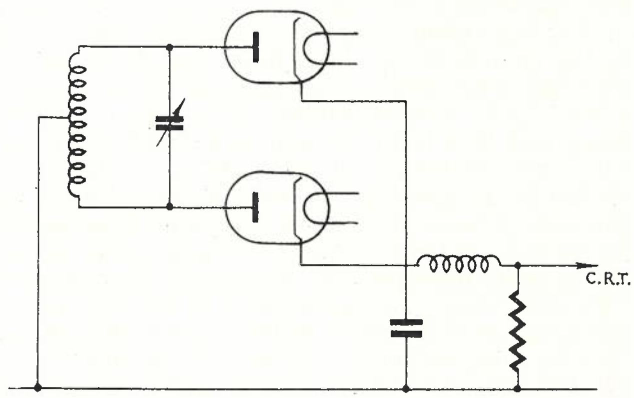

Fig. 9.—Diagram of Push-Pull Detector.

is very important in a vision channel, particularly one of the T.R.F. type, where the detector feeds directly on to the cathode-ray tube without vision frequency amplification, as a large amount of radio-frequency current in the output lead will cause instability. When the modulating potentials are taken directly from a detector, a voltage of between 10 and 30 volts, peak to peak, is required across the load. The slight curvature near the origin of the I_p/V_g curve will affect the picture to synchronising-pulse ratio, but not to such an extent as when a vision amplifier follows the detector, when the synchronising pulse, if the gain of the amplifier is high, may lie entirely on the

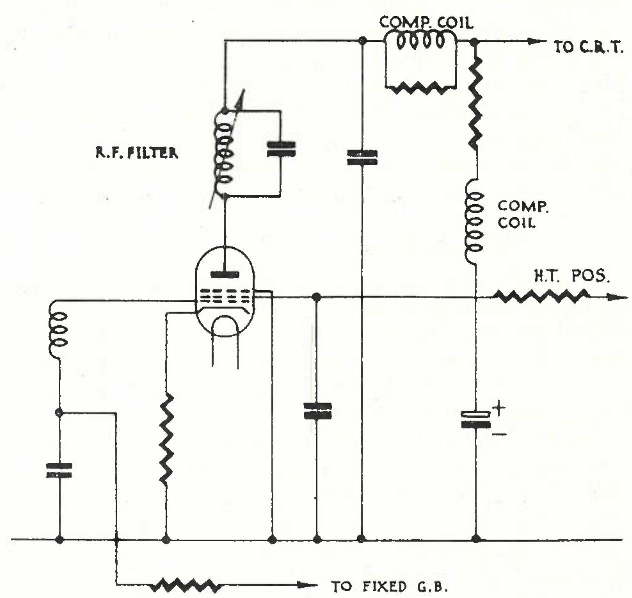

Fig. 10.—Diagram of Anode-Bend Detector.

curved portion of the characteristic. This results in a considerably reduced ratio of synchronising-pulse to picture signal.

The anode-bend detector, as shown in Fig. 10, is essentially a half-wave rectifier, but as a much smaller radio-frequency voltage is required to operate it, the radio-frequency current in the supply leads is much reduced and stable receiver operation can easily be effected with this detector. The anode-bend detector has a further advantage in that the tuned circuit is lightly damped, owing to the comparatively high input resistance under working conditions. It is essential to use a valve whose I_p/V_g characteristic has a sharp bottom bend, and if it is to be used in a T.R.F. receiver, the high frequency characteristics of the valve should be as good as those of valves employed in the radio-frequency stages. An EF50 type radio-frequency pentode functions satisfactorily as an anode-bend detector for ultra-high frequencies. The anode-load resistance value is limited in the same way as the diode load by shunt capacitances. The total capacitance may be a little lower than for the diode detector, and if compensation, as previously discussed, is used, a substantially flat frequency response up to 4.5 mc/s can be obtained with a 5,000 ohm load resistance. The chief disadvantage of the anode-bend detector is the non-linear input-output voltage relationship. This results in the synchronising pulse being attenuated and the high lights in the picture being accentuated. Negative feed-back applied in the form of an unbypassed cathode resistor will reduce this effect considerably, although a compromise will generally have to be made between linearity and gain. The picture to synchronising-pulse ratio can be altered to almost any degree by means of a biased diode across the feed-back resistor, or across a resistor with a higher value than the load resistor, in series with the load resistor. This added complication is not usually considered economical, as a satisfactory compromise can be effected with a carefully chosen negative feed-back resistor. It is important to stabilise the grid bias, since, with normal cathode bias, the bias point will alter with picture content. In the latter case the black level will fluctuate and affect the synchronisation.

Vision Frequency Amplification

Cathode-ray tubes require about 25 volts peak-to-peak signal voltage to reproduce the full range of brightness from black to white. Thus the detector output needs to be amplified before application to the cathode-ray tube, at least one stage being necessary. The wide range of frequencies, from D.C. to at least 4.5 mc/s, which is present in the vision amplifier makes careful design essential. The D.C. component is essential for correct reproduction of the image as it provides the datum of average brightness, for example, the average light content of the picture is different for outdoor and indoor scenes. It is somewhat similar to the iris of the eye, which adjusts itself according to the amount of light present, yet preserves the same relative degree of contrast between the objects or images viewed. In the receiver this change can only be appreciated if the D.C. component is present at the grid of the cathode-ray tube reproducer. Fortunately, this D.C. component can be restored by connecting a diode across the output of the vision frequency stage, thus eliminating the necessity for incorporating a D.C. amplifier in the vision frequency stage.

Fig. 11 shows a typical vision frequency amplifier circuit, and stray anode capacitances are represented by C_1 and C_2. These combine with the wiring and valve input capacitances to form the effective total stray capacitance which is usually of the order of 30 $\mu\mu$F. At high frequencies the reactance of this falls to a comparatively low value, and this limits the value of the anode load resistance R_o, to about 1500 ohms for a reasonable frequency response at the highest frequency to be passed by the amplifier. The amplification of the stage at any frequency f is $g_m R_o/(1 + jw C_s R_o)$ where C_s is total stray capacitance. Compensation circuits are often applied to the vision frequency amplifier to improve its high frequency response, but their design is beyond the scope of these notes.

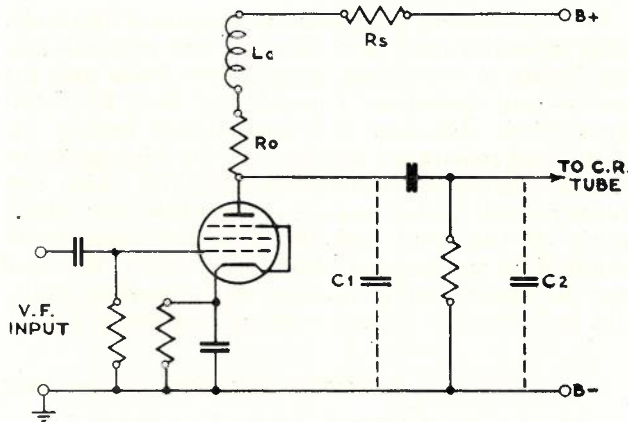

Fig. 11.—Vision Frequency Amplifier Schematic.

Frequencies below 10 kc/s contribute more to the vertical than to the horizontal detail of a picture. Poor low-frequency performance of the vision frequency amplifier affects background intensity, causing it to vary from top to bottom of the picture; for example, an all white screen may be reproduced as a screen gradually shading from white to grey from top to bottom, or vice versa. Phase distortion, which is caused by the increasing reactance of coupling and self-bias capacitors as the frequency is decreased, is also a serious source of trouble at low frequencies. Careful design and some form of compensation help to minimise this effect, but care must be taken that "motor-boating" does not occur as a result of over-compensation.

D.C. Restorer

The restoration of the D.C. component to the signal after it has passed through the vision frequency amplifier is necessary in order to preserve the average background illumination of the picture and proper synchronising pulse separation. The average illumination of a scene may be regarded as the intensity of the source of illumination of the scene. There will be a difference in the relative contrasts between colors according to whether they are illuminated by the sun, by reflected light of a cloudy day, or indoor scenes illuminated by daylight or by artificial light. The effect on the signal of the presence or absence of the D.C. component on three signal waveforms is shown in Fig. 12. It will be noticed firstly, that reduction of the amplitudes of white and normal signals is greater than the reduction of black, so that contrast is lost. The signal tends to adjust itself so that equal areas occur on either side of the zero line. Secondly, the bottom of the synchronising pulses is variable, and this could result in pulses being missed. If the signals of Fig. 12 were applied to the grid of the cathode-ray tube, the average brightness or background illumination would be incorrect, since this is determined by the D.C. component. The reproduced picture might have the correct contrast between the various picture elements, but the background shading would not be right. The alternating voltages of the signal vary above and below the average value of the D.C. component, depending on whether they represent elements that are darker or lighter than the background illumination. With this fixed reference point, black, grey, white, or any one color is always reproduced by the same illumination. With the D.C. component removed we have no information as to its absolute value, and what is black, or any other color, at one point may not be the same color at another point. Finally, with the D.C. component present, all the blanking and synchronising pulses are on the same level with the correct bias applied to the cathode-ray tube grid, and these pulses will automatically drive the grid beyond cut-off. With the D.C. absent, the pulses assume various levels, as shown in Fig. 12, and each now requires a different bias on the grid to blank out the beam.

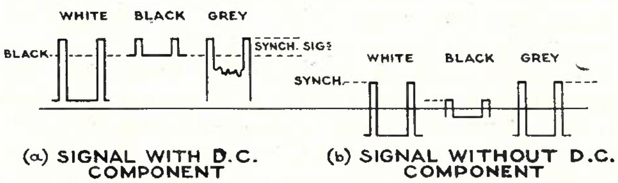

Fig. 12.—Effect of D.C. Component.

The D.C. component could, of course, be retained by making the vision-frequency amplifier a D.C. amplifier, but this is neither economical nor easy. Several methods of re-introducing the D.C. are in use, but reinsertion by means of a diode only will be considered here. Fig. 13 shows the arrangement for this method, and it will be seen that a diode V_2, which is preferably of the low resistance type, is shunted across the grid leak R_3. In the signal applied to the restorer, the blanking and synchronising pulses are below the zero line. When applied to points 1 and 2, the signal will cause point 1 to become negative with respect to point 2. The other portion of the signal,

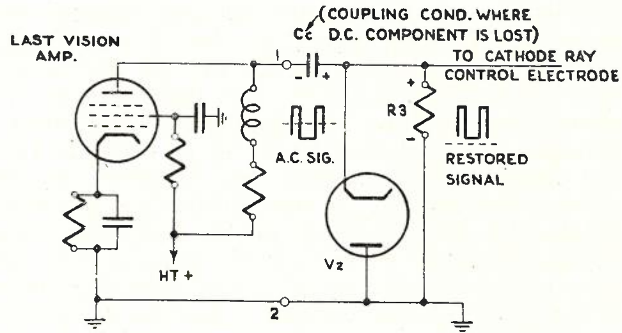

Fig. 13.—D.C. Reinsertion by a Diode.

which contains the information, is above the line, and, when it is applied across points 1 and 2, will make 1 positive with respect to 2. The diode in the circuit conducts only when its plate is positive with respect to its cathode, or when point 2 is positive with respect to point 1. When the polarity of the video signal at point 1 is negative, point 2 and the plate of the diode are positive. A flow of current will occur through the tube, and condenser C_c will charge to a value dependent upon the strength of the signal acting at points 1 and 2. The polarity of the charge is indicated in the figure. During the positive portions of the video signal at the input of the circuit condenser C_c will discharge through R_3, since the diode plate is now negative, and the tube is non-conducting. The value of R_3 is high, about 1 megohm, and C_c will discharge slowly. The values of C_c and R_3 are so designed that the voltage on the condenser remains fairly constant throughout an entire horizontal line, or during the time that the positive part of the A.C. signal is acting on the picture tube grid. This charge is between grid and ground or cathode, and hence acts as a variable bias in series with the A.C. signal. When the negative portion of the signal acts at the input. the plate of the diode again becomes conductive. The charge on C_c will now be adjusted automatically to the amplitude of the negative pulse. A bright line will place a larger positive voltage on the condenser C_c than a darker line. The positive voltage will cause the grid to become more positive and the line will receive its correct value. The bias will raise each line until the blanking pulses are lined up again. Thus, in this instance, we have a bias developed which is proportional to the impulse amplitudes, which are in turn governed by the average brightness of the line. Irrespective of the type of modulation, negative or positive, of the transmitter, the signals are reduced to the correct polarity as required by the cathode-ray tube at this stage.

Synchronising Pulse Separation

This is one of the most important functions in a television system and is therefore discussed in some detail.

Synchronising Pulses: Up to this point we have studied the action of the various stages of the television receiver in amplifying and changing the form of the video signal, so that it was finally suitable for application to the grid of the picture tube. Nothing, however, has been said so far about the method of supplying the proper voltages to the deflection plates or coils, so that the image will be swept out properly on the cathode-ray screen. To accomplish this, we must obtain the synchronising pulses from the video signal and apply them to other circuits that will eventually connect directly to the deflecting plates of the picture tube. Since each line has a separate synchronising pulse, it becomes possible to lay them out on the screen in their proper position exactly as they were scanned on the mosaic of the pick-up camera. The synchronising pulses that are responsible for the correct positioning of the various lines are referred to as the horizontal synchronising pulses, or perhaps more simply, as the horizontal pulses. These pulses are diverted to amplifiers that control the action of the horizontal deflecting plates and coils. After the electron beam sweeps out the correct number of horizontal lines and arrives at the pottom of the picture, a vertical synchronising pulse is applied to the vertical deflection plates, and the beam is brought back rapidly to the top of the screen again. This vertical pulse is transmitted along with the horizontal pulses in the vision signal, separated by filters at the receiver, and applied to a set of amplifiers that end at the vertical deflection plates. The block diagram of Fig. 14 illustrates the general path of all the synchronising pulses within a television receiver.

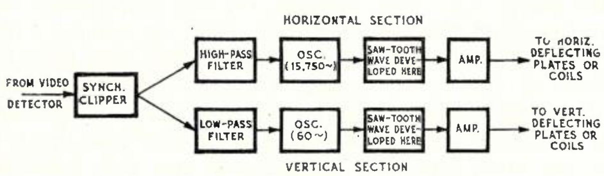

Fig. 14.—Path of Synchronising Signals.

There is nothing in sound receivers that resembles this action, and a detailed examination becomes necessary. The pulses, separated from the rest of the wave as already outlined, will be held in abeyance while the form and functions of the horizontal and vertical pulses are developed in greater detail.

It is already known that, as each horizontal line signal arrives at the grid of the picture tube, the electron beam should be in correct position, ready to sweep out the information contained in the signal. The position of the electron beam is controlled by saw-tooth oscillators. In order that the oscillator shall have the beam in the correct position, horizontal synchronising pulses are inserted into the video signal. They could have been sent separately, but the present method is cheaper and simpler in operation. It should be remembered that the function of the horizontal synchronising pulses is to trigger an oscillator in order to bring the electron beam from the right-hand side of the screen to the left-hand side. Once the beam is at the left-hand side, the oscillator is no longer directly under the control of a pulse and goes about its normal function of sweeping the beam across the screen. Thus each horizontal pulse that precedes the line detail sets up the beam in readiness for the scanning out of this information. The next pulse arrives when the beam is at the far right-hand side of the screen, at the end of a line.

There are 625 lines sent out every $^1/_{25}$ of a second. In one second, then, we have 625 times 25, or 15,625 lines. This means that the frequency of the horizontal pulses is 15,625 per second, or one arrives every 1/15,625 sec. The time interval is quite small, being only 0.00006 sec. In similar manner, the vertical pulses serve the purpose of bringing the electron beam back to the top of the screen for the beginning of each field. With interlaced scanning every other line is scanned, with each field ($\frac{1}{2}$ frame) taking 1/50th of a second. The beam next sweeps out the lines that were missed, this also in 1/50th of a second. The total frame, with all lines, is accomplished in 1/50th plus 1/50th of a second, or 1/25th of a second. Thus we see that the vertical pulses must occur once every 1/50th of a second, or 50 times in one second. This frequency is considerably less than that of the horizontal pulses and it is because of this fact that they can be separated with comparative ease.

With the preceding ideas in mind, let us closely examine the construction of the video signal with its synchronising pulses. In Fig. 15 several lines of an image are shown, complete with the detail information, blanking voltages, and horizontal synchronising pulses. The blanking and synchronising voltages occupy approximately 20 to 25 per cent. of the total signal amplitude. The blanking voltage retains its control over the cathode-ray tube grid for some time before and after each synchronising pulse. This is done to make certain that no beam retrace is visible at all on the screen. As soon as the blanking voltage relinquishes control of the grid, the line detail becomes active once again. All the lines of one field follow this form, the only difference occurring in the camera detail of the various sections of the image. At the bottom horizontal line, it is necessary to insert a vertical impulse that will bring the beam back to the top of the screen again. During the period that the vertical pulse is active, it is imperative that the horizontal oscillator should not be neglected. If this did occur, the horizontal generator probably would slip out of synchronisation. To avoid this, the vertical pulses are arranged in serrated form and accomplish vertical and horizontal synchronisation simultaneously.

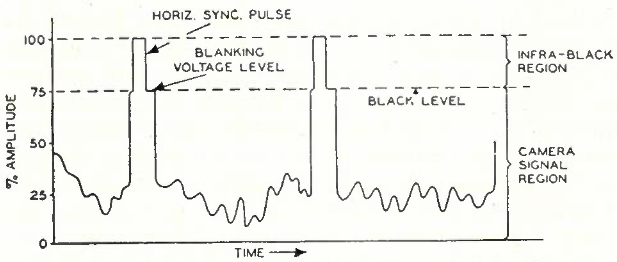

Fig. 15.—A video signal with its synchronising (horizontal) pulses.

Serrated Vertical Pulses: To understand the form of the vertical pulse that has finally been evolved, start with the voltages shown in Fig. 16. At the bottom of the image, a long vertical pulse is inserted into the signal. This controls the vertical synchronising oscillator and forces the beam to be brought back to the top of the screen. No

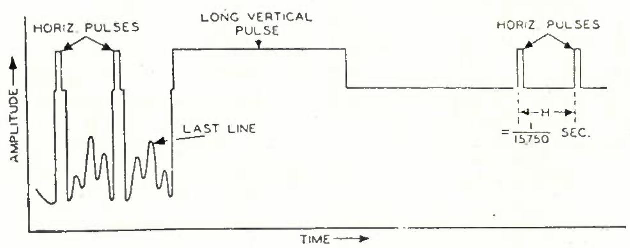

Fig. 16.—The basic form of the vertical synchronising pulse.

provision is made in the signal, in this preliminary form, to provide horizontal oscillator control while the vertical pulse is acting. As stated above, such a condition is undesirable as it permits the horizontal oscillator to slip out of control. To prevent this, the vertical pulse is broken up into smaller intervals and now both actions can occur simultaneously. The vertical synchronising pulse, in the modified form, is shown in Fig. 17, and is

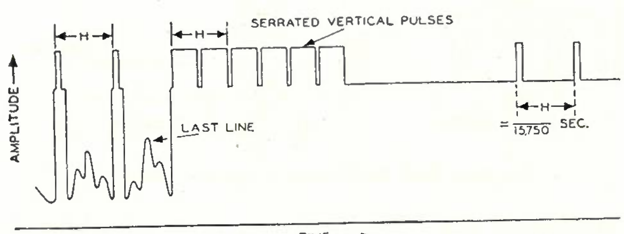

Fig. 17.—The serrated vertical synchronising pulse.

known as a serrated vertical pulse. While the vertical pulse is broken up to permit the horizontal synchronising voltages to continue without interruption, the effect on the vertical pulse is substantially unchanged. It still remains above the blanking voltage level practically all of the time it is acting. The interval is much longer than the previous horizontal pulse frequency. The two pulses are still capable of separation because their wave forms are different, as can be seen in Fig. 17.

Due to the fact that an odd number of lines is used for scanning, the form of the signal just prior to the application of the serrated vertical pulse must be still further modified. With an odd number of lines, 625, each field contains $312\frac{1}{2}$ lines from the beginning of its field to the start of the next. In Fig. 18 the notation is made that

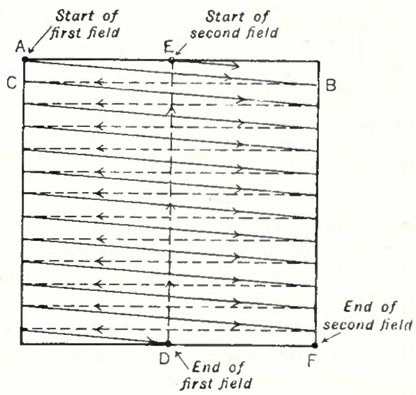

Fig. 18.—The motion of the electron beam in interlaced scanning. For simplicity, the retrace from point D to point E has been shown as a straight line.

the end of the visible portion of each field occurs at the bottom of the image. However, the actual end of that field is not reached until the beam has been brought back to the top of the screen again. At the end of the visible portion of the first field, the beam must be interrupted at point D and the vertical synchronising pulse inserted. Point D occurs during the middle of a horizontal line. From D, the beam is brought up to point E, and the second field is begun. The visible portion of the latter field is completed at point F, the end of a complete horizontal line, and is returned to point A to repeat the entire sequence. The reasons for employing this particular method of scanning were explained earlier.

When the beam is blanked out at the bottom of an image and returned to the top, it does not move straight up, but instead it moves from side to side during its upward swing. The reason is due to the rapidity with which a horizontal line is traced out as compared to the vertical retrace period. In fact, there are approximately 20 horizontal lines traced out while the vertical synchronising pulses are bringing the beam back to the top of the picture. Thus, in each field, about 20 horizontal lines are lost in the blanking interval between fields. Of the 625 lines which are specified, only 625 - 2 x 20 or 585 lines, are actually effective in forming the visible image.

The fact that the vertical pulse is once inserted into the video signal when a horizontal line is half completed and once at the end of a complete line, necessitates a further modification of the video signal just prior to the arrival of the vertical pulse. A serrated video signal for each case is illustrated in Fig. 19. The half-line difference between the two diagrams may not affect the horizontal synchronising generator operation, but

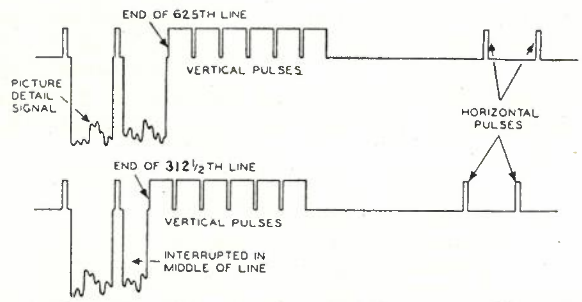

Fig. 19.—The form of the video signal at the end of 312½ and 625 lines. The equalising pulses are not shown here.

it can cause the vertical oscillator to slip out of control. In order that the vertical pulse oscillator receive the necessary triggering voltage at the same time after every field, a series of six equalising pulses is inserted into the signal immediately before and after the vertical synchronising pulses. These equalising pulses, shown in Fig. 20, do not

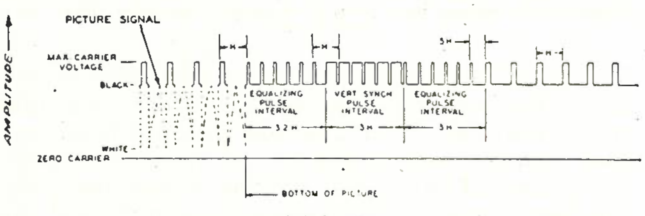

Fig. 20.—The position of the equalising impulses in the video signal.

disturb the operation of either oscillator, as will be shown later, but they do permit the vertical pulse to occur at the correct time after every field. Once the serrated vertical pulse is ended, the six equalising pulses are again inserted in the signal, and the line detail assumes control while the next field is swept out. One vertical pulse occurs at

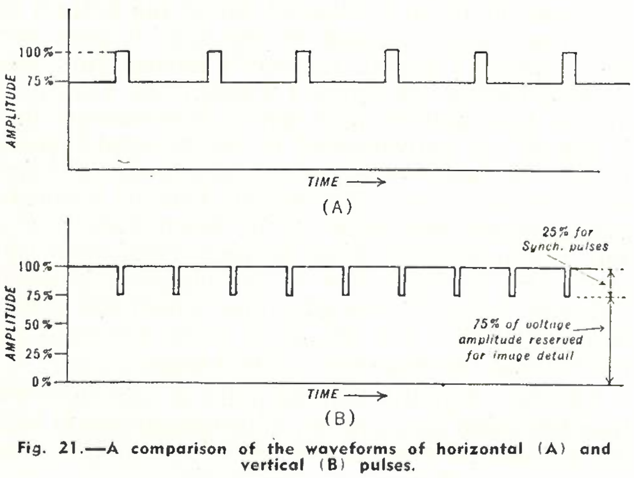

Fig. 21.—A comparison of the waveforms of horizontal (A) and vertical (B) pulses.

the end of every 312½ lines, while a horizontal pulse appears at the end of each line. A comparison of vertical and horizontal waveforms is shown in Fig. 21.

Pulse Separation: To use the pulses of a television wave, they must first be separated from the other portions of the signal. Two actions are involved in pulse separation; the first, known as amplitude separation, divides the I.F. or V.F. signal into vision and pulse components and rejects the former; the second, known as frequency separation, divides the synchronising voltage into frame and line pulses, which are then used to lock the frame and line scanning generators employed for deflecting the cathode-ray tube spot across the screen. The presence of the D.C. component is necessary in order that the pedestal or datum level be established. The output of the vision amplifier employing a D.C. restorer is a convenient place to pick out the pulse signals.

Amplitude Separation: The tube that separates the synchronising pulses from the rest of the wave is called the "clipper." Both horizontal and vertical synchronising pulses are clipped from the

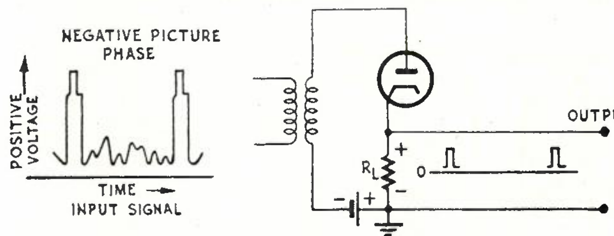

Fig. 22.—Basic Diode Clipper—Negative Phase.

wave by this tube, the further separation of these two pulses then occurring at another point beyond this stage. The type of tube that may be utilised for the synchronising separation is not restricted. Practically every type is suitable since the action consists merely in biasing the tube so that only the top portions of the video wave, where the pulses are found, affect the tube and cause current to flow. The basic principle of "clipping" is illustrated for a diode in Figs. 22 and 23.

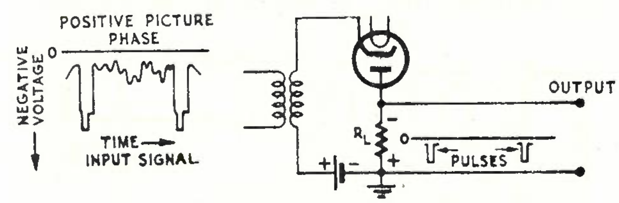

Fig. 23.—Basic Diode Clipper—Positive Phase.

Considering Fig. 22, the video signal is applied between plate and ground while the output voltage is developed across the diode load resistor R_L. The small battery is inserted with its negative end toward the plate. This prevents current from flowing until the video signal acting on the tube becomes sufficiently positive to counteract the negative biasing voltage. Current then flows.

With the circuit constants properly chosen, current should flow only at the synchronising pulses which are the most positive for a signal having negative phase, and the output will consist only of these short pulses of current. The picture phase at the input of this diode must be negative, as indicated in Fig. 22. The D.C. biasing voltages necessary for these diodes may be taken from the low-voltage power supply.

Circuits using a diode do not provide any gain, and the use of triodes or pentodes of the sharp cut-off type in leaky-grid or anode-bend detection circuits offers some advantages. A pentode arrangement is shown in Fig. 24, and the valve has zero bias with no signal on the grid. When a signal is applied grid current will flow and cause a relatively steady bias voltage to be developed

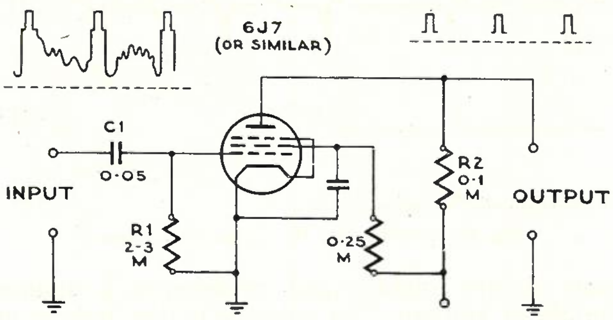

Fig. 24.—Pentode Clipper.

across the grid-leak R_1. The time constant of R_1 C_1 is so chosen that only the synchronising pulses bring the valve out of "cut-off." Thus plate current flows only during these pulses, and the picture modulation has no effect on the output of the clipper stage.

Frequency Separation of Line and Frame Signals: The line and frame synchronising pulses must now be separated from each other, and interaction between the scanning generators, particularly from line to frame, must be prevented, otherwise erratic interlacing occurs. Normal filter circuits do not provide sufficient discrimination without severe mutilation of the wave shape. The most satisfactory form of filter for selecting the line pulse has proved to be the differentiator type. This may consist either of a high resistance and an inductance, or a capacitance and a low resistance, to which is applied the pulse voltage, the output voltage being in the first case across the reactance, and in the second, across the low resistance. The filters employed separate the vertical and horizontal pulses from each other and then modify their form slightly so that they are suitable for controlling the frequency of the oscillators that follow. To see how this occurs, let us apply a square-top pulse to the high-pass filter shown in Fig. 25, the output being obtained from the resistor. At the application of the first edge of the square-wave pulse, known as the leading edge, a momentary flow of current takes place through the resistor to charge the condenser fully to the value of the applied voltage. Once the full value is reached, nothing further occurs all along the flat portion of the pulse because a condenser, and hence a condenser and resistor in series, react only to changing voltages, not to

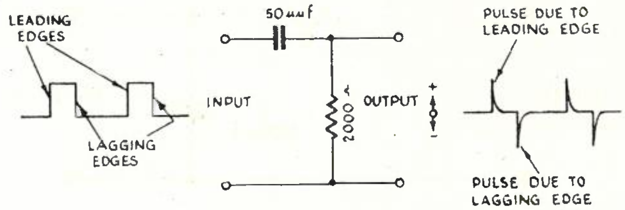

Fig. 25.—Effect of High Pass Filter.

steady voltages. The voltage along the flat top of the pulse is steady. At the next, or lagging edge of the pulse, where the voltage drops suddenly, another momentary flow of current takes place, this time in the opposite direction, discharging the condenser. The result of the application of the square-wave synchronising pulse to the input of the high-pass filter is the output wave indicated in Fig. 25.

Each incoming synchronising pulse gives rise to two sharp pulses at the output of the filter, with one above and one below the reference line. This, of course, is due to the fact that one is obtained when the front edge of the incoming pulse acts on the filter and one when the lagging edge arrives. For control of the sweep oscillator, only one of these two output pulses is required. If the first pulse at the output of the filter is negative (below the line) and a positive pulse is required, the conversion is readily made by applying these pulses to an amplifier and the first pulse becomes positive. The amplifier introduces a phase shift of 180°, which is equivalent to reversing every value in a wave. The oscillators that are used, either the blocking or multivibrator types, respond to the first pulse, becoming insensitive immediately thereafter to other pulses that do not occur at the proper point in the oscillator frequency interval. When the next horizontal pulse arrives, it is again in position to control the oscillator action. In this manner, any pulse occurring at an intermediate interval is without effect.

Vertical Pulse Filters: For vertical pulse separation, we use a low-pass filter of the type shown in Fig. 26. This is identical with the high-pass filter, except that the positions of the condenser and resistor have been interchanged and the output is obtained from the condenser. Besides the difference of position, the time constant of the condenser and resistor is much greater than that of the previous filter. A long time constant means that the condenser will charge and discharge slowly and will not respond as readily as the previous filter to rapid changes in voltage. Hence, when a horizontal pulse arrives at the input of this filter, its leading edge starts a slow flow of current through the resistor, and the condenser begins to charge. But this charging process is slow and, almost immediately afterward, the lagging edge of the wave reaches the filter and reverses the current flow, bringing the condenser

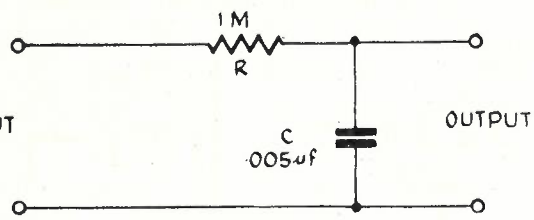

Fig. 26.—Low Pass Filter.

back to its previous value. Very little change has occurred during this short time interval, and the vertical synchronising oscillator is designed so that it does not respond to these small fluctuations. What is true of the effect of the horizontal pulses on the vertical filter is even more true with respect to the equalising pulses, which rise and fall much more rapidly. Essentially, then, we have eliminated the possibility of the higher frequency pulses affecting the operation of the vertical synchronising generator.

The building up of the voltage across the condenser for the output begins when the serrated vertical pulses are reached. Even though the pulse is serrated, it still remains above the reference line for a relatively long time. The condenser charges slowly in the manner indicated in Fig. 27.

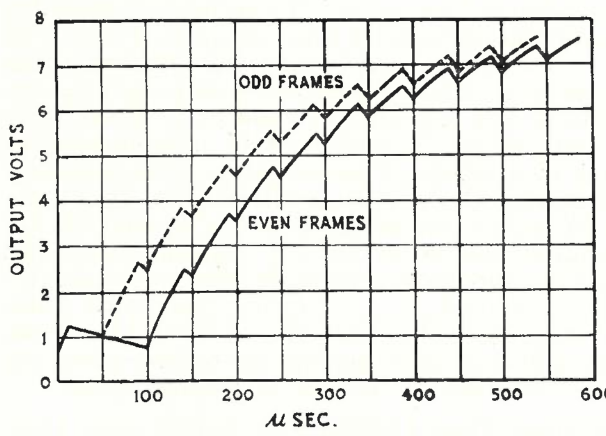

Fig. 27.—Condenser Charging for Vertical Pulse.

The small notches in the wave are due to the serrations. At these points, for a small fraction of a second, the voltage drops and then rises again. As previously noted, these changes affect the horizontal filter but leave the vertical filter output substantially unchanged because of their rapid disappearance.

A comparison of the vertical and horizontal pulse forms is shown in Fig. 28, and it may appear that the vertical pulse is not very sharp. This is because the vertical pulse is shown extended over quite a few horizontal pulses and the comparison exaggerates the extent of the vertical pulse. If the vertical pulse were drawn to a larger interval, then it, too, would appear sharp. So far as the vertical synchronising oscillator is concerned, this

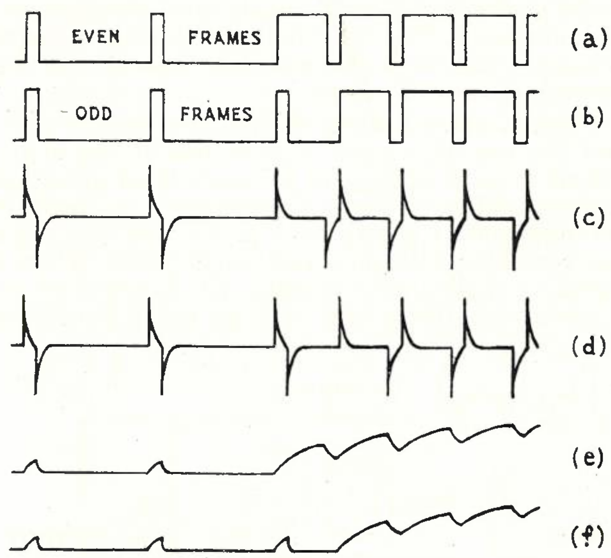

Fig. 28.—Vertical and Horizontal Pulse Forms.

pulse occurs rapidly and represents a sudden change in voltage. The polarity of the pulses, as obtained at the output of their respective filters, may or may not be suitable for direct application to the controlled synchronising oscillators. This depends upon the type of oscillator to be controlled. For a blocking oscillator, the leading pulse must be positive. Since the polarity of the pulse is negative at the output of the synchronising clipper, and consequently also negative at the output of either filter, a reversal of 180° must be introduced.

Typical Circuits: A circuit diagram of a typical frequency separator is shown in Fig. 29. The inductance L_1 forms the differentiator for the line synchronising pulse, which is taken from L_2 to

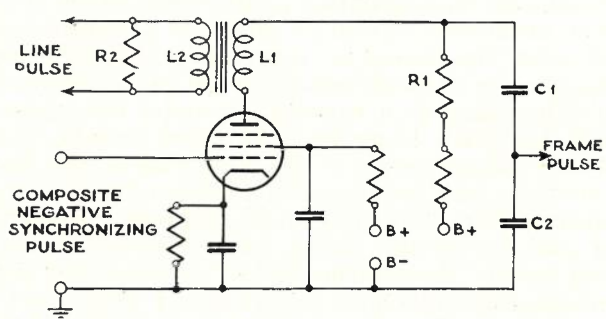

Fig. 29.—Typical Circuit for Separating Line and Frame Synchronising Pulses.

the line scanning generator. The frame integrator circuit is provided by R_1 (10,000 ohms) in parallel with C_1 and C_2 in series. This circuit requires a negative direction pulse.

The Scanning Generator

Introduction: The voltage or current needed to produce the electric or magnetic field for deflecting the cathode-ray tube is usually obtained from an amplifier to which is applied a voltage from a scanning generator. The shape of the output voltage required from the latter depends on the method of deflection employed; if it is electrostatic a saw-tooth voltage is required; if electromagnetic, a saw-tooth current.

The most important features required of the scanning generator are:—

(1) the frequency and amplitude of its output voltage should be stable, and yet susceptible to manual control;
(2) synchronism should be easy to establish;
(3) the output wave shape should conform to that required by the deflection amplifier.

The scanning generator normally consists of a resistance-capacitance charge circuit, across which the saw-tooth voltage is developed, and a device for periodically discharging or charging the capacitance. Typical of these devices are: The blocking oscillator, and the multivibrator. The former will be described briefly, and is illustrated in Fig. 30.

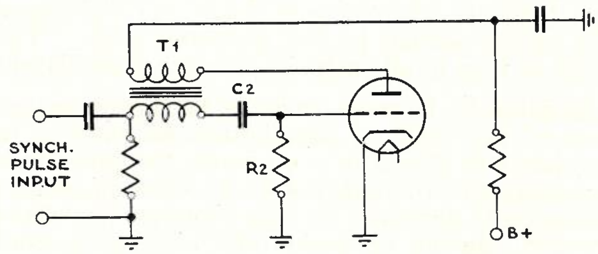

Fig. 30.—Blocking Oscillator.

Transformer T_1 provides the necessary feedback from the plate to grid circuit as in normal oscillator operation, and is so connected that mutual effects are additive. An increase of current in the plate circuit causes, through the transformer, a positive voltage on the grid which increases electron flow to the plate, and this in turn increases the plate current, and so the cycle repeats itself. However, the flow of grid current charges condenser C_2, which gradually builds up a negative charge and eventually thus reaches a value sufficient to "block" the electron flow from the cathode. The oscillator would cease to function under this condition so a grid-leak resistor, R_2, is included to permit a relatively slow discharge of the electrons accumulated on C_2. Because of the slow discharge of C_2, electrons which have accumulated on the grid remain there in sufficient numbers to give it a large negative bias, sufficient to block or stop the plate current flow. Gradually the electrons accumulated on C_2 pass through R_2 back to the other plate of C_2, and the negative bias on the grid slowly becomes less. When the discharge is almost complete, electrons from the cathode once again reach the plate, plate current starts up, quickly reaches its high value, drives the grid positive, and the process repeats itself. Thus, during every cycle there is a short, sharp pulse of plate current, followed by a period during which the tube blocks itself until the accumulated negative charge on the grid leaks off again.

The frequency of these pulses is determined by the values of C_2 and R_2, and it is possible to control the frequency of this oscillator if a positive pulse is injected into the grid circuit at a certain instant. This is the function of the synchronising

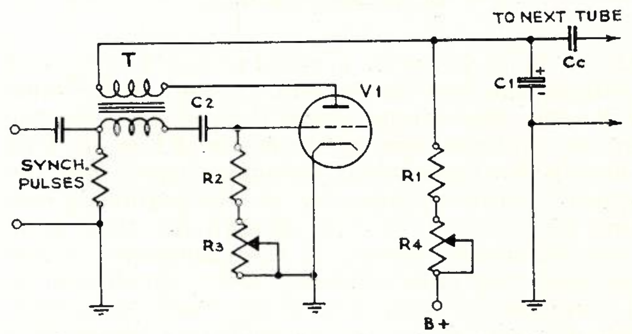

Fig. 31.—Simple Saw-Tooth Voltage Generator. C.1 is the Charge and Discharge Condenser

pulses as transmitted with the signal. To be effective, the frequency of the controlling pulse must be near the free frequency of the oscillator. By free frequency, we mean the natural frequency at which it will oscillate if permitted to function alone. It is only when the grid condenser C_2 is almost completely discharged, that any pulse will control the oscillator's frequency effectively, and it is, therefore, at this instant that the pulse is injected. Equalising pulses which occur at the half-way point in the oscillator cycle do not possess sufficient strength to bring the tube out of cut-off. Thus the synchronising pulse controls the start of the oscillator's cycle. If left alone, the oscillator would function at its natural period which, more often than not, would not coincide with the incoming signal. Through the intervening action of the synchronising pulse, both oscillator and signal are brought together, in step. Naturally, for effective control, both synchronising pulse and oscillator frequency must be close enough together to permit locking-in.

The output from the oscillator may be taken from either the plate or the grid circuits and used directly on the charge and discharge condenser, or it may be applied through another tube. The simplest method of obtaining the saw-tooth deflection waves is shown in Fig. 31. But before this diagram is analysed, it may be helpful if we discuss briefly the saw-tooth wave and its properties.

Saw-Tooth Waves: The desired shape that the saw-tooth waves should have is shown in Fig. 32, namely, a long, straight, gradual rise in voltage until a predetermined value is reached, and then a quick, sudden drop to the initial starting level.

The process then repeats itself, 15,625 times a second for the horizontal oscillator and 50 times a second for the vertical oscillator. Practically, the simplest way of obtaining the gradual rise in voltage followed by a sudden drop is by charging and discharging a condenser. If a condenser is

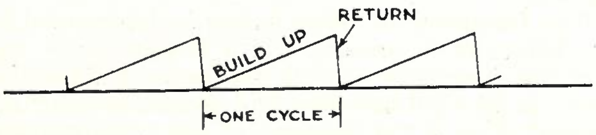

Fig. 32.—Saw-Tooth Wave.

placed in series with a resistor and a source of voltage, the flow of current through the circuit will cause the voltage across the condenser to rise in the manner shown by the curve of Fig. 33. This curve is not linear along its entire length, but the approximation of linearity at the beginning section of the curve is close enough for most practical purposes. Hence, if the condenser is discharged, just as it reaches point A on the curve, we will have a satisfactory saw-tooth wave suitable for application to the deflecting plates of a cathode-ray tube. The discharge of the condenser should be as rapid as possible since during the time the condenser is discharging the electron beam is blanked out at the tube and no picture is appearing on the screen. The shorter the time spent in discharging the condenser, the greater the interval during which the useful portion of the video signal may be acting at the screen.

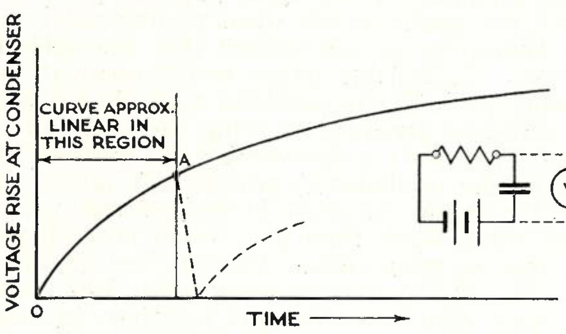

Fig. 33.—Voltage across Condenser being charged.

A simple and inexpensive method of charging and discharging a condenser to produce the necessary saw-tooth waves is given in Fig. 31. Triode V_1 is connected as a blocking oscillator, and the charge and discharge condenser is placed in the plate circuit. From the preceding discussion of the operation of these oscillators, we know that a short, sharp pulse of plate current flows once in every cycle. During the remainder of the time, the grid is negatively biased beyond cut-off, and no current flows in the plate circuit. Throughout the time when no plate current is flowing, condenser C_1 is charging because one side of this condenser connects to the positive terminal of the power supply through resistors R_1 and R_4, and the opposite plate of the condenser is attached to ground. The charge this condenser absorbs assumes the polarity shown in Fig. 31. When the plate current does start to flow, it is only for a very short period, and during this time the resistance of the tubes becomes very low. Condenser C_1, which is actually in parallel with the tube, then quickly discharges through this low resistance path. At the end of the short pulse of plate current, the grid has been driven very negative by the accumulation of the electrons in C_2 and the tube becomes non-conducting again. C_1 no longer has this easy path for discharging and slowly starts to charge, as previously explained. The saw-tooth variation in voltage across C_1 is transmitted to the next tube, an amplifier, through coupling condenser C_c. The process repeats itself, either at the horizontal scanning frequency or at the vertical frequency, depending upon its constants.

It will be noted from the foregoing action, that the instant the synchronising pulse arrives at the oscillator, it triggers the oscillator, the tube becomes conducting, and the condenser developing the saw-tooth voltage discharges. Hence, whenever a pulse arrives at the grid of the blocking oscillator, the condenser discharges and the electron beam is brought back from the right-hand side of the screen to the left-hand side. This action is true in all such synchronising oscillators.

Resistor R_4 is made variable to permit adjustment of the width of the picture. As more of its resistance is placed in the circuit, the amount of charging current reaching C_1 is lessened, with a subsequent decrease in the voltage developed across C_1 during its period of charging. A small voltage variation at C_1 means, in turn, a small voltage applied to the deflecting plates. The length of the left to right motion of the electron beam is consequently shortened, resulting in a narrower picture at the viewing screen. This is the reason for labelling R the "Width Control." In the vertical synchronising circuit, this same control would adjust the height of the picture Here it would be labelled "Height Control."

With the foregoing oscillators, as the grid voltage approaches the cut-off value, it becomes increasingly sensitive to noise pulses which may have become part of the signal. A sufficiently strong interference pulse, arriving slightly before the synchronising pulse, could readily trigger the oscillator prematurely. When this occurs, the electron beam is returned to the left-hand side of the screen before it should and the right-hand edge becomes uneven. Severe interference causes sections of the image to become "torn." To prevent this form of image distortion, several television receiver manufacturers have designed synchronising systems which respond only to long period changes in the pulse frequency. Since interference flashes seldom have regular pattern they cannot affect these special systems.

Deflecting Systems

Electrostatic Deflecting System: The schematic of an electrostatic deflecting system is shown in Fig. 34. It has been altered slightly for the sake of clearness and simplicity, but beyond a very few changes remains essentially as designed by the manufacturer. The video signal at the output of the detector is fed to the second triode of the 6F8G tube (T_1) for amplification. This tube is the first video amplifier. The synchronising pulse clipper, which is one triode of a second 6F8G (T_2), obtains its input signal voltage from the plate of the first video amplifier. The second triode section of T_2 is the first video output amplifier (not shown here).

In order to have the pulses possess the necessary positive voltage at the clipper input with negative picture phase, the output of the detector T_1 in this instance must be in the positive picture phase. Inspection of the diagram will reveal that this is the case. If there had been no intervening amplifier, and if the output of the detector had been connected directly to the clipper, then a negative picture phase signal output from the detector would have been required. In any situation, it is merely necessary to remember that passage of the video signal through an amplifier will reverse its phase by 180°.

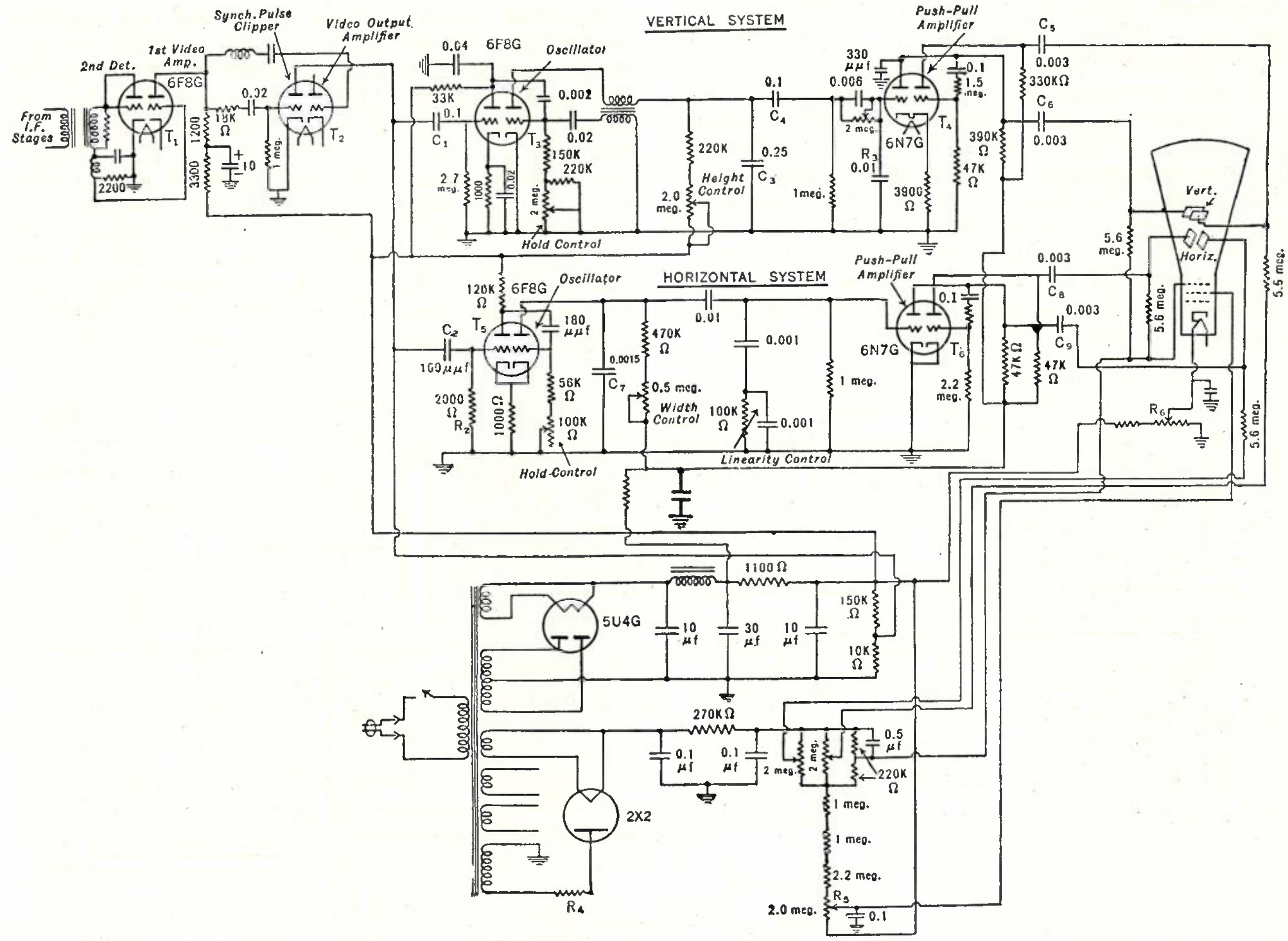

Fig. 34.—An Electrostatic Deflecting System.

In the present circuit, the 9.02 μF condenser, in combination with the 1 megohm resistor, has a relatively long time-constant and so biases the tube that only the large synchronising pulses cause plate current to flow. The remainder of the signal is of too low a value to overcome the bias and has no effect on the plate circuit. The tube thus "clips off" the synchronising pulses and discards the rest of the signal. Hence the term "pulse clipper" as applied to this tube.

The output of the clipper stage is fed to both the vertical and horizontal deflecting oscillators. The method for separating the low-frequency vertical pulses from the higher-frequency horizontal pulses is to employ the proper combination of resistors and condensers in each circuit. In the vertical system, the 0.04 μF condenser and the 33,000 ohm resistor in the plate lead of one triode section of the 6F8 G tube respond to the longer vertical pulses. For the horizontal system, C_2 (100 $\mu\mu$F) and R_2 (2,000 ohms) combine to form a low time-constant circuit.

The variable resistor R_3 is known as the vertical linearity control. Its function is to correct the shape of the saw-tooth waves so that they rise linearly. The name of the control is derived from this action. The need for correction arises from the tendency of the charging voltage across C_3 to increase in a manner not quite linear.

The horizontal synchronising oscillator T_5 is a multivibrator circuit, the output of which controls C_7, the charge and discharge condenser. The variable resistor of 500,000 ohms controls the charging rate of C_7 and is,therefore, the width adjustment. T_6 serves the same function here as T_4, and the output deflecting voltage is connected to the cathode-ray tube plates through condensers C_8 and C_9. A 100,000 ohm variable resistor acts as the horizontal linearity control.

In the power supply, one transformer is used for the rectifier plate windings of the low voltage and also of the high voltage unit. A 5U4G rectifies the low voltage and a 2X2 does the same for the high voltage. Resistor R_4 in the plate lead is inserted to prevent an excessive current that could prove injurious to the tube. This might occur if some component in the unit became shorted.

Note that in this high-voltage unit, the negative end of the bleeder resistor string does not connect to ground, but rather to the positive terminal of the low-voltage supply. In this way it reaches the cathode-ray tube through the brightness control R_6. The B - lead of the high-voltage supply could have been attached directly to the viewing-tube cathode, but it could not have been directly grounded, because the cathode is at ground. Hence a direct connection from the B – R_6 is at the grounded end of that control. This can be traced out in Fig. 34. At all other settings of the R_6 potentiometer arm, the cathode is above ground. Hence a direct connection from the B-terminal of the high-voltage unit to ground is impossible.

Another reason for not grounding the negative end of this supply is due to the position of the focus control. This potentiometer connects to the first anode of the cathode-ray tube and must be several hundred volts more positive than the cathode. It is at this potential in this unit because the negative end of the high-voltage supply connects to the positive end of the low-voltage unit. The cathode of the viewing tube is attached to the brightness control which is less positive than the focusing resistor. The preceding description will hold for many of the power units found in a television receiver. In some, perhaps, the B –

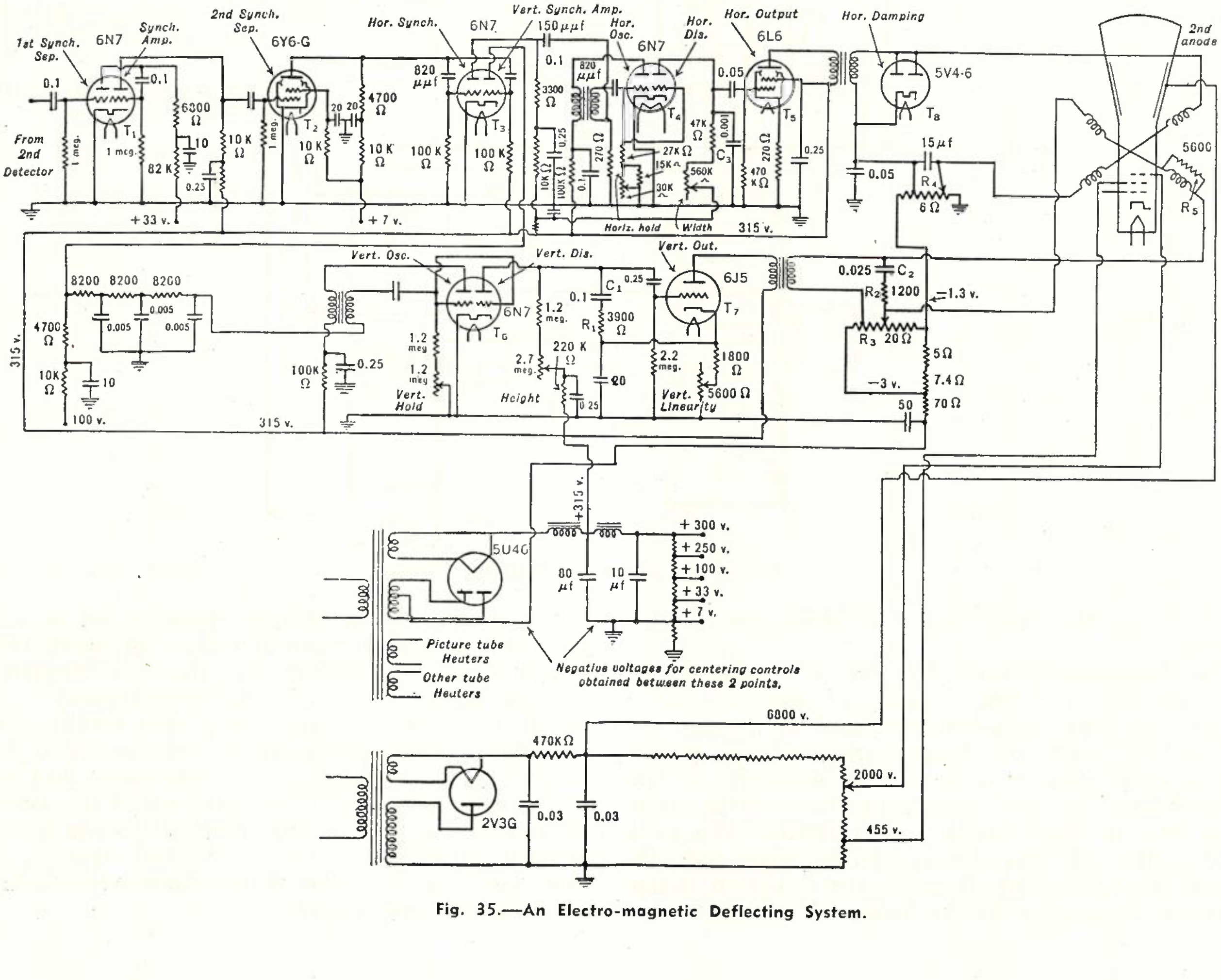

Fig. 35.—An Electro-magnetic Deflecting System.

end of the high-voltage unit is so arranged that it can be directly attached to the ground, whereas in others, like the above, this will not be possible. The arrangement depends on the circuit design.

Electromagnetic Deflection System: The system undertaken for this analysis is given in Fig. 35. The synchronising signal is obtained at the output of the second detector and applied to one triode portion of T_1 (6N7). This tube has no fixed bias of its own, the operating point being determined by the pulse level of the incoming signal. As previously explained, the grid coupling condenser is charged by each pulse and then slowly discharged through the 1 megohm grid resistor. With the low plate voltage of the tube (33 volts), plate current is permitted to flow only at the most positive portions of the video signal, which is assumed by the synchronising pulses in this case. The signal at the input of T_1 must be in the negative picture phase.

The output of the first synchronising separator, or clipper, is then amplified by the second triode section of T_1 and relayed to T_2, a pentode (6Y6G). This tube is the second synchronising separator, where any unwanted video voltage that may have passed through the first separator is suppressed. Note that here again the pulses are positive at the control grid. The plate is operated at an extremely low voltage (7 volts) to aid in the separation. In this design there is an unusually large number of stages (3) devoted to separating the synchronising pulses from the rest of the signal.

After T_2, separation of the vertical and horizontal pulses takes place. For the horizontal pulses, we have the low time-constant circuit connecting the horizontal synchronising triode portion of T_3 and the horizontal oscillator (150 $\mu\mu$F condenser and a 270 ohm resistor). For the vertical pulses there is a three-stage low-pass filter composed of three 8,200 ohm resistors and three 0.005 μF condensers.

For the vertical deflecting system, T_6 serves as the vertical blocking oscillator. The vertical pulse from T_3 is sent through the low-pass filter composed of three 8,200 ohm resistors in series, bypassed by three 0.005 μF condensers. The filter eliminates any high frequency horizontal pulses that may be present. The 1.2 megohm variable resistor in the grid lead controls the natural frequency of the oscillator and hence is the vertical hold control. It is adjusted until the blocking oscillator is locked in by the incoming positive pulses.

In this receiver a separate tube, the second triode of T_6, controls the discharging of condenser C_1. The grid of the discharge tube is directly connected to the blocking oscillator grid and follows its voltage variations. Once in every cycle a sharp positive voltage appears on these grids, both tubes become conducting, and C_1 discharges rapidly through T_6. The input for T_7 is obtained from across the series combination of C_1 and R_1 and provides the necessary peaked voltage form.

When applied across the deflecting coils, the voltage will generate the necessary saw-tooth wave of current. The charging rate of C_1 can be varied by the 2.7 megohm resistor in the plate circuit of the second triode of T_6. This resistor would be the height control.

The vertical output amplifier, a 6J5, receives the vertical voltage wave, increases its amplitude, and then applies it to the vertical deflecting coils through an output transformer. A variable resistor of 5,600 ohms is inserted in the cathode leg of T_7 to provide a vertical linearity control.

In the secondary circuit of T_7, there are two resistors R_2, R_3 and a condenser C_2. The function of R_3 is to permit a small current to flow through the vertical deflecting coils for centering the electron beam. A fixed tap is provided for one connection to the deflecting coils, while the other end of the coil is attached to the centre, movable arm. In this way it is possible to have a small current flow either in one direction or another, or to eliminate it entirely when the movable arm is at the tap. A similar arrangement is found in the horizontal deflecting circuit (resistor R_4).

The horizontal deflecting system, starting with tube T_4, parallels the vertical deflecting system in all but two respects. One is the type of saw-tooth deflecting voltage that is generated, and the other concerns the damping circuit.

The power units in this receiver are simply constructed and require no special explanation. A 5U4G operates as a full-wave rectifier in the low-voltage unit, while a 2V3G is utilised in the high-voltage unit. The 6,800 volts in the 2V3G supply is connected directly to the second anode of the 12-inch viewing tube to provide the necessary focussing and accelerating action.

Conclusion

A general outline has been given of the operation of the chief components required for a black and white television system. Fuller details of specific installations when they are made in this country will, no doubt, be given in later articles.

CHARACTERISTICS AND FUNCTIONS OF PHOTOGRAPHIC PROCESSES

A. W. Moore

Introduction

It is the intention in this article to outline briefly the various processes in which the action of light is employed to reproduce drawings and to record objects and events. The action of light on matter was known two thousand years ago, but the discovery of photography is attributed to Johann Schultz, who, in 1725, became aware that light action on silver salts could be intensified by an optical system using convex lenses.

During the one hundred years that followed this discovery, many people, scientists and laymen alike, strove to create a process in which a photographic image could be rendered in a permanent form. The modern form of photography began with the work of Fox Talbot almost one hundred and fifteen years ago. Since that time its progress has kept pace with the requirements of science and industry. Photography to-day is so much a part of our daily life that it is very hard indeed to imagine a world without photographs. Its use for medical research would alone justify its existence, but, with a multitude of applications it becomes one of the greatest utilities of the age.

Readers of the Telecommunication Journal will have noticed the important part photographs take in the illustration of the letterpress, for, no matter how lucid the text may be, a photograph helps to make the story clearer. It establishes locale and introduces dimension to the subject. The camera records detail with infinite capacity, its product, the photograph, presents this detail for study and analysis whenever required.

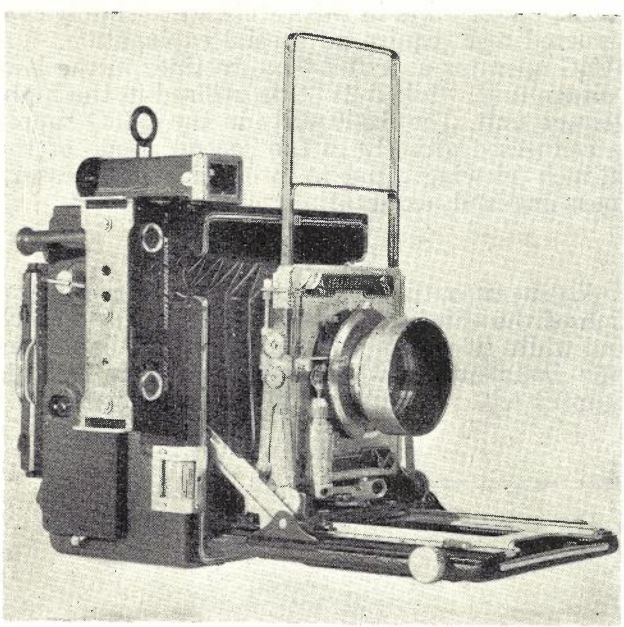

Fig. 1.—A Modern Hand Camera.

Plan Reproduction

The simplest form of photography used in the Postmaster-General's Department is blue printing. In 1842 Sir John Herschel discovered the chemical cal reaction that led to this most useful and economical method of plan reproduction. The printing paper is sensitized on one side with ferric compounds. It is yellowish green in colour. The drawing to be copied is placed in contact with the blue print paper and fed into a printing machine. An endless belt, moving around a curved plate-glass surface, exposes the plan and copy paper to a pair of arc lamps. These lights are constantly in motion, moving from one end of the machine to the other, thus ensuring an even distribution of light as it passes through the plan to the printing paper.

The action of the light has now reduced the ferric salts to a ferrous state. This ferrous image reacts with potassium ferricyanide to precipitate an insoluble blue compound. Where the opacity of the india ink line drawing has prevented transmission of light the ferric salts remain unconverted and, upon immersion in a water bath containing potassium bichromate are washed out, leaving the white paper base to form the white lines of the reproduction against a background of prussian blue. The print is given a final wash and is heat-dried between endless canvas belts. Blue prints are fairly stable unless exposed to strong light for long periods, or subjected to the bleaching effect of alkaline perspiration from finger prints.

Another process allied to blue printing is the sepia negative. This method is based on the ability of ferrous salts to reduce silver ions to metallic silver. Lightweight paper is sensitized with ferric salts and silver nitrate. In contact with the drawing linen it is exposed in the printing machine. The light reacts with the ferric salts converting them to a ferrous state, such action having the capacity to reduce the silver nitrate content of the paper coating into a metallic form. The action of the light also affects the silver nitrate directly, forming metallic silver. After exposure the negative paper is fixed in a two per cent. solution of sodium thiosulphate (hypo).

The exposed area of the paper now becomes a dense sepia colour, which consists of the metallic silver plus a yellow iron precipitate. The unexposed area of ferric salts and silver nitrate is washed out in the fixation, leaving the paper base as the line. From this, negative blue prints having blue lines on a white base can be made. The sepia background of the negative is dense enough to prevent transmission of the light from the printing lamps, the negative paper base is thin enough to permit the light to reach the blue print copy paper, and so the ferric and ferrous salts react as previously described. By supplying an identical sepia negative to each printing machine operator mass production of blue brints is made possible. It also saves wear on a valuable drawing office linen that multiple printing would impose.

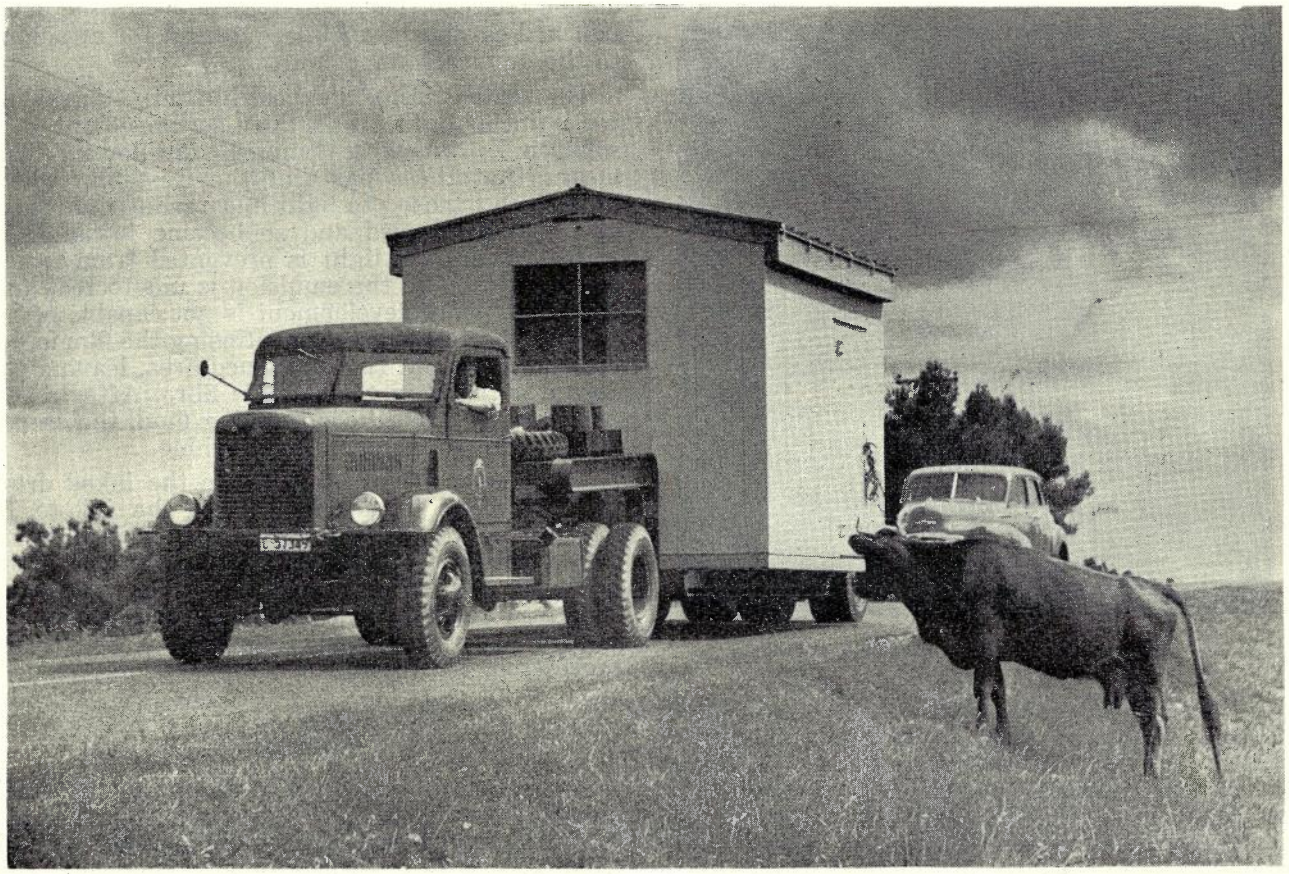

Fig. 2.—RAX on 400-mile trip, Sydney to Albury. A newsworthy photo.

The fastest printing process in use is the dyeline method. It offers the means of obtaining a positive copy from a drawing office linen in from thirty to forty seconds. This is possible because of the high sensitivity to light of the diazo coating, the small amount of fluid absorbed by the paper base during development of the image, and the complete elimination of washing and drying, the bottle-neck in large scale blue print production. Diazo is the name applied to certain organic compounds containing two nitrogen atoms in a particular combination. Diazonium compounds are also important intermediates in the manufacture of numerous synthetic dyes. It is this ability to form dyes that has enabled the diazo process to be adapted to photo-copying. Upon exposure to strong light the diazonium salts quickly decompose owing to the nitrogen being displaced. Unexposed salts can be coupled with a dye-forming solution to produce a visible image.

The method of printing is basically the same as previously described for blue prints. The drawing linen is placed in contact with the dyeline paper and exposed to light. This exposure produces slight visible changes in the sensitive coating. The print is passed between rollers damped with the dye coupling developer and the secondary reaction occurs. The result is a positive copy from the positive drawing linen. The opaque lines of the original drawing simply prevents the light from decomposing the diazo salts so that they will react to the dye coupling solution.

Photographic material in general usage consists of either film, glass plates or paper coated with an emulsion. This emulsion is comprised of two principal ingredients, gelatine impregnated with well dispersed silver halide particles. Upon exposure to light a latent image is formed. To render this image visible the exposed material is developed in a chemical solution having the property of selectively reducing the exposed silver halides into black metallic silver in the proportion to the intensity of the light action upon them. The unreduced silver is removed by the solvent, sodium thiosulphite (hypo). This removal of the unreduced silver compounds fixes the image and ensures its permanency. Processes now to be described utilise this silver emulsion type of material. It is necessary to have a photographic darkroom for the "developing out" operation.

A modern photo-copying process is the photographic tracing cloth. A tracing linen type base having a transmission density of 0.35, is silver sensitized with a high contrast orthochromatic emulsion. This material is exposed under the

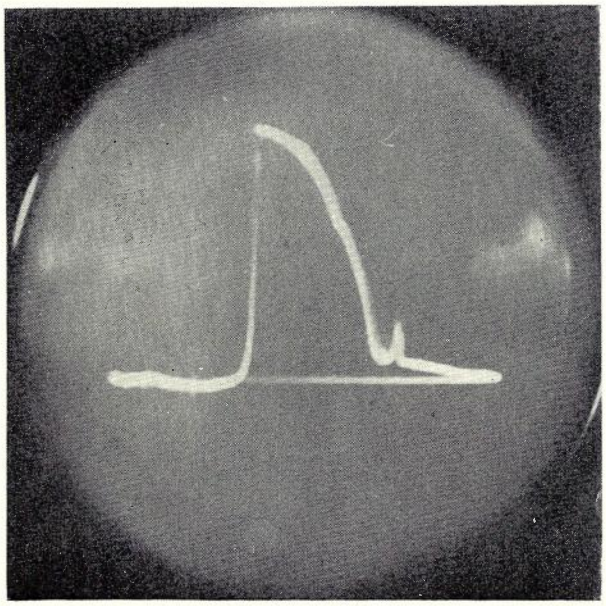

Fig. 3.—Analysing Circuit Characteristics with an Oscilloscope.

drawing office linen by artificial light. A vacuum printing frame is used to maintain maximum contact between original and copy material during the exposure period. The exposed photo-linen is developed in a high-contrast metol-hydroquinone developer, fixed with a solution of sodium thiosulphate, then washed in running water for a short time.

The first copy from the drawing office linen is in negative form, that is, the tones of the original have been reversed. From the negative photo-linen, by repeating the printing process, a positive photo-linen is obtained. This product is similar in appearance to the drawing office linen, and is very suitable for reproduction by the printing machine processes previously mentioned.

Although comparatively expensive, the value of this copying process may be gauged from the following instance. In the planning of a large multi-storied building, in which the requirements of various departments demanded a different layout for each floor, the designer drafted a single linen of the basic floor space, showing pillars, stairways, fire escapes, toilets, etc. The next step was for the photographic section to provide a photo-linen for every floor level. On this the individual planning of the floor space began. In a few hours a photographer had produced all the necessary copies. The labour saved in eliminating repetitive drawing was considerable.

The common office stencil duplicating machine cannot escape the application of an ingenious photographic technique. This process is known as the Gestefilm. It consists of a fine paper base, usually the Japanese tissue, Yoshino, which is coated on both sides with a silver light-sensitive emulsion. It is available in two sizes, foolscap and double foolscap. The coated tissue bears the usual punched cardboard registering head for attaching to the duplicating machine.

The coated tissue is exposed under the drawing by artificial light. It is then developed-out in a solution known as a "tanning" developer. This means that those parts of the Gestefilm which have been exposed to light and rendered developable will be tanned and so become insoluble in water. Where the light is prevented from reaching the Gestefilm the emulsion is unaffected, and, therefore, upon development is not capable of receiving the tanning action. Rinsing the film in hot water washes out this untanned area, leaving the design outlined in clear tissue fibre. After a few minutes in a special conditioning fluid, the stencil is ready for the duplicating machine.

The Gestefilm is positioned on the inked drum and the clear tissue area allows the ink to be transferred to the standard type of duplicating paper. Hundreds of copies may be obtained from a single film. Where diagrams have to be included in reports, staff training manuals, examination papers, etc., and economy of production considered, the Gestefilm process is most valuable.

Photostats

Photostats are made with a large camera which stands about seven feet high and is almost half a ton in weight. A roll of hard, thin paper is sensitized with a fast orthochromatic emulsion. This paper is eighteen inches wide and three-hundred and fifty feet in length. It is loaded into the camera in much the same way as a roll film is loaded into a kodak. The maximum area of the photostat is twenty-four inches by eighteen inches, and each loading provides one hundred and seventy-five copies this size. Intermediate sizes can be obtained by means of a masking blind built into the camera.

The plan or document to be copied is simply laid flat on a horizontal easel and illuminated with mercury vapour strip lighting, This camera photographs "around a corner" by means of a prism mounted in front of the lens. The sensitized paper in the camera is held in a vertical position, whilst the copy board is horizontal. The prism to lens arrangement solves the problem of lateral inversion, for a lens alone would give a wrong way round image on the opaque paper. The light image from the copy board enters the prism, is reversed, enters the lens, becomes corrected and is recorded in a readable form on the photostat paper.

The photostat is developed in a normal metol-hydroquinone photographic print developer, rinsed in an acetic acid short stop bath and fixed in hypo. A final wash in running water for about half an hour leaves the print ready for drying. Although the tones of the original have been reversed, the photostat copy is readily accepted in that form. However, should a facsimile of the original be desired it is simply a matter of re-copying the photostat negative.

This useful apparatus will copy same size from documents up to twenty-four inches by eighteen inches in area. It's range extends from half-scale copies of plans measuring forty-eight inches by thirty-six inches to double-size reproductions from documents, etc., measuring twelve inches by nine inches. Oversize maps, etc., can be copied in sections and mosaic join-ups made. With the use of an accessory book-holder, two pages of a book may be copied at the one exposure without the necessity of taking the book apart. Photostat copies, correctly processed, are permanent and durable. Facsimile detail is faithfully rendered at a speed with which no other process can compete.

Photography and Camera Technique

In a service as extensive as that of the Postmaster-General's Department there are, naturally, a number of branches with extremely diverse activities, and, similarly, their photographic requirements are equally diverse.

There are staff training schools, so photographs are required to illustrate training manuals. New building projects are recorded as construction proceeds. Equipment installations are photographed. Faults in machinery, scenes of accidents, a spark jumping across an air space are recorded for analysis. Photography also aids favourable publicity. News-worthy photographs are welcomed by journals. Window displays inform and educate the public. During a recent staff recruitment drive, a picture story of the privileges and facilities offered to telephonists attracted much attention, both in potential employees and the press. The camera can easily record an oscilloscope pattern one moment and a thousand yards of an aerial trunk route the next.

For lectures, lantern slides are made in black and white or colour. When a large group of people has to be instructed, the lantern slide is equal in importance to the lecturer as is his script. Ordinary tone slides are adequate for many illus-

Fig. 4.—Checking Telephone Circuits, Kempsey. The camera records the detail of a flood-time emergency.

trations, as are line diagrams in black and white, but for subjects such as apparatus using a colour code in wiring, or for modern Post Office buildings, only natural colour slides can portray the necessary realism.

At times the photographer is called upon to make pictures where lighting conditions are more or less impossible, or where high voltage would be inconvenient and, in wet tunnels, etc., even dangerous to use. To overcome this difficulty there has been successfully developed a method of putting light into "bottles," and flashing this light for a brief moment whilst the camera shutter opens.

A bulb about the size of a sixty watt electric lamb globe is filled with a fluffy looking ball of finely drawn wire. This wire usually consists of an aluminium-magnesium alloy, which is sealed into the bulb together with dry oxygen. The firing circuit comprises two filaments which extend into the ball of wire. Each filament is tipped with a priming paste and joined, one to the other by a very fine filament to make the electrical circuit. To ignite the bulb, current from two or three dry cells of the pocket torch type is applied. This current heats the tiny filament, explodes the priming paste, which then quickly ignites the combustible wire content, resulting in a brilliant flash of one-twentieth of a second duration. The camera shutter is tripped electrically and is synchronised to be fully open at the peak of the flash bulb's output. For such a small size the light quantity is amazing, for the light is rated at 2,500,000 peak lumens. These bulbs permit camera shutter speeds up to one millisecond's duration to be used, allowing high speed photographs to be made where existing lighting conditions would make such a task hopeless. The bulbs described in the foregoing are expended for each flash. The latest in photo-flash equipment is the electronic repeating flash lamp. The flash lamp, or tube, is filled with a rare gas, usually xenon, into which electrodes are sealed. The electrical circuit is designed to permit a large quantity of electrical energy at about two-thousand volts to be stored in a condenser connected across the lamp. When this current is released a brilliant flash, lasting approximately ten milliseconds occurs. The main value of this brief flash is its ability to freeze motion and permit the camera to record this stop-action. By this means phase action of high-speed machinery may be examined at any point, for the flash camera may be fired by contacts placed on the machine itself, by photo-electric cell, or sound wave via a microphone.

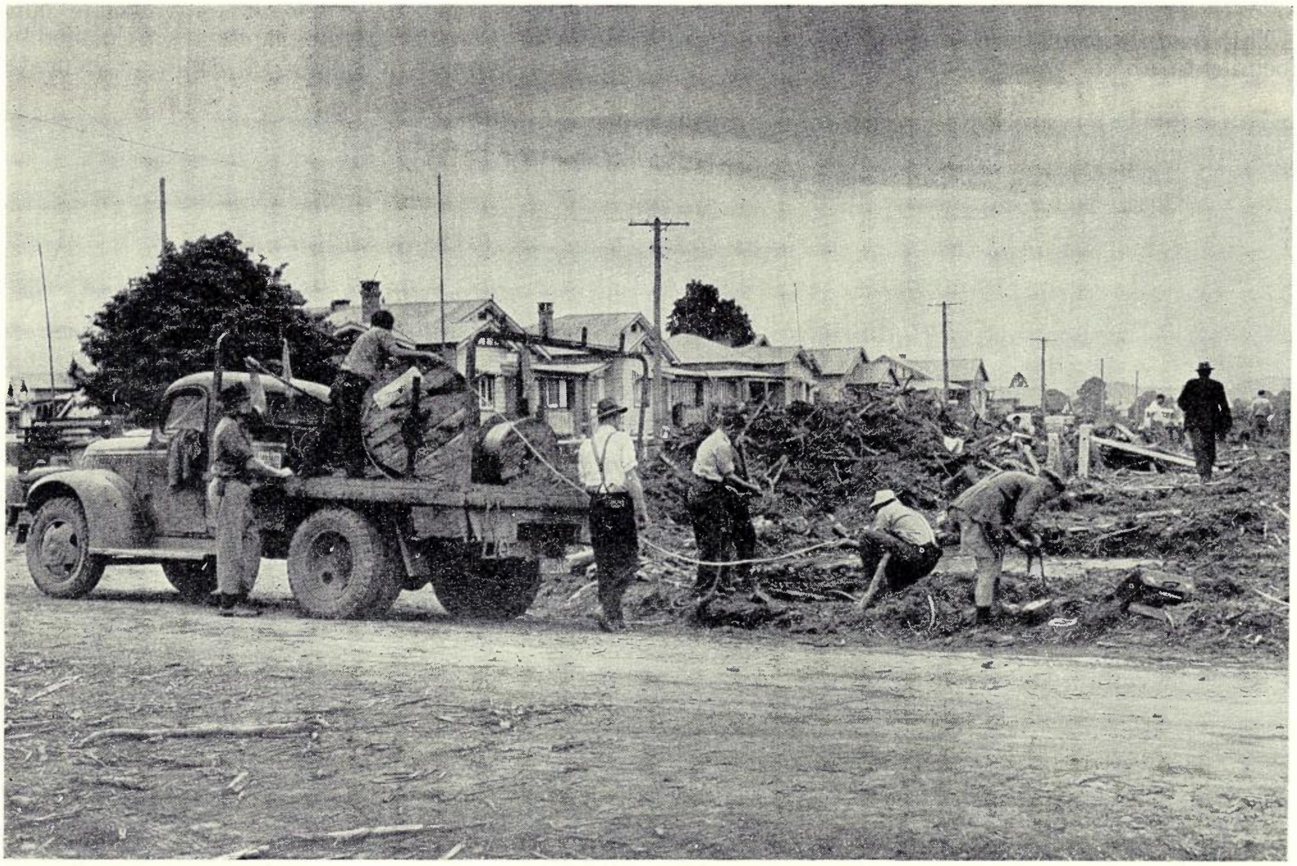

Fig. 5.—Kempsey Flood Scene.—Relaying cable amid debris piled shoulder high.

Some mention must be made of the value of the motion picture film. Besides being perhaps, the greatest medium of expression ever created, it presents, for training purposes a tireless method of imparting instruction to students, for, unlike the human, the film cannot deviate from its establishment theme. The producer of the film can rest assured that, without deliberate and mischievous interference, the message the film contains reaches the viewer as he intended. The film permits knowledge to be assimilated mixed with the tonic of entertainment, for people to-day are highly film conscious. The art of the film can, and does, bring to the viewer a feeling that he is present at the scene. He can watch the colourful blending of dyestuffs, the splicing of an ocean cable, the welding of metals, and feel that the instruction is personal. It is for this reason that modern training establishments have so readily exploited the educational qualities of this medium.

Another useful branch of photography is micro-file film reproduction. This method is used when bulky quantities of literature, large maps and drawings which, if left in their original size, would occupy an excess of storage space, or to reduce consignment costs if required to be air-freighted long distances. Micro-file film is a fine grained panchromatic film of standard thirty-five millimetre gauge, possessing high contrast and great resolving power. This type of film is very suitable for copying originals having very fine detail.

The resolving power for micro-film is one-hundred and sixty lines per millimetre. This almost unbelievable capacity is determined by photographing, at a distance of eighty-one times the focal length of the camera lens, a plane surface bearing parallel black lines half a millimetre thick, and separated by half a millimetre of white ground, so that each line will be distinguishable on the negative. The negative area of thirty-six by twenty-four millimetres is, therefore, capable of recording 5,760 lines twenty-four millimetres high at a lens to chart distance of approximately thirteen feet. The concise type of dictionary running into fifteen hundred pages can be recorded on approximately fifty feet of this remarkable film. Reproductions from these tiny frames reveal all the detail of the original, for enlargements can be made greater in size than the original document.

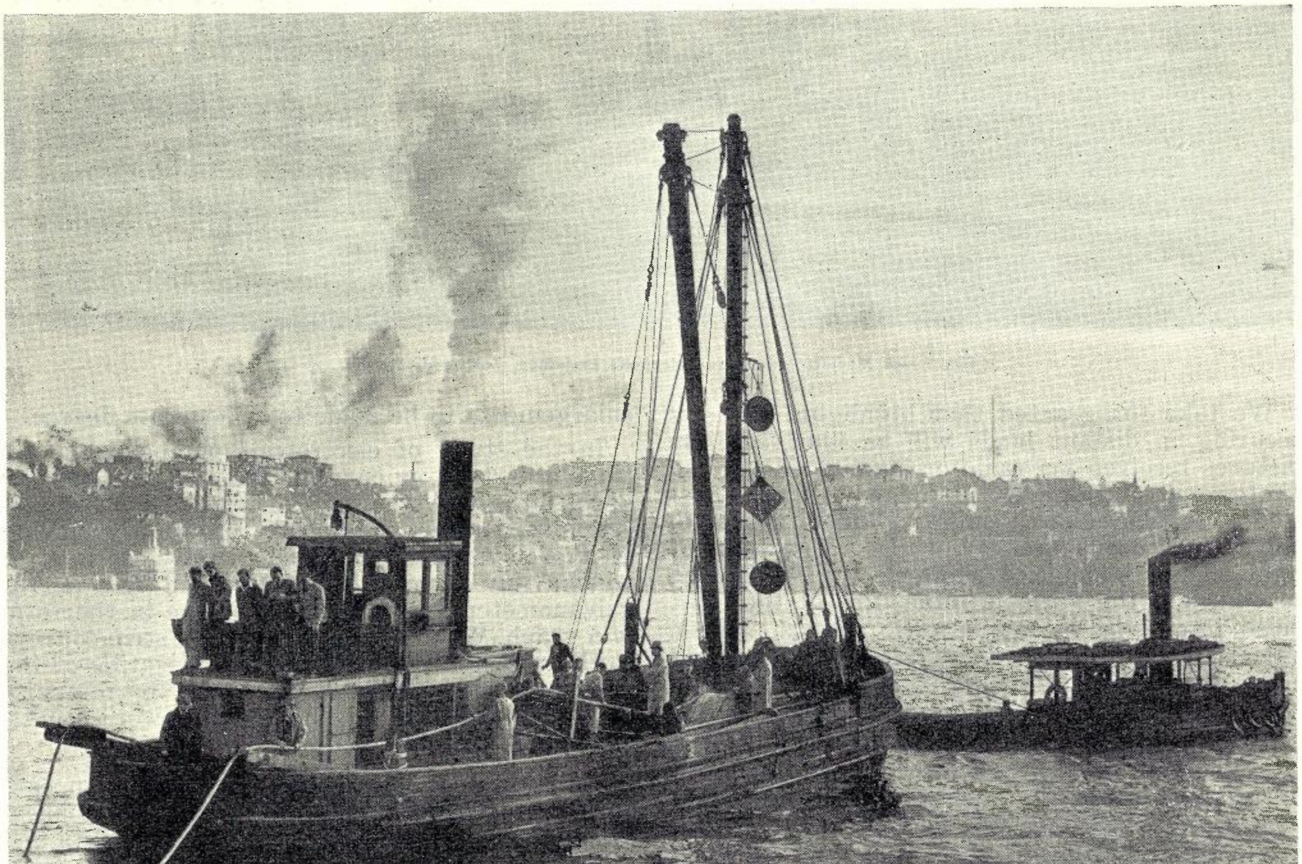

Fig. 6.—Submarine Cable Laying, Sydney Harbour.

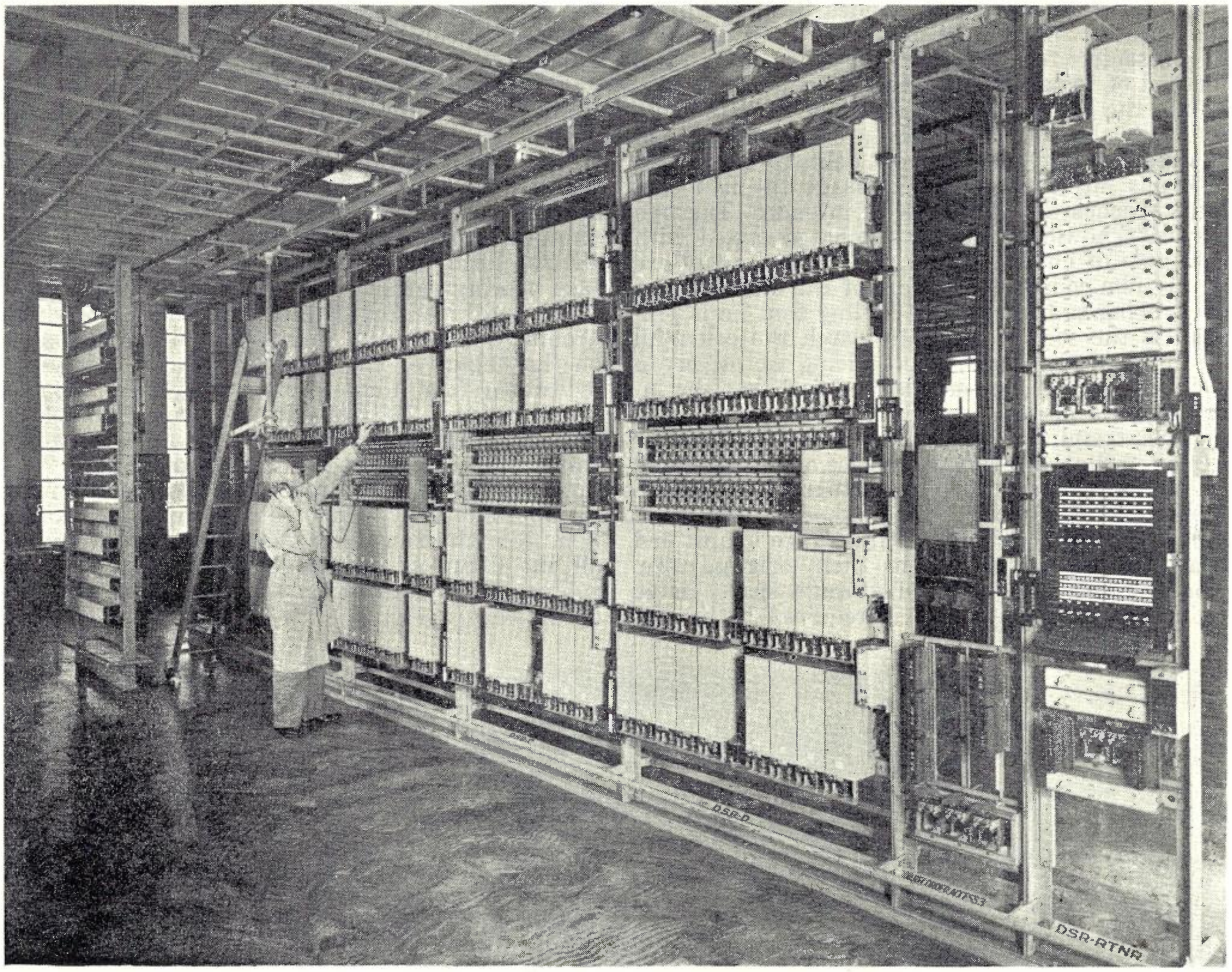

Fig. 7.—A Modern Automatic Telephone Exchange, Eastwood, Sydney.

We take for granted that highlights of news occuring in distant lands will be illustrated by pictures received via radio or landline. When the photograph of the event is lodged for transmission it is placed on a small cylinder which revolves, and moves laterally, whilst a tiny beam of light scans the image. A photo-electric cell is used to translate the variable intensities of the light beam into proportionate electric signals. These signals, amplified and transmitted, are received and converted into variable light intensities once more. In the receiving machine this light beam is directed on a sensitized film revolving and moving laterally at a speed synchronised with the transmitting apparatus. The sheet of photographic film now bears a latent image with the tones of the original photograph reversed. It is removed from the drum in a dark-room for the normal photographic development-out and printing process. The received copy, being in the form of a negative transparency, permits easy distribution of multiple copies in a short time, and also allows enlargements to be made to a moderate degree.

In the study of electrolysis photography also plays a part. Stray currents from electric railway and tramway systems are measured by a photographic recording voltmeter. In a slowly moving strip of silver sensitized paper twelve centimetres wide, a tiny beam of light, activated by a mirror galvanometer, traces a latent image in the form of a graph. When developed-out this strip conveys to the research engineer where mitigation of the effects of electrolysis is necessary to minimise corrosive action on telephone and power circuits, water and gas mains.

The future of functional photography appears very bright indeed. The search for new applications of this science never ceases. Physicists and others are ever striving to improve existing technique. Some recent achievements deserve special mention, for what is new and exciting to-day soon becomes adapted to everyday usage. Three dimensional photographs are already in production and are available at a reasonable cost. The electron microscope has been developed to give a magnification up to 100,000 diameters with satisfactory definition.

In medical research infra-red film is being used to record detail not visible to the human eye. The same film enables an object to record its own image solely by the infra-red radiations it emits when heated. A method of printing photographs into glass to a depth of two inches has been perfected. At Mount Palomar photographs are being made through the giant two-hundred inch telescope of hitherto unknown star groups, whose light takes three million years to reach the earth.

Of special interest is Xerography, pronounced Zer-og-raphy. It is a new, fast, dry printing process now being produced in America.

The surface of a specially coated plate is charged with positive electricity and exposed under the original. The positive charges disappear when exposed to light, the unexposed areas, still positive, accept a negatively charged powder. A sheet of paper is now placed in contact with the dusted plate and given a positive charge. The positively charged paper attracts the negative charged powder in the pattern formed by the original drawing. Thus on the paper a positive image is formed. This print is simply heated for a few seconds to fuse the powder and form a permanent print.

The transmission of motion picture films by overseas television services is now an accomplished fact. With the introduction of television to this country, yet another photographic technique may be added to departmental activities.

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JUNCTION CARRIER EQUIPMENT AND ITS INTEGRATION INTO UNIT FREE AUTOMATIC NETWORKS IN N.S.W.

G. R. Lewis, (B.E., A.M.I.E, Aust.)

Introduction: One of the main factors leading to the use of junction carrier systems in the Sydney unit fee network was the time factor. Some junction groups had an inadequate number of junctions and relief, by means of the provision of additional cable pairs, depended on the carrying out of large construction works which were not expected to be completed within two years and would probably take much longer. At the same time the junction requirements were increasing rapidly, and it was essential that additional junctions should be provided by some speedier method, such as by means of carrier channels.

Junction Requirements: Before dealing with other factors and with the types of junction carrier system which are available for use, let us see how the junction requirement figures are obtained and how they are used. These requirement figures tell us how many junctions should be provided, incoming and outgoing, in any particular junction group between automatic exchanges. The figures should be as accurate as possible as they govern the quantity of plant provided and affect the grade of service which is given to the telephone user. The figures are made available by the Telephone Equipment Planning Section and show for any two automatic exchanges, the number of junctions required to enable the standard grade of service to be maintained. The figures give this information as at the present time and for periods up to twenty years.

In considering a particular junction group, a comparison is made between the number of junctions which are required and the number of junctions which exist. If this comparison shows that additional junctions should be connected then an order is issued and forwarded to the Cable Records Section. The Cable Records Section nominates additional cable pairs and the order is then sent to the various installation staffs concerned so that additional junctions can be brought into service. It might be mentioned here that the requirement figures are also used by both Lines and Telephone Equipment sections as a basis for planning and carrying out engineering works so that the junction requirements can be met as they arise. For instance, as far as the Lines section is concerned, provision of cable ducts is normally based on the 20-year figures and the provision of cable on the 8-year figures, while in the Telephone Equipment Section, the provision of banks and racks is based on the 5-year figures, but switches are provided to meet the 2-year figures.

Sometimes, as a result of lack of either cable pairs or exchange equipment or building accommodation, it is not possible to bring the required additional junctions into service. The result of this, therefore, is that within a short time there is an insufficiency of junctions and this is reflected in a deterioration of the grade of service. As time goes on, more subscribers' services are connected and the grade of service deteriorates still further. It is only a matter of time before serious consideration may need to be given to closing the exchange as far as the connection of additional subscribers' services are concerned.

The junction requirement figures are based on traffic measurements which are being made continuously throughout the automatic exchange network. The measurements are made at each exchange at approximately 2-yearly intervals and figures are obtained showing the number of traffic units; that is, the number of simultaneous connections during the busy hour on the particular junction group concerned. Both incoming and outgoing traffic is, of course, measured. This number

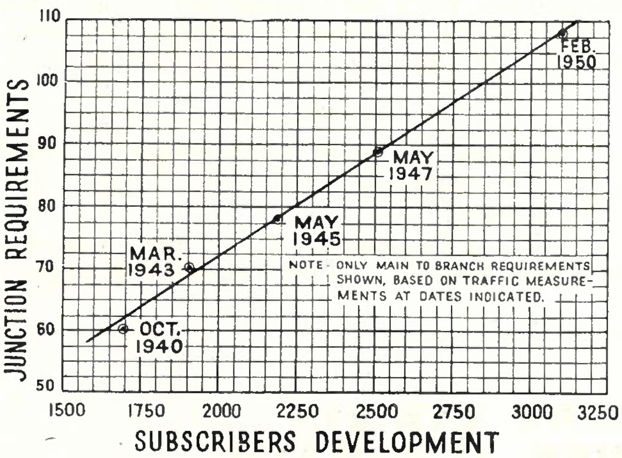

Fig. 1.—Graph showing linear relationship between junction requirements and subscribers' development in a typical branch exchange (over the 10 year period 1940-1950).

of traffic units is a basic figure which represents the density of traffic at the time of measurement only and must be modified in order to arrive at a figure representing the density of traffic to be expected at a period of some years later. Traffic studies have shown that junction traffic is approximately proportional to the number of subscribers connected. Fig. 1 shows a typical example of this relationship. Therefore, in order to arrive at the value of traffic density in, say five years' time, it will be necessary to multiply the value of measured traffic by the ratio of the number of subscribers to be connected in five years' time to the number of subscribers connected at the time of measurement. This ratio of the future to the existing number of subscribers is known as the growth factor. Then allowance must also be made for the seasonal fluctuations which recur fairly regularly from year to year for each exchange, for example, traffic during the summer months at a particular exchange might be substantially greater than in the winter months. Each exchange has its own particular pattern of traffic variation throughout the year. The variation for an exchange in an industrial area, for example, is different to that for a city exchange, or an exchange in a residential area. Traffic studies have also shown that the density of traffic at automatic exchanges is approximately proportional to the magnitude of the exchange battery discharge current. For each automatic exchange a graph similar to Fig. 2 is available, which shows the general variations of busy hour battery discharge current per 1000 subscribers' lines throughout each year. From this graph a value of discharge current is obtained representing the average discharge for the busiest three months of the year. This representative value of discharge is then compared with the normal or usual discharge at the time the traffic measurements are made and the ratio of the two values gives the factor by which the measured value must be multiplied in order to allow for the general seasonal fluctuations.

Amongst other matters which must be considered when estimating future requirements are:

(1) Alterations proposed to network switching pattern, effect of establishment of new exchanges, etc.

(2) Increase to be provided for in busy hour calling rate of subscribers.

(3) Effect of change in character of subscribers' services, for example, from residential to industrial.

These methods, which have just been described briefly, are the methods used to arrive at the density of traffic to be expected in so many years' time in a particular junction group. The next step is to calculate the number of junctions which will be required to handle this amount of traffic and maintain a standard grade of service. The number of junctions is not a constant for a given amount of traffic, but depends to a considerable degree on the type of exchange equipment which

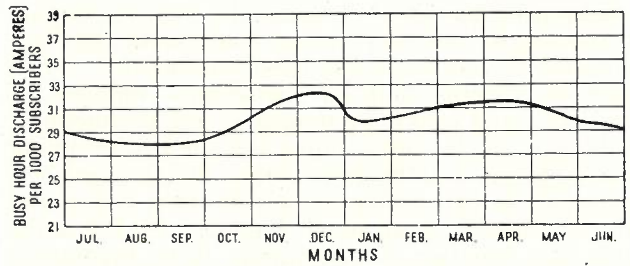

Fig. 2.—Variation of Battery Discharge during year. Typical exchange in good residential area.

is used. For instance, the number of junctions required will vary, depending on whether switches of homing or non-homing type are used, on the number of outlets on the switch banks and on similar considerations.

Development and Use of Junction Carrier Equipment: In recent years there have been serious delays in the provision of additional junctions as a result of lack of cable pairs. There are many reasons for this, the main one being the shortages of labour and materials which have such a marked effect in delaying the carrying out and completion of works. These are the circumstances which led up to the use of carrier methods in order to obtain additional junctions. The idea of using carrier systems to obtain automatic exchange junctions is not new and the method has been considered many times in many places. However, apart from economic considerations, the carrier equipment which was available in the past was not designed for junction working, and as there was not very much of it available anyhow, it was better to use it for its designed purpose of providing trunk channels over long open wire lines. These open wire systems, however, have been, and are still being, operated satisfactorily over pairs in trunk and junction cables, but they provide trunk circuits and not junction circuits. For instance, the New South Wales south coast open wire type carrier systems have been operated since 1937 over cable pairs between Sydney and Hurstville, and other similar systems have operated over cable pairs between Sydney and Ashfield. The main disadvantages of these systems, when considered for junction working, were that they require a relatively large floor space for their accommodation, they provide a maximum of three channels only per system, and their signalling equipment was not readily adaptable for dialling operation. Moreover, in normal times, the high initial and maintenance costs of carrier systems compared with cable would prohibit their use. For these reasons, therefore, and in view of the fact that the junction position in the past was not desperate, carrier methods were not used.

In 1945, however, the situation as far as certain groups of automatic exchange junctions were concerned, was very serious. Not only was the number of existing junctions insufficient, but the requirement figures showed that fairly large numbers of additional junctions would be needed year by year. In some cases relief depended entirely on the undertaking of large conduit and cable construction works and in view of the demands existing throughout the Sydney metropolitan exchange network and New South Wales generally, it was clear that the works would not be completed within at least two years and probably much longer. At the same time, there was in particular areas an inadequacy of exchange plant, and this meant that the full number of subscribers for the area would not be connected. The result of this exchange plant shortage was reflected in an easing of the pressure as far as actual junction requirements were concerned, but this effect was not sufficient to reduce appreciably the seriousness of the junction position. At this time, therefore, an investigation was made of the junction position generally, with the object of applying carrier methods to the problem. As it is most economical to use carrier systems over long distance lines, the only junction groups considered were those in which the automatic exchanges were more than five miles apart in radial distance and for which, of course, there was an insufficiency of junctions. These cases were selected from those groups in which there were no spare ducts for additional cable, and in which line construction work was not actually proceeding, or if the work was proceeding was not likely to be completed within two years. A number of cases were selected by these methods and these were investigated further in regard to future junction requirements, transmission characteristics of the cable pairs making up the groups and the amount of space available at each automatic exchange for the accommodation of additional exchange plant and carrier equipment. These investigations indicated that the most suitable routes for the use of junction carrier were the following:—

(1) Between Newtown and Miranda.
(2) Between Newtown and Hurstville.
(3) Between Parramatta and Castle Hill.
(4) Between Chatswood and Hornsby.
(5) Between North and Dee Why.

These routes are illustrated in Fig. 3.

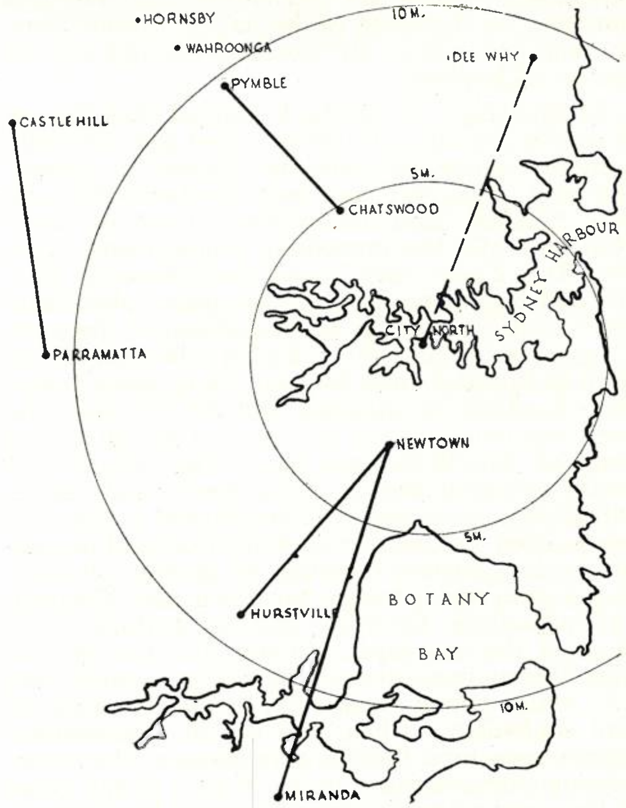

Fig. 3.—Sydney Network, Junction Carrier Routes.

One other advantage in using carrier systems of course, is that the carrier junctions can be arranged to have zero transmission loss. There are cases in which the use of carrier might be justified from this view point, but at the time the justification was based solely on the expediency of obtaining urgently needed junctions quickly. Economic comparisons were made and these showed that generally the use of carrier would not be justified economically, but the seriousness of the position was such that, within reason, the all important consideration was time and not cost. The transmission tests indicated that, based on a limit of 60 db far end crosstalk, up to 40% of the pairs in a cable could be used as bearer circuits for carrier systems using frequencies up to 50 kc/s, and a smaller number of pairs for higher frequencies. In order to avoid near end crosstalk it is necessary to use different frequency groups in each direction of transmission, that is "go" and "return." Alternatively, the same frequency groups could be used if there were two completely separate cables for "go" and "return" transmission respectively.

The tests also indicated that the noise level was satisfactory. The initial noise tests, however, were made during night time and it was found later that there is a very large increase in noise on some cables during the busy hour. The noise is due to the high frequency components of dialling currents and switch operation currents particularly, which are transmitted over physical junctions in the same cables as the carrier bearers, and are induced by crosstalk into the carrier bearer cable pairs.

At this stage, therefore, it seemed that the use of carrier was practicable provided that specially designed equipment could be obtained at reasonable cost. The best case was Newtown-Miranda. One hundred and thirty-nine junctions were existing while the immediate requirements were 160. The 2-year and 5-year requirements were 253 and 328 respectively. No spare cable ducts were available, and the estimated cost of the work of laying a 540 pair, 20 lb. loaded cable from Newtown to Rockdale, and 250 pair, 40 lb. loaded cable from Rockdale to Miranda, was £61,000 when the work was debited with the cost for one cable duct required for immediate use. The actual cost would be higher because extra ducts would be required for development. Accordingly it was recommended that carrier equipment should be purchased in sufficient quantity to provide 60 additional channels between Newtown and Miranda. The signalling facilities had to conform with those of the standard auto-auto junction circuit. Also, the equipment was required to operate from A.C. mains power supply and to give channels of zero equivalent without the use of intermediate carrier repeaters. Details were given of the transmission characteristics up to 50 kc/s of the types of line over which the system would be operated. Later, a contract was made with Communication Engineering Pty. Ltd., for the supply of 24 junction carrier systems, each of six channels designed for operation over junction cables. Each of these systems (see Fig. 4) is operated over one cable pair and directional filters are used at each carrier terminal in order to separate the "go" and "return" carrier frequency currents or, in other words, to obtain the equivalent of 4-wire operation over a 2-wire line. The cross-over frequency of each set of directional filters is approximately 26 kc/s, and as the channel modulator carrier frequencies are spaced at intervals of 4 kc/s there are 6 channel band widths in the low frequency group below 26 kc/s and 6 channel band widths in the high frequency group between 26 and 50 kc/s. The system is of the transmitted carrier type, which has advantages over the usual suppressed carrier type system as far as simplification of signalling equipment is concerned. The use of transmitted carrier frequency current permits demodulation to be effected by rectification and eliminates the possibility of faulty synchronisation. Also, as demodulator oscillators are not necessary the carrier supply equipment is simplified and comprises six carrier oscillators only for each terminal station. The main disadvantages of transmitted carrier operation are overloading of common amplifiers and cross talk from the transmitted carrier current. In this case, however, these items are not very important as there are no intermediate carrier repeaters, and as all the systems have the same frequency allocation, crosstalk from transmitted channel carrier frequency current will not fall inside the pass range of the channel band filters. A full description of this system was given in a previous article in this journal (1).

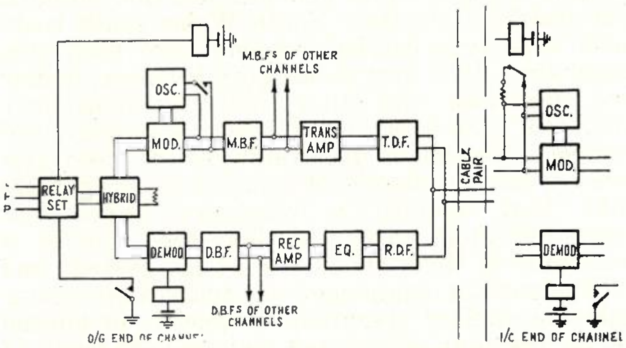

Fig. 4.—Schematic of 6 Channel Junction Carrier System.

Relay sets are provided to link the exchange circuits to the carrier circuits. The signalling method is very similar to that of the physical junction, so that when the carrier junction is seized, carrier current is transmitted and causes a relay to operate at the receive end of the channel, and so loops the incoming automatic switch. During impulsing over the channel the transmitted carrier current is interrupted so that the make to break ratio of the impulses are similar to those of the dial and these impulses are repeated into the incoming automatic switch. Release is effected simply by stopping transmission of the carrier current. In the reverse direction, it is necessary to arrange for one signal only, and that is the reversal which follows the answer of a call. In this direction, carrier current is transmitted continuously since it may be necessary for speech to be transmitted back over the channel prior to reversal occurring as happens when a manual exchange telephonist answers an incoming junction. Also, prior to reversal, it may be necessary to transmit busy tone or ring tone, and in some circumstances, dial tone. Signalling in the reverse direction is therefore arranged by changing the level of the transmitted carrier current and using this change in level to operate a marginal relay so that the reversal can be passed back towards the calling subscriber.

All of the 24 carrier systems purchased have been supplied, and 12 are in service between Newtown and Miranda, 5 between Newtown and Hurstville, and 4 between Parramatta and Castle Hill. This represents a total of 21 systems in New South Wales, and the 3 remaining systems are working between the Oakleigh and Springvale exchanges in the Melbourne automatic network. These systems include the relay sets which are provided at each end of each channel for the purpose of linking up the carrier channels with the normal exchange relay sets and switches. All the carrier channels are identical, and the relay sets at each end of a particular channel can be interchanged if it is desired to alter the direction of the channel, that is, to make it an out-going or an incoming junction as far as a particular exchange is concerned. Experience has shown, however, that there are some advantages in using separately mounted relay sets. Maintenance operations are facilitated and a saving of several relays for each carrier junction can be made with a decrease in the number of impulse repetitions over the junction if required. New relay sets for mounting separately have been designed, therefore, and these are to be mounted on relay set racks as part of the automatic exchange equipment. Another order has been issued for a further quantity of 6-channel junction carrier systems and these are similar to the first 24 systems, except that relay sets are not included. These systems are being installed now between Newtown and Miranda and between Newtown and Hurstville, and when the present installations of 6-channel systems are completed there will be a total of 28 systems between Newtown and Miranda, 21 systems between Newtown and Hurstville and 4 systems between Parramatta and Castle Hill. It is intended that ultimately all these systems, together with the 3 systems that are working in Victoria, that is a total of 56 systems, will be installed between Newtown and Miranda.

The Parramatta-Castle Hill route, although small, was a good case for junction carrier operation. The junction requirements were 40 at December, 1946, while only 25 junctions were in service. To provide additional cable pairs it would have been necessary to open the ground over the whole length of the route, a distance of about six miles, in order to lay another cable duct. A total of four 6-channel carrier systems was installed, and the resulting increase in the number of junctions in the group has enabled a reasonably satisfactory grade of service to be maintained until cable relief is given.

The North-Dee Why case was originally proposed as at December, 1946, when there were only 114 junctions in service, while the junction requirement was 205. By the time the carrier systems were delivered, however, the work of providing additional cable on the route was advanced too far to be interrupted so that the proposal to instal carrier equipment was not followed up.

The Newtown-Hurstville case was similar to that of Newtown-Miranda. At December, 1947, 208 junctions existed, while the 2-year requirements were 385. The installation of 21 systems will bring the group total up to 313 which, although not meeting the requirement, has gone a considerable part of the way towards it.

The Chatswood-Hornsby case is rather complex, in so far as there are existing exchanges at Chatswood, Killara, Wahroonga, and Hornsby, while new exchanges are being established at Lindfield and Pymble. In addition, several major cable construction works, although mainly subscribers' cable, were being undertaken over some parts of the route. The route distance is 9 miles approximately, and it was necessary to defer cable construction work in some sections, particularly between Killara and Pymble, as parts of the route were to be diverted in order to eliminate roadway manholes, and this work depended to some extent on probable road widening operations. The attenuation over the whole distance of the route between Chatswood and Hornsby was too high to allow for carrier systems being used without intermediate repeaters. Although space was available at the Wahroonga Exchange, it would be needed for additional exchange plant in 1953, so that it was decided finally to instal the carrier systems between Chatswood and Pymble. The Chatswood-Pymble junction carrier installation is now well advanced. and in this case two separate cables are available and standard cable-type carrier systems are being used, as these can be recovered later for normal trunk use. These systems are identical with those which are in operation over the Sydney-Newcastle-Maitland carrier cables and over the western carrier cable to Penrith and Katoomba. A total of 9 systems, each of 17 channels, is being installed and will be operated over cable pairs on a 4-wire basis, with the "go" and "return" circuits in separate cables respectively.

These systems (see Fig. 5) are of the suppressed carrier type and use conventional hybrid coils, copper oxide rectifier modulators and demodulators, channel band filters and common transmitting and receiving carrier amplifiers. The carrier supply equipment at each station is common to all the systems and consists of a harmonic generator which operates with a fundamental frequency of 4 kc/s. Seventeen (17) separate channel carrier frequencies are selected from the generator output by means of carrier supply filters and are distributed to the respective modulator and demodulator circuits. The carrier generators at each terminal are locked in synchronism by means of a synchronising current of frequency 76 kc/s, and either terminal can be used as the control station. The frequency generators are duplicated in order to cover emergency conditions.

Since the 4-wire cable circuits are arranged so that the "go" and "return" circuits are in separate cables there is no near end crosstalk problems and, therefore, the same channel carrier frequencies can be used in both directions of transmission. The relay sets link the exchange circuits to the carrier circuits and all signals in both directions for seizing, impulsing, release and reversal are transmitted over signalling channels of a special separate path signalling system.

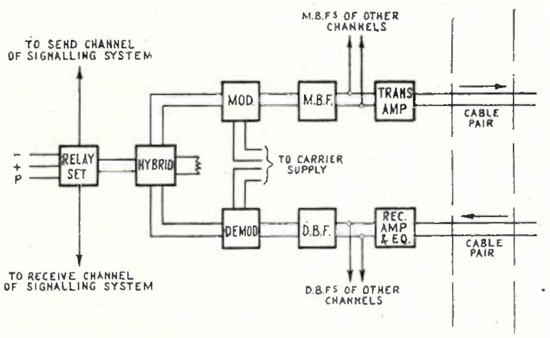

Fig. 5.—Schematic of 17 Channel Junction Carrier System.

Signalling facilities for these 17-channel carrier systems will be obtained by using special simplified voice frequency signalling systems. These systems were developed by Standard Telephones and Cables Pty. Ltd. to operate with standard 12-channel trunk carrier equipment when used under emergency conditions for junction working. Equipment of this type was proposed at one stage for extensive use in the Melbourne network. Each signalling system will give 12 signalling channels in each direction of transmission, and each system will be operated, in this case, over one broad band telephone carrier channel or bearer circuit, although it usually operates on physical circuits. The nine 17-channel carrier systems will give a total number of 153 telephone channels. Twelve of these channels will be allocated as bearer circuits for signalling systems so that the final number of circuits available will amount to 144 both way signalling circuits and 141 telephone channels. From these the physical circuits released for the carrier bearers must, of course, be deducted.

The signalling systems (see Fig. 6) are unusual in so far as the sending channel band filters have been dispensed with by making use of valve-type modulators having a particular circuit arrangement. This cheapens the system considerably. The valve normally operates as a pentode amplifier with voltage from a voice frequency oscillator connected to the control grid. The valve either amplifies or blocks this voice frequency signal, depending on whether the suppressor grid is connected to ground potential or to 50 volts negative. When the junction is seized the signalling valve is blocked and remains in that condition until impulses of tone are transmitted as the calling subscriber dials, or until the caller releases. The plate circuits of the 12 modulators of a system are connected in parallel and all feed through a common transformer through which signals are transmitted to the sending amplifier. In order to prevent interaction with this circuit arrangement, the load impedance is made very small in comparison with the modulator valve impedance and a signal shaping network is connected to the suppressor grid. At the receiving end of the signalling system, receiving channel band filters are used to separate out the various signalling currents and connect them to the channel detectors. Each detector circuit is arranged to rectify the voice frequency signalling current, and the resultant direct current is used to control a receiving relay and so repeat the impulses to the incoming automatic switch. In the other direction of transmission the reversal signal will be transmitted by the same method. The relay sets are interchangeable in the same way as for 6-channel junction equipment. The twelve channel signalling frequencies are spaced at 240 c/s intervals from 420 to 3060 c/s. Each frequency is supplied from a separate valve-type voice frequency oscillator, and in each case one oscillator is arranged to supply the modulators of up to 12 systems with voice frequency signalling voltage, although more systems can be added with simple modifications, as each system draws no load.

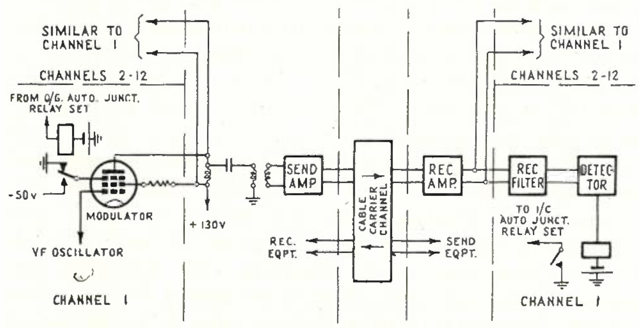

Fig. 6.—Schematic of V.F. Signalling System. Used with 17 Channel Cable Carrier System.

In addition to the types of system described previously, carrier junction circuits have also been provided using 1 + 4 type systems. This is a portable and rather compact type of system which was designed for Army use during the war. During 1947 an experiment was made using a 4-channel system of this type to provide additional junction circuits between the City West and Malvern automatic exchanges in the Melbourne network. A Type "R" Telegraph System, which gives 4 signalling circuits in each direction of transmission was used to control the incoming and outgoing relay sets which linked the carrier system channels to the automatic exchange equipment. Results of the trial were satisfactory, but as spare type "R" Systems are not available, this particular method has not been applied elsewhere.

Other types of signalling equipment are available, however, and 12 of these 4-channel systems are being installed now to provide auto-manual junctions in the Newcastle network. The unit fee area at Newcastle, shown in Fig. 7, has been extended recently, and now covers all exchanges within approximately ten miles radial distance of Newcastle, whereas formerly the distance was five miles. The Toronto and Belmont manual exchanges are now in the unit fee area. Toronto is

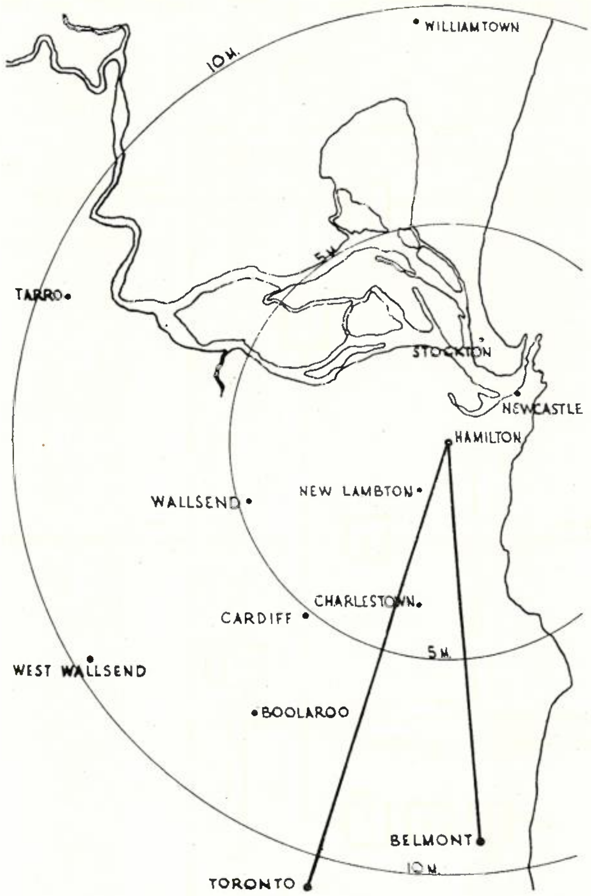

Fig. 7.—Newcastle Network, Junction Carrier Routes.

19 route miles from Newcastle and is connected to the Newcastle Trunk exchange by a group of 9 physical trunk circuits, which include 14 miles of aerial wire route. The 4-channel carrier systems are being installed now, and these will provide a group of 24 junction circuits between Toronto and the Hamilton automatic exchange. The requirements at present call for 37 circuits and, although the carrier circuits are not sufficient to meet the requirements, they will allow a restricted service to be maintained pending the laying of a trunk and junction cable. These 6 Toronto-Hamilton systems will be operated over 6 metallic circuits on a direct 2-wire basis.

Belmont is approximately 13 route miles from Newcastle, and a group of 7 trunk circuits exists between Belmont and the Newcastle Trunk Exchange. These circuits are obtained by using phantom circuits in the Sydney-Newcastle carrier cables between Hamilton and Belmont. Six 4-channel carrier systems are being installed now, and these will provide 24 junction circuits between Belmont and Hamilton automatic exchange. In this case the present requirements call for 28 junction circuits, so that the carrier junctions will provide a reasonable grade of service pending the laying of a junction cable. These 4-channel systems will be operated in sets of 3 on a 4-wire basis, as shown in Fig. 8, that is, 2 pairs of wires will serve as bearers for three 4-channel systems. Two of the systems in each set of 3 will be connected direct to the cable pairs and will use the frequency range below 32 kc/s, while the third system will be connected to the cable pairs by means of filters and group modulating carrier equipment which have been designed and manufactured locally and transmit frequencies in the range above 32 kc/s.

As these carrier junctions are to be used as auto-manual junctions, the voice frequency ringer equipment, which is supplied as part of the carrier equipment, can be used for signalling in the auto to manual direction. In the manual to auto direction dialling facilities will be provided by means of simple single frequency V.F. dialling equipment.

Maintenance: As far as exchange maintenance operations are concerned, the carrier junctions can be treated in exactly the same way as are the physical junctions, and the usual daily routine test of impulse weight under long and short line conditions should be made. The carrier equipment must undergo the usual carrier maintenance tests, of course, so that the exchange maintenance routines would need to be similar to those existing at automatic exchanges such as Ashfield, Chatswood and Hurstville, where carrier equipment has been maintained for many years.

Conclusion: In conclusion, mention should be made of the possibilities for the use of junction carrier equipment in the future. So far it has always been a matter of acute service emergencies in which cable relief was not possible within reasonable time. In the future there will be scope for use of carrier equipment for this same reason, but also it should be possible to substantiate the use of carrier junction by reason of the fact that zero transmission loss can be obtained over the junction circuits. One possibility is to use them to provide relatively small groups of junctions, such as trunk junctions. At the present time special trunk junction circuits exist between the trunk exchange and the main automatic exchanges. Under the present numbering scheme these special junctions are used for revertive trunk traffic only, but if a separate level is allocated eventually to the trunk exchange, the special trunk junctions will carry both demand and revertive traffic. At present the trunk junctions are accommodated in junction cables, and in some locations, because there is a limit of $7\frac{1}{2}$ db attenuation for trunk connections between the trunk exchange and any automatic exchange in the network, the use of heavy gauge cable may be necessary in order to meet the transmission limits as far as the trunk junctions are concerned. There are, therefore, in this case, advantages to be gained by the use of carrier junctions as trunk junctions between the trunk exchange and main automatic exchanges.

Another possible use for junction carrier equipment is to provide trunk circuits to the closer

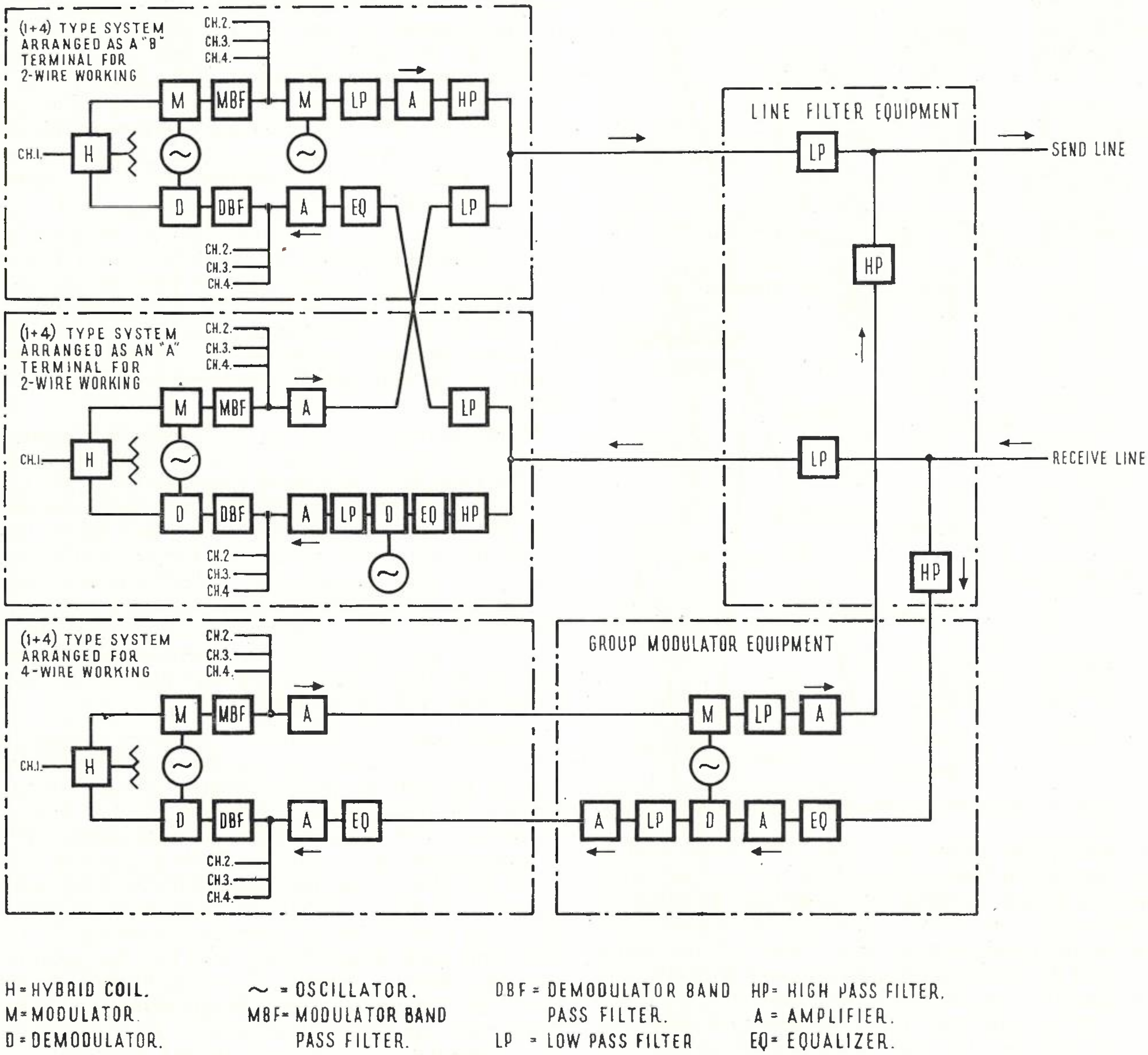

Fig. 8.—Block Schematic showing arrangement of three (1 + 4) type carrier systems and group modulator equipment for operation over a 4-wire cable circuit.

trunk exchanges such as Blacktown, St. Mary's and Campbelltown. Four of the Newtown-Miranda carrier junctions have been given up recently in order to provide for trunk circuits to Engadine. In this case aerial wires were available from Engadine to Sutherland, and cable pairs from Sutherland to Miranda. These circuits were extended to Sydney by using carrier junctions in the Newtown-Miranda section, and this enabled the overall equivalent of the trunks to be maintained within reasonable limits.

Another aspect is that there will be increasing scope for the use of carrier junctions if the economic comparison with physical junctions can be made more favourable. In this respect it may be possible for manufacturers to reduce the cost, size and weight of the carrier equipment as improved materials become available, and as newer technical processes are applied in the future.

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MECHANICAL HANDLING OF MAILS — NEWSPAPER AND PACKET SORTING

V. G. Magnusson

Introduction

The main purpose of this article is to give a description of the newspaper and packet sorting machine which has been in operation at the Melbourne Mail Branch, G.P.O., Spencer St., since January, 1947. A brief description is also included of the newspaper and packet sorting machine which has been operating in the Mail Branch, G.P.O., Sydney, since 1930. The Melbourne installation differs from the latter, in that a unit principle of design has been adopted which it is expected will simplify future similar installations.

The handling of mail matter, particularly in the larger mail branches in the capital cities in Australia, is a major problem and considerable attention during recent years has been given to the same problem by a number of overseas Postal Administrations. Whilst machinery has been developed to handle mail matter mechanically, development has been by no means rapid. Perhaps the main reason for the slow development and restriction of mail handling equipment has been the limited world demand and the resulting high costs associated with individually produced units.

It is very likely that the main impetus to the more general use of mail handling equipment in the future will be the development of unit construction applicable generally to sorting processes, irrespective of location. It would seem that only by these means will the installation of mail handling machinery become economical in the smaller centres.

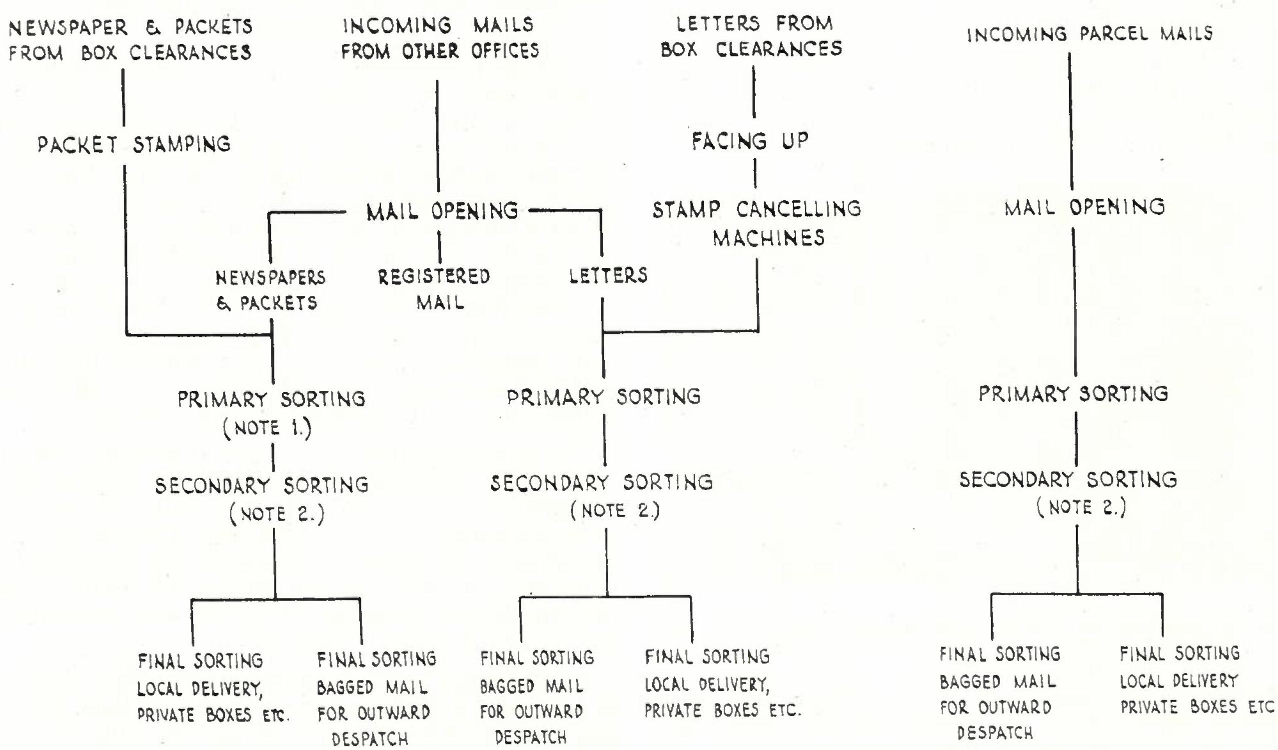
Summarised, the objectives of mechanisation are to:

(a) improve the efficiency of sorting operations;

(b) obviate, wherever possible, the need for heavy manual labour and provide more comfortable conditions;

(c) effect economies in the handling of mail matter.

To reach these objectives a study of Mail Branch traffic flow and requirements is essential before any attempt to develop a mechanical handling scheme can be made, as the extent and nature of the mechanisation will depend on the flow scheme it is proposed to introduce. This alone is a major problem, but it is possible to develop a general growth pattern to which the traffic flow arrangements in any Mail Branch in the Commonwealth could conform. The extent to which the pattern is followed would depend largely upon the average daily load.



Notes.—1. It is for this process that the machine described in the present article is used.
2. Secondary sorting is not necessary in all cases.

Fig. 1.—Flow Diagram, Melbourne Mail Branch.

The traffic problems in Mail Branches can be likened in some respects to those obtaining in large manual exchanges, the posting of letters being similar to telephone calls originated by subscribers. Mail branch traffic or mail matter, however, may conveniently be stored during periods of heavy load and requires to be conveyed mechanically from point to point. The first can be used to advantage, but the second necessitates a comprehensive system of mechanical conveyors and other mechanisms to enable mail matter to be distributed for further operations in sequence.

Apart from the value of reliable traffic data to any Mail Branch organisation the efficient mechanisation of mail handling processes is only possible after a close study of traffic flows, recurrence of peak periods and mail clearance times. As a machine system is introduced only so that the mail matter can be handled expeditiously and economically, the extent and manner of provision must be such that a most efficient traffic flow is possible at all handling stages. It follows also that a mechanised system should be flexible so that throughout its life flow conditions may be modified to meet changes in traffic conditions.

Mail matter is divided into three groups—letter mail, newspapers and packets and parcels. This division is based mainly on size and shape, and the design of handling equipment, whether manual or machine, varies considerably in each of the three groups.

Fig. 1 is a basic flow diagram for a typical Mail Branch, giving the sorting processes that mail matter may pass through from incoming to outgoing bags. Loads of one and a half to two million articles are handled daily in Sydney and Melbourne, and further complications are introduced by the considerable quantities of pre-sorted mail

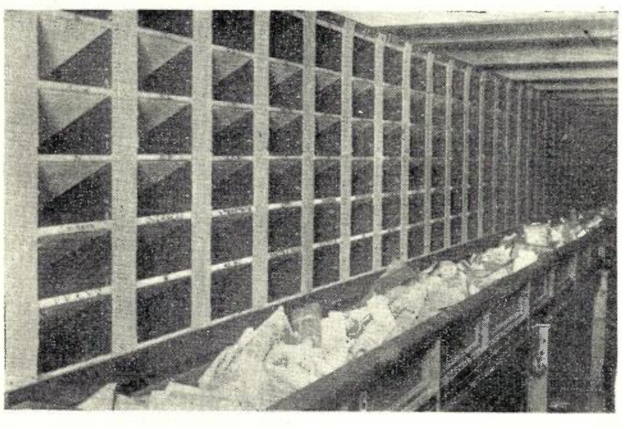


Fig. 2.—Newspaper and Packet Sorting Machine, Sydney G.P.O. View showing mail matter ready to be sorted and sorting bins.

matter forwarded from other offices. The pre-sorted mail matter is introduced into the main flow at the particular point appropriate to the extent of previous sorting.

Mathematical formulae similar to those used for the determination of switch and traffic provision in exchanges, can, with advantage, be used when dealing with mail handling problems. Such formulae assist in the examination of handling methods and the development of efficient flow

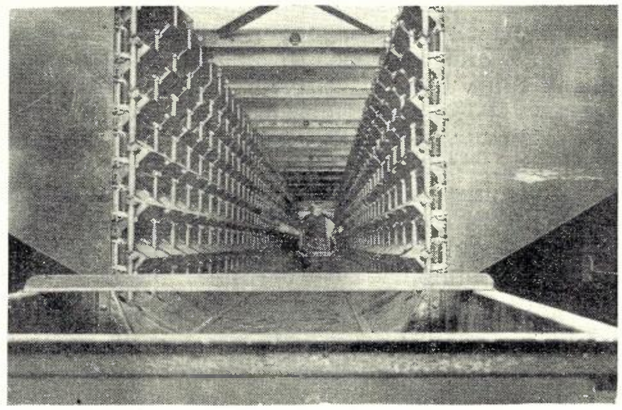


Fig. 3.—Newspaper and Packet Sorting Machine, Sydney G.P.O. Rear view, showing central conveyor belt with automatically controlled bin clearance doors on each side.

schemes. The comparison of methods and alternative schemes is not practicable nor can reliable conclusions be reached unless a sound basis of this nature is used to build upon. The detailed study of this problem, however, is beyond the scope of the present article.

Newspaper and Packet Sorting Machines, G.P.O., Sydney

Several newspaper and packet sorting machine systems are in operation in the Mail Branch, G.P.O., Sydney, and each of these systems deals with a particular stage in the sorting of this class of mail matter. These machines have been designed with vertical sorting fields and may be fitted with one or two clearance belts, depending on the size and design of the particular machine. The prime purpose of these machine systems is to co-ordinate the work of many sorters and to automatically convey sorted mail matter to the next operation in sequence, thus eliminating much of the labourous manual handling normally associated with mail handling in large offices.

At predetermined intervals the doors on all bins on the vertical sorting fields for a given destination open automatically and mail matter falls onto a clearance belt, a sufficient interval of time being allowed between clearances to prevent the possibility of the various groups of mail matter intermingling. General views of the equipment are shown in Figs. 2 and 3.

Sorted mail matter passing from the machine is carried by distribution belts to various receiving points. At intervals along the distribution belts are fitted diverters which, when operated, deflect particular groups of mail matter to storage hoppers where further processing is awaited.

Newspaper and Packet Sorting Machine, G.P.O., Melbourne

The machine installed in Melbourne has been developed on the unit principle so that the use of this aid may be introduced into all capital cities. In evolving the design of this machine system traffic requirements were regarded as the first consideration and designs were developed accordingly. It will be realised that the size and weight of articles of mail matter vary considerably, and the behaviour of any article when sorted into bins, conveyed on belts or during the process of diversion, is difficult to predict, and if machinery is not correctly designed a complete system may be made inoperative due to the vagaries of one article. A close check of articles of mail matter is also necessary to determine the upper limit to bin size. It is not desirable to design machinery to accommodate articles which have unusual dimensional characteristics, as the larger the area of the sorting field the slower the sorting rate. Therefore, there is normally a small percentage of mail matter which may require to be manually handled and in this connection the newspaper and packet sorting machine installed in the Melbourne Mail Branch has been designed to handle over 99% of the incoming mail matter. Needless to say, if all articles of mail matter were of standard size and weight the design of handling equipment would be a relatively simple matter.

The machine, known as the "newspaper and packet sorting machine, horizontal sorting face," permits of increased sorting speeds and more comfortable working conditions, besides enabling the provision of improved lighting and ventilation. In addition, the short clearance cycle time made possible by the triple belt provision, has assisted in the development of the concentrated sorting field.

All newspapers and packets conveyed from the mail opening positions and packet stamping tables requiring primary sortation are handled on the machine system. The position of the machine with regard to the main flow may be seen by reference to the flow diagram (Fig 1). An average flow of 160,000 articles per day passes through this machine with seasonal peak loads of 320,000 articles per day. It is appropriate to mention that in the final mechanisation plans for the proposed new Melbourne Mail Branch, five separate machine systems for the handling of newspapers and packets are to be installed. The main machine system, which will be used for the primary sorting of articles, will feed mail matter into the remaining four machine systems where the secondary sorting operations will take place.

The sorting fields, each consisting of a number of bins, are mounted side by side in multiple so that the discharge from the bins will fall on to one of three clearance belts which run the length of the machine. The drop door fitted to each bin is normally latched in the closed position, so that sorted articles deposited therein are held awaiting discharge during the bin clearance cycle. As each bin in any section of the field is repeated in every other section, it follows that if a corresponding bin in each field opens at the same time all mail matter within a particular geographical group will discharge simultaneously onto one of the three clearance belts. This group of mail matter is conveyed to the receiving points and the belt is then clear to receive the discharge from the next bins opening in sequence. This operation continues until all bins are cleared when the cycle repeats itself. Sorting is continuous without regard to the machine operation.

As will be seen from Fig. 4, three rows of bins run continuously along the full length of the sorting machine. Under each row a clearance conveyor, 8″ wide, travelling at a speed of approximately 300 feet per minute, is fitted. By the provision of an individual clearance belt for each of the three longitudinal rows of bins it is possible to discharge three bins in each section simultaneously and to complete the machine clearance

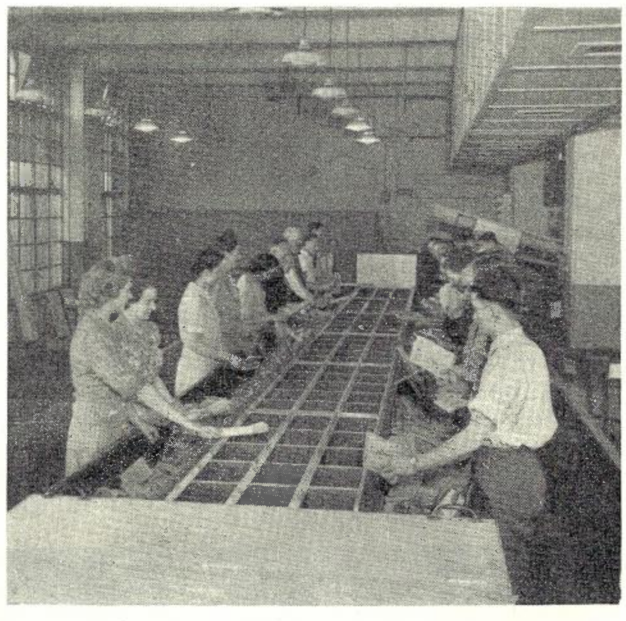


Fig. 4.—Sorting bins of newspaper and packet machine, with trough conveyors on each side.

cycle with five operational sequences. The mail matter which is to be sorted is fed to the sorting officers on each side of the machine by means of trough conveyors, which can be moved at a speed of 15 feet per minute.

The drop doors in each transverse row of bins are mounted on a common shaft to which is fitted an arm so that on one side of the machine there is an engagement arm for each transverse row of doors. A push rod, on which is fitted closing cams, runs the full length of the machine. Each cam is individual to a particular transverse shaft. Normally each bin door is held in the closed position by means of an electro-magnetically operated latch.

The push rod is timed to pass through a reciprocating motion every 21 seconds, and all cams are withdrawn from the transverse shaft engagement arms. Should any of the latches be energised whilst the push rod is withdrawn, the corresponding door opens by means of gravity. For a period of 17 of the 21 seconds the push rod with its cams is holding all bin doors in the closed position by means of the engagement arms and shafts. During the remaining 4 seconds the push rod is passing through its stroke.

By means of a synchronised system corresponding transverse rows of doors in each section are opened simultaneously, and all other transverse rows follow in sequence at intervals of 21 seconds. Therefore, during a time period of 105 seconds (that is, five operational sequences) the machine system has passed through a complete clearance cycle, and this cycle is repeated continuously during the subsequent operation of the machine.

Before describing the further operation of the system it may be of interest to note that each bin door is spring loaded. Should, by chance, an article be sorted to a bin whilst the door is closing damage does not result and the article remains held by the partly closed door until released by the sorting officer or until the next clearance.

The groups of mail matter which are discharged at 21 seconds interval from the sorting machine are conveyed by the clearance belts (under the machine) to distributing belts which in turn convey the mail matter to the location where the next manual operation is to take place (see flow diagram, Fig. 1). At each of these locations sloping belts are installed, i.e., one for each of the three distribution belts fed by the machine. As will be seen from Fig. 5, the sloping belts are tilted at an angle of 25 degrees to the horizontal plane, so that mail matter is conveyed by the belt along the lower side of the trough. Along the troughing on this lower edge are five drop panels

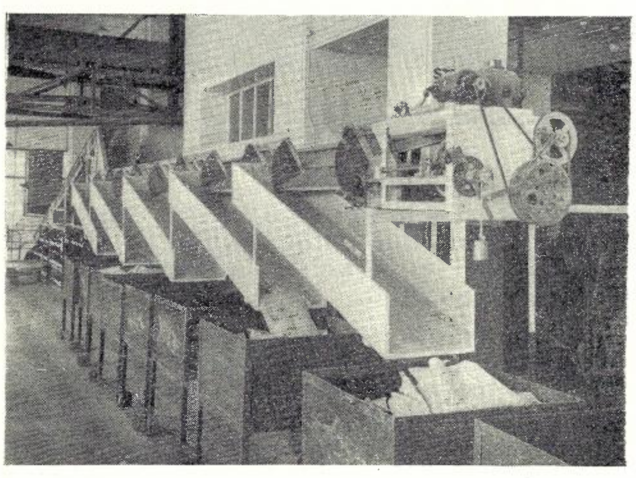


Fig. 5.—Distribution belt and drop panels of newspaper and packet sorting machine.

which are normally latched in the closed position by means of latch magnets.

Running the full length of the lower edge of the trough is a shaft to which is fitted drop panel release arms one for each drop panel. Every 21 seconds the shaft with its arms turns through 90 degrees and then returns to the normal rest position. This operation occupies a time period of 2.5 seconds. During the operation any drop panel which may be in the open position is closed and latched, and the next drop panel in sequence is lowered to the full open position by its release arm, provided the panel release latch is operated during the period of shaft motion.

The complete machine system is synchronised so that each drop panel opens a few seconds before the arrival of the particular load which is to be discharged at that point. As each drop panel is opened for approximately 21 seconds there is ample time for the load to discharge before the closing of the drop panel.

The method of operating the shaft to which are fitted the drop panel release arms, is an interesting feature of the installation. One end of the shaft is fitted with a single-toothed rachet wheel over the periphery of which a pawl is oscillating. When the pawl is operated by means of an electric pulse from the synchronising system, the pawl engages with the single tooth of the rachet and carries the ratchet and shaft through its 90 degrees travel.

The main advantage of the sloping belt over the flat belt using diverters is that the possibility of mechanical stoppages due to diverter blockages is eliminated. The use of the sloping belt also enables one operating mechanism to be used for a group of drop panels, thereby reducing installation and maintenance costs. In addition, the chance of damage to mail matter due to machine handling has been overcome.

The synchronising circuit is designed to operate from a 50 volt D.C. supply, and standard automatic telephone relays have been utilised for the various operations, including magnetic latching of doors and panels. The sequence of electrical operations is controlled by means of a four-bank rotary switch.

The machine has been designed primarily as a working model to accommodate 24 sorting officers, and is capable of disposing of 24,000 articles of mail per hour. During busy periods the staffing is increased when the output is correspondingly greater. Providing floor space is available, the machine is capable of extension by the addition of further units to provide for normal staffing of 60 sorting officers, or 80 officers at a maximum. This extension can be effected without materially increasing the clearance time cycle. If the quantity of mail matter to be handled at the peak requires the efforts of more than 80 officers for expeditious handling, multiples of the machine system feeding into common distribution belts, can be installed.

Following the unit construction principle the carcase of the machine was manufactured in 26 parts and the installation, excluding driving mechanism, belts and push rod, was carried out in a period of one week. The erection of distribution belts to various parts of the building and the sloping belts occupied approximately three months, a staff of one technician and three artisans being employed on the work. All conveyor troughing was manufactured in unit lengths, however, so that installation work for the complete system could be kept to the minimum.

It is worthy of mention that the trial installation has shown that the construction of mail handling machinery can be considerably lightened in future designs. Canvas belts, made by the departmental canvas workers, and which were originally fitted to the machine are still in operation, and showing little signs of wear. All motors are of one H.P. rating or under, excepting the main driving motor on the machine, which is rated at three H.P.

Conclusion

The foregoing description covers only one aspect of mechanical handling as applied to mails. Such equipment as face-up tables, package stamping tables, bag lifters, mail bag opening units, stamp cancelling machines, tray conveyor systems for letters and automatic weighing has already found extensive application in Australia. In addition, the mechanical handling of letters has been the subject of experiment and investigation for some years and systems ranging from simple tray conveyors to machines fitted with keyboard selectors are operating overseas.

Of the letter sorting machines in operation overseas, perhaps the most interesting is the Transorma machine, which makes possible the sorting of letters into three hundred or more separations. In this machine system the operator inserts each letter into an aperture and operates a keyboard to pre-select the receiving receptacle to which the letter is to be lodged. Sorting speeds of up to 45 letters per operator per minute are possible. Up to five sorting positions may be provided on a machine unit, depending on the size. The most extensive, and probably the most fruitful, investigations are those now being conducted by the British Post Office on letter handling using photo-electric cells.

The traffic flow pattern in this country has led to the development of letter sorting machines with relatively few separations, but providing many sorting positions. The first experimental sorting machine of this type was installed in the Melbourne Mail Branch in July, 1950. It is intended that a description of this machine will be dealt with in a subsequent article.

No reference has been made to the third group of articles which require to be handled in Mail Branches, namely parcels, but experiments being made in Australia have been promising, and it is expected that machines using keyboard selection for parcels sorting will eventually become the standard provision in larger offices. In England the British Post Office recently installed a prototype putton operated parcels sorting machine at the Mount Pleasant Office, London.

This article is more descriptive than technical as the subject, "mail handling," covers a considerable field and the traffic problem alone could well form the subject for a separate article as "traffic flows" and distribution are the fundamental bases for machine provision. It is hoped, however, that the foregoing description of a particular aspect of mail handling equipment will indicate to the reader the scope available for carefully planned mechanisation.

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1. "Post-Betriebsmechanik," Books 1 and 2. Dr. H. Schwaighofer.

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ANSWERS TO EXAMINATION PAPERS

The following answers generally give more detail than would be expected in the time available under examination conditions. The additional information should be helpful to students.

EXAMINATION No. 2817—ENGINEER—TELEGRAPH EQUIPMENT

A. F. Hall.

Q. 6.—(a) An engine generator is required as an emergency power supply for a large C.T.O. building. Discuss the size and type of prime mover plant you would propose. Assuming a case list the various power demands you would include if you were arranging the provisions.

(b) When installing the plant discuss the steps you would take and the precautions necessary to ensure satisfactory operation.

A.—(a) The general reliability of electric power supply in this country in the past has reduced the necessity for extensive provision of emergency supply for telegraph purposes, but the position has changed in recent years, particularly in some States for the following reasons:—

(i) The general overloading of supply plant due to greatly increased demand in winter.

(ii) Difficulties of maintaining coal output and distribution.

(iii) The greatly increased importance of telegraphic communication as related to air service schedules and weather information.

For these reasons more attention must be given to the adequate provision of emergency power supply to maintain telegraph service. The provision of fixed plant is the most satisfactory method of making such provision, and certainly more reliable than depending on portable equipment which, under conditions of emergency, is greatly in demand. It should also be mentioned that where departmental activities are conducted in proximity to the C.T.O., and where these activities require emergency provision, the requirement should be met by one emergency plant capable of meeting the needs of all such activities. By this means, the maximum advantage may be taken of diversity of requirement over the 24 hours, and a more economical installation effected. In this country the modern practice is to reduce the demand for D.C. supply by transferring the load, so far as is possible, to A.C. supply of 3-phase 50 cycles, 400-230 volts. In answering the question, the following assumptions have been made:—

(i) The principal power supply to the C.T.O. building will be 3-phase A.C., with D.C. supply limited to small requirements for special telegraph operating plant.

(ii) The building will be a multi-storey structure, used solely for telegraph purposes, and will have installed lift services, air-conditioning equipment and pneumatic tube plant.

(iii) The carrier telegraph equipment is not located in the C.T.O. building.

(iv) The calculation of drains from telegraph line and local batteries is not within the scope of the question.

A.C. Services.

Lift.—In a multi-storey building used as a C.T.O. where lift services are provided, it is reasonable to provide emergency power supply sufficient to permit working of one lift, although such provision will increase considerably the size of the emergency plant.

Air Treatment.

No provision should be made to continue this service under emergency conditions.

Pneumatic Tubes—Street.

If normal power supply is reliable and occasional interruptions of, say, up to 8 hours duration, are to be covered pneumatic tube plant could be shut down at such times and messenger service instituted. Should longer and more frequent interruptions be anticipated, provision should be made for the continuance of street tube service at least to city post offices from which deliveries are made. This may not exceed 10% normal provision, but the requirement will be affected by the size of units of plant.

House Tubes.

Provision should be made for continuous operation of this plant.

Lighting.

Lighting to the extent of 50% of that normally provided should also be met by the emergency plant.

Telegram Conveyors.

This load is relatively small and also very important and should be continued in emergency.

Start-Stop Machines.

Under emergency conditions, the majority of local services would be unable to continue, only those private offices covered by local emergency provision would be in operation. Country and interstate services may not be affected. The proportion of normal services remaining in operation may reach 75%.

Battery Charging.

It is assumed that line and local batteries are operated on the "float" system with rectifier equipment. Provision should be made for the operation of the rectifiers associated with all groups, namely, Positive 60V, 120V. Negative 60V, 120V. Local 40V. Reasonable figures for emergency power demands are as follow:—

A.C. Services.

Lift.—Assuming 5 floors; car loading, 15 cwt.; speed, 150 ft. a min.; a winding motor of 11 h.p. would be required.

Allow 15 k.V.A. owing to fluctuating nature of the load.

Street Tubes.—Assuming normal load 50 h.p.

Allow 10 k.V.A.

House Tubes.—Using Roots Blower driven by motor of 5 h.p.

Allow 7 k.V.A.

Lighting.—Assuming 15,000 sq. ft. effective area with normal loading 1.8 watt per sq. ft.

Allow 1 watt per sq. ft. to include public lighting = 15 k.V.A.

Conveyors.—Assuming 22 table belts and 8 floor belts, ¼ h.p. on half load.

Allow 7 k.V.A.

Start-Stop Machines.—Total machines 90, but 60 in operation.

Allow 6 k.V.A.

D.C. Services.

Multiplex.—Assuming 8 double sets, with a power requirement of .5 k.W. per set.

Allow 5 k.V.A.

Rectifiers.—Allow a total of 2.5 k.V.A.

Equipment	% Normal	Estimated Emergency
Lift	33%	15 k.V.A.
Street Tubes	10-15%	10 k.V.A.
House Tubes	100%	7 k.V.A.
Lighting	50%	15 k.V.A.
Conveyors	100%	7 k.V.A.
Start-Stop	66%	6 k.V.A.
D.C. Services	100%	8 k.V.A.
Machine Tools, Testing, etc	33%	2 k.VflA.
Total		70 k.V.A.

Some diversity is allowable, particularly in respect of lift and lighting loads. A direct coupled Diesel alternator set would be satisfactory, and a slow speed machine has advantage from the maintenance viewpoint. A typical engine would develop 45 h.p. per cylinder at 600 r.p.m. Therefore, a twin cylinder unit coupled to a 75 k.V.A. 3-phase 400V alternator, with direct coupled exciter, would be satisfactory. The D.C. provision may be obtained from a rotary converter driven from the emergency supply. Distribution would be effected as far as possible through normal circuits. Automatic starting would not be a necessary requirement, and elimination of such equipment would simplify both installation and maintenance and reduce expenditure. The plant should be installed in the basement of the building.

(b) The following precautions should be taken:—

Adequate ventilation of engine-room.

Removal of water seepage.

Adequate engine cooling facilities.

Provide underground fuel tank of sufficient capacity to run the plant for 1 week.

Voltage variation should be maintained to within ± 6%. Frequency should be held to within ± 1%.

Alarms should be provided to give warning under the following conditions:—

(a) If engine speed is too high.
(b) If engine speed is too low.
(c) If alternator volts are too high.
(d) If alternator volts are too low.
(e) If lubricating oil pressure is too low.
(f) If cooling water temperature is too high.

The set should be installed on a concrete bed isolated from the main structure of the building, and precautions should be taken to reduce engine vibration.

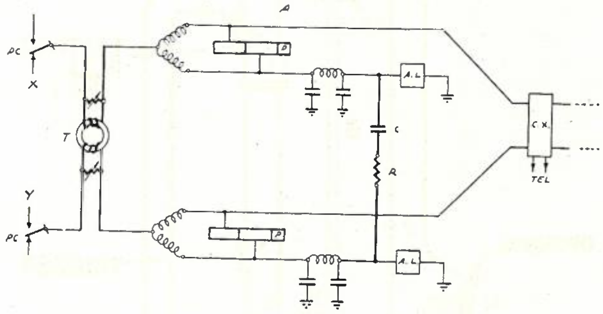
Q. 7.—Two manual duplex sets are operated simultaneously between two stations over two long physical channels on adjacent pole positions. It is found that satisfactory working is upset when both work simultaneously.

Discuss the cause of the trouble and show by a sketch how you would improve conditions by alterations or additions to the equipment terminals.

A.—Mutual interference between ground return telegraph circuits in proximity to one another on pole lines or in cable is known as "telegraph cross fire." Its effect is to limit the speed of operation or to seriously impair the quality of the received signal.

The trouble is caused by mutual coupling between the circuits, and operation of one circuit will produce extraneous current impulses in the other circuit. These impulses adversely affect the telegraph signals in the receiving equipment of the disturbed circuit.

In the case of long, closely paralleled circuits interference is generally experienced both at the sending station and at the distant station, and the two effects are known respectively as "sending end crossfire" and "receiving end crossfire." Crossfire depends chiefly on mutual capacitance and, to a lesser extent, on mutual inductance of the lines. During periods of low insulation resistance, mutual conductance or leakage is responsible for some d.c. crossfire. The gauge of wire, separation between wires, length of circuit and presence of other wires on the pole line have considerable influence. Crossfire is most pronounced between the four wires of a phantom group. Composite sets and filters used in connection with superimposed carrier systems introduce coupling and may contribute to the trouble. Simple measures to reduce crossfire are indicated in Q.7, Fig. 1.



Q. 7, Fig. 1.

Sending End Crossfire. C is a condenser and R a timing resistance applied at the beginning of the artificial line. The arrangement provides mutual admittance between the two artificial lines to simulate that existing between the real lines. Operation of the pole changer of circuit Y causes impulses of short duration, corresponding to the steeply sloping sides of the generated wave, to pass through C R and the receive relay of circuit X at A, in such a direction as to oppose the cross-fire current from the real line. The values of C and R are determined by the characteristics of individual circuits.

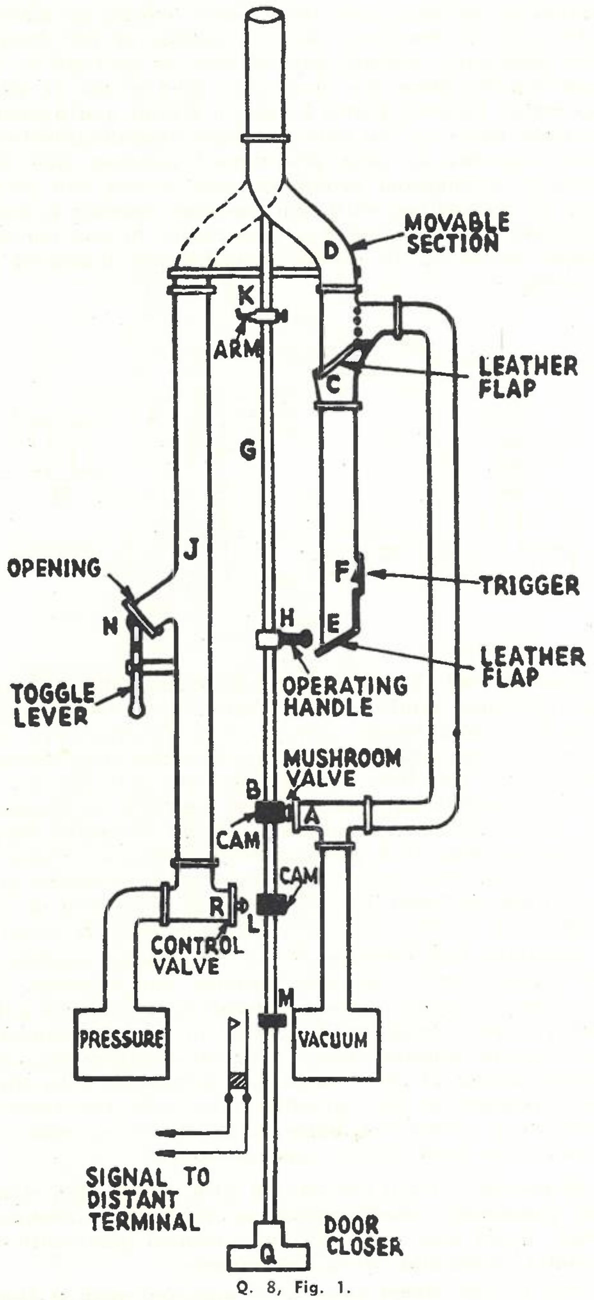
Receiving End Crossfire. T is a transformer applied at the sending end to reduce receiving end crossfire. It introduces into the disturbed circuit an additional pulse which travels along the line so as to arrive at the distant station simultaneously with the crossfire impulse. Proper poling of the transformer is necessary to effect neutralisation of the crossfire effect and the variable resistances adjust the pulse level. Both measures are effective for both circuits simultaneously.

Q. 8.—(a) Give a description with sketch of a standard pneumatic tube terminal as used on a both-way single street tube worked from a central plant with air supplies above and below atmosphere.

(b) If this street tube were operated with a Roots blower individual to the tube, what arrangements would be necessary to make the terminal function satisfactorily?

A.—(a) The standard pneumatic tube used in the operating room for both-way single street tube service is diagramatically shown in Q. 8, Fig. 1, which shows the condition with vacuum applied to the tube by way of a double balanced mushroom valve, A, held open by cam B. The tube is sealed off from atmosphere by leather flap valve C.

Receiving. An incoming carrier, propelled by atmospheric pressure, will pass through the short movable section D and strike flap valve C with sufficient force to lift it from its seat. Atmospheric pressure will immediately close flap valve E and pressure on both sides of C will be approximately equalised, allowing the carrier to move C and pass through the opening. Before reaching E



Q. 8, Fig. 1.

the carrier will operate trigger F, admitting atmospheric pressure which will balance the pressure on both sides of E, but this pressure will also seal off the tube at C. The weight of the carrier will allow E to open and deposit the carrier quietly into the semi-circular trough provided. The receiving condition is the normal or "rest" position of the terminal.

Sending. The toggle lever is operated and the carrier is inserted into the opening N, after which N is again closed. Operating Handle H, attached to shaft G, is rotated through about 120°, and the following sequence of operations occurs. The movable section D disconnects the tube from the receiving section of the terminal and connects it to the dispatching limb J, Cam B releases A, which closes. Towards the end of the travel of H, Cam L opens the double balanced mushroom valve R, applying pressure to the tube by way of J. H is now at the end of its travel where it is held by a latch which engages arm K. It is only after D is correctly positioned that R operates and the carrier can be propelled on its way. The shaft G is turned to the sending position against the control spring in a door closer movement Q, mounted at the bottom of the shaft. Simultaneously with the admission of air to the tube air is also admitted to the underside of the piston of a timing mechanism not shown in the figure. The piston is connected to a rack engaging with a clockwork escapement in a separate compartment and running in an oil bath. The piston, therefore, can operate only very slowly. Its period of full operation is governed by the time taken by a carrier to traverse the tube together with a safety margin. At the end of the timing period the latch, associated with arm K, is released and the control spring of Q restores the terminal to the "rest" position.

An additional cam, M, on the main shaft closes a pair of contacts to signal to the distant station that a carrier is in transit.

(b) The necessary alteration to permit operation of the tube from a Roots blower would be to provide access to atmosphere by the blower under the conditions of both suction and pressure operation of the tube. For example, when in the receiving position the air, drawn from the tube, should be passed to atmosphere from the pressure side of the blower with minimum back pressure. Similarly, when sending, the air required to propel the carrier should be readily available to the suction side of the blower. Reference is made to Telecommunication Journal, Vol 7, No. 2, October, 1948, Examination No. 2721, Q.9, P. 121, which gives a description of operation and schematic diagram of such a terminal.

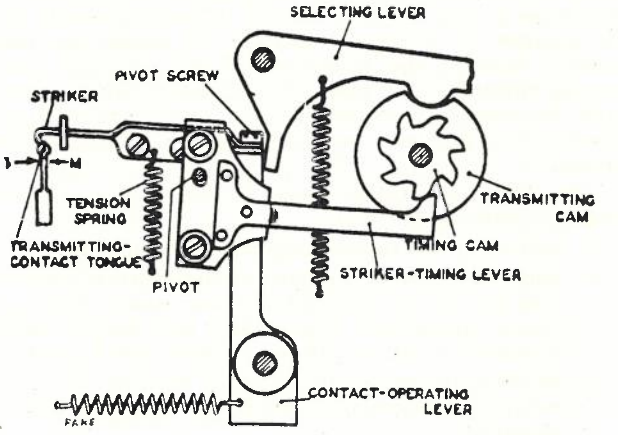
Q. 9.—Describe, with the air of sketches, the principles embodied in the Creed teleprinter 7C (keyboard transmission and page reception) in the transmission and reception of a message.

A.—It is assumed that a general description is required of the operation of the machine during transmission and reception of a signal train of impulses.

Transmission: The transmitting mechanism may be divided into two units, a keyboard unit, and a transmitting unit.

Keyboard Unit: When a key is depressed against action of its restore spring the upper horizontal portion of the associated keybar is lowered into the path of the comb bars, of which there are five, together with a locking bar. Movement of the keybar also actuates a trip bar and an associated additional locking bar which engages the rear end of all keybars to prevent operation of a second key until the first is released. The trip-bar, by means of link motion, causes a single revolution clutch to engage and drive the transmitting cam shaft which is described under the heading "transmitting unit." The initial motion of the transmitting cam shaft releases a resetting lever which, in the normal position, holds the five comb bars and the locking bar against the tension of their operating springs. The latter endeavour to move all bars to the right. The locking bar moves freely and locks the selected key bar in the depressed position until transmission has been effected. The position of certain projections on the upper edge of the comb bars, in their relation to the depressed keybar, determines whether or not certain comb bars may move to the right. Those which so move permit release of their associated selecting levers at the appropriate time during transmission.

Transmitting Unit: This unit comprises essentially a cam assembly, six selecting levers, and a contact assembly. The cam assembly is driven from the continuously rotating keyboard operating gear, but rotates only when the single revolution clutch is engaged by operation of the trip lever mechanism. The arrangement of the cams is as follows: Resetting lever cam, send-receive cam, signal cams 1, 2, 3, 4, 5, start-stop cam, timing cam. The selecting levers are in the form of pivoted bell cranks, one end of each of which is above the associated comb bar and the other adjacent to one edge of the contact operating lever. A projection on each bell crank is associated with the particular signal cam. The contact assembly is indicated in Q. 9, Fig. 1.



Q. 9, Fig. 1.

The latest type, known as the striker type, is shown. In this device a striker is driven by the timing cam and forces the contact tongue smartly and positively to the particular contact selected, thus giving a minimum transit time. The description returns to the initial movement of the transmitting cam shaft. Simultaneously with the release of the resetting lever the send-receive cam permits operation of the send-receive switch to the "send" position. The start-stop selecting lever also rides out of its cam depression and permits the contact operating lever to set the striker in such position that its downward travel will drive the transmitting contact tongue to the spacing side and transmit the "start" signal which precedes the signal impulse train. Continued rotation of the transmitting cam shaft is attended by the orderly transmission to line of the train of selected impulses. As the opening of each signal cam is presented to the associated selecting lever, transmission of mark or space is determined by the position of the comb bars. Only those selecting levers from beneath which the associated cam bars have been withdrawn are permitted to ride into the cam opening and move the contact operating lever into the marking position. Final movement of the transmitting cam shaft to its normal position permits the start-stop selecting lever to enter its cam depression and a mark or stop signal to be transmitted to line.

Simultaneously the send-receive switch is operated by its cam to the receive position and the resetting lever is caused to withdraw the comb bars and the locking bar, thus freeing the selected key bar.

Reception: The receiving portion of the machine may be divided into three sections, receiving, selecting and printing. Receiving is effected by means of a polarised electro magnet which not only transfers its motion to the trip shaft, but also actuates the automatic starting switch for the motor. The trip shaft performs two functions:—

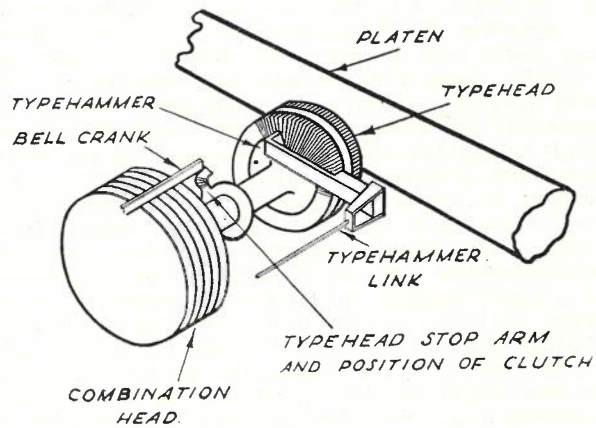
(a) Controls rotation of the receiving cam sleeve,
(b) Guides the finger setting blade.

The receiving cam sleeve is operated by a single revolution clutch which engages with each "start" signal. This sleeve has five grooves cut in its periphery. Its function, performed by means of these grooves, is to operate certain levers at appropriate times and carry out the following functions:—

(a) Actuate the finger setting lever,
(b) operate the type hammer,
(c) transfer reciprocating motion to the traversing lever,
(d) actuate the bell crank lifting lever,
(e) operate the comb setting lever.

The finger setting blade engages the finger setting pin to cause the appropriate fingers to be set corresponding only to marking impulses of the signal train.

Selection is effected in the combination receiving head in which there are five receiving combs and one shift comb, which determine upper or lower case selection. The shift comb has a series of indentations on its periphery. The receiving combs are similar in form, but the indentations are arranged in combination. As a train of signal impulses is received, each marking signal causes the appropriate comb setting finger to be displaced beneath the respective receiving comb extension. Final movement of the receive cam sleeve causes the finger block to be raised and its upward movement causes slight rotation of the selected combs. By this means one alignment of all five receiving comb indentations with the shift comb is effected and one particular bell crank is selected and enters the slot. The function of the selected bell crank is to arrest the motion of the revolving typehead. The typehead is driven by a clutch, the clutch-stop of which engages the selected bell crank and arrests the typehead in such position that the selected character is opposite the typehammer. Printing is not effected, however, until the next train of signal impulses is being received. During the intervening period the selected combination is stored in the combination head. A diagramatic sketch of combination head and typehead is shown in Q. 9, Fig. 2.



Q. 9, Fig. 2.

The sequence of operation of the receive cam links is as follows:—

With the initial motion of the cam sleeve the traversing link, carrying the finger setting pin, commences its to and fro motion from its position of rest opposite No. 2 finger, towards No. 1 finger. During its subsequent motion it moves successively opposite Nos. 2, 3, 4, 5, 4, 3, and 2 fingers, where it completes its motion.

The comb setting lever simultaneously lowers the comb setting fingers to their normal positions.

The setting blade lever moves successively five times, once during the reception of each signal pulse.

As the fifth pulse is received the type hammer lever operates to print the character previously selected.

Immediately after this occurs the bell crank lifting lever raises all bell cranks, permitting the receiving combs to restore to normal and the typehead to again rotate.

Finally, the comb setting lever again raises the comb setting fingers to permit selection of the character just received.

Printing: The printing is performed by the action of the typehammer driving the selected type into contact with the ribbon and imprinting the character on the paper which feeds over the platen.

EXAMINATION No. 2817—ENGINEER, LINE CONSTRUCTION

F. C. L. Taylor, B.Sc., A.M.I.E. (Aust.).

PART C—AERIAL WIRES

Q. 8.—A new trunk pole line is to be erected between two towns. Briefly indicate the factors which would influence your choice of a route and any inquiries and investigations you would make before reaching a decision.

Give a list of items of material and approximate quantities, also approximate total man-hours and total cost for erecting 1 mile of such a pole route suitable for 12 channel carrier operation assuming wooden poles (basic height 26 feet) and that one arm of 200 lb. H.D.C. wires is required initially.

A.—(a) Usually the cheapest and most direct route between two towns will follow the most direct road or railway line adjoining them. A roadside route is preferable as it provides easier access for maintenance. The development likely to occur over the next 20 years or so between the two towns will, however, have a very important bearing on the route finally selected. Apart from closely examining the likely telephone development of intermediate towns, it will be advisable to consult the power, railways, roads and municipal authorities regarding any extensions they may have in mind. Later works such as new roads, deviation or widening of existing roads, new gateways to properties and new power lines, or deviations of existing power line, are all things that may result in unexpected parallels or crossings. It is important that the exact position of any future construction be accurately anticipated to avoid later such prospects of having to shift an important transposition pole, or the costly process of raising the height of one or more poles carrying numerous working circuits to provide sufficient clearance over a new road or gateway. A knowledge of projected telephone development is important as heavy settlement in new areas arising, for example, from future industrial enterprises may occasion new offices with a demand for trunk line facilities that will best be met by the new pole route which must be routed accordingly. The question of costs must be considered. In other words, should the planning engineer outlay additional capital to deviate his route initially to meet development which will not occur for some years, or will he provide a direct route initially at lower cost and spend additional money in say 8 years on a branch pole or cable route to cater for development occurring at that time? Once in full possession of the facts of future development, both telephone and of other authorities, he may be faced with several alternatives involving varying expenditures at varying stages of development, and perhaps including among them entirely separate routes for the new line. A consideration of the relative present values of the costs involved as well as the difficulties inherent to each scheme will thus be important. Before arriving at a decision, irrespective of costs involved, each alternative route must be thoroughly traversed to determine the extent and nature of such practical difficulties. Important points to watch are the extent of clearing required, the holding qualities of the soil for poles and stays, the extent of staying required, way-leaves required on private property, presence of power lines or other sources of inductive interference such as arc-type rectifiers, neon signs, etc. Steep or irregular grades, or areas subject to flooding should also be avoided. It is usually desirable to bypass the main streets through the intermediate and terminal towns where vehicular and pedestrian traffic is much heavier and hazards such as ornamental trees, power supply leads, close proximity to buildings, etc., are more frequent.

The important things then, in broad terms, are to select a route which will—

(i) best cater for future telephone development.

(ii) allow the highest standard of engineering construction, i.e., as free as possible from angles, curves, irregular grades and poor holding soil, and be readily accessible at all points for maintenance purposes;

(iii) avoid as far as possible hazards such as power circuits, busy streets, ornamental trees and railway crossings;

(iv) represent the most economical means of providing the service required; and

(v) suitably meet eventualities arising from future work by outside people and organisations.

As explained, it is sound policy to take pains in determining exactly what form these eventualities are likely to take and at what date.

(b) **Material.**

(i) **Poles.**

At 44 yards spacing 40 poles will be required, assuming the mile to be an intermediate section of the route. The basic pole height is 26′. Assume that grading for ground level irregularities requires the provision of four 28′ poles and two 30′ poles.

Assume also that the route follows a fence-line and crosses one gateway where a wire clearance of 18′ is required. The normal ground clearance along a fence-line is 8′, and under these circumstances it may be presumed that the basic pole has been designed to provide this clearance at its ultimate development, and that 36′ poles will be required each side of the gateway to obtain the prescribed 18′ clearance. Grading poles of 32′ and 28′ will be required each side of the gateway.

Thus **Pole requirements** over the mile section will be:

Pole, Wood	36′	2
Pole, Wood	32′	2
Pole, Wood	30′	2
Pole, Wood	28′	6
Pole, Wood	26′	28

Cost of poles may vary considerably, depending on type of wood and locality. At average cost of £3/10/-, total cost = £140, plus 80 gallons of creosote at 2/- = £148.

(ii) **Staying**

Longitudinal stays should be fitted every 16th pole, total 3, and transverse stays every 8th pole, total 5. Assuming 3 angles in the mile section, total stays = 19.

Material for Staying

				£	s.	d.
Stay Rod 6′ x ⅝″	19	at	12/–	£11	8	0
Plates, stay, steel 12″ x 12″	18	at	4/–	3	16	0
Wire S.S. Gal. 7/14	80lb.	at	6d.	2	0	0
Bolts, hook	57	at	4d.	0	17	4
Stay Guards	19	at	5d.	0	7	11
Eyebolts, Bent ¾″ x 10″ ..	11	at	2/6	1	7	6
Eyebolt Lug, ⅝″	8	at	6d.	0	4	0
				£20	0	9

(iii) **Wire, Arms, Transpositions.**

Assuming the section is part of a standard E section, there would be approximately 60 transpositions. The arm would be transposed to Dwg. CL26OC Design 1. Arms SS and steel spindles would be required at the three angles. 4 Spindles, Transposition, will be required with each transposition plate, and eight spindles Tk ⅝″ L.S. at each angle. Spindles, Transposition, 240 and spindles Tk ⅝ L.S., 24. Insulators Tk P.L.S. Total 440. Transposition Plates, P.L. 6″, total 60.

Sumarising Material:—

		at	£	s.	d.
Arms, W.S. 108″/8-6″	37	6/–	£11	2	0
Arms, S.S. 108/8-6″	3	6/–	0	18	0
Bolts 9-10-11″ x ⅝″	40	6d.	1	0	0
Bolts, 3½″ x ⅝″	80	3d.	1	0	0
Screws, Coach 3″ x ⅝″	40	4d.	0	13	4
Braces, Arm, Long	80	1/4	5	6	8
Washers, Flat ⅜″	80	6d. lb.	0	2	0
Washers, Flat ⅞″	120	6d. lb.	0	4	0
Washers, Dished, ⅝″	120	7d. lb.	0	4	6
Petroleum Jelly	5 lb.	1/–	0	5	0
Plate Transposition PL-6″	60	6/3	18	15	
Spindles, Transposition ..	240	1/3	15	0	0
Spindles, Tk ⅝″ L.S.	24	1/3	1	10	0
Spindles, Tk Wood L.S. ..	176	3d.	2	4	3
Insulators, Tk P.L.S.	440	1/–	22	0	0
Wire, 200 H.D.C.	1600 lb.	2/2	173	6	8
Sleeves, W.J. Press type	16	5d.	0	6	8
Tapes, C 100/237	380	3/– per 100	0	12	0
Wire, soft copper, 50 lb...	10 lb.	2/–	1	0	0
			£255	9	10

(c) **Labour** (approximate)

				Manhours
Erecting poles	40	@	6	= 240
Laying out poles	40	@	1½	= 60
Arming Poles	40	@	1	= 40
Fitting Poles	40	@	½	= 20
Running wire	8	@	17	= 126
Fitting Transpositions	30	@	1	= 30
Marking poles	10	@	0.2	= 2
Loading poles at depot	40	@	0.3	= 12
Clearing	1 mile	@	30	= 30
Fitting stays	19	@	5	= 95
Recording units (388-400)	25%			= 165
Total				820

Labour cost = 5/- per manhour = £205.

Engineer's Administration @ 3/- = £123.

Incidentals—Freight, cartage, etc. = £12.

Total approximate material cost—

(i) £148—Poles.

(ii) 20—Stays.

(iii) 255—Arms, wires, transpositions, etc.

(iv) 7—Sundries.

£430

Approximate total cost of section = £770.

Q. 9.—A 30 ft, tubular steel pole, 12 inches diameter at the base, tapering to 6 inches at the top and fitted with 8 pin crossarms, carries forty 200 lb. H.D.C. wires (0.112 inches diameter) at a tension of 200 lb. each. Crossarms are at 28 inches vertical separation and spans are 44 yards each. Maximum wind pressure is 15 lb. per square foot on full projected areas and top wires are in a plane 3 inches above the top of the pole.

If the pole were in the straight what would be the maximum bending moment at the ground line?

If the pole were at an angle of 140° in the line and a ground stay bisecting the angle and set at 45° to the horizontal were connected to the pole at the point of resultant pull of the wires what would be—

(i) the tension in the stay wire?

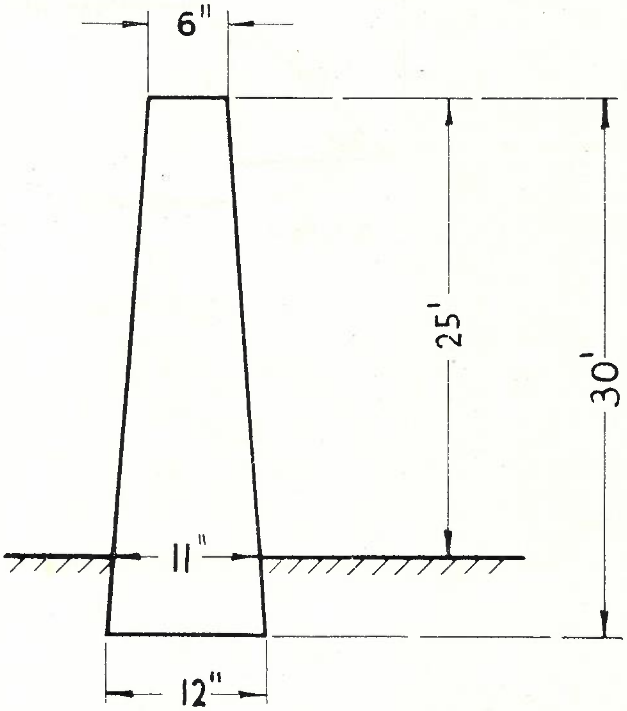
(ii) the downward thrust on the pole?

(Cos. 70° = 0.342.)

A.—Maximum wind pressure on wire surface areas when the pole is in the straight =

$= 40 \times (0.112/12) \times 132 \times 15$

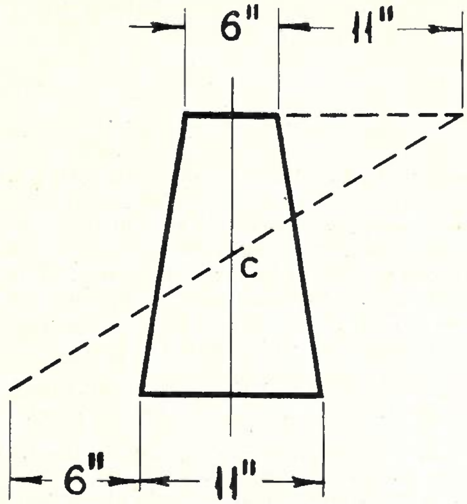
= 739.2 lbs., acting at a point 56 inches from the plane of the top wires, is 53 inches from the top of the pole or 20′ 7″ from the ground line.



Q. 9, Fig. 1.

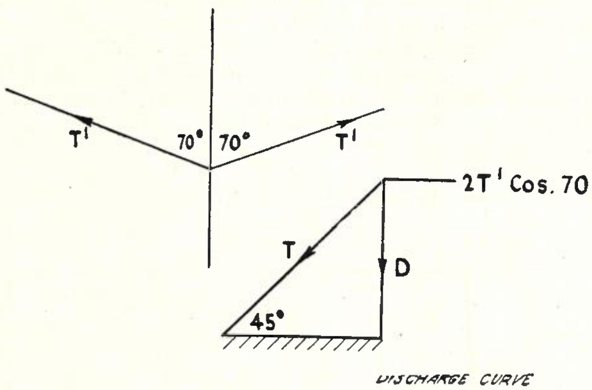
Total wind pressure on the pole will be (425/24) × 15 lbs. = 265.63 lbs., acting at a point 11.28′ from ground level.

Total BM at GL = 265.63 × 11.28 + 739.2 × 20-58 = 2996.3 + 15212.7 ft. lbs. = 18,209 ft. lbs.



Q. 9, Fig. 2

Figure 2 shows a simple construction to determine the centroid of the projected pole area at which point the wind pressure may be taken as acting in calculating the B.M. due to wind pressure on the pole.



Q. 9, Fig. 3.

If T^1 = total tension of wires on each side of the pole and T = tension in the stay wire, then

$T \cos 45'' = 2\ T^1 \cos 70$

$T/\sqrt{2} = 2\ T^1 \times 0.342 =$

$T = 2\ T^1 \times 0.342 \times 1.414$

$= 16000 \times 0.4836$

$= 7738$ lbs.

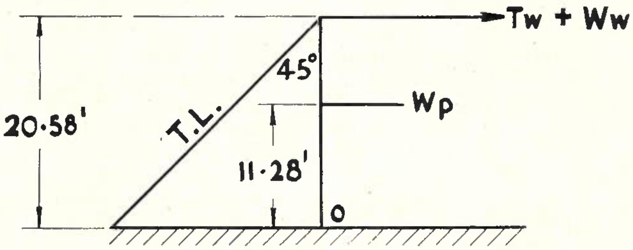
If D is the downward thrust on the pole,

$D = T \cos 45$

$= 2\ T^1 \cos 70$

$= 16000 \times 0.342$

$= 5472$ lbs.



Q. 9, Fig. 4.

(It will be noted that these answers ignore the presence of wind pressure on the pole and wires. If a wind pressure of 15 lbs. per square foot were present as shown in Figure 4 it would be necessary to take moments about O and solve for T from the resulting formula, viz.—

$T \cos 45 \times 20.58 = (Tw + Ww) \times 20.58 + Wp \times 11.28$

$Tw = T^1 \cos 70$ as above

Ww = total wind pressure on the projected areas of the wires

$= 739.2 \sin 70°$

and Wp = wind pressure on pole as determined above.

From the information given it would appear that wind pressures may be ignored in answering this part of the question but it may be of interest to students as an exercise to show that under conditions of maximum wind pressure the tension in the stay wire would increase to approximately 8926 lbs.)

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