THE
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THE EQUIPMENT OF THE CENTRAL TELEGRAPH OFFICE, NEW DELHI

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INTRODUCTION.—In a previous number of the Journal a short description of the telephone and telegraph system of New Delhi was published (Vol. 20, Part 3, page 160). The article mentioned briefly the equipment installed in the Central Telegraph Office in the new city. It is thought that a more detailed description of the plant would be of interest.

As was previously noted, the office has been equipped on a remote control basis following American practice, the instrument room fittings being confined only to those units of the apparatus necessary for traffic operations. The remaining apparatus is installed in an adjacent room known as the "Test Room." The many advantages gained by this system are indicated in the course of the description of each unit.

Test Boards and Testing Apparatus.—The telegraph and telephone lines are brought into the test room in underground cables, which are terminated on an ordinary telephone type M.D.F. From the cable terminal tag blocks all lines are jumpered *via* protecting apparatus to the "line" tag blocks of the test boards. The test boards are fitted with ten-line five-point break jack strips, the strips of jacks forming the terminations of the line and apparatus units. Permanent cross connections of the units are made to the inner springs of the jacks through jumper fields.

Trunk Lines.—All trunk lines are arranged to

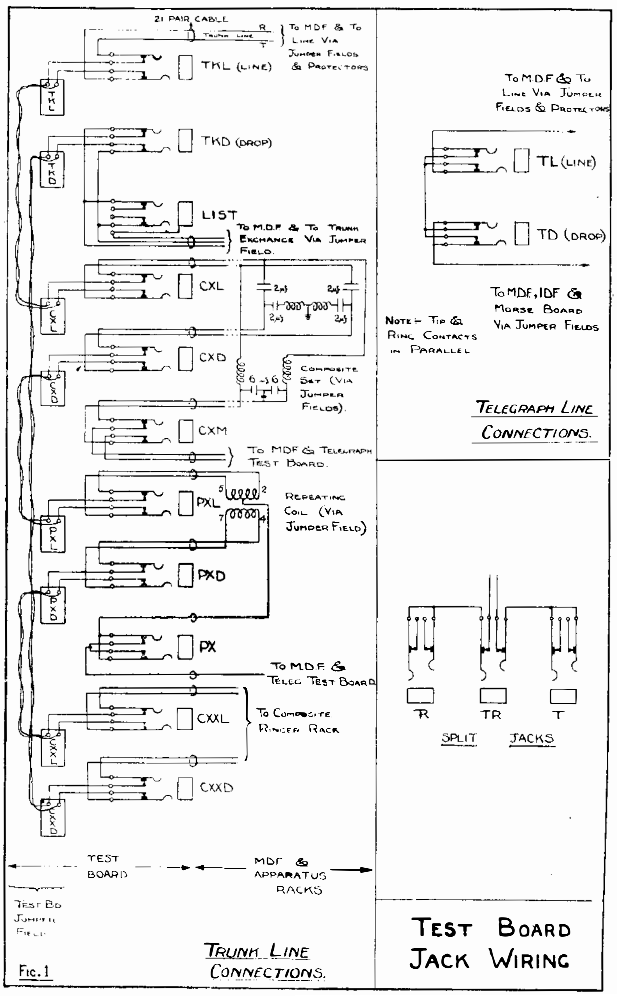


Fig. 1

permit of composite working, using the ordinary 5AA retardation coil composite sets and 135-cycle ringing. The trunk line test section therefore contains jack strips for handling and testing the composite set units, as well as the repeating coils used for phantom telegraph working. In Fig. 1 is shown a schematic diagram of the jack wiring and jumper connections for a trunk line permanently wired for composite working. This plugged into the TKL jack and PXL jack, and a second cord from PXD to TKD will remove the composite set and ringer from the line and revert to repeating coil working, the phantom point being available for telegraph use at the PX jack. In the same manner a faulty composite ringer can be cut out of circuit and a spare ringer introduced using the PXD and TKD jacks of the line and the CXXL and CXXD

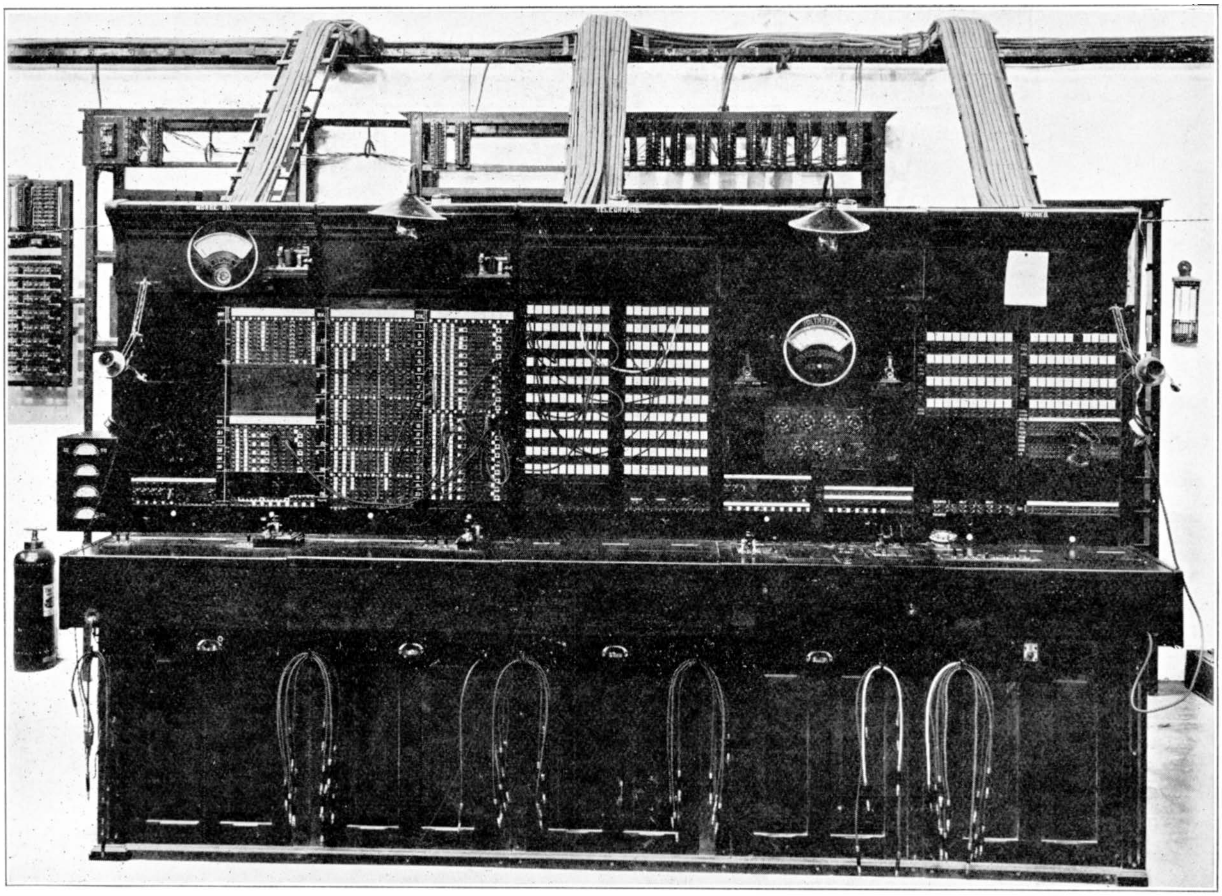


FIG. 2.—TEST AND MORSE BOARDS.
Right to Left: Trunk Line section, Test section, Telegraph Line section, Duplex and Simplex section, Baudot and Duplex section.

permanent wiring is done in jumper fields provided in the test board section itself. All temporary changes or departures from normal are made by means of "patch" cords; double-ended tinsel telephone cords which are kept beneath the test board keyshelf (Fig. 2). From Fig. 1, it can be seen how temporary changes are quickly made. For instance, a patch cord jacks of the spare ringer, and so on for other changes and substitutions.

Fig. 3 shows the arrangement of the trunk line jack panels, and shows how the apparatus units are designated.

Fitted on the trunk section are also break-jack strips carrying the telephone repeater balancing network units treated in a manner similar to the units of the line apparatus. Changes in the latter are, of course, followed by corresponding changes in the appropriate repeater balance units, *e.g.*, when a composite set and ringer are introduced into a line, composite set and ringer balance units are patch-corded or jumpered into the corresponding repeater network. Fig. **4** shows the break-jack arrangement at present in use for the network circuits.

In addition to the above equipment the trunk line section is also fitted with " split " jacks for separating the tip and ring wires for test purposes, Fig. **1**, and with transfer jacks wired to the Morse board to deal with temporary superimposed telegraph connections.

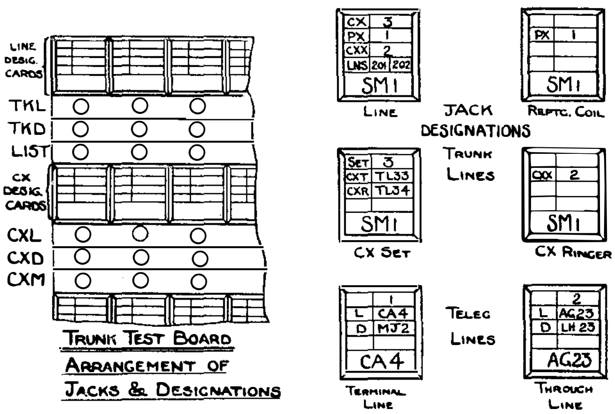


Fig. 3.

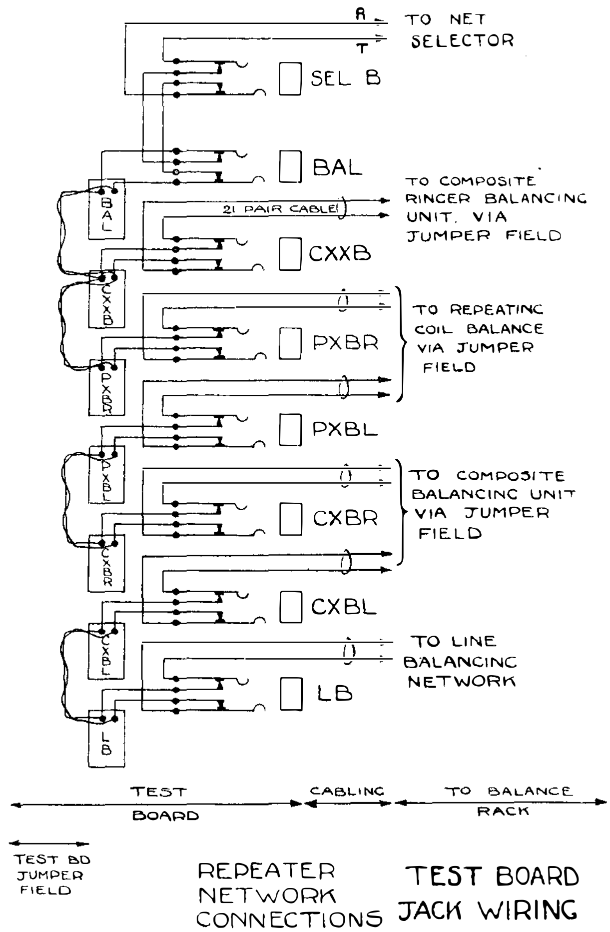


Fig. 4.

Telegraph Lines.—The telegraph line test panel contains all direct and superimposed telegraph outlets arranged suitably for testing and making line to line cross connections. Each telegraph channel is connected through " line " and " drop " jacks as shown in Fig. **1**, while the types of jack designations used are indicated in Fig. **3**. Telephone cable pairs used for the key, sounder, and alarm wires from local offices are also brought through the telegraph section for test purposes.

Test Section.—Between the trunk line and telegraph line sections of the test board is the test position (Fig. **2**) equipped with testing instruments and speaking circuits. The instruments shown in the photograph are a testing voltmeter and milliammeter, Wheatstone bridge, closed circuit Morse sets, as well as trunk and local telephone circuits. Testing and telegraph battery taps are available on the board, all testing apparatus units and battery taps being jack-ended and used with the ordinary patch cords. Practice has shown that the use of break-jacks on the line test boards and test section greatly facilitates the whole of the testing work.

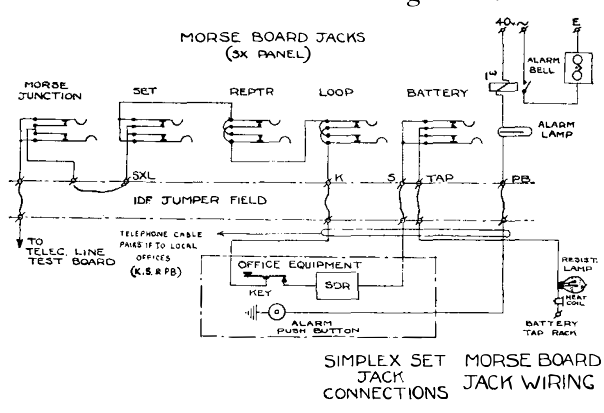


Fig. 5.

Morse Boards and Telegraph Apparatus.—Telegraph lines are connected from the drop jacks of the telegraph test board to the Morse junction jacks of the Morse boards, and from the latter to the various telegraph sets *via* a jumper field on the M.D.F. The Morse boards are fitted as an extension to the test board, although such an arrangement is not, of course, an essential.

The Morse junction jacks on the Morse board provide a line to set a cross-connection field; temporary changes being made by means of patch cords while permanent wiring is jumpered. The panels of the Morse board sections are divided into units containing break-jack strips wired according to types of sets, and also provide the Morse junction jack fields, spare battery jacks for changing set battery taps, the means of monitoring on Morse wires with either a Morse set or milliammeter, and facilities for set testing.

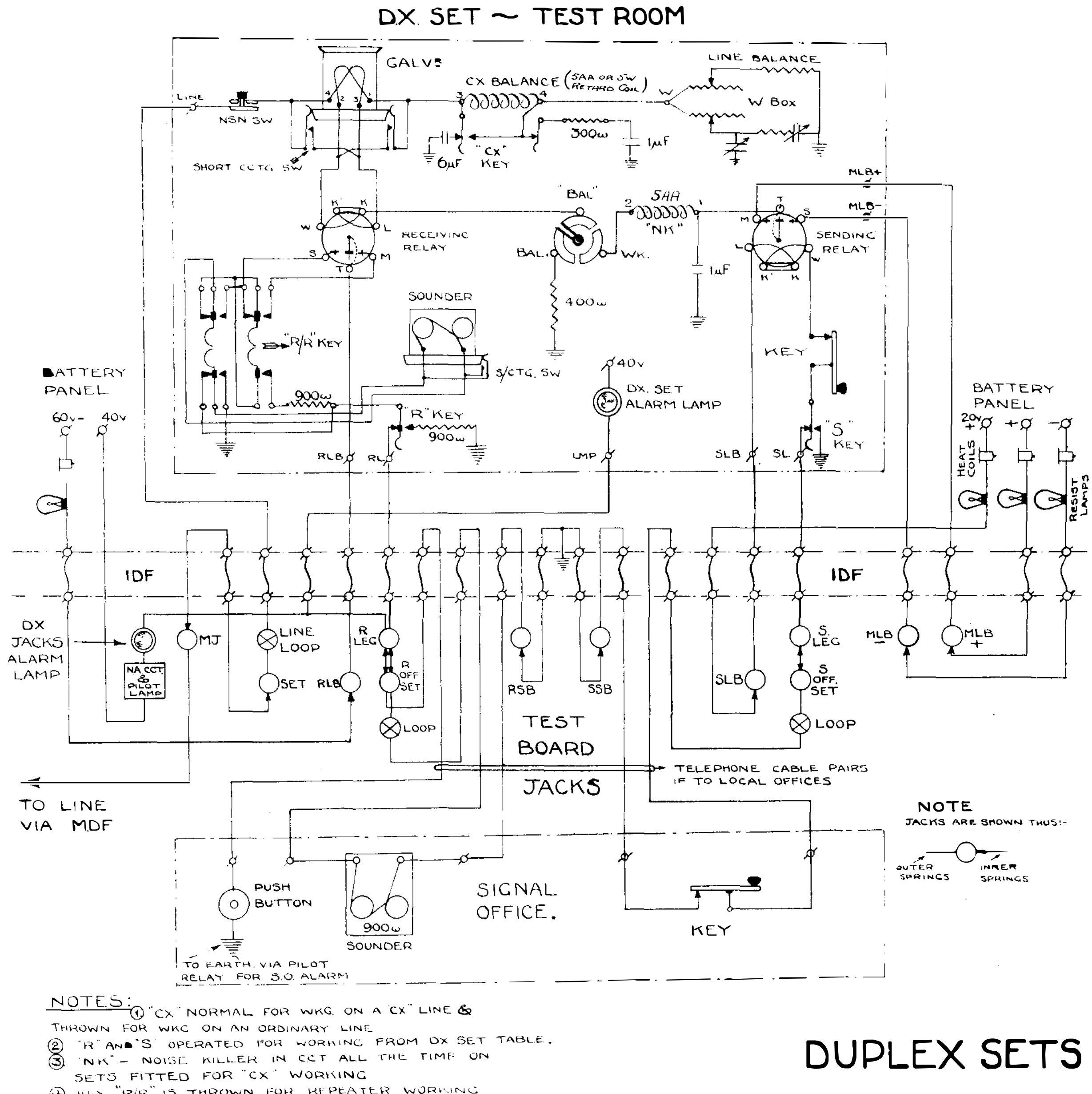


FIG. 6.

Simplex Sets.—Fig. **5** shows the jack connections of the closed circuit simplex sets. Two closed circuit sets and two Morse junction jacks are provided in each jack strip, one panel of the Morse board being equipped with the jacks and alarm lamps for 70 sets. The office key and sounder, the alarm, line, and battery tap are connected to each closed circuit set *via* jumper fields on an I.D.F. (an ordinary block to block telephone type frame). Temporary changes of office working position, battery voltage, etc., are carried out with patch-cords, using the "Morse junction" and "set" jacks or "battery" jacks, etc. The "loop" jack is used for circuit monitoring without interfering with traffic, for testing and current measuring.

Alarm Operation.—In cases of circuit trouble, one of the signal office staff, by pressing the push button of the set concerned, lights the set alarm lamp on the Morse board. Simultaneously with

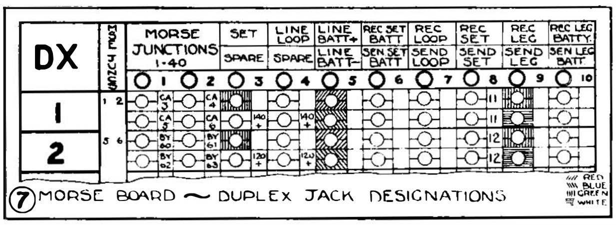


Fig. **7**.

the lighting of the alarm lamp, the section pilot relay and alarm bell are operated, calling the attention of the test room staff. A member of the latter, by plugging a closed circuit test set into the loop jack of the faulty set, is able to locate and deal with the fault from observations of the test set operation or from information given by the office staff. Exactly the same alarm and fault procedure is followed on the sets worked from small local offices in the city. These local offices are supplied with battery from the central telegraph office on telephone cable pairs, the central office fully controlling the circuit arrangements and testing. This arrangement has led to the saving of the batteries and battery maintenance in the local offices and has provided for expert supervision of the circuits.

Duplex Sets.—The duplex set panels are each equipped with break-jack strips for 20 duplex sets and associated Morse junction and spare battery tap jacks. Two strips of jacks carry four Morse junctions, two spare batteries and one duplex set as shown in Fig. **7**. The duplex set jacks are divided into three groups: line, receiving leg, and sending leg. The first group comprises the "set" jack, "line loop," and "positive" and "negative main line batteries"; the second, the "receiving leg," "receiving set," "loop" and batteries; and the third, the "sending" jacks arranged as in the receiving

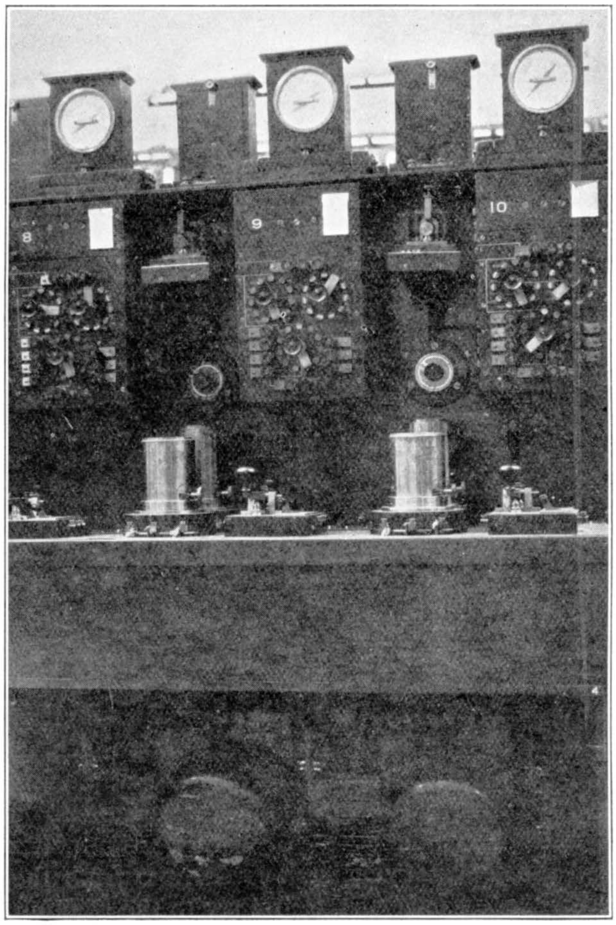


Fig. **8**.—Duplex Test Table.

leg. The duplex sets are worked on the differential principle. The apparatus is mounted on tables in the test room, twenty sets per table, the units being set out for convenience in monitoring and handling. The upper portion of the table carries the relays, galvanometer, test key and sounder, and switches; while the base of the tables is fitted with composite balancing units, noise killers, and resistances (Fig. **8**). It will be noticed that each set is fitted with a sending relay and also with a second key and sounder in series with the office equipment, which, as in the case of the simplex sets, consists of key sounder, and alarm push button, whether in the central office or in the local offices in the city.

The test room technical staff carry out the balancing, testing, and maintenance of the sets. The provision of the second sounder permits of constant supervision being maintained on the working of the circuits.

It will be seen from the duplex set connections, as shown in Fig. **6**, that the system of wiring provides great flexibility. Cross-connections with patch-cords from receiving and sending leg jacks to office receiving and sending set jacks allows any office position to work on any one of the sets. Therefore, should a set fault develop, the procedure in dealing with it is to patch-cord the office position to a spare set. The traffic channel is kept working instead of being held up while the fault is being investigated, so that no avoidable loss of circuit time results. Moreover, by the same means, temporary rearrangements of office positions to suit traffic requirements are readily carried out and office positions can be concentrated at night as required.

The provision of the sending relay in each set has a number of advantages. The office set wiring is simple and has to carry only low voltages, a quicker pole change is obtained, thus maintaining a better balance. Furthermore, each set is made universal — it may be utilised as a regular duplex terminal set, as half of a duplex repeater or, as the duplexing unit for machine telegraphs. To make up a repeater with this system of working is a matter of a moment. Two patch-cords, one from the receiving leg jack of the first set to the sending leg jack of the second set, and the second cord in the reverse manner are plugged in on the Morse board and on each set the "repeater" key is thrown to complete the operation. This feature is found to be very useful both for ordinary repeater working and for repeating on temporarily built-up circuits, such as may be required during cases of line breakdown. Spare duplex sets are used to build the repeaters or, if there are not sufficient spare sets, repeaters are made from sets released from unimportant short lines, which are reverted to simplex working.

It will be seen from the jack connections shown in Fig. **6** that the loop jacks fitted in the line, sending and receiving legs provide a ready means for monitoring, measuring currents and testing from the Morse board. Battery changes to deal with departures from normal conditions are made by the use of the main battery jacks and the spare battery taps available on the board.

Keys are fitted on the sets, (1) to allow the composite balance to be switched in or out of the circuit, as required by the line conditions, *i.e.*, "CX" key; (2) to allow the office equipment to be switched out of the circuit for testing and speaking from the set—"R" and "S" keys; and (3) to provide means for balancing and repeater working—"BAL" and "R/R" keys.

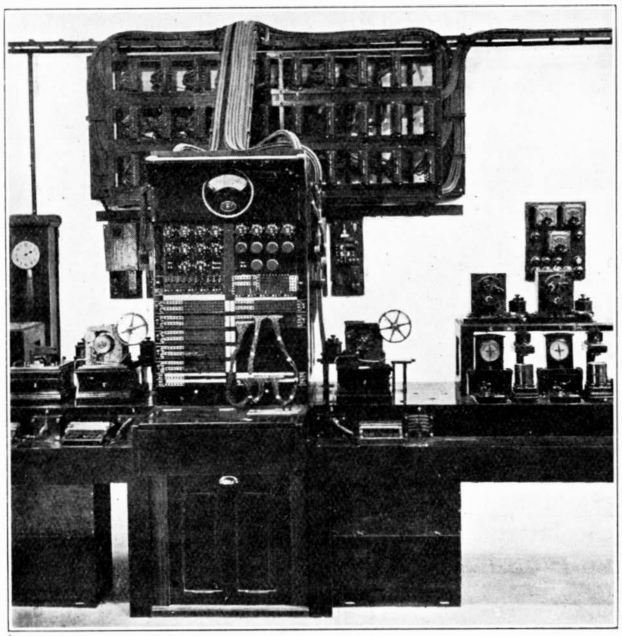


FIG. **9**.—ARRANGEMENT OF BAUDOT TEST BOARD AND BAUDOT SETS.

Fig. **6** also shows how the permanent set arrangement of batteries, office position, etc., are made in the I.D.F. jumper fields and also shows the alarm system, and the battery tap protection as provided on the battery panels, etc.

The alarm operation is similar to that already described in simplex working, but a second additional alarm lamp is provided over the DX set, as well as the one on the Morse board. Patch-cord changes of set to office positions are arranged to change the alarm wires as well as the instrument connections—" R leg " and " R set " jacks.

Baudot Sets.—The Morse board Baudot equipment consists of the alarm lamps and jacks (shown in Fig. **10**) wired one set per jack strip. Connections from set to line are made from the " set " jacks to the Morse junctions; the battery taps required are jumpered or patched to the battery jacks. The loop jacks provide means for line current measurement and the " DX MAM " and " RL " jacks are used for duplex connections. The cabling from the Morse board jacks terminates on tag blocks on the I.D.F. From the latter, jumper fields connect to the test board, battery taps, and to blocks cabled to the Baudot test board.

The Baudot section of the Morse board is equipped with double current Morse sets for speaking on Baudot lines, also with local telephone sets to the signal office, and with the Morse board voltmeter—milliammeter—Fig. **2**.

Baudot Test Board and Baudot Apparatus.—It was mentioned in the previous description of the New Delhi Signal Office, that arrangements were in progress for the operation of Baudot telegraph sets on a remote control basis. This system has now been investigated and installed and the arrangement of sets and Baudot test board at present in use is shown in Fig. **9**.

Ten simplex two-arm distributors and line equipments with four test receivers and keyboards are mounted on a table with a test board in the centre. The signal office is equipped with receivers, keyboards and alarms, cabled to the test room I.D.F. and jumpered as required for permanent working to the " office " side of the 20 way break jack strips on the test board.

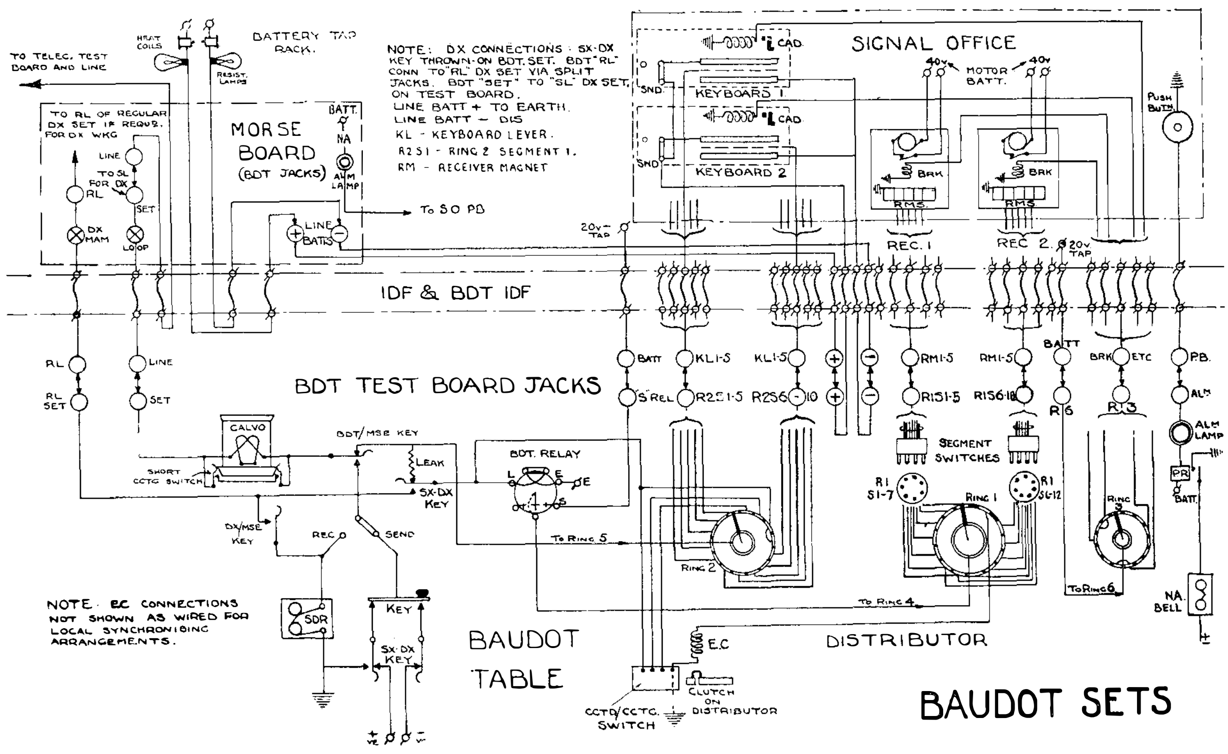


FIG. **10**.

The " distributor " side jacks are wired to the set segments, line apparatus, etc., the inner springs of the " office " and " distributor " jacks being looped.

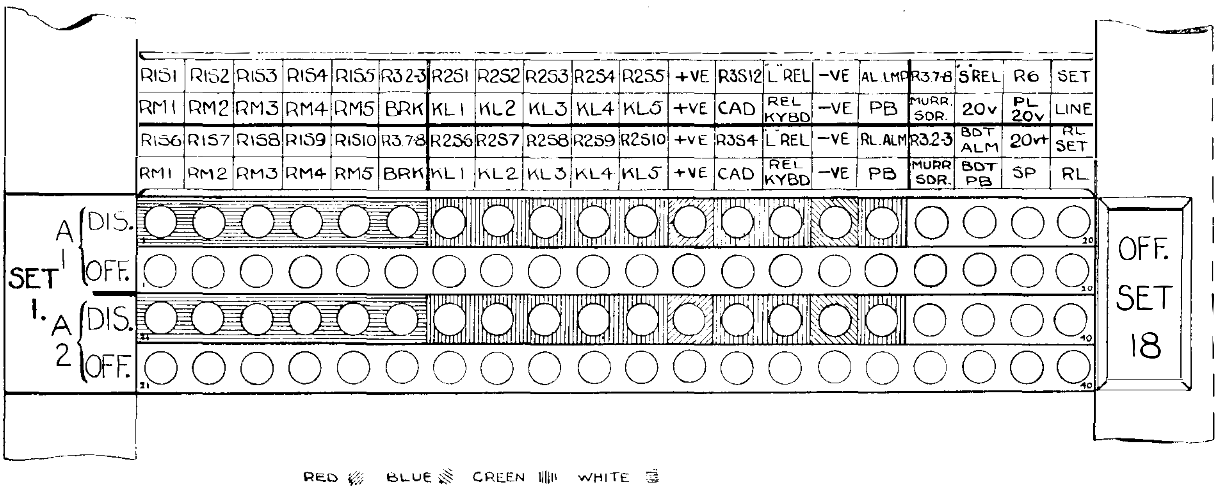
From the jack connections (Fig. **10**) it can be seen that the use of patch-cords enables any office position to be cross-connected to any distributor, and the receiving arms and keyboards of each set to be crossed and varied at will. Multiple patch-cords are used, six-way plugs for receiving arms and five-way plugs for keyboard comnnections, two five-way cords being used for each keyboard. The test set receivers and keyboards are jack-ended on the test board and used with patch-cords. A test receiver and keyboard are shown plugged into set 7 in Fig. **9**.

The flexibility obtained by the use of the test board jack field permits of a change of distributors to be made in case of a set fault without altering the office position. Baudot positions can be concentrated in the signal office as traffic decreases in the evening and lines revert to Morse working, without change of distributors or loss of synchronism. It is of considerable value to be able to interchange quickly the local copy receiver and base with the incoming arm unit without loss of synchronism or alteration of circuit conditions. When cases of persistent trouble are experienced on the moderator of the incoming receiver base, the faulty unit is crossed with the local copy receiver, to perform the comparatively unimportant work of printing a local record, until the trouble is removed.

The test board jack connections are arranged so that when a patch-cord from a test receiver is plugged into a set, the test and office receivers work in parallel. This arrangement serves two purposes—(1) the Baudot Supervisor in the test room is able to monitor on the sending and receiving arms of the sets and check incoming and outgoing signals without interfering with the traffic, and (2) when the supervisor is attending to a fault at the test board, the office staff are kept informed as to what is happening by taking observations on their receivers.

Carpentier type keyboards are used, but the office keyboard switches are permanently set to " send," the condition required for reception being obtained by the use of a multiple plug on the test board jacks. The plug connects the sending segments to the line terminals of the relay. This saves time by eliminating changes of office apparatus. These " receive " plugs are shown in use on sets 4 and 5 in Fig. **9**.

The test board is fitted with a combined voltmeter and milliammeter with jack-ended connections, the instrument being brought into use by means of a doubled plug and cords. Line currents are measured by plugging into the " line " and " set " jacks. Similarly, currents in each branch of the receiving and sending arms can be checked independently.



(11) BAUDOT TABLE—JACK DESIGNATIONS.

Interposed between the distributor receiving segments of ring 1 and the receiving arm jacks are radial plug switches which permit of the receiving segments being quickly moved from segments 6-10 to 7-11 or 8-12, when this is necessary owing to the retardation on long lines —" segment switches " in Fig. **10**.

Alarm lamps are provided for each set, operated from the office push button, to call the attention of the Baudot supervisors in case of trouble; keys on the test board are arranged to light a lamp and give an alarm in the signal office, when the set is ready to work after a fault. In cases of faults of short duration, the recommencement of the keyboard cadence on the office keyboard when the test keyboard is removed gives the indication that the fault has been rectified.

The alarm procedure followed is similar to that previously described in the Morse simplex set operation, the test receivers and keyboard being used to investigate troubles not obviously line faults.

Retransmitter working.—As in the case of Morse duplex sets, any two Baudot sets can be jumpered or patch-corded together to form a retransmitting repeater. This necessitates, of course, that the two sets be first locally synchronised. Special 20-way jack strips are fitted on the test board for retransmitter working. To these are wired the connections to the coils, levers, battery taps and release magnets of retransmitting relay units; connections to ring three segments 6, 11 and 13; the electric corrector of each of the ten sets, and sets of " loop " jacks. Sets are locally synchronised by cross-connecting the required jacks with short single patch-cords in this jack field as shown in Fig. **12**.

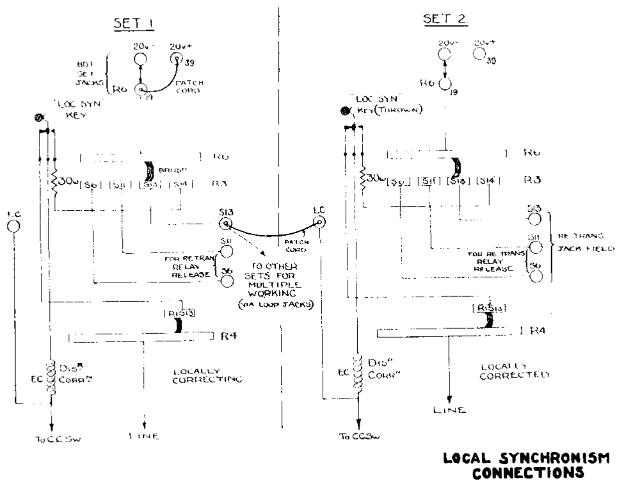


FIG. **12**.

The diagram shows that one set is allocated as the locally correcting set. The battery to ring 6 on this set is changed from 20 volts negative to 20 volts positive by means of a looped double plug joining jack 19 to jack 39 in the set jack strips. In the retransmitter jack field a patch-cord is plugged from the ring 3) " segment 13 " jack of the controlling set to the " EC " jack of the set to be synchronised. On the latter, the " Local Synchronism " key is thrown and the speed adjusted to give an ordinary correction on the electric corrector. The correcting current is received when the batteries of opposite polarity meet on the beginning of segment 14 on the corrected set and the brushes of the latter are retarded to segment 13. Other sets can be similarly synchronised locally by plugging the cord from the segment 13 jack of the controlling set to loop jacks and from the latter group as many cords as there are sets to be synchronised are connected to the various EC jacks. Sets can be locally synchronised in a very short time.

The two sets of a retransmitter are used as " correcting " sets in relation to the distant terminal stations. The retransmitting relays are jumpered to the sets, or connected with patch-cords as follows:—Five-way cords are used to connect the receiver segments of the receiving arm of the first set to the magnets of one retransmitter relay and the levers of the latter to the sending segments of the second set. Single cords connect the positive and negative batteries from the second set jacks to the battery jacks of the relays, and the ring 3 " segment 6 " jack to the release jack of the relays. Connections in the reverse manner from set 2 to a second retransmitter relay unit complete the repeater, Fig. **13**.

The retransmitted signals are monitored with the test receivers in the receiver jacks of the sending arms in the usual way. In the same way that duplex Morse repeaters are built up to deal with line emergencies so Baudot retransmitting repeaters can be made up. If necessary, unimportant short Baudot lines are reverted to Morse working to set free apparatus to provide the retransmitting repeaters on temporary long and important circuits. The system has the advantage that standard terminal sets are used for all types of work, which results in a saving in the provision of special sets and spares.

Multiple working.—The same system of local synchronism is used for the simultaneous sending on a number of sets from one keyboard for multiple press transmission. The sending arms of the sets concerned are looped to the signal office keyboard from which it is desired to send and the line battery voltages are equalised, Fig.

14. The arrangement facilitates the disposal of long press messages booked for a number of stations and also frees office staff for other work. The incoming receiving arms of the sets concerned continue work in the normal way.

jack of the Baudot set jacks is earthed, the negative left disconnected, and the receiving leg jack of the Baudot jacks connected to the RL jack of the duplex set. The keyboard thereby operates the sending relay of the duplex set and

PATCH-CORD CONNECTIONS—SX BAUDOT REPEATER 2-ARM

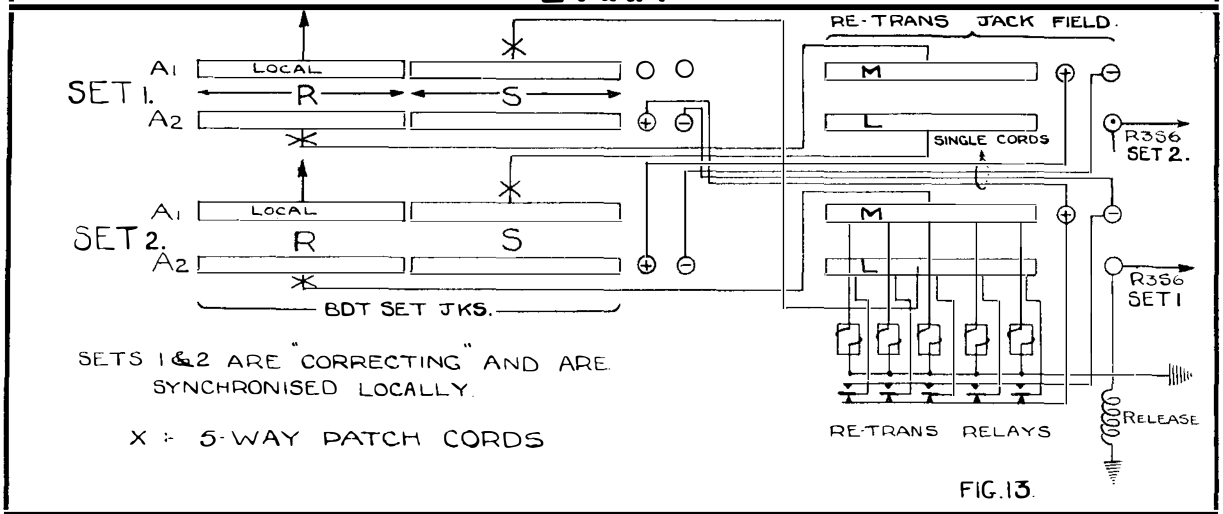


FIG. 13.

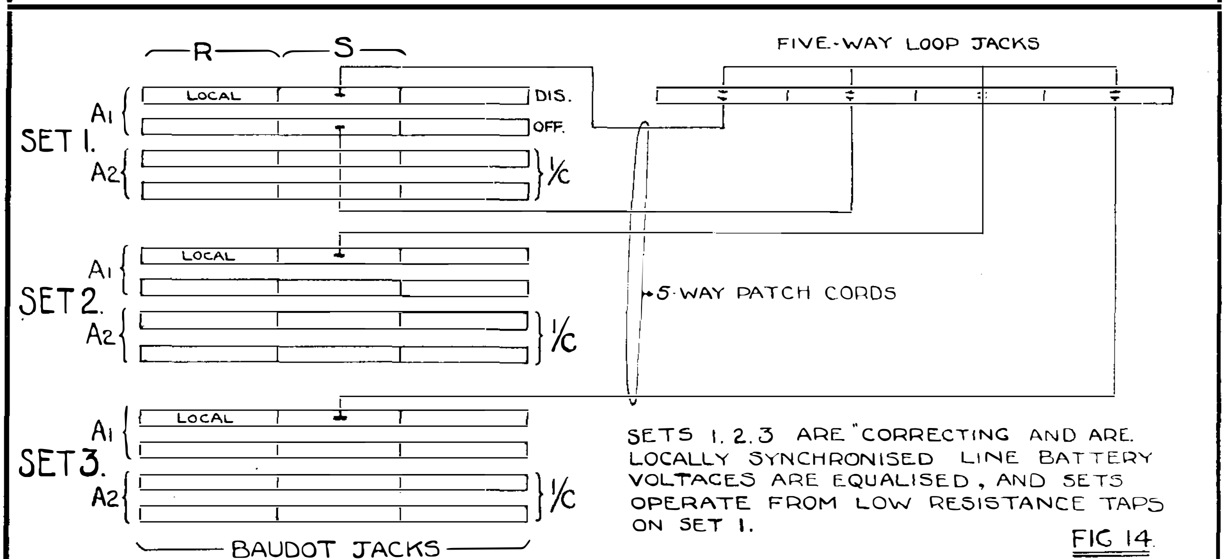


FIG 14.

SIMPLEX BAUDOT MULTIPLE WORKING (2-ARM).

Duplex working.—Baudot sets are duplexed by means of jumper or patch-cord connections on the Morse board connecting the Baudot set to one of the regular Morse duplex units. In the system in use at present, the positive line battery

the receiving circuit is connected to Ring 4. A loop jack (DX/MAM) in the receiving leg is provided in the Baudot jacks for obtaining a finer adjustment of the line balance after the ordinary hand balance has been found. A DX-

SX key on the Baudot set is thrown to change from simplex to duplex conditions. Fig. **10**.

Miscellaneous Apparatus.—Of the Test Room miscellaneous apparatus, it may be of interest to mention the type of battery tap racks in use. All battery taps are fed through 20-unit panels, each tap connection passing from a bus bar through a disconnecting type of heat coil and protecting resistance lamp to the I.D.F., where the tap is jumpered to the set block required. The heat coil is arranged to operate at slightly less current than the MDF standard telephone type heat coil in order that fleeting line faults may disconnect superimposed telegraph channels rather than disconnect the trunk speech circuit.

Routine Testing.—All the test room apparatus is subject to a rigid system of weekly routine testing in a manner similar to that used in automatic telephone exchanges. The testing is usually performed by the night staff, and ensures the maintaining of all working and spare apparatus in a state of efficiency. Fault records are kept to indicate the standard of apparatus operation and to facilitate the tracing of recurring faults and detection of worn apparatus. In practice it is found that Morse apparatus faults are extremely few. Lost time on Baudot circuits due to apparatus faults is kept at a low figure by the application of routine testing and by the flexibility introduced which permits of changing a faulty instrument quickly.

Signal Office Fittings.—The simplicity of the office fittings has enabled a neat arrangement of apparatus to be adopted. Baudot sets can be fitted two per table where there was room for only one previously.

Power and Battery Room Apparatus. — A radial type of change-over switch is fitted in the telegraph battery discharge leads. This is a simple reversing switch, which interchanges and reverses the two halves of the battery so as roughly to equalise the discharge on all cells. The battery is tapped every twenty volts, and line currents, etc., are adjusted by variation of voltage rather than by battery tap resistance.

Test Wires.—Among the future developments of the test room system of operation is the provision of a " test wire " between station test boards. This channel is intended to be reserved for service messages ordering line crossings, etc., relieving the ordinary channels of non-revenue earning loads. As messages will be received directly, the delay in completing service operations is expected to be reduced to a minimum. A thermostat calling device has been designed for use on such closed circuit lines to give a positive lamp and alarm bell calling signal.

In conclusion, following the successful establishment of the test room system in New Delhi, it has been decided to fit an adjacent large office in the same manner. On the experience which will then become available the desirability of the future extension of the system to all the larger offices of the Department will be considered.

COMPOSITED TELEGRAPH AND TELEPHONE WORKING.

J. M. Owen, A.M.I.E.E., and J. A. S. Martin.

INTRODUCTION.—Superposing telegraph circuits on the unloaded phantoms of telephone pairs by means of transformers is a method that is well known to communication engineers. When, however, the phantom circuits are loaded and therefore not available for superposing telegraphs, the problem becomes more complicated. It is the object of this article to show how a loaded underground circuit can be successfully used for simultaneous telegraph and telephone working. This system is known as Composited Working and, for reasons that will be obvious later, is sometimes referred to as Sub-Audio or Infra-Acoustic Telegraphy.

The frequency band necessary for high grade telephone transmission is from 200 to 3000 cycles per second. It will be apparent that the range from 0 to 200 c.p.s. can be utilised for telegraph transmission, provided that some device is used to prevent the low frequency telegraph signals producing noise in the telephone circuit. A device such as this should not appreciably degrade the telephone transmission.

A square-shaped telegraph signal can be

shown by means of Fourier's Integral to be made up of a fundamental frequency and a number of harmonics, some of the latter being in the frequency range required for telephone transmission.

In order therefore to effectively separate the telephone and telegraph signals it will be first of all necessary to suppress the higher harmonics of the telegraph signals before such signals are impresssed on the line. For example, a Wheatstone speed of 62.5 words per minute—*i.e.*, a fundamental telegraph frequency of 25 c.p.s.—would contain harmonics in the range between 200 and 300 c.p.s.

The telegraph problem therefore consists essentially in transmitting telegraph signals to line so as to effectively operate a telegraph relay at the distant end and to be free from harmonics of telephone frequency. Experiment has shown that signals whose shape approximates to a sine wave are sufficient for this purpose. In order to smooth or round-off the signals a low-pass filter is used in the telegraph circuit. Such a filter is made to suppress all frequencies higher than the calculated cut-off point, usually about 40 to 60 c.p.s.

For the purpose of blocking out the low telegraph frequencies from the local telephone circuit a high-pass filter is inserted in series with the line and telephone. The cut-off frequency of this filter, as previously mentioned, should be 200 c.p.s. As the name suggests, this filter suppresses all frequencies below the cut-off value.

A low-pass filter is necessary at the receiving end, for although there is no question of smoothing the signals received from line, another cause of disturbance has to be provided for. The actuation of the relay armatures between the pole-pieces causes variations of flux and produces currents of telephone frequency. There is also a possibility of impulses being transmitted to the telephone circuit by virtue of the capacity of the relay winding with respect to its core.

Further, if the relay used at the receiving end is a " G " relay, currents are transmitted from the tongue to earth through the " G " windings. These currents cause disturbing impulses to be transformed back into the telephone circuit through the line windings of the relay.

It will be appreciated that the low-pass filter will cause considerable sparking at the contacts of the transmitting relay and therefore spark quench devices are fitted. Sparking also causes disturbances in the telephone circuit and it has been found beneficial to equip both the transmitting and receiving relays with spark quench devices.

Before describing the system in detail it will be of interest to enumerate the conditions that have to be met, both as regards the telephone and the telegraph case.

Considering the telephone case first, the several conditions to be met in the Department's underground network can be classified as follows:—

(*a*) Short telephone circuits worked on loops without transformers and using C.B. signalling.

(*b*) Short telephone circuits without transformers, using magneto signalling.

(*c*) Telephone circuits, side-and-phantom-loaded, using modified C.B. signalling.

(*d*) Telephone circuits, with or without two-wire repeaters, side-and-phantom-loaded, using magneto signalling.

(*e*) Telephone circuits, side-and-phantom-loaded, used for two-wire repeatered circuits, and using V.F. signalling.

(*f*) Telephone circuits, side-and-phantom-loaded, used for four-wire repeatered circuits, and using V.F. signalling.

(*g*) Telephone circuits, side-loaded only, used for either two or four-wire repeatered circuits.

(*h*) Telephone circuits in which the loading coils are of the iron wire core type.

In the case of (*a*), (*b*) and (*g*) the phantom circuit is not required for telephone transmission, and it would be more economical to superpose by the transformer method. As regards (*g*) the low frequency telegraph signals would be bye-passed at the telephonic repeaters by connecting the mid-points of the line sides of the transformers either side of the repeaters. It will be apparent that any form of battery signalling would have to be replaced by either magneto or voice frequency signalling.

As regards (*c*) to (*f*), composited working would be resorted to, as in these cases the phantoms are required for telephone purposes.

The low-pass filter admits all frequencies up to, say, 60 c.p.s., depending of course on the design of the filter. Therefore it will be obvious that magneto signalling would interfere with the telegraph signals. Also, battery signalling could not be used and under these circumstances voice frequency signalling must be adopted. Where all the pairs in the cable are not required for composited working, a modified type of battery signalling could be used where the signalling is composited on a single wire to earth, instead of round the loop. A smoothing device is used to smooth the signals before they are impressed on the line, in fact the signalling could really be described as composited signalling. Where the phantoms are not required for telephone working, two quads would provide signalling for four telephone circuits and leave two side circuits for compositing the telegraph. Where the phantoms are in use for telephone working, four quads will provide signalling for eight side circuits and four phantoms, and leave two side circuits for compositing the telegraph.

In the case of repeatered telephone circuits, both two- and four-wire, it will be necessary to have both high- and low-pass filters either side of the repeater. The low frequency telegraph signals will be byepassed by connecting the two low-pass filters together. Where two-wire repeaters are used, it will be necessary to modify the line balance as the addition of the filters will slightly change the impedance-frequency characteristic of the circuit.

The iron-wire-cored loading coils are not suitable for composited working as they tend to become magnetised with the flow of direct current. This produces modulations in the speech currents. As, however, the greater number of coils in use at the present time are of the dust-core type this is not a matter for serious consideration.

In addition to the aforementioned conditions there is the question of the different types of loading. Although the majority of loading is medium heavy, *i.e.*, 177 mH coils in the side circuits and, where loaded, 106 mH in the phantoms at 1.125 miles spacing, there are a number of cables with the same value coils, but spaced at 1.6 miles. There are also cases in which both the coils and spacings are different from those mentioned above.

As the filter network must match the impedance of the particular cable with which it is associated, it will be readily appreciated that the values of the capacity and inductance components used will require modification for each particular type of cable.

Telegraph Case.—In considering the telegraph case, the following points require consideration :—

(1) The use of a single wire using earth return.
(2) Loop working.
(3) Working round the loop with the " B " line earthed at the sending end.
(4) Simplex or duplex working.
(5) Type of apparatus to be used.

The use of single-wire earthed circuits tends to unbalance the wires of a pair.

Loop working presents two difficulties. Firstly, separate insulated batteries are required for each circuit, and, secondly, two relays are required at the sending end to reverse the battery across the loop. This latter is termed double commutation. In the case of circuits with no telegraph repeaters the relays can be adjusted to operate reasonably alike for satisfactory working, but where repeaters are in circuit the satisfactory adjustment of the relays throughout the circuit is difficult, and gives rise to cumulative bias. As a compromise between single wire earthed, and loop working, the " B " line is earthed at the sending end so that there is a close approximation to loop working, whilst permitting the use of a single transmitting relay, and the ordinary universal telegraph battery. In this case a device is necessary to prevent interference with other circuits in the cable due to the surge caused in one leg of the loop by the application of the battery. A transformer is so connected that a surge in one leg will be repeated into the other leg and so prevent a condition of unbalance.

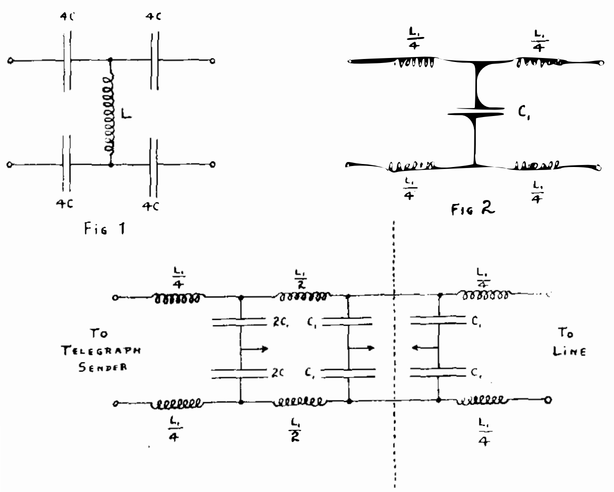
The question of simplex or duplex working depends upon the number of pairs available and the telegraph facilities required. Where sufficient pairs are available, it is better to use a pair for transmitting in each direction, as troubles due to the duplex balance will be eliminated. Two pairs would therefore give the same facilities as a duplex circuit.

Composited working is, by virtue of the limitations to speed imposed by the low-pass filters, essentially suitable for teleprinter working. The speed of the latest type is 25 c.p.s., which is considerably below the cut-off point of the low-pass filter. From this it will be seen that even on long lines a fair working margin exists.

Filter Details.—It has already been mentioned that in this system high- and low-pass filters are used. The filter values were calculated by the use of well-known formulæ, but it might be of interest to show in a simplified form how this was done. The values of the filter components depend upon the type of circuit used, so that the electrical constants of the circuit must be known before the calculations can be made.

In one particular case the circuit used was a 40-lb. medium heavy loaded one, *i.e.*, 177 millihenry coils in the side circuits and 106 mH coil in the phantom circuit, spaced 1.125 miles apart. Further, the characteristic impedance $Z_0 = 1556 \backslash 1°56'$ ohms at $\omega = 5000$ rads. per sec.

Consider the case of the high-pass filter. It was desired that this filter should have a cut-off frequency $f_c = 200$ cycles per sec. ($\omega_c = 1256$ radians per sec.). That is to say, all frequencies below 200 c.p.s. must be suppressed.



FIGS. **1**, **2** AND **3**.

Fig. **1** shows a single section (T circuit) high-pass filter. Capacities form the series elements, and an inductance forms the shunt element.

$$\text{Now } \omega_c = \frac{1}{2\sqrt{LC}} \quad \ldots\ldots\ldots\ldots (1)$$

where $\omega_c = 2\pi f_c = 1256$ rads. per sec.

$$\text{and } Z_0 = \sqrt{\frac{L}{C}}\sqrt{1 - \frac{1}{4\omega^2 LC}} \quad \ldots\ldots\ldots\ldots (2)$$

$$\text{from (1) } C = \frac{1}{4\omega_c^2 L} \quad \ldots\ldots\ldots\ldots (3)$$

and substituting (3) in (2) we get

$$Z_0 = 2\omega_c L\sqrt{1 - \left(\frac{\omega_c}{\omega}\right)^2}$$

$$\therefore \quad L = \frac{Z_0}{2\omega_c\sqrt{1 - \left(\frac{\omega_c}{\omega}\right)^2}} \quad \ldots\ldots\ldots\ldots (4)$$

$$\therefore \quad L = \frac{1556}{2 \times 1256\sqrt{1 - \left(\frac{1256}{5000}\right)^2}}$$

$$= 0.642 \text{ henry}$$

$$\text{and } C = \frac{10^6}{4 \times (1256)^2 \times 0.642} = 0.2465\ \mu\text{F}.$$

Whence the capacity element becomes 4 × 0.2465 = 0.986 μF. and the inductance element becomes = 0.642 henry.

The inductance was obtained with about 1500 turns of No. 24 S.W.G. D.S.C. wire on ¾″ stampings and with an air gap of about 60 mils.

Consider now the case of the low-pass filter. In this particular instance $Z_0 = 2000$ ohms at 25 cycles per sec. ($\omega = 157$ rads. per sec.). The working speed of a Teleprinter 3A is approximately equal to 25 cycles per second. It was desired that this filter should have a cut-off frequency of 60 cycles per sec. ($\omega_c = 377$ rads. per sec.)—that is to say, all frequencies above 60 cycles must be suppressed.

Fig. **2** shows a single section (T circuit) low-pass filter. Inductances form the series elements and a capacity forms the shunt element.

$$\text{Now } \omega_c = \frac{2}{\sqrt{L_1 C_1}} \quad \ldots\ldots\ldots\ldots (5)$$

where $\omega_c = 2\pi f_c = 377$ rads. per sec.

$$\text{and } Z_0 = \sqrt{\frac{L_1}{C_1}}\sqrt{1 - \frac{\omega^2 L_1 C_1}{4}} \quad \ldots\ldots\ldots\ldots (6)$$

$$\text{from (5) } C_1 = \frac{4}{L_1 \omega_c^2} \quad \ldots\ldots\ldots\ldots (7)$$

and substituting (7) in (6) we get

$$L_1 = \frac{2Z_0}{\omega_c \sqrt{1 - \left(\frac{\omega}{\omega_c}\right)^2}} \quad \text{.................(8)}$$

$$\therefore \quad L_1 = \frac{4000}{377 \sqrt{1 - \left(\frac{157}{377}\right)^2}}$$

$$= 11.65 \text{ henries.}$$

$$\text{and} \quad C_1 = \frac{4 \times 10^6}{11.65 \times (377)^2} = 2.42 \ \mu F.$$

Whence the inductance element becomes 2.91 henries and the capacity element becomes 2.42 μF.

The inductance was obtained with about 2200 turns of No. 24 S.W.G. D.S.C. wire on ¾″ stampings, and with an air gap of about 10 mils.

In the case of the low-pass filters it is necessary that the inductances should be carefully balanced in order to keep the crosstalk, and particularly the side to phantom crosstalk as low as possible. For a similar reason the condensers in the high-pass filters should be carefully balanced. It is also essential that the effective resistance values in these cases should be as close as possible.

It has previously been mentioned that it is necessary to smooth the telegraph signal wave shape before transmitting to line. For this purpose a smoothing circuit is used. This is nothing more or less than a low-pass filter. It will be readily realised that as the smoother unit is joined directly to the low-pass filter it is essential that the characteristics of this filter should not be affected. The smoother unit is therefore so designed that when it is joined to the line or filter unit, the whole becomes a two-section filter with characteristics similar to that of the single section low-pass filter.

Fig. **3** shows the completed low-pass filter circuit. The part to the right of the dotted line is associated with the line unit, whilst the part on the left is the smoother unit. The values of the components are so arranged that the circuit has the same characteristics as those of the filter shown in Fig. **2**. The condensers in Fig. **3** are split as shown, in order to standardise the line unit, and this enables the filters to be joined through to form the telegraph bye-pass at the telephone repeater stations without any alterations being required.

Detailed Description. — The compositing apparatus comprises a telegraph unit, a smoother unit and a line unit.

As a smoother unit is only required at a transmitting point, which may include a telegraph repeater, it is mounted on the same rack as the telegraph apparatus.

The telegraph unit carries the transmitting and receiving relays, together with associated apparatus. The relays used are of the P.O. Standard type, fitted with flexible spring tongues and with cores annealed in hydrogen. This type is particularly free from contact chatter and residual magnetism and is designed for efficient operation at low current values. The receiving relay is of the " G " type, the resistance and capacity values being fixed so as to give steady reversals at 25 c.p.s. Both relays are fitted with spark quench circuits. Four galvanometers are provided, two for the local circuits to and from the telegraph office, and two for the cable circuits, send and receive. These galvanometers are of the moving coil differential type, specially made for panel mounting. The scale is calibrated to give a deflection of 10 milliamps either side of zero with both coils in series. One leg of the loop is taken through each coil. Resistance is added in each leg of the cable send circuit for the purpose of regulating the steady line current which is kept at a value of 3 to 4 milliamps. It will be seen from Fig. **4** that a 300 ohms coil is in series with the B leg regulating resistance to compensate for the 300 ohms battery resistance and so preserve the balance of the circuit.

As previously mentioned a surge or kick transformer is also inserted in the transmitting circuit.

The line unit comprises two high-pass filters for the side circuits and two low-pass filters, as well as one high-pass filter for the phantom circuit. The line transformers are also mounted on this unit, and in the case of two-wire circuits additional transformers are provided for the balance circuits. Such a unit equips the two pairs of a quad in a multiple twin cable.

It will be obvious that in the case of two-wire circuits a line unit will be associated with both the telegraph send and receive circuit. Where, however, four-wire circuits are composited, a line unit will serve two sending circuits, the receiving circuits being served by the line units associated with the " Returns " which will be in a different balancing group in the cable.

Fig. **4** shows a send and receive telegraph circuit, using single commutation composited on two two-wire repeatered telephone circuits. The operation of the circuit is as follows:—Signals from the telegraph office operate the transmitting relay. From the tongue of this relay with earthed battery on its contacts, the signals are repeatered into the A line of the telephone loop *via* the regulating resistance, one coil of the kick transformer, one coil of the differential milliammeter, A line of smoother unit and A line of low-pass filter. The surge in the A leg which will take place when the voltage is first applied will be repeated in the " B " leg by means of the kick transformer. The signals pass along the line and at the telephone repeater station, they are byepassed through the coils of the low-pass filters. The high-pass filters, as at the sending end, prevent the telegraph signals from entering the telephone repeater.

After byepassing the repeater, the signals again pass to line and at the receiving end pass through one coil of the low-pass filter, both coils of the telegraph receiving relay and back to the B line through the other coil of the low-pass filter. As at the sending end, and at the telephone repeater these low frequency signals are blocked from entering the telephone circuit by virtue of the high-pass filter. After passing to the " B " line the signals are again byepassed at the telephone repeater and eventually find earth at the sending end *via* one coil of the low-pass filter, B line of smoother unit, one coil of differential milliammeter, one coil of kick transformer, regulating resistance, and 300 ohms resistance.

At the receiving end the signals are repeated to the telegraph office by means of the tongue and earthed battery on the battery contacts of the relay.

Speech currents pass to line *via* the high-pass filter, are amplified through the telephone repeater and received at the far end *via* the high-pass filter. In all cases these voice frequency currents are blocked from the telegraph circuit by means of the low-pass filters.

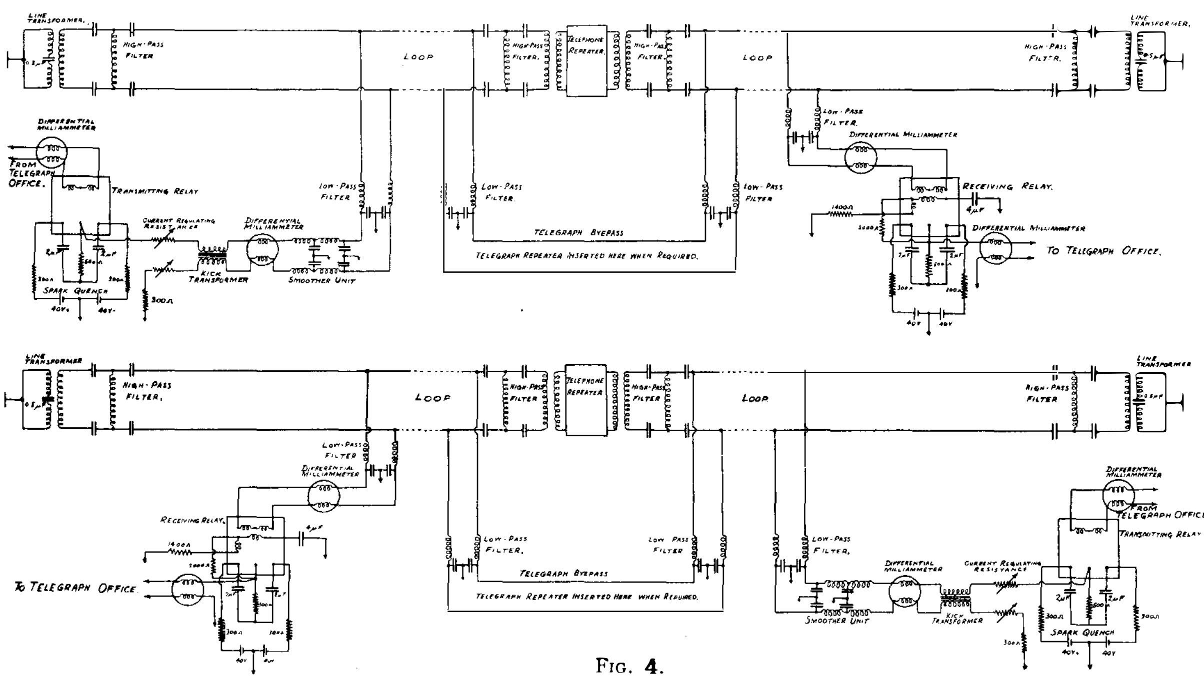


Fig. **4**.

It will be apparent that as in this particular case two-wire telephone circuits are used, speech transmission will take place in both directions. As regards the telegraph case, however, the second loop will be used for transmission in the opposite direction to the first loop.

A slight modification is required at a telephone repeater station where it is necessary to install a telegraph repeater. A " G " relay is used for this purpose and the conditions for reception are the same as those used at a terminal station. The local circuit, however, now becomes a transmitter and the conditions are similar to the transmitting end, and consequently it is necessary to insert a smoother before the re-energised telegraph signals are again impressed on the line. It is possible that before long the telegraph relay will be replaced by a thermionic repeater.

Fig. **5** shows a schematic lay-out of the system and will give some idea of the component parts of the circuit.

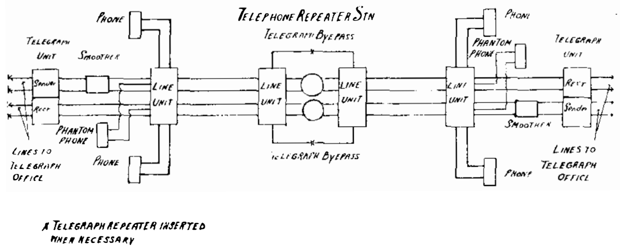


FIG. **5.**

The successful working of any system depends to a large extent upon the efficient maintenance of the apparatus. In this case the efficiency of the telegraph working will depend to a large extent upon the accurate regulation of the telegraph relays. In order to ensure as far as possible that relays are properly adjusted, a relay test panel has been designed. By means of this it will be possible to test relays for sensitivity, neutrality, and percentage of contact time. A speed measuring device is also associated with this unit in order to check the speed of vibrations of the receiving relays, which, as previously mentioned, are vibrating relays.

In conclusion, it may be of interest to quote the proposals as laid down by the C.C.I. with regard to composited working.

It should be noted that the C.C.I. Conference at present being held in Berlin has these proposals under review and it is possible that several alterations may be made.

In order not to prejudice the transmission quality of telephone circuits the following requirements must be met:—

1. The E.M.F. produced in the line circuit by the telegraph transmitter must not exceed 50 volts.

2. When the terminals of the telegraph transmitter are closed through a resistance of 30 ohms substituted for the line, the current through this resistance must not exceed 50 mA.

3. The increase in the attenuation of the telephone line due to composited telegraph installations must not exceed $b = 0.06$ or 0.5 TU for a line section having the length of the section between two successive repeaters, and over the frequency range of 300 c.p.s. and the maximum frequency transmitted.

4. Over 4-wire circuits the variation of line impedance produced by composited telegraphs must not exceed 10 per cent. in the frequency range indicated. As regards 2-wire circuits, composited telegraph installations must not exceed the values prescribed by the Telephone C.C.I. for the exact simulation of the impedance of the line by balancing networks.

5. Interference noise produced in telephone circuits by telegraph apparatus must not exceed a value which corresponds to an interference voltage of 0.1 mV for a transmission level $b = -1.0$ or -8.7 TU and an impedance of 800 ohms.

6. The increase in crosstalk produced by composited telegraph installations shall be determined as follows:—

The cable quads are replaced by artificial lines free from crosstalk and reproducing, within the closest possible limits, the impedances of the circuits (terminal apparatus for quads). Under these conditions the attenuation corresponding to the crosstalk measured from the telephone office side must not be inferior to the following values:—

(*a*) For 4-wire circuits: $b = 7.5$ or 65 TU for the crosstalk between any two speech circuits in the same quad.

(*b*) For 2-wire circuits: $b = 8.5$ or 74 TU for the crosstalk between any two speech circuits in the same quad.

(*c*) For 4-wire and 2-wire circuits: $b = 10.0$ or 87 TU for the crosstalk between two speech circuits in different quads.

7. For international telephone communications the total length of circuit sections employed simultaneously for composited telegraphy must not exceed 450 km. (approx. 280 miles).

8. After composited telegraph systems are connected into a circuit the unbalance to earth must not exceed the value prescribed by the C.C.I.

RURAL AUTOMATIC EXCHANGES.

NEW TYPE INTRODUCED BY BRITISH POST OFFICE.

A. Speight and J. C. Dallow.

INTRODUCTION.—(1) Several years ago the Department installed several "village" automatic exchanges. These were of different types in order that experience could be gained as to the feasibility of employing automatic plant in areas where only a limited amount of attention could be given. Several of these early exchanges are still providing a good service and the others have been converted to satellite exchanges.

(2) Apart from the few exchanges mentioned above, no serious attempt was made by the Department to introduce automatic working in rural areas until 1928 when consideration was given to the development of apparatus in "unit" form, thus catering for a small number of subscribers initially and allowing additional units to be added as required by subsequent growth.

(3) The main reasons for a reconsideration of the matter were as follows:—

(*a*) The increasing difficulty in obtaining caretaker operators for rural manual exchanges and the constant expense entailed in removing such exchanges to other premises because of the operating problem.

(*b*) The growing demand for a continuous service throughout the night as well as the day.

(*c*) The general introduction of automatic working at the larger exchanges, thus leading to the desirability of standardising automatic working for all sizes of exchanges.

(*d*) The great improvement in the design of automatic plant and consequent reduction of fault liability appeared to make it a more feasible proposition to leave automatic switches for considerable periods without attention.

(4) *R.A.X. Unit.*—This equipment is known as "Unit Auto No. 5" (see Fig. 1) and has the following features:—

(*a*) The unit is in cabinet form, 6 ft. 3 ins. high × 2 ft. wide × 1 ft. 3 ins. deep, and is closed at the front and rear by sheet iron air-spaced doors closing on to felt. Each unit has capacity for 25 lines (subscribers and junctions) and a maximum of four units can be installed in one exchange. Junctions, as required, are provided to distant exchanges, the termination being on a manual board.

(*b*) The equipment is designed to function from secondary cells with a voltage range of 46 to 52 volts and a dial range of 7 to 14 I.P.S. Standard automatic telephones, with central battery talking, are fitted at the subscribers' premises.

(*c*) "Busy," "Ringing" and "N.U." tones are provided.

(*d*) Automatic metering on local calls.

(*e*) Coin box working and the provision of a distinctive coin box tone to the operator at parent exchange.

(*f*) Supervising signal on junction call, in either direction, controlled by the R.A.X. subscriber's switch-hook.

(*g*) Forced release is applied in 12 to 25 seconds to a selector held by a subscriber who has failed to dial or has dialled one digit only.

(*h*) In order to avoid waste of battery power in cases of permanent loop or equivalent conditions, the equipment is so arranged that after an interval of 15 to 30 seconds, the subscriber's calling equipment is cut off and the fault held on a high resistance relay. If the subscriber replaces the receiver, or in case of line trouble the fault disappears, the circuit is restored to normal working.

(*i*) No alarms are provided, but the operator at the parent exchange can, by dialling "99," ascertain the conditions at the R.A.X.

(i) Inverted ringing signal, when received, indicates that none of the faults, mentioned in ii. and iii., exists.

(ii) Receipt of "NU" tone indicates that a selector has failed to restore, a fuse has blown, or the charging set has stopped before charging has been completed.

(iii) If neither signal nor tone is re-

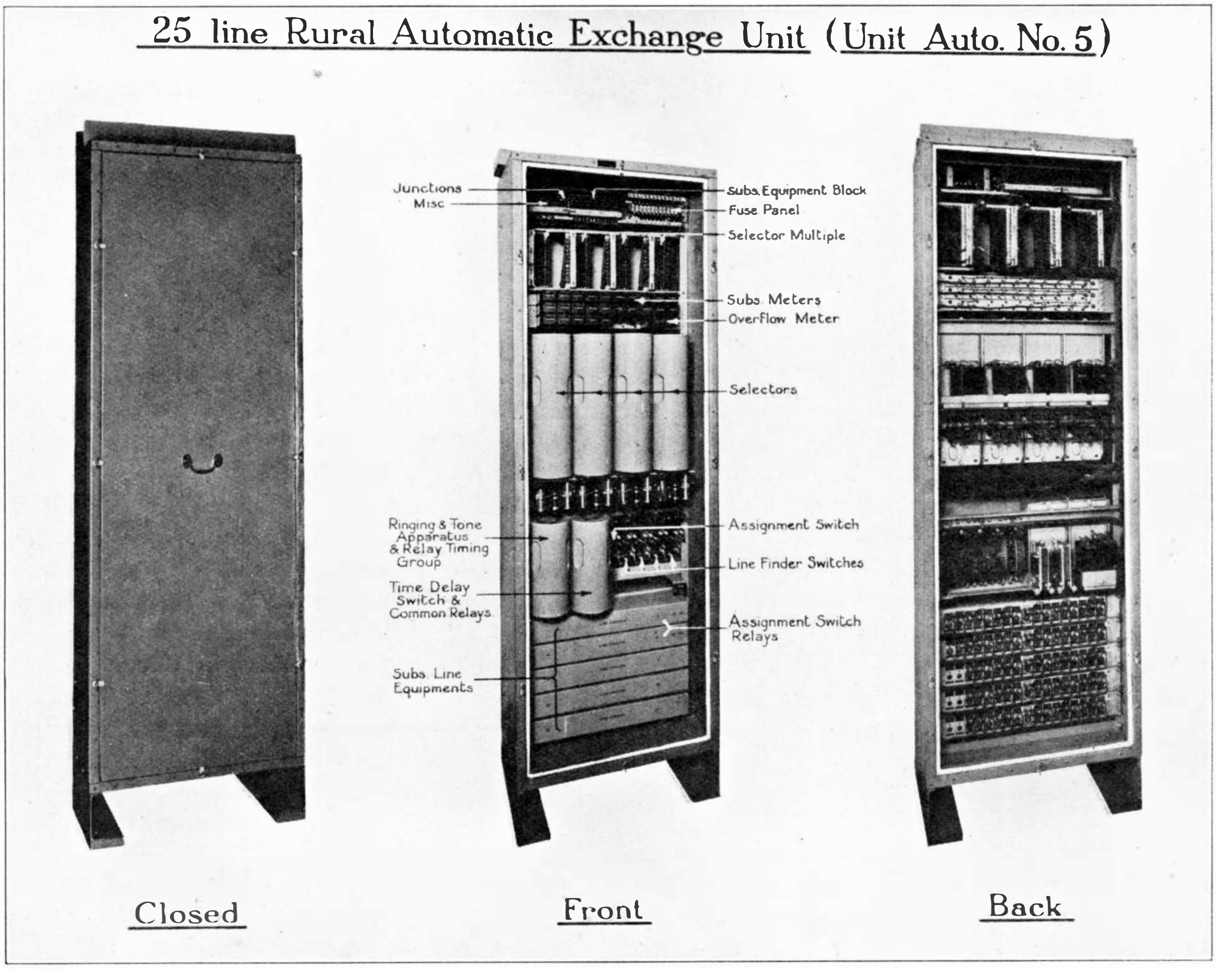


FIG. 1.

ceived the indication is that ringing has failed or the junction is out of order.

(5) Certain facilities, not considered to be essential, have not been catered for:

(*a*) Dialling tone.
(*b*) Party line working.
(*c*) Trunk barred facilities.
(*d*) Trunk offering and Operator hold.

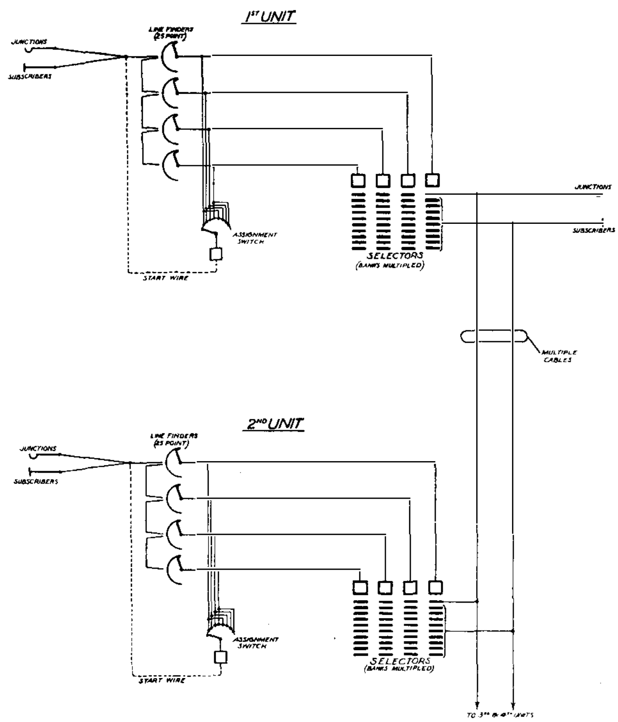


FIG. 2.

(6) The trunking scheme is shown in Fig. 2. All calls, both junction and local, are effected by the dialling of two digits, the connections for both subscribers' and junction calls being made by means of "Connecting Links," four of which are fitted in each unit. Each "Connecting Link" consists of a Line Finder (a Non-homing Rotary Line Switch) associated with a 2-motion selector of the Strowger type.

An "Assignment Switch" allocates the connecting links in consecutive order as calls are originated. Normally the wipers of this switch are standing on the contacts of a disengaged connecting link and this link is seized by the next call. The assignment switch is then stepped to the next free link.

The subscribers' and junction lines are connected to the banks of the Line Finders and are also multipled on the banks of the Selectors. When a call is originated the Line Finder of the Connecting Link is brought into operation and its wipers are rotated until they reach the bank contacts associated with the calling line on which they stop. The selector of the Connecting Link is thus connected *via* the Line Finder to the calling line and receives the two trains of impulses from the caller's dial. The selector is stepped to the number dialled, ringing is automatically applied and cut off when the called party answers. Metering takes place on local calls when the called subscriber lifts the receiver. All apparatus returns to normal when the calling party replaces the receiver.

(7) The numbering scheme is arranged so that levels 1 to 9 of the selectors are used for subscribers' lines. When an exchange consisting of one unit is opened, the subscribers' numbers commence on level 2 and continue as more units are added to level 9, level 1 being the last level to be brought into service.

Level 0 is reserved for junctions in all cases. Junctions to more than one exchange may be provided. If there is only one group of outgoing junctions the number to be dialled would be "01." If there are two groups the second would be called by dialling, say, "05."

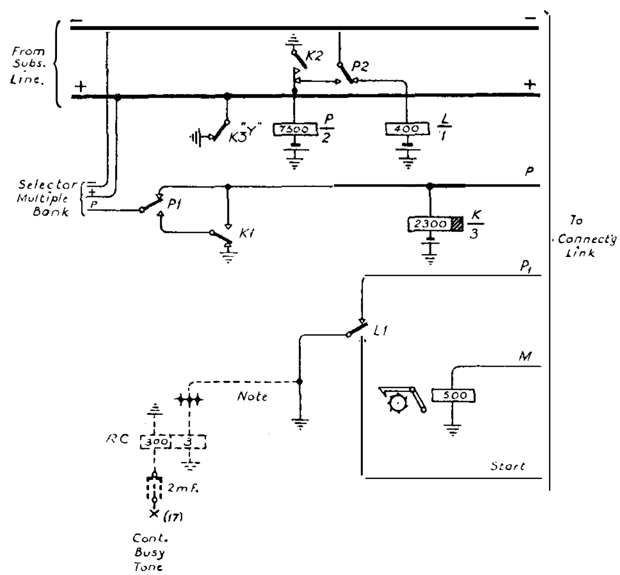


FIG. 3.

Note.—When a coin box line is connected to this circuit Earth is disconnected and dotted connections made.

RURAL AUTOMATIC EXCHANGE (25/100 LINE 2 DIGIT SYSTEM) CONNECTING LINK.

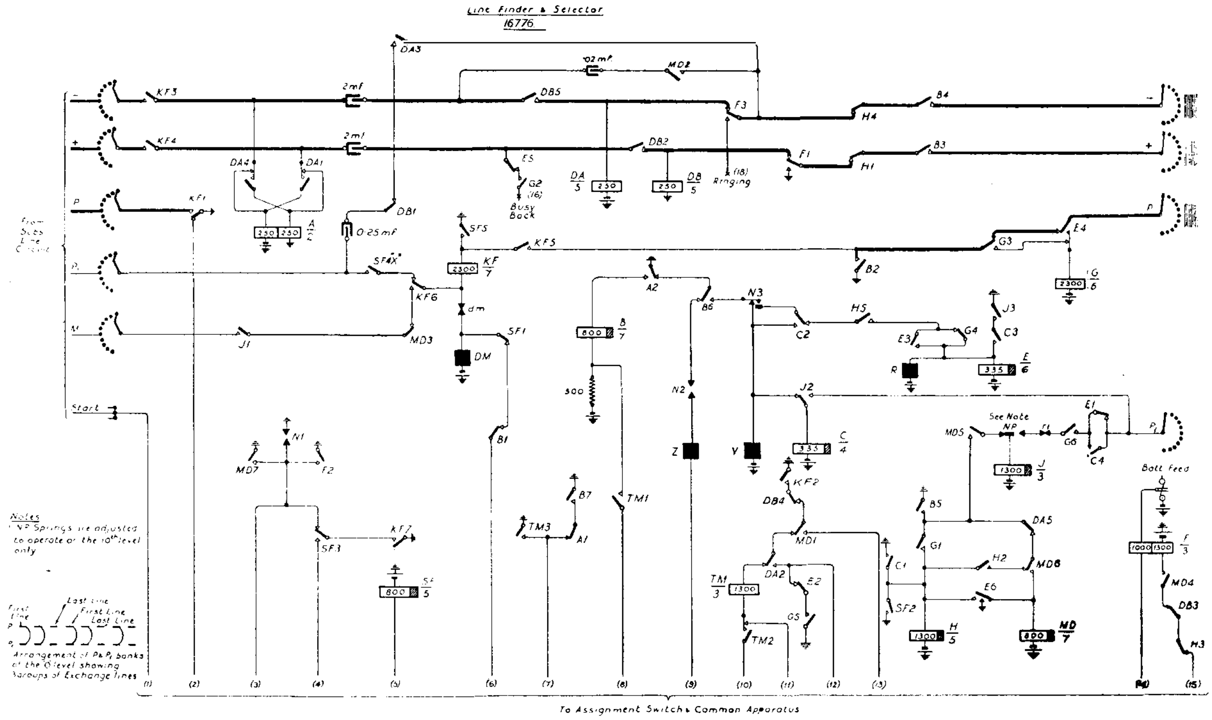


FIG. 4.

RURAL AUTOMATIC EXCHANGE (25/100 LINE 2 DIGIT SYSTEM).
ASSIGNMENT SWITCH AND COMMON APPARATUS.

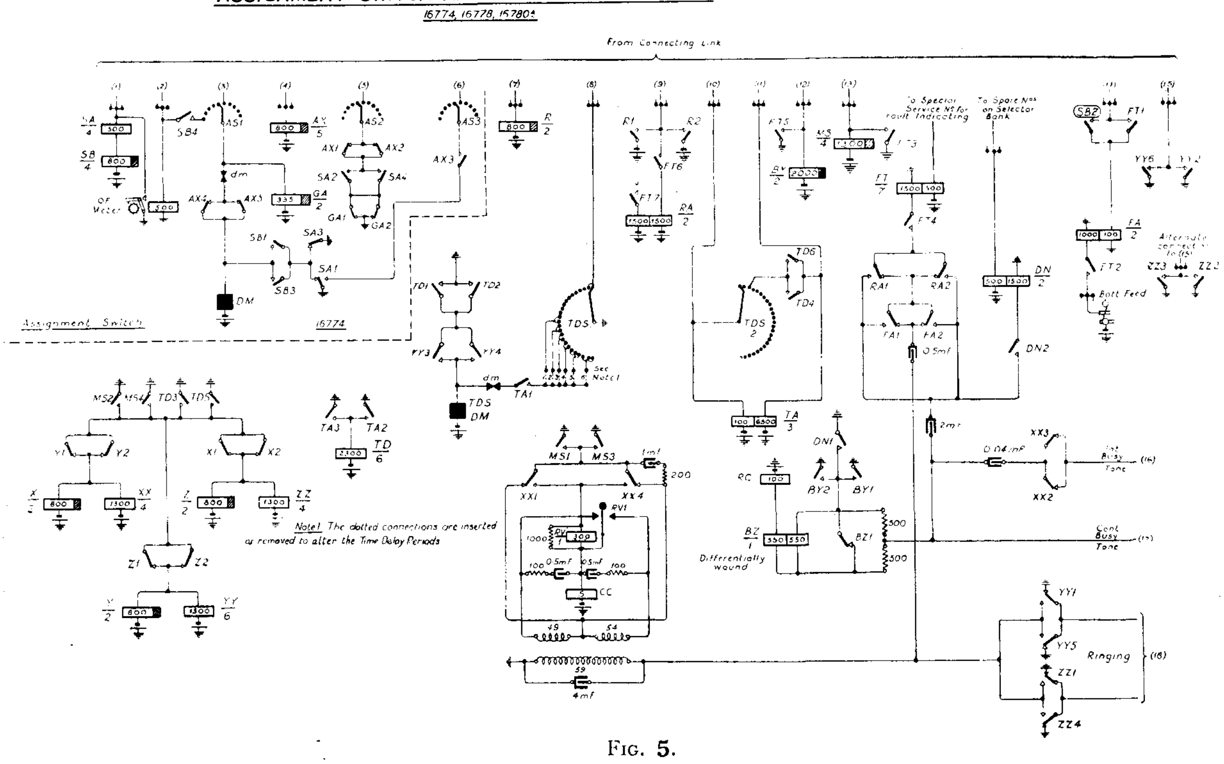


FIG. 5.

The total number of outgoing junction terminations cannot exceed ten. Since junctions to more than one exchange may be provided, several small groups of junctions may be accommodated, each group being terminated on a group of consecutive bank contacts. When the second digit of the junction number has been dialled an automatic stepping circuit is brought into use on the 0 level, causing the selector wipers to step on if the first junction to the required exchange is engaged. This automatic stepping continues as long as the selector wipers encounter busy junctions until the last line to the required exchange is reached. If this be engaged, busy tone is returned to the calling party.

Both junctions and subscribers are equipped with similar calling apparatus so that the operation of the apparatus on an incoming junction call is the same as that in the case of a subscriber's call.

(8) In cases where the rural automatic exchange has junctions to only one exchange, that exchange is known as the parent exchange. In cases where the rural exchange has junctions to more than one exchange, the exchange which deals with the indirect junction and trunk traffic is termed the parent exchange.

Two rural automatic exchanges cannot work direct to each other, but one manual exchange may gain access to another *via* an intermediate rural auto exchange.

(9) Figs. **3**, **4** and **5** show the circuits of the automatic apparatus comprising the unit, and Fig. **6** gives a typical example of the auxiliary apparatus required to be installed in the junction termination on the manual board at the parent exchange. A brief description of the circuit operation is given as an appendix to this article.

(10) *Power Plant.* — A small power plant comprising two sets of 25 - 40 amp. hour secondary cells, a power board and means of charging is provided. When a public electric supply is available a Dynamotor or Tungar Rectifier is fitted, depending on whether the supply is direct or alternating current. If a public supply is not available a petrol-electric charging set is installed. In all cases the plant is so arranged that charging ceases automatically when a predetermined number of ampere hours has been put into the cells; attention during charging is therefore unnecessary.

(11) *Lay-out.*—A typical lay-out is given in Fig. **7**, which shows four 25-line units assembled, together with a small M.D.F. In connection with the latter a cable trench is provided for the underground leading-in cables.

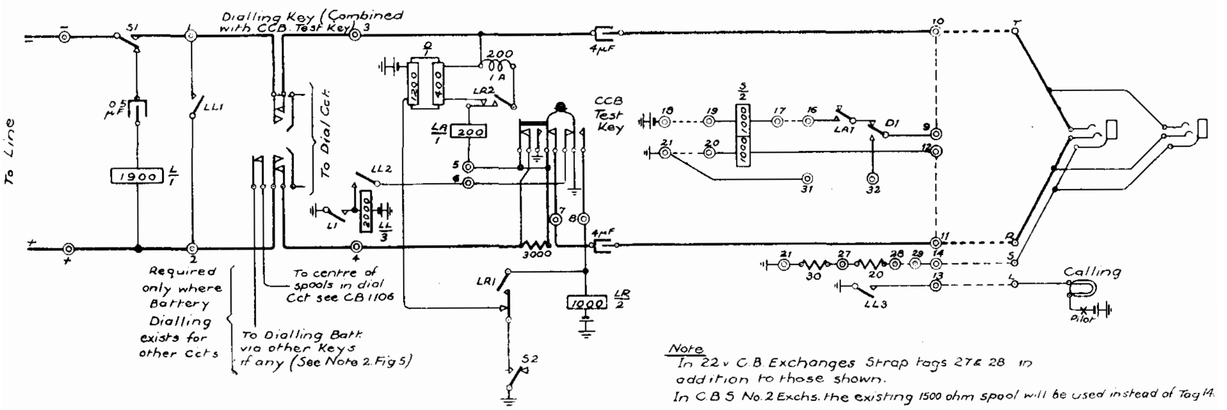


FIG. **6**.

(12) *External Plant.*—The external plant is provided in accordance with the Department's usual standard practice. The limiting resistance for junctions is 1200 ohms. As regards insulation resistance on both subscribers' and junction lines, it was appreciated that open wire construction would be concerned and therefore the automatic equipment was designed to allow an insulation resistance of 20,000 ohms on either line to earth or between the positive and negative lines. The high resistance relay which holds a line under P.L. conditions (see paragraph 4 *h*) does not retain until the insulation resistance decreases to about 9,000 ohms.

(13) *Building and Site.*—The whole of the ex-

change equipment for an ultimate of 100 lines is housed in a non-pretentious building (see Fig. **8**) having internal dimensions of 14 ft. × 7 ft. × 6 ft. 8 inches high. A site measuring 60 ft. × 20 ft. is specified in order to allow for future extension in cases of abnormal growth when an additional building unit would be erected, end-on to the existing one, and any necessary modifications to the plant carried out.

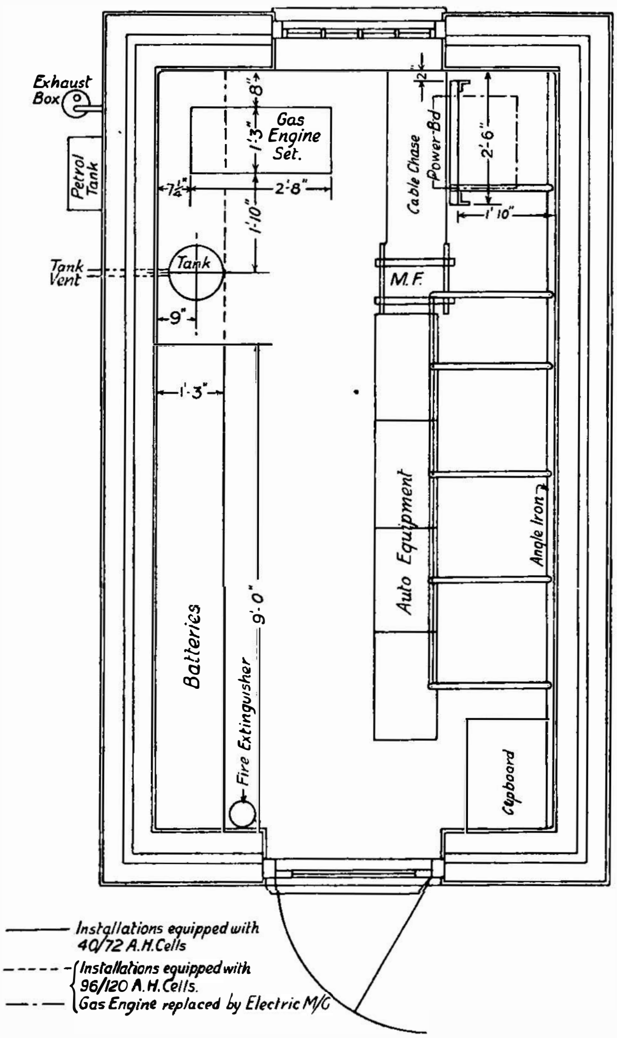


Fig. **7**.

The building is provided with hollow walls to prevent rapid changes of temperature and this, together with the feature of the sheet iron air-spaced doors fitted on the automatic unit, is intended to avoid the necessity for heating the building.

A call office kiosk containing a prepayment coin box will usually be erected on the exchange site, local calls being obtained in an automatic manner and junction calls *via* the parent exchange.

Opportunity is taken to make the exterior of the building and the site in keeping with the amenities of the locality by providing a modest garden, a privet hedge, climbing roses, a plot of grass, etc.

Conclusion. — The first of the new type of rural automatic exchange was opened at Haynes (Bedfordshire) on February 4th, 1929, and since then twenty additional exchanges have been opened. In spite of very severe conditions this winter and a temperature below freezing point being experienced in at least one of the exchanges, the apparatus has functioned satisfactorily and appears to be justifying expectations.

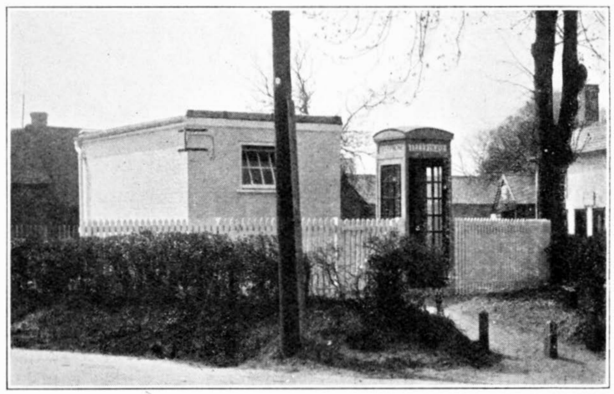


Fig. **8**.

It is the Department's intention to build rural automatic exchanges in areas where a minimum of eight subscribers are forthcoming, thus it can rightly be said that an effort is being made to provide telephone facilities in the sparsely populated country districts. It is hoped that the experiment will be a success and help in the education of the nation towards the acquisition of the "telephone habit."

APPENDIX.

Circuit Operation.

Limitations of space will not permit a detailed account of the circuit operations. The following description indicates the functions and working of the chief items of the equipment for the various types of call which it is required to handle.

(1) *Local call—called subscriber free.*—When a subscriber removes the receiver, relay L (Fig. **3**) operates and earths the " start " wire of the assignment switch relays SA and SB (Fig. **5**). The SF relay of the connecting link (Fig. **4**) on which the switch is standing is operated *via* SA2 and connects the magnet of the line finder to the P1 wiper of the latter switch. All the P1 bank contacts except that of the calling line are earthed *via* the resting L1 contacts, so that the wipers are rotated (provided they are not on the calling line) and stop when the calling line is reached. The absence of earth on this P1 contact also allows relay KF to operate and the subscriber is switched to relay A. Earth *via* KF1 and the P bank contact busies the multiple contact and operates the subscriber's relays K and P, thus releasing relay L. KF2 starts the time delay switch (see paragraph 10).

Relay A operates, closing the circuit for relay B, and the subscriber dials the two digits required. The vertical and rotary stepping circuits operate in the usual manner, relay C being in parallel with the vertical magnet. Relay E, operated when the second digit is dialled, operates relay MD and holds relay H. MD1 removes the earth operating the time delay switch and closes the circuit of the ringing vibrator (see paragraph 7), MD 5 operates relay J, thus preparing the metering circuit. When the wipers reach the required line relay G tests, relay E releases and earth is extended to operate the called subscribers' K and P relays. Relay H releases, and connects the circuit of the 1300 ohm winding of relay F to the common apparatus *via* H3, and also extends the circuit of the required subscriber to F1 and F3. An intermittent earth then operates and releases relay F. Ringing current is applied on the " make " contact of F3 while the relay is operated, so that the wanted subscriber's bell is rung. During the released periods of relay F, relays DA and DB are extended to the called subscriber's line, these relays being operated in series during the next silent period after the called subscriber has removed the receiver. DB2 and 5 complete the speaking circuit between the two subscribers. DB3 disconnects relay F, so that it will not operate again. DB4 removes earth from the ringing apparatus.

DA1 and 4 reverse the lines to the calling subscriber (this facility is used for junction supervision only—see paragraph 5), DA5 breaks the circuit of relay MD, which releases after an interval. MD5 releases relay J, but as this relay is slow to release, a circuit is completed *via* MD3 and J1 to the calling subscriber's meter, which registers the call.

Assuming that both subscribers replace the receivers simultaneously relay A releases and completes the circuit *via* B7 and A1 of the release relay R (Fig. **5**). Relay B releases after a short interval, breaking the circuit of relay R and closing the circuit of the release magnet **Z** *via* R1 and B6. Relay R, being slugged, maintains the circuit of **Z** so that the magnet operates.

On release of the selector the earths holding the K relays of each subscriber are removed, and these relays, in releasing, extend the P relays to the subscribers' lines. The P relays are already operated and will lock if the line resistance is less than about 9000 ohms.

(2) *Local call—called subscriber busy.* — The operation of the apparatus is similar to that described above until relay G tests the required subscriber's line. G now operates *via* the P wiper, and on the release of relay E, locks *via* G3. The tone generating circuit is completed *via* G5 and E2 (see paragraph 8), busy tone being transmitted to the calling subscriber *via* G2 and E5. Relay H is held operated *via* G1, thus preventing connection of the negative and positive lines to the busy circuit.

Release is similar to that under " called subscriber free " conditions.

(3) *Spare number dialled.*—The positive selector bank contacts of spare circuits are strapped on the connection blocks and connected to relay DN, which operates in series with relay DB when a spare number is dialled. Continuous tone is then generated (see paragraph 8) and is transmitted to the calling subscriber *via* relay DN (which functions as an induction coil), positive bank contact, and the connecting link.

(4) *Outgoing junction call.*—Groups of junctions are accommodated on the " 0 " level. The P1 contacts on this level are wired to the connection blocks, and the P and P1 contacts of the first and intermediate lines in each group are strapped. The P1 contact of the last line of each group is left disconnected.

When a junction call is originated, the subscriber dials 0 and one other digit. The selector operates the normal post springs on the tenth step, thus changing over relay J, the metering relay, to become the rotary search relay. The second digit dialled causes the selector wipers to rotate to the first junction of the group, which is tested in the usual way by relay G. If disengaged, ringing current is transmitted in the same manner as for a local call. If the first junction is busy both P and P1 contacts will be earthed. Relay G operates and locks. Relay J operates *via* P1, completing the circuit of relay C. J3 and C3 close the circuit of the rotary magnet and relay E, and the wipers are stepped to the next contact. The rotary interrupter springs then open the circuit of relay J. The second junction is tested while relay E retains, and if busy, the same cycle of operations occurs, and continues until a free line or the last line of the group is reached. Since the P1 contact on the last line is disconnected the rotary stepping cannot continue and busy tone is transmitted when relay G operates.

On seizing a free junction, ringing current is transmitted to the distant exchange and chatters relay L (Fig. **6**). Relay LL operates and locks and the calling signal is given. Relay S operates on the insertion of the plug and the ringing is tripped by the short circuit at LL1. The operator next depresses the coin box key thus releasing LL, and operating LR. This key also earths the negative line of the junction *via* relay LA and the 200 ohms retard coil, and earths the positive line *via* a 3000 ohm spool. Under these conditions the operator hears continuous tone if the call is originated by a coin box subscriber (see paragraph 9). Absence of tone indicates that an ordinary subscriber is calling. When the key is released a dry loop is provided across the junction by the retard coil and relay LA and the circuit of the cord supervisory relay is completed *via* one winding of relay S and LA1. The operator then speaks to the calling subscriber and completes the connection.

When the calling subscriber replaces the receiver the selector releases, releasing the K relay associated with the junction. As K releases it extends relay P to the junction, which holds *via* LA and the retard coil. P holds and busies the selector bank contact, but LA releases and gives a clear to the operator. When the plug is removed P releases.

(5) *Incoming junction call.*—On plugging into the junction jack relay S operates, thus connecting LA and one winding of D across the junction, and completing the circuit of the other winding of D. D and LA operate and disconnect the cord supervisory relay, so that a clear is given. The operator throws the dial key, releasing both D and LA while the key is operated, and the clear continues. A connecting link at the R.A.X. is seized and the selector is stepped to the required number as the operator dials. Ringing is applied and when the called subscriber answers relay DA (in the connecting link) reverses the direction of the current in the junction. Relay D now releases while LA retains, so that the supervisory relay is connected and the clearing signal removed. When the called subscriber replaces the receiver the current in the junction is restored to the original direction and relay D re-operates, giving the clearing signal. On removing the plug S1 breaks the junction circuit and releases the connecting link.

(6) *Relay timing group.*—This is a group of six relays in the common apparatus which control the ringing vibrator and time delay switch, and provide the interruptions in the busy tone.

The three slugged relays X, Y and Z (Fig. **5**) are connected so that the circuit of each of them is dependent on the break contact of one of the other two. When a call is originated earth is extended *via* KF2 and relay TM (Fig. **4**) to operate relay TA in the common apparatus. TD is operated, and completes the circuit of all the relays simultaneously. Since it is practically impossible to obtain relays with exactly the same operating lag one of the three breaks its contacts first and the relays immediately commence operating and releasing in a cyclic order. The auxiliary relays XX, YY and ZZ operate with the control relays, each being operated in turn for approximately $\frac{1}{3}$ second.

(7) *Ringing.*—When a caller dials the second digit relay MS operates *via* MD1, retaining the circuit of the relay timing group, and closing the circuit of the vibrator magnet *via* XX1, these contacts operating and releasing as described in paragraph 6. The bob of the vibrator is attracted and held when the contacts are closed. When XX releases the bob vibrates mechanically between its two contacts, and an alternating current of about 16 cycles is generated by induction in the 59 ohm winding of the transformer in the ratio of $\frac{2}{3}$ sec. ringing $\frac{1}{3}$ sec. silence. Interruptions of $\frac{1}{3}$ sec. ringing $\frac{2}{3}$ sec. silence are supplied to the selectors *via* YY1 and ZZ1.

(8) *Tones.*—Continuous tones is generated by relay BZ. When its circuit is closed by BY1 or DN1 the relay operates and removes the short circuit from its second winding. This causes the relay to release, and thereby replaces the short circuit. These operations occur rapidly, and a tone of approximately standard pitch, *i.e.,* 400 periods per second, is generated.

Busy tone is provided by interrupting the continuous tone at XX2. Interruptions of $\frac{2}{3}$ second tone, $\frac{1}{3}$ second silence are given.

(9) *Coin box lines.*—The continuous tone is extended to one winding of the coil RC (Fig. **3**). The L1 contacts of coin box circuits, instead of being connected direct to earth, pass *via* the 3 ohm winding of the coil RC and then to earth. When a call is made to a distant manual exchange, the operator, on depression of the coin box test key earths the lines of the junction (paragraph 4) and releases relay DB (Fig. **4**). Tone is then induced in the coil RC and passes *via* L1, line finder, 0.25 m.f. condenser, DB1 and DA3, to the negative line of the junction and to the operator.

(10) *Time delay switch.*—When a call is originated KF2 extends earth and operates relay TA *via* its high resistance winding. Relay TM in the connecting link does not operate. TD is operated, the relay timing group is brought into use, and relay YY operates the magnet of the time delay switch once per second. The switch steps, and when the third bank contact is reached the two windings of relay TA are connected in parallel. The reduction in resistance allows TM in the link to operate. The switch continues stepping until the 12th contact, when the magnet circuit is completed *via* interrupter contacts. The wipers then rotate rapidly to the first contact where earth is now extended *via* TM1 to short circuit the " B " relay of the connecting link. The selector releases, removes the holding earth of relay K, which on release extends the P relay to the subscriber's line. The latter relay holds until the line is disconnected, and also busies the multiple contact.

The time delay switch is operated on every call, but it is cut out by MD1 when the second digit is dialled so that it is necessary to dial the two digits within a limited period. The switch is also brought into use under " called subscriber held " conditions.

It will be seen that any fault or subscriber's misoperation which causes a connecting link to be seized without giving two digit trains will result in the circuit being automatically switched over to the associated " P " relay and the common apparatus freed in less than 30 seconds. By the removal of the straps connecting the bank contacts the delay period may be varied approximately, between a minimum of 12 to 25 seconds and a maximum of 25 to 60 seconds.

(11) *Provision against breakdown.*—In an unattended automatic exchange it is especially important that all common apparatus shall be as fault proof as possible and that as far as practicable faulty circuits shall not be picked up. In order to attain the former condition all the more important relay contacts in the common apparatus are made of platinum and are duplicated. The latter condition is attained in certain cases as follows :—

(*a*) *Faulty lines.*—Any subscriber's or junction circuit which develops a loop or negative line earth is isolated and busied as described in paragraph 10. The high resistance of the P relays used for this purpose (7500 ohms) also minimises the current consumption so that the danger of battery failure when such faults occur is greatly reduced.

(*b*) *Blown link fuses.*—When a connecting link fuse blows the spring on the underneath side of it prepares the 1000 ohm winding of relay F (Fig. **4**). On relay SB being operated by a calling subscriber relay F operates *via* SB2, the link is busied on the assignment switch bank by earth extended *via* F2, and the faulty link is passed over.

(*c*) *Subscriber's line equipment fault.*—It has been found necessary to provide against a possible breakdown which could be caused by the L1 resting contacts of a subscriber's equipment becoming dirty and failing to maintain earth on the line finder banks.

Should this fault occur and another subscriber makes a call, the line finder of the link hunts and (if it does not encounter the caller's line first) stops on the faulty circuit. KF (Fig. **4**) operates and extends the circuit to the A relay, but as the faulty circuit is not calling, A does not operate. KF7 operates relay AX (Fig. **5**) *via* SF3. AX1 breaks the circuit of SF. When SF releases the circuit of AX is broken, but a circuit for the line finder magnet is completed *via* SF1, B1, assignment switch, AX3 and SA1 during the releasing period of AX. When AX releases the circuit of SF is again completed, and the normal hunting circuit re-established.

(12) *Testing from distant exchanges.*—In order that the " parent " exchange may verify that the R.A.X. apparatus is free from certain faults, the special testing facility is provided, as previously indicated. A " parent " exchange operator calls " 99 " at intervals during the day. The positive wiper of the selector completes the circuit of relay FT (Fig. **5**) which is connected to the positive bank contact of 99. FT operates and the ringing and tone apparatus is started.

Equipment OK.—If none of the undermentioned faults exists, the operator hears interrupted ringing tone in the ratio of $\frac{2}{3}$ second tone $\frac{1}{3}$ second silence transmitted *via* FA1, RA1, FT4 and relay FT, the relay functioning as an induction coil.

Ringing or relay timing group failure.—The tone is absent or irregular according to the fault.

Blown fuse.—Should a fuse be blown relay FA operates *via* a fuse alarm bar, relay F, FT1 and the 100 ohm winding of relay FA, or alternatively *via* FT2 and the 1000 ohm winding of relay FA. FA1 connects N.U. tone to relay FT and the tone is transmitted to the operator.

Switch release failure.—In this case the off normal springs of the selector are closed, so that the closure of FT6 causes relay RA to operate. RA1 again causes N.U. tone to be sent out.

Charging plant failure.—Should the charging plant fail before being automatically stopped by the ampere hour meter on the power panel, FT7 will be earthed and on the operation of FT the circuit of RA is completed and N.U. tone is again transmitted.

LLANDUDNO AUTOMATIC EXCHANGE FIRE.

A. SPEIGHT.

ON February 26th, 1929, late in the evening, a fire broke out in the Head Post Office building. In this building, a three-storey one, is conducted the postal and telegraph work, and the automatic telephone exchange, 1,200 lines equipped capacity, is housed on the second floor. The fire appeared to originate in a stores room on the third floor, above a portion of the automatic exchange, and before the outbreak was got under control a portion of the roof collapsed, and also some of the third storey flooring was burnt out. Blazing material thus fell on to the automatic apparatus, resulting in the complete destruction of the main cable run to the Main Distributing Frame, the meter cables, power cables, and also the switches on the upper shelves of the 1st preselector racks. The remainder of the auto apparatus not actually burnt or damaged was flooded with water. There was a severe frost at the time and the water froze, with the result that the building and adjacent roadway were thickly coated with ice.

A survey was made of the automatic exchange and it was a great relief to find that the power plant and M.D.F. were intact, although the latter had suffered from water. A decision was soon arrived at that it was impossible to restore the automatic equipment within a reasonable time and therefore it was necessary to revert temporarily to C.B. manual working.

FIG. 1.—EMERGENCY MANUAL SWITCHBOARD, SHOWING STATE OF RECONSTRUCTION ON 4TH MARCH, 1929.

Llandudno is part of a multi-office area with the auto-manual switchboard located at Colwyn Bay. Penrhynside is a satellite on Llandudno for originating calls other than local and O level. Fortunately there were a considerable number of spare circuits in the underground cables between Llandudno and Colwyn Bay, also between Penrhynside and Colwyn Bay; it was thus possible to restore service to all Penrhynside subscribers and to Llandudno call offices and important subscribers by connecting them direct to Colwyn Bay.

Meanwhile, a 1200-line fire emergency switchboard, capable of meeting various circuit conditions, was on its way from the Birmingham Stores Department. It was decided to clear the telegraph instrument room and install four 3-position "A" sections, one 3-position "B" section and one single position dummy section in the room thus vacated, and by 7.0 a.m. on February 28th (36 hours) all the sections were lined up in position. The fire emergency equipment comprised approximately 80 packing cases, many very large, and the writer will never forget the circumstances under which these had to be handled in darkness from the railway depot (the conditions of snow and frost on the roads were too bad for motor transport from Birmingham), unpacked in the roadway in the intense cold and the equipment carried up a comparatively narrow staircase. The M.D.F. was dried out, counter E.M.F. cells to reduce the voltage from 60 to 22 volts were installed, and as a result of much hard work and little sleep the sections were wired, a fuse panel and cord circuit special apparatus rack fitted, cabling to the old M.D.F. provided and a portion of the manual emergency switchboard brought into service at 12.30 p.m. on March 4th (134 hours). The work was pressed forward and all the subscribers reconnected by March 6th, or 6 days after the fire.

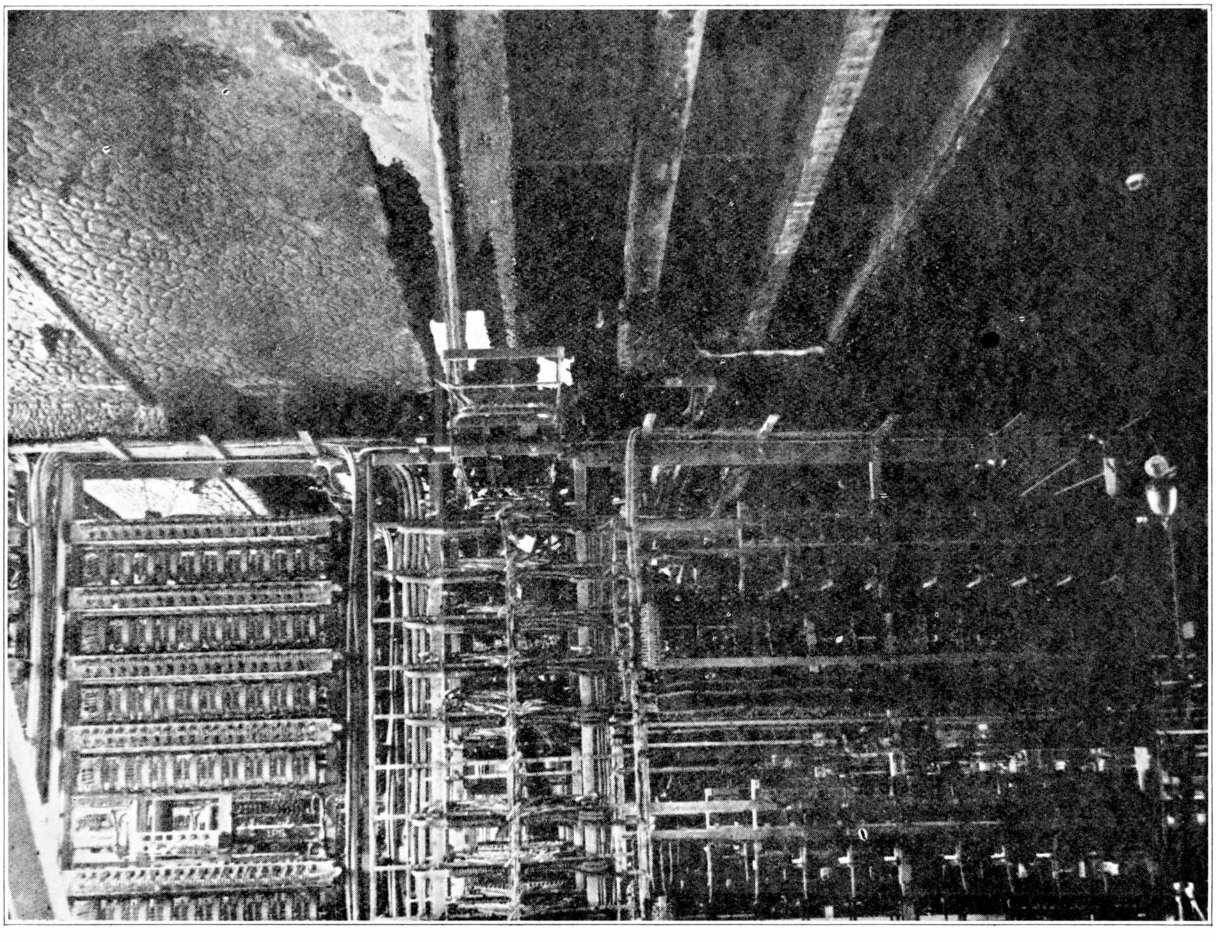


FIG. 2.—DAMAGED CEILING. DAYLIGHT SHOWING THROUGH DESTROYED ROOF.

While the installation of the emergency switchboard was proceeding, the automatic plant was receiving attention, as it was realised that unless the matter was dealt with at once rusting and corrosion would be so widespread that none of the plant could be used again. Every effort was therefore made to save as much of the apparatus as possible. All the selectors, relay sets, bank shelves, etc., were removed from the racks, given a preliminary cleaning and set aside on wooden shelving in a hot room to dry. Apparatus which could not be removed conveniently was dried out in position by means of a large number of hairdressers' electric hair driers disposed about the racks. That this policy was to be successful was demonstrated when after three days several dried-out relay sets were tried at Colwyn Bay automatic exchange and found to function perfectly, their insulation being infinity on test.

Messrs. Siemens Bros., the makers of the equipment, were entrusted with the work of reconditioning the exchange and commenced operations within a week of the fire. The " drying out " scheme was so successful that the whole of the switching plant not damaged beyond repair was brought into use again, and therefore the restoration resolved itself into reassembly and adjustment of the apparatus, plus new cabling. The Contractors rose to the occasion magnificently and, thanks to their efforts, the automatic plant was cut into service again with complete success on May 11th, or 10½ weeks after the fire.

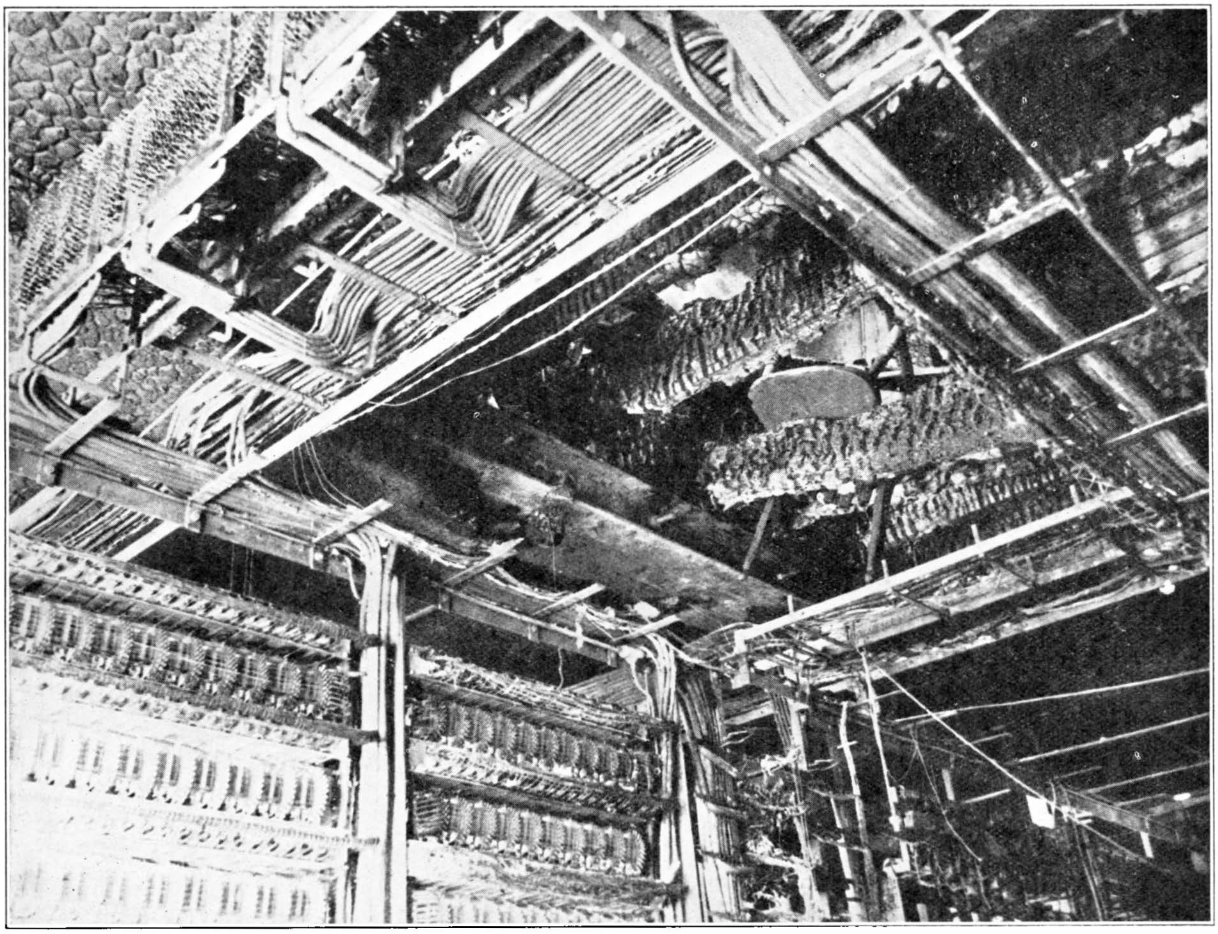


Fig. 3.—Burned out Ceiling, Automatic Apparatus Room.
Note the destruction of main cable run and section I.D.F.

The speed with which service was restored after the fire is thought to be a very satisfactory performance, and the Engineering Department is indebted to the Traffic and Stores Departments for the cordial co-operation so freely given.

AUTOMATIC ROUTINE TESTERS FOR AUTOMATIC TELEPHONE EXCHANGES.

PART II.

IN the previous article on this subject in the April issue, a general outline of the functions and operating procedure common to most automatic routiners was given. It is now proposed to describe features of particular interest in the Director and Coder Call Indicator (C.C.I.) Relay Set Routiner circuits.*

Director Routiner. — This routiner is so arranged that three types of tests may be made, viz.: " General Routine," " Continuous Routine " and " Group Routine."

The two former types are also made in the First Code Selector Routiner, certain features of which were mentioned in Part I. of this volume. The last type of test divides the Directors into groups corresponding to the levels of the " A " Digit Selectors in order that tests may be made of translations which are common to a particular group only. Fig. **1** shows the allocation of these

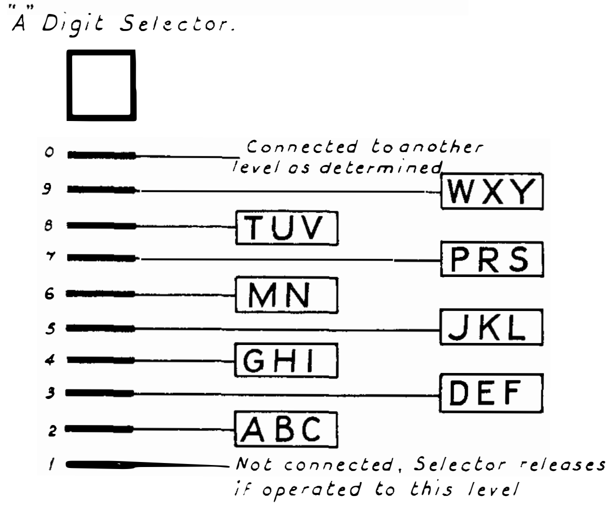


FIG. 1.

groups on the " A " Digit Selector shelves. To commence this last type of test, the required code and digit keys, or code keys only, are thrown, together with the cancel keys of codes and digits not required. The " Group " key is then thrown and afterwards the start key. The primary distributor hunts for the group to be tested and then commences the tests. The hunting circuit is shown in Fig. **2**. When the

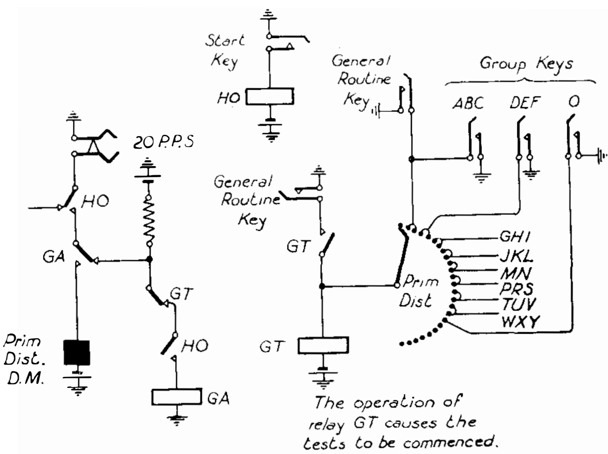


FIG. 2.

Start Key is thrown, relay HO operates and introduces the split-impulse guard relay GA; pulses are then delivered to the Primary Distributor DM. Relay GT will operate when the Primary Distributor reaches the contact, associated with the operated Group Key and will prevent further stepping.

The access points required in connection with this routiner are P, +, −, PU and in some equipments M. The M connection is the Director meter switch jack point.

In the first few exchanges to be brought into use a " Busying Ahead " feature was incorporated in order that the next Director to be tested was busied as soon as it became free, while tests were in progress on the previous Director. This feature has, however, been omitted from later routiners on account of the reduction in availability of " A " digit selector outlets which it entailed and of the short holding time of Directors.

On operation of the Start Key under " General

* *Typical Director circuits are shown in diagrams E 228, E 266 and E 247. C.C.I. Relay Set circuits in diagrams E 160, E 263, E 444 and AT 1956.*

Routine " conditions the Primary Distributor is stepped off-normal and the routiner is thereby connected to the first Director position of the " ABC " group. The routiner now applies a test to determine that the position is equipped and then tests the private for the engaged (earthed) condition. Should the Director be engaged for a period exceeding 30-60 secs. an alarm is given.

In some exchanges this is followed by a test for 400 ohms-battery, which is the only condition under which these Directors should normally be seized.

When the Director is disengaged, it is seized in the normal way by connecting a relay to the pulse lead, and the private is then tested to ascertain that it is guarded. The necessary delay period for making this test is provided by means of a slow relay. This test precedes all the main tests made by the routiner.

The routiner now waits for the " Forced Release " condition, which should occur within 30-60 secs. after seizure of the Director, and is tested by the relay connected to the pulse lead. Should " Forced Release " not occur within 90-180 secs. an alarm is given.

If earth is not removed from the private within a given time after the Director is released from the routiner at the end of each of the main tests, an alarm operates.

Some Directors receive impulses repeated from the First Code Selectors, and others impulses from the subscriber's dial, and it will be readily realised that these impulses may be distorted due to variation of dial speed and line conditions. To prove that the Director will respond to impulses within certain specified limits, two impulsing tests are made by the routiner, viz.: " Series " and " Shunt." Difficulty has been experienced in providing correct ratio impulses at constant speeds of 7 and 14 i.p.s. Hence the amount of impulse distortion caused by the worst permissible limits was measured in the Circuit Laboratory and values of series and shunt resistances, which when included in a 10 i.p.s. impulsing loop would produce the same amount of distortion, were determined. 10 i.p.s. impulses are now used for all impulsing tests, with series and shunt resistances added to simulate 7 and 14 i.p.s. respectively, as shown in Fig. 3.

The " Series " test is made first. Two digits, representing the " B " and " C " digits, are sent to the Director, while the sending of the numerical digits is delayed until the first translated digit is received by the routiner. Condenser impulsing is employed in some exchanges

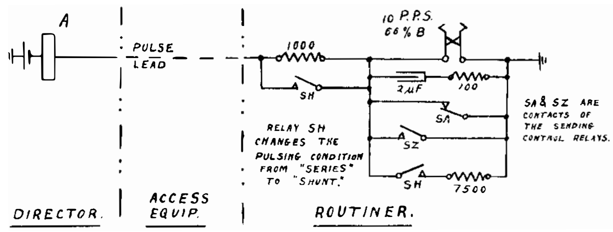


FIG. 3.

for sending the digits. This method of impulsing ensures the same ratio of break-to-make in each impulse, irrespective of the normal variation in speed of the impulse machine. A voltmeter with a suitably damped action is fitted on the routiner and can be connected in the impulsing circuit by the operation of a key. When so connected it indicates the mean voltage of the circuit during impulsing. The ratio of the indicated voltage to the battery voltage gives the percentage " make " period of each impulse.

The pause between the reception of the first and second translated digits is measured by means of a rotary switch, stepping at 20 i.p.s. Fig. 4 shows the connections of this switch.

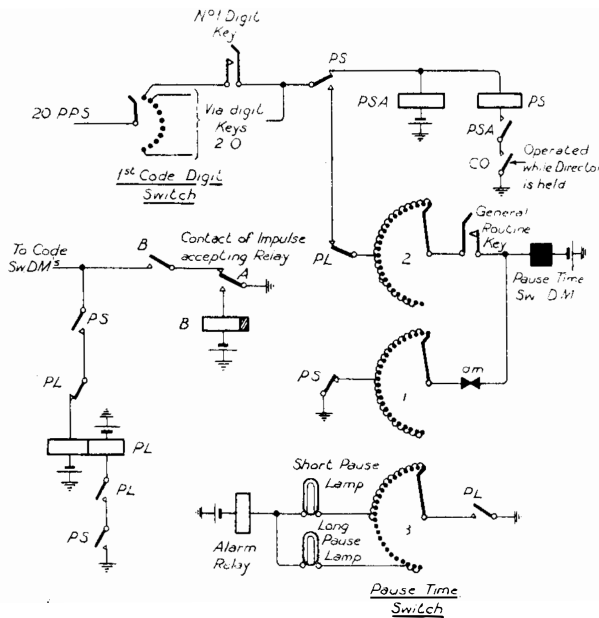


FIG. 4.

When the " First Code Digit Switch " arrives at the contact associated with the digit sent, relays PSA and PS operate and direct the 20 i.p.s. to the Pause Time Switch DM, which continues stepping until the A contact again releases, when PL operates and causes the relevant lamp to glow should the pause be incorrect. The alarm is operated by the relay in series with the lamp. After the second digit has been received, the impulsing loop is reversed for a given period. In some exchanges the Pause Time Switch is used to measure this delay period. When this condition is applied the Director D relay should operate and prevent further digits being sent. The " Pause Time " and " Loop Reversed " tests are not made during " Group Routine " tests.

In most equipments the digits received by the routiner are distributed to each successive digit switch by means of a Digit Distributor, while in other equipments they are switched through by means of " two-step " relays. In the former case the digits are displayed together, and in the latter as they are received. The duration of the display is for 3-6 secs. Fig. 5 shows the

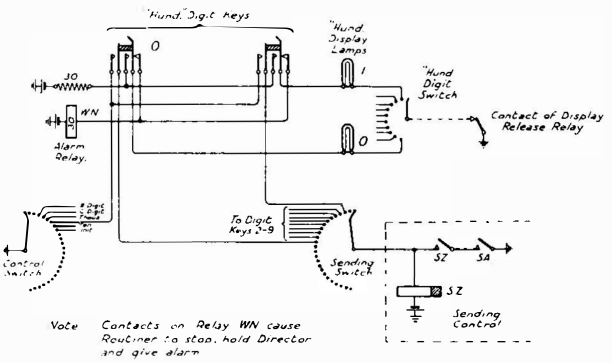


FIG. 5.

connections of the Digit Keys and Display Lamps. As the Control Switch steps, earth is connected to each group of digit keys in turn and allows the digit to be sent as determined by the key which is thrown. The Digit Switches respond to the impulses received and the relevant display lamp glows. Relay WN operates the alarm should there be a discrepancy between the digit received and that sent, as determined by the key operated. The correct release of the Director is proved by the satisfactory operation under the subsequent tests.

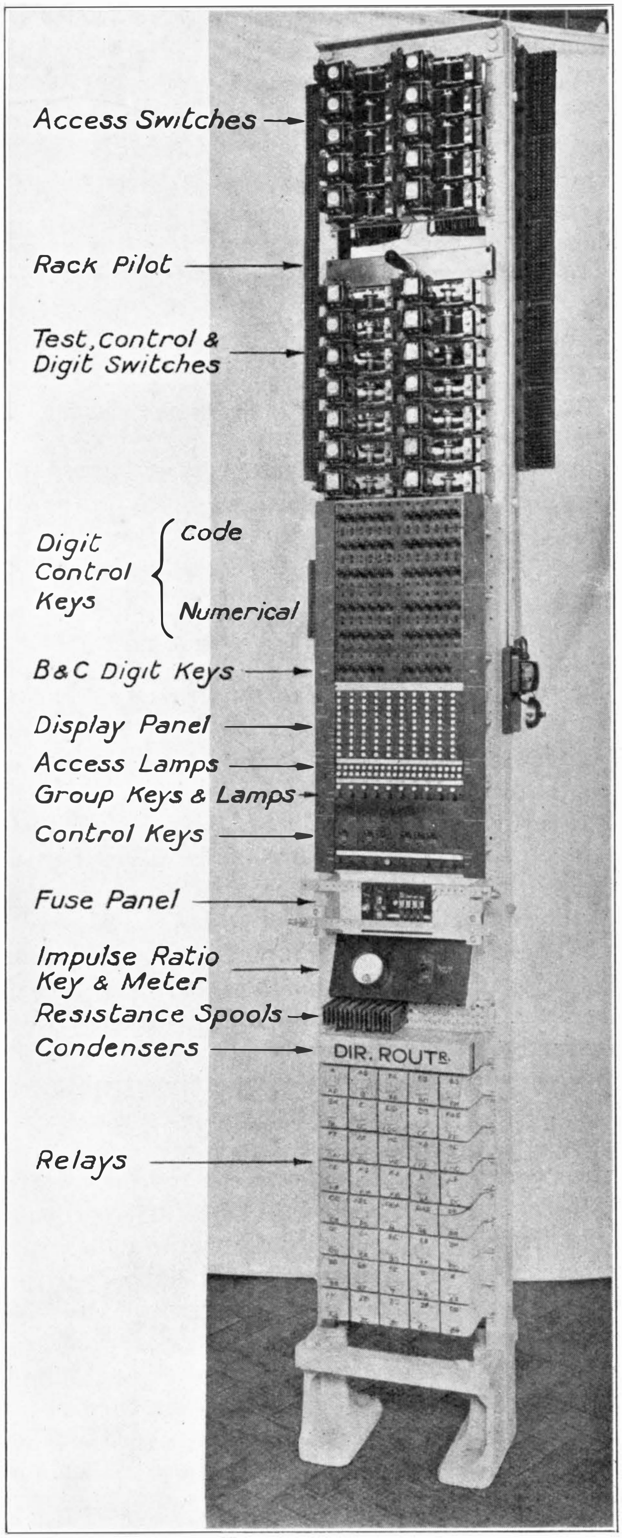


FIG. 6.—DIRECTOR ROUTINER.

The " Shunt " test, which follows, repeats all the functions of the " Series " test with the resistance in the pulse lead changed as previously mentioned.

Three main tests are therefore applied to each Director by the routiner, viz. :—" Forced Release," " Series Impulsing " and " Shunt Impulsing." Test cancel keys are provided in order that either or two of the tests may be cancelled.

During " General " and " Group " routine tests, when each Director has been satisfactorily tested, the Access Switch is stepped to the next position and the testing equipment restored to normal.

The timing of the release of the Director is now considered to be unnecessary and hence it has only been included in one or two of the early exchanges.

Certain Directors associated with the last choices of each of the " A " Digit Selector levels are also connected to the " O " level of this selector, for the purpose of routing Assistance Calls to the Manual Board. These Directors are connected to an Access Switch serving only " O " Level Directors, as well as to the one associated with other Directors on the same selector levels. When tests are made *via* this Access Switch the routiner connections are automatically changed in order to test the " ' O ' Level " feature. The routiner seizes each of the Directors with the − and + leads reversed and the Director should immediately send out the necessary digits for routing to the Manual Board.

A meter is connected to the routiner in such a manner that it records each time a Director meter is operated due to routine testing. The " M " (meter) access point is used for this purpose in later exchanges.

The routiner provides individual lamp indication of the particular Director being tested.

Fig. **6** shows the lay-out of apparatus on a typical Director Routiner rack.

C.C.I. Relay Set Routiner. — The C.C.I. equipment at the manual exchange end of " Auto-manual " junctions is so arranged that any calling condition applied to the junction will be passed through to an operator's position, and the junction held until it is released by an operator. It will, therefore, be appreciated that, when routine testing or making adjustments to the C.C.I. Relay Sets at the Automatic Exchange terminations of such junctions, it is necessary to avoid applying any conditions which are likely to produce false calling signals. To accomplish this, a relay is added to each C.C.I. relay set in the manner shown in Fig. **7**

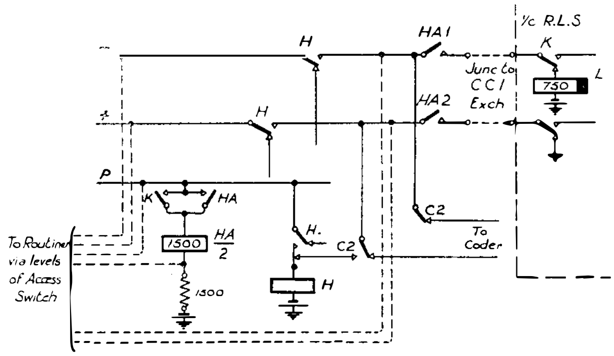


FIG. **7**.

and the inset to Fig. **9** in order to keep the junction disconnected when such operations are in progress.

The relay designated " HA " is connected to the private wire and is operated therefrom when the relay set is seized under normal conditions, but its connections are such that it can be short-circuited by the routiner when required.

Routiner access for C.C.I. Relay Sets is arranged by means of " Primary Distributors " and " Access Switches " as described previously, the former being mounted on the routiner rack, whilst the latter are fitted on the apparatus racks. The numbers of C.C.I. Relay Sets in general warrant more than one " Primary Distributor " and the scheme as employed for 1st Code Selectors is also used in this case.

The number of access points on " C.C.I. Relay Sets " is such that two switches are required for each " Primary Distributor " stage and it is necessary that these two switches shall be synchronized. Stepping is therefore controlled as shown in Fig. **8**; the drive magnet of the first switch being stepped by the normal routiner stepping circuit and the auxiliary switch then stepping by self-interrupted drive due to the " slipped " multiple between the arcs as shown.

A test switch is fitted for applying the sequence of tests and changing the testing conditions.

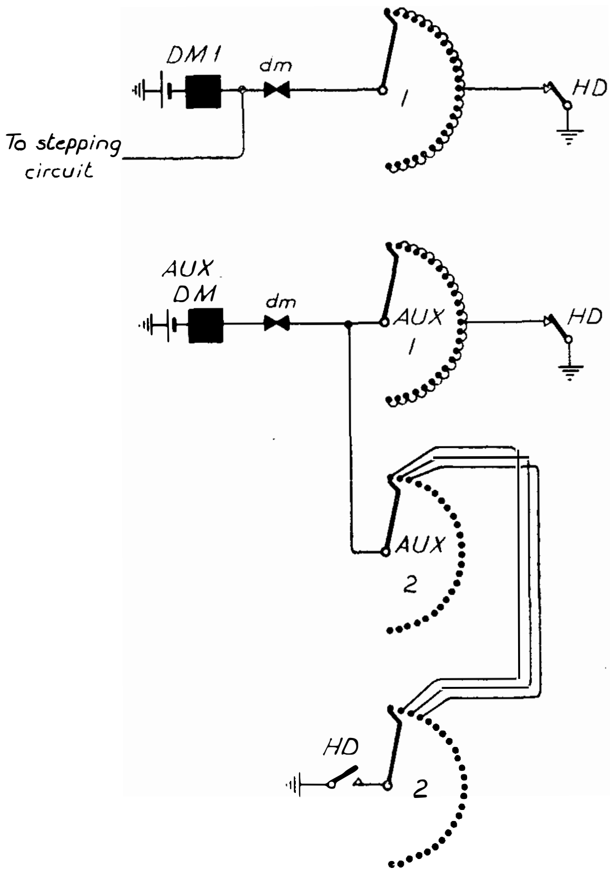


Fig. 8.

On operation of the " Start " key, the routiner tests the " Primary Distributor " outlet to ascertain whether it has an " Access Switch " connected to it. This is termed the " Unequipped " test and if the outlet is unequipped the " Primary Distributor " is stepped until an equipped outlet is found. The associated access switch is then stepped in a similar manner.

Fig. **9** gives a typical illustration of the circuit used for this test. Relay KA is connected to the HA relay access point, which is earthed in the case of unequipped positions, giving a circuit for relay KA which releases relay DB, thereby allowing a further step of the access switch.

When an equipped outlet is found, the private of the associated relay set is tested for busy condition. Again referring to Fig. **9** relay TC operates and energises relay PE; contact PE1 closes a circuit for its second winding to the private of the Relay Set. While the latter is busy, relay PE will hold and prevent the test switch from stepping. If it is still busy after a period of 3-6 minutes, an alarm will be given.

When the Relay Set becomes disengaged, the routiner earths the private, steps the Test Switch and applies a simple test to check the presence of battery and earth on the respective lines of the junction to the C.C.I. exchange. This test is made by means of high resistance relays in the routiner, which are connected to the − and + junction lines in turn. The current required for operating these relays is insufficient to operate the line relay at the C.C.I. exchange.

The " HA " relay is now short-circuited to prevent interference with the junction during subsequent tests. In the standard case, the release of this relay is checked before proceeding with the tests, by noting the disconnection of earth from the + line.

The operating adjustment of the " A " relay is tested next. A loop of such resistance that a current equal to the specified " Non-operate " current of the relay flowing *via* a " Shunt Field " relay is applied for a given period. Should the " A " relay operate under this condition, the associated coder finder will hunt to find a free coder and when the latter has been found the battery on the incoming lines to the relay set will be reversed, thereby releasing the shunt field relay, causing the routiner to be stopped and an alarm to be given.

Fig. **10***a* shows this circuit. Relay TF operates with the application of the loop when

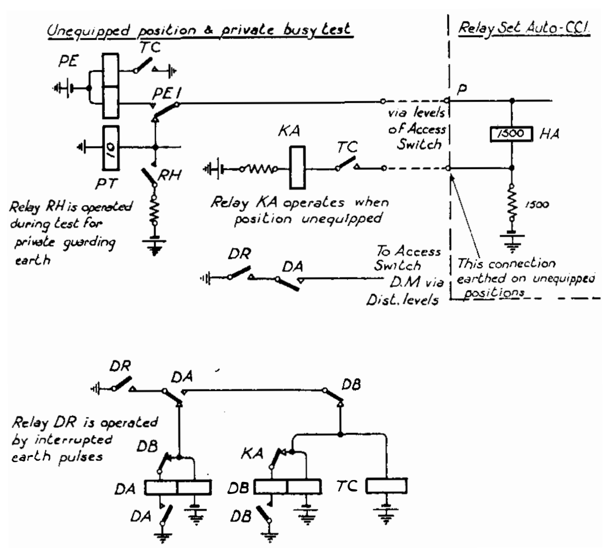


Fig. 9.

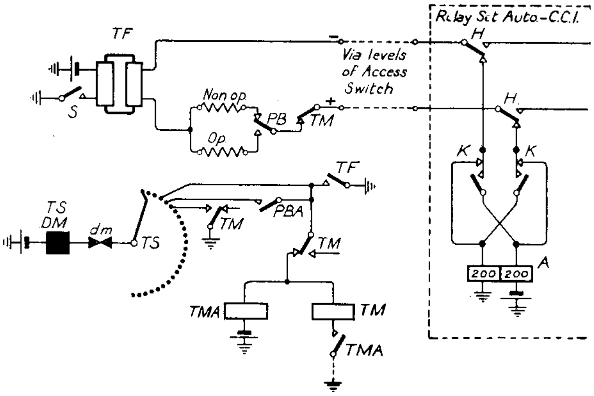


FIG. **10***a*.

the battery condition on the incoming lines to the relay set is normal. Should the "A" relay operate with this current the reversal of the battery condition releases relay TF, thereby allowing TM to operate and lock, thus preventing further operation of the routiner. This being a negative test, a time delay has to be arranged by a group of relays, operated by pulses, of which relay PBA is the last to operate. Relay TF will not release when the A relay is in correct adjustment, and the test switch is therefore stepped in this case when PBA operates.

On the test switch stepping, after the "Non-operate" test, relay PB is operated to change the resistance of the loop in order to allow the operating current for the "A" relay to flow. The indication of satisfactory functioning under this test (being the reversal of the incoming

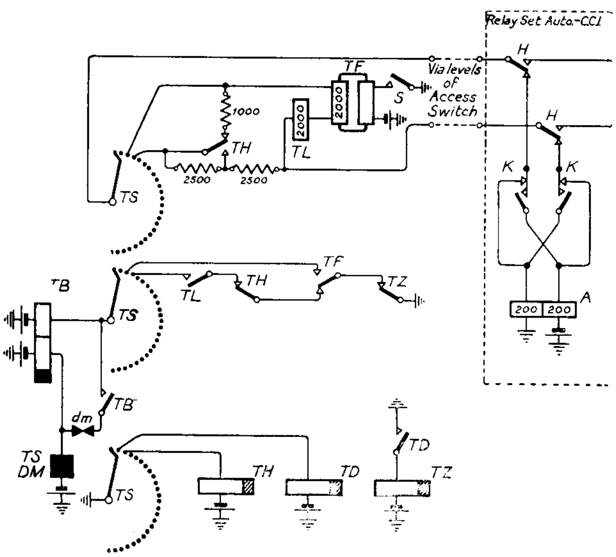


FIG. **10***b*.

lines) causes TF to release and TM to operate, thus stepping the test switch.

Fig. **10***b* shows a modified form of this circuit for obtaining the same result, the delay period for the "Non-operate" test in this case being obtained by two slow relays TD and TZ releasing in tandem. An additional feature is incorporated for the "Operate" test which allows the current in the "A" relay to flow *via* a non-inductive circuit during the period of release of relay TH. This is to prevent the possibility of a premature release of the "A" relay, due to the inductive discharge from relays TL and TF should reversal occur before the current in the A relay had reached a certain value. It was found during tests that such release did occur

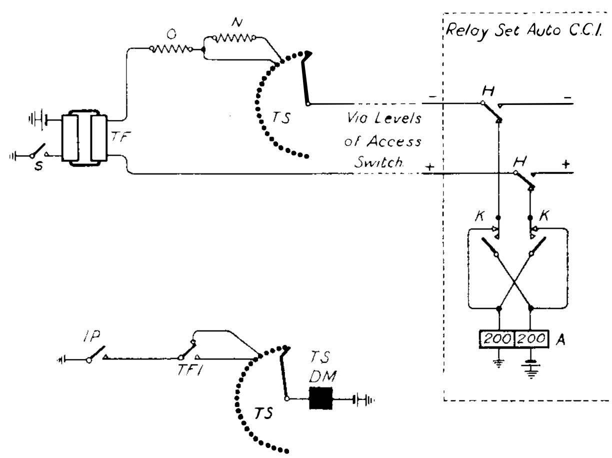


FIG. **10***c*.

when the coder finder seized an early choice coder.

In the standard routiner circuit the converse operation obtains, relay TF not operating when "Non-operate" conditions are applied and operating when the "Operate" current test is satisfactory as shown in Fig. **10***c*.

The routiner now sends a four digit number in order to cause the coder to send. Since the adjustment of the "A" relay has been checked, it is considered unnecessary to send trains of impulses for this purpose; four digits of one impulse each are therefore used.

Fig. **11***a* shows one of the methods employed for sending and receiving the digits. Relay TM is operated on contact 7 of the Test Switch and prepares relays A and SA. Relay SA opens the short-circuit across the loop springs and pre-

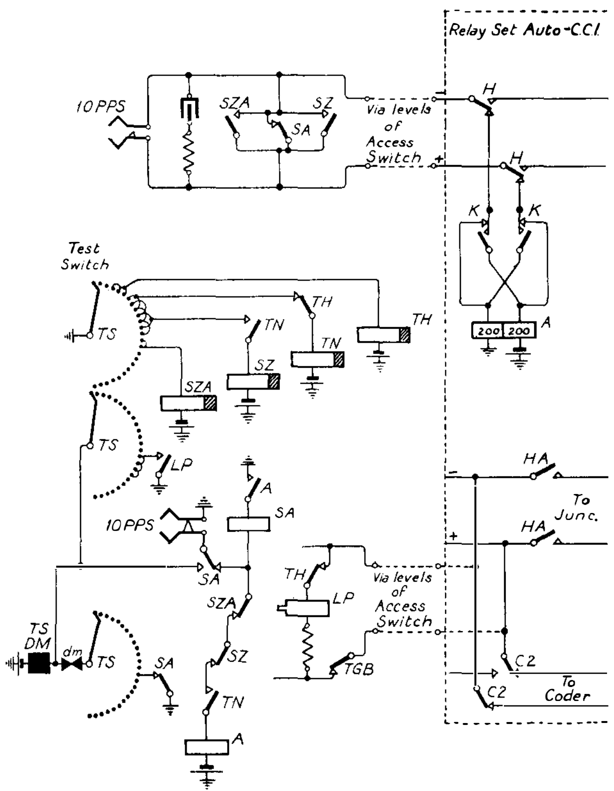


FIG. 11*a*.

pares for stepping the Test Switch. While the latter is energised, an impulse is sent to the relay set by the loop springs. The test switch then steps, relay SZ operates to short-circuit the loop springs and release A and SA. TN and SZ, being slow to release, give the necessary pause between the digits. When four such operations have been performed, relay SZA operates to prevent further digits from being sent.

Referring to Fig. **11***b* it will be seen that the counting of the digits is arranged by successive operations of four " Two-Step " relays designated E—H, the operation of relay H stepping the Test switch to prepare the routiner for receiving the coded digits *via* relay LP, the circuit of which is also shown in Figs. **11***a* and **11***b*. Relay LP is a polarized relay similar to that employed in the " C.C.I. Decoder " and is arranged to operate with each " Light Positive " pulse received from the " Coder." Each digit comprises one " Light Positive " pulse in addition to other pulses, and the " Test Switch " is therefore stepped over four contacts, indicating that the four digits have been received.

There is a disadvantage in checking the receipt of the positive pulses only; should the positive lead from the " C.C.I. Relay Set " to the Coder be earthed this fault would not be discovered. The standard circuit has therefore been so arranged that the routiner " Test Switch" is stepped by the positive pulses of the four digits and then the two " Light Negative " pulses of the last digit are also checked.

When the Coder has sent all four digits the C.C.I. Relay Set should guard the incoming private until the call has been cleared at the Manual Exchange, in order to prevent wrong connections in the event of a premature clear by a calling subscriber. This guarding condition is checked by means of relay PT, shown in Fig. **9**. Relay PT is an earthed relay of low resistance and is normally connected to the private,

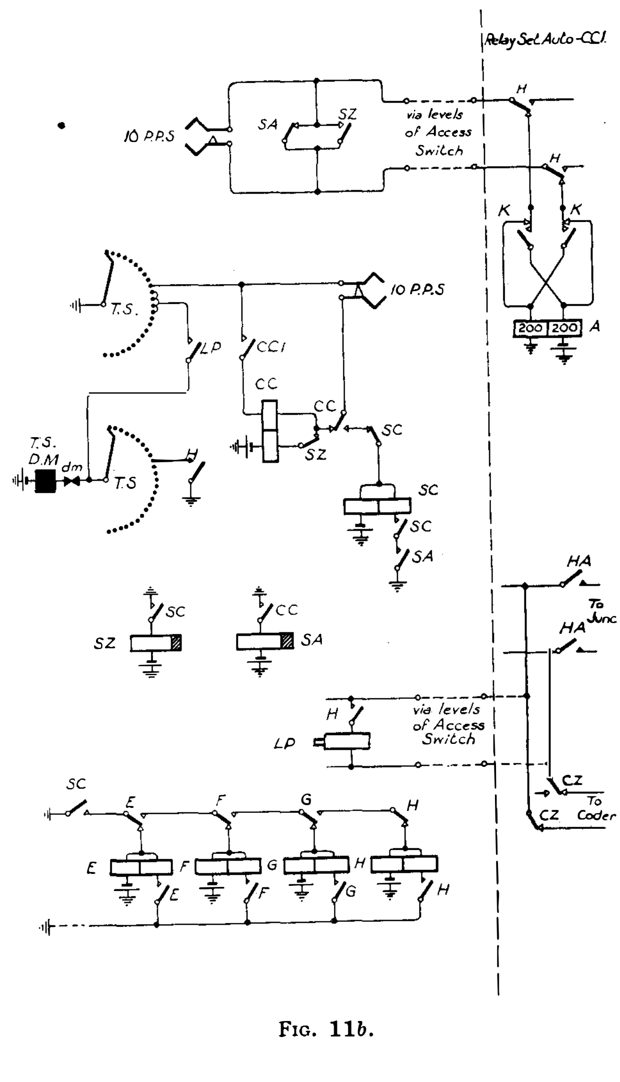


FIG. 11*b*.

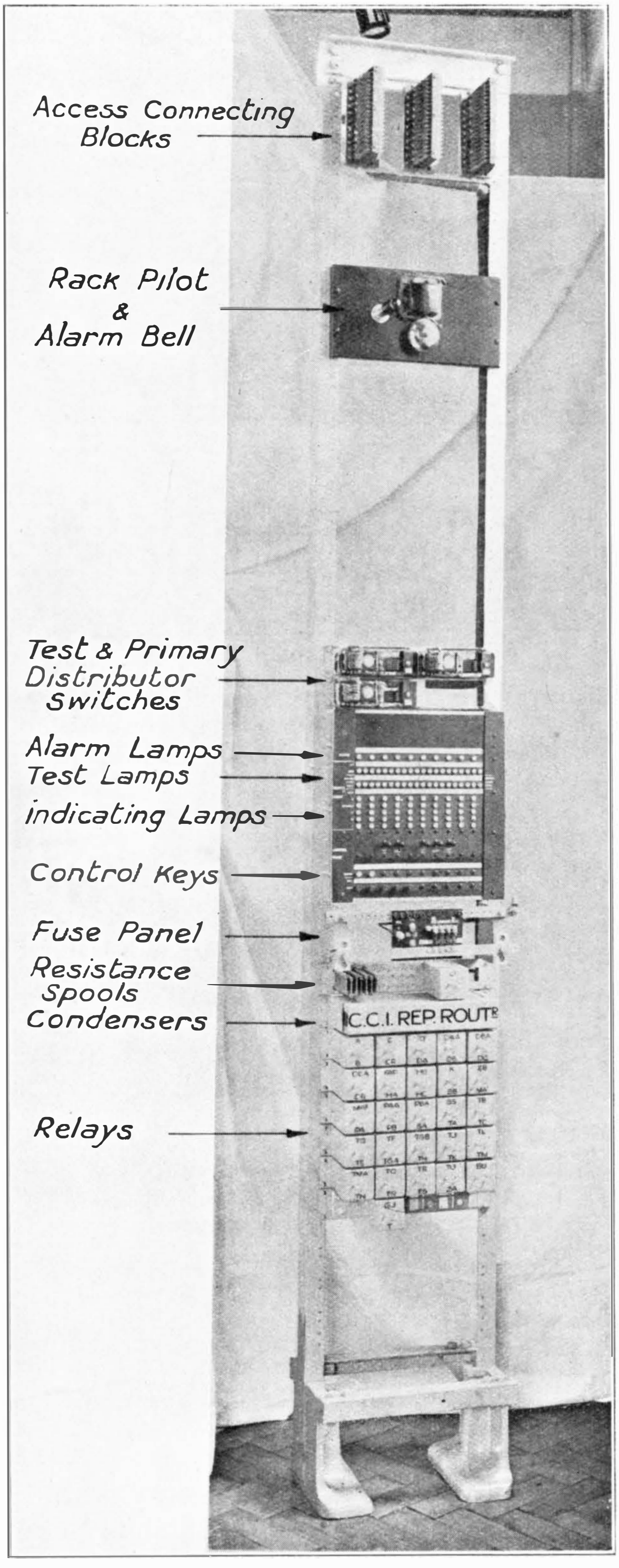


FIG. 12.—C.C.I. SET ROUTINER.

thereby providing the routiner guarding condition while testing is in progress. When it is required to check the "Relay Set" earth, battery, *via* a suitable protective resistance, is connected to the private by relay RH; thus, while the private is earthed, relay PT remains short-circuited, but should it be disconnected or earthed *via* a high resistance PT will operate and give an alarm.

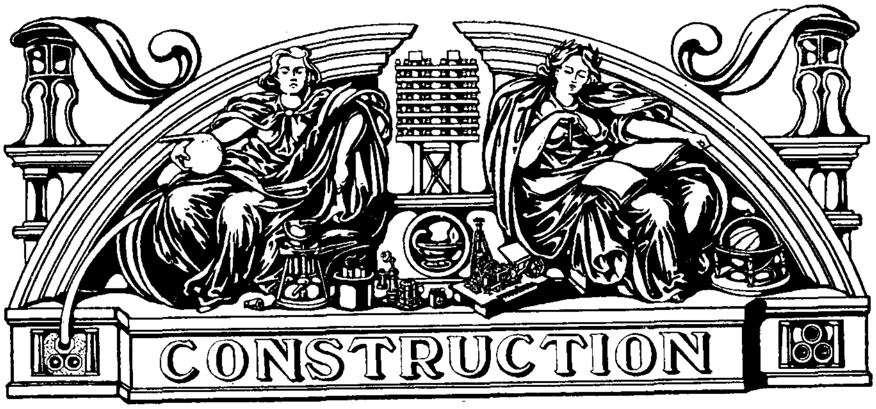
The H relay of the Relay Set is now operated, the worst working conditions of line and battery being simulated and the through connections are checked. This test is of a simple character, the check for continuity and the presence of extraneous earth or battery conditions only being necessary.

In the standard circuit, relay HA is connected to the private, as shown in Fig. **7**, and it is desirable that the holding circuit *via* contact HA1 shall be checked. To accomplish this, it is necessary to arrange the sequence of tests so that relay HA is operated before relay H. The sequence is therefore arranged as follows:—When the private has been tested for guarding earth ("CZ Operated" Test), relay HA is re-operated by removing the short-circuit, and the earth on the positive junction line is thus extended to operate relay H. The latter relay causes relay K to release and the "Coder Finder" to "home," and then relay CZ releases. CZ releasing removes earth from the private thereby removing the short-circuit from relay PT, which operates in series with relay H in the Relay Set and steps the "Test Switch." Thus the operation of relay H and the homing of the Coder Finder are checked. The holding circuit of relay HA is now tested by stepping the "Test Switch" with interrupted earth, the stepping circuit being dependent on the receipt of earth on the positive line of the junction.

"Fault Imitation" keys are provided in this routiner to check the operation of the routiner under the following conditions:—"Junction Reversed," "Junction Disconnected" and "Relay Set Busy."

The delay periods before alarms are given are 3 minutes for faults and 9 seconds approximately for release alarm.

Fig. **12** shows the lay-out of apparatus on a typical C.C.I. Relay Set Routiner rack.



THE LONGITUDINAL DISTRIBUTION OF MUTUAL ELECTRIC CAPACITY IN TELEPHONE CABLE CIRCUITS AND ITS EQUILISATION.

A. Morris, M.I.E.E., and G. W. Hodge.

SYNOPSIS.—Deals with the non-uniformity of M.E.C. in coil loaded telephone cables as a cause of irregularity of their impedance-frequency characteristics. Gives definitions relating to, explains a method of analysis of uniformity of and describes the technique of equalisation of longitudinal distribution of M.E.C. Furnishes scheduled data in respect of manufacturing and loading section lengths. Presents curves of capacity distribution and of impedance-frequency characteristics for cables of modern and earlier type, in illustration of recent improvements.

Introduction.—Electric capacity equalisation along the length of loaded trunk cable circuits, for the purpose of ensuring efficient two-wire telephonic repeater working, is quite distinct from electric capacity balancing for interference immunity purposes. Capacity balancing is directed towards securing symmetry of those electrical systems of the cable comprised of possible interfering elements and is based upon a consideration of the direct wire-to-wire and the direct wire-to-earth capacities within such systems. Longitudinal equalisation of capacity aims at securing a uniform and similar distribution of mutual electric capacity along the length of the various circuits of a cable. For long-distance duplex repeatered cables capacity equalisation is undertaken additionally to capacity balancing, since interference immunity may be secured even with non-uniform longitudinal distribution of capacity, provided such distribution is symmetrical, *i.e.*, exactly similar for each of the elements comprising such a system.

Two-wire duplex repeater working.—For two-wire duplex repeater working it is necessary to provide at each repeater along the circuit a line-balancing or line-compensating network. The impedance of this network simulates that of the line to which it is connected at all frequencies comprised in that portion of the audio frequency range which it is necessary to freely transmit in order to ensure intelligibility.

The nearer the impedance of the balancing network simulates that of the line the smaller will be the circulating currents which tend to cause the repeater to oscillate or " sing " and the higher the amplification at which the repeater can be effectively worked.

Fig. 1 shows the variations, with frequency, of the characteristic impedance of a certain medium heavy coil loaded underground circuit. The reactance and effective resistance components of the impedance are shown separately. Each curve may be considered to consist of a main curve, called the " Smooth Mean Curve," with a number of superposed humps.

In working this particular circuit with two-wire duplex repeaters it would be desirable to construct a line balancing network whose impedance-frequency characteristic simulated that shown in Fig. 1. Such a network would be complicated and bulky. In practice a network would be constructed to simulate " the smooth mean curve " of Fig. 1.

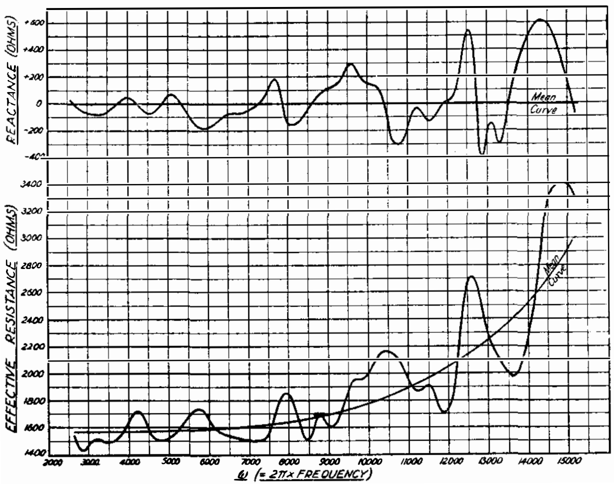


Fig. 1.

Assuming a network which simulates the smooth mean curve of the line, then, for each frequency at which the smooth mean and actual line impedance curves do not coincide the impedance of the balancing network will differ from that of the line and a current will circulate around the repeater tending to cause it to " sing."

Apart then from other transmission considerations, a more efficient and satisfactory repeatered circuit will be obtained if the line is so constructed as to give a smooth impedance-frequency curve.

Causes of irregularities in impedance-frequency curves.—The humps or irregular variations in the impedance-frequency characteristic curves shown in Fig. 1 are caused by a portion of the power sent into the line being reflected from some point or points along the line at which one or more of the primary constants, resistance, inductance, mutual electric capacity (M.E.C.) or leakance of the line are not uniformly distributed with length.

Lump or coil-loaded cables by reason of their construction give in general, impedance-frequency curves of a humpy nature. If the electrical constants of the line were absolutely uniformly distributed with length then its impedance-frequency curve would be quite smooth. High grade continuously-loaded cables possess such characteristics.

In modern coil-loaded cables the length distribution of conductor resistance and of leakance is normally essentially uniform. Furthermore the inductance of loading coils and the lengths of loading coil sections of cable deviate to a very small extent from their respective average values. In the case, however, of the M.E.C. of cable circuits the manufacturing deviations have hitherto been of sufficiently large magnitude, as to give rise in repeatered circuits and particularly in those of relatively low " Cut-off," to electrical instability, owing to imperfect balance of the line and its network, long before the full amplification of the repeaters could be utilised. The necessity for special treatment of M.E.C. thus arises, and about the year 1923 the first attempts, on a large scale, at equalising the longitudinal distribution of the M.E.C. of cable circuits were made in this country.

The degree of loading employed has a direct bearing upon the magnitude of the variations, from a smooth curve, of the impedance-frequency characteristics of a circuit. For a given non-uniformity of length distribution of M.E.C. in a circuit, the heavier the loading of that circuit the greater will be the variations of the impedance-frequency characteristics from a smooth curve. This will be so for two reasons :—

(*a*) The heavier loading results in a smaller attenuation constant for the circuit, thus the magnitude of the reflected power arriving at the sending end is greater and the magnitude of the humps will thus be greater.

(*b*) The heavier loading results in a larger phase constant and therefore slower velocity of propagation. This will result in a greater number of humps over a given frequency range.

It has been found advantageous in the case of certain repeatered cables to decrease the loading of those circuits in which the impedance-frequency characteristics departed considerably from a smooth curve. The resulting increase of attenuation length of the line was, however, more than compensated by the increased amplification which could be utilised at the repeaters owing to the improvement in the impedance-frequency characteristics of the line.

Before proceeding to discuss the results obtained at these first attempts or the results obtained upon present day cables, certain fundamental definitions which have been adopted in connection with this subject will be given. These definitions are applicable not only to the manufacturing but also to the field constructional stages of the work. The figures for the various characteristics quoted in the British Post Office specifications for modern cables are also given.

Mutual Electric Capacity.—The M.E.C. of a circuit is the electric capacity measured between the two limbs of that circuit when all the other conductors in the cable and the cable sheath are earthed.

Mean M.E.C.—The Mean M.E.C. of a group of circuits of a cable length is the average or mean value of the individual capacities of each of the circuits of that length comprised in that group. In British cables the magnitude of the Mean M.E.C. of pair circuits expressed in microfarads per mile, must not be less than 0.057 nor greater than 0.067 in any factory length of a complete cable, whilst in each factory length of at least 90% of the total number of such cable lengths, 0.059 and 0.065 are the limiting values. These magnitudes correspond to 0.062 ± 8% and 0.062 ± 5% respectively. The Mean M.E.C. of the phantom circuits of any factory length are specified not to differ from 1.62 times the actual Mean M.E.C. of the pair circuits of that length, by more than 5%.

Average Mean M.E.C.—The Average Mean M.E.C. of a group of circuits in a number of lengths of cable is the average value of the mean capacities of that group in each individual cable length.

M.E.C. Deviations.—The circuits of a cable may be divided into groups for balancing purposes or for the special needs of particular kinds of circuit working, *e.g.*, four-wire repeater working, in which case one group will consist of "Go" circuits only and another group of "Return" circuits only. The grouping may be arranged in layers, or in sectors by means of a diametral separation. A combination of both methods may be used. Owing to the special features of cable manufacture it is seldom possible to obtain exactly the same value for the Mean M.E.C. of each layer, or of each group of any particular factory length, or exactly the same value for the Mean M.E.C. of a particular group in each length of complete cable. In addition the M.E.C. of any circuit of a cable length will generally differ from the Mean M.E.C. of all similar circuits (of the same group) of the same length. Similarly the M.E.C. of any circuit of a cable length will differ from the Average Mean M.E.C. of all similar circuits (of the same group) of a number of cable lengths. Furthermore, as already stated in other terms, the Mean M.E.C. of a group of circuits of a cable length will differ from the Average Mean M.E.C. (of that group) of a number of cable lengths. These differences are referred to as capacity deviations and are classified into "Circuit Deviations" and "Length Deviations" of capacity. Such deviations, although inherent to commercial processes, are capable of being maintained within narrow limits by careful supervision, inspection and testing and the application of modern methods of manufacture.

Circuit Deviation of M.E.C.—The M.E.C. deviation of a circuit is the difference (irrespective of sign) between the M.E.C. of that circuit and the Mean M.E.C. of all similar circuits of the same group in the same length, expressed as a percentage of the Mean M.E.C. of that group in that length.

In British cables, this quantity is specified not to exceed 12.5 per cent. for any factory length. For any circuit of a loading coil section a figure of 3 per cent. must not be exceeded, whilst for 95 per cent. of such circuits 2 per cent. is the limiting value.

Mean Circuit Deviations of M.E.C. — The mean M.E.C. circuit deviation of a group of circuits of a cable length is the sum of the circuit deviations, irrespective of sign, of all the similar circuits in the same group in the same length divided by the number of such circuits, the result being expressed as a percentage of the Mean M.E.C. of that group of circuits in that length.

In British cables this quantity is specified not to exceed 4 per cent. for either the pair or phantom circuit of any factory length. The maximum circuit deviation allowed in loading sections of cable is 3 per cent.; the mean circuit deviation will therefore be very small and it is accordingly not specified.

Length Deviation of M.E.C. of a Group of Circuits of a Cable Length.—The length deviation of M.E.C. of a group of circuits of a cable length is the difference between the Mean M.E.C. of the circuits (of that group) of that cable length and the Average Mean M.E.C. of the circuits (of that group) of all the similar cable lengths of the complete cable, expressed as a percentage of that Average Mean M.E.C.

In British cables this quantity is specified not to exceed 2 per cent. for either the pair or phantom circuits of any loading coil section. Furthermore adjacent loading sections must not differ from each other in this respect by more than 3 per cent.

Length deviations of M.E.C. are not specified by the British Post Office for factory lengths of cable, sufficiently narrow limits in this respect being secured by the practical operation of the clauses which limit the magnitude of the Mean M.E.C. of side and phantom circuits.

M.E.C. of the Circuits of Factory Lengths of Cable.—For any particular length of cable there will be a certain value for the mean circuit deviation and a certain value for the maximum circuit deviation. Each of these quantities will generally be of different respective value in one cable length from what they are in another. In the analysis of such data for the purpose of presenting in a brief but comprehensive form, information as to the order of magnitude of the circuit deviations for the whole of the lengths of a complete cable it will be necessary to obtain average and maximum values of each of the previously mentioned quantities, as in the analagous case of capacity unbalance analyses.

Table No. 1 gives the magnitude of the circuit and length deviations of M.E.C. for the factory lengths of a repeater section of 60/40 M.T. cable. The Average Mean M.E.C. of the various layers and groups are also included in the Table.

M.E.C. Uniformity Requirements for Repeatered Cables.—Considering for the moment one circuit in a repeater section of cable not only should (i) the length deviations of M.E.C. of each portion of it situated between loading coils, *i.e.*, of each loading section, be as small as possible, but in addition (ii) the length deviations of M.E.C. of adjacent loading sections should not be widely different from one another.

As already mentioned, values not exceeding 2 per cent. and 3 per cent. for (i) and (ii) respectively are specified in British cable practice.

In considering the whole of the circuits of any particular group of a repeater section of cable it is highly desirable that (iii) the circuit deviations of M.E.C. be as small as possible in order that with the consequent similarity of M.E.C. of such circuits a standard basic network may, with minor adjustments, be applicable to the whole of the circuits of the group. In order to secure this advantage in British cables the circuit deviation of any circuit of any group in any loading section is specified not to exceed 3 per cent. whilst the individual circuit deviation of 95 per cent. of such circuits must not exceed 2 per cent.

The capacity requirements (i), (ii) and (iii) are secured in modern cables almost entirely by limiting the circuit and length deviations of M.E.C. in the manufacturing stage of the work. In conjunction with the exercise of manufacturing control, grading or the allocation of factory lengths to definite loading sections is also resorted to with a view to minimising length deviations of M.E.C. of loading sections. Thus the Mean M.E.C. of the circuits of factory lengths is required to be of such magnitude that when suitably allocated the length deviations of the loading sections shall not exceed 2 per cent.

Selected Jointing of Factory Lengths of Cable to ensure equalisation of the M.E.C. of the Circuits of Loading Sections.—In those cases where the circuit deviations of the factory lengths are so near the specified maxima that requirement (iii) above, is, in the absence of special precautions, unlikely of achievement, adjustment will be necessary during the constructional stages of the work. It is interesting to note in this connection that if $\triangle$ is the average mean circuit deviation of the factory lengths of a repeater section of cable, then in the absence of special capacity adjustment δ the probable average mean circuit deviation of the loading sections is given by $\delta = \frac{\triangle}{\sqrt{N}}$ where N is the number of factory lengths per loading section. The adjustments referred to are effected generally during the jointing of the factory lengths into loading sections by the use of the crossing method, a circuit with a positive deviation in one length being connected to a circuit of equal (or as nearly equal as possible) negative deviation in an adjacent length. Such adjustments will generally require to be made, if at all, at one joint only, and this can conveniently be the middle or final joint of a loading section at which crossing for interference immunity purposes would normally be of secondary importance. The process follows the systematic lines of measurement and selection adopted in capacity balancing for interference immunity purposes. Whereas direct capacity unbalances are normally measured in this latter case, mutual capacities will of course require to be determined in the case of capacity equalisation.

During the selecting processes, the assumption is made that the arithmetic sum of two M.E. Capacities is the resultant M.E.C. of two M.E. Capacities connected in parallel. This is not absolutely accurate, but the discrepancy involved provided there is reasonable symmetry of the earth components of such M.E. Capacities is negligibly small.

The selecting work is relatively easy since pair crosses only are of utility for pair circuit adjustments, whilst core crosses only are of utility for phantom circuit adjustments. It should be noted in this connection that a wire cross in connecting two pairs together will not affect the M.E.C. of the complete pair circuit unless there is considerable asymmetry of the earth capacities of the wires of the pairs, whilst a pair cross in connecting two cores together will not affect the M.E.C. of the phantom circuit unless there is considerable asymmetry of the earth capacity of the pairs of the cores.

It is obviously impossible to alter the Mean M.E.C. of the circuits of a loading section by the previously described field operations, involving selecting and jointing. Capacity adjustments may, however, be effected in the field by the artificial addition of capacity to cable circuits, either by means of additional cable or by the use of condensers. This method is not generally regarded as entirely satisfactory and in view of the availability of other means is not used in the construction of British cables. Thus the Mean M.E.C. of the factory lengths may be controlled within definite limits by careful manufacture, whilst by grading, the Mean M.E.C. of such loading sections may be made to approximate closely to the Average Mean M.E.C. of the whole cable.

In those cases where, owing to unavoidable causes there are differences in the lengths of loading sections along a route, it would be necessary in order to meet the fundamental requirement of equality of M.E.C. per loading section, to so manufacture or allocate the single lengths comprising such sections as to secure the desired result. The importance of the drum sections being of equal length and of the lengths of loading sections deviating by as small a value as possible from the average length of all the loading sections along the route, will be obvious from these considerations.

Examination of the Magnitude and Distribution of M.E.C. in the Circuits of Repeater Sections of Cable.—By plotting the value of the mean, maximum and minimum M.E. capacities for each group of circuits for each loading section, an analysis may be made of the magnitude and distribution of the M.E.C. of the circuits of a repeater section of cable. In the case of end sections, which differ materially in length from the normal loading section length, the Mean M.E.C. values for such sections will require to be converted to equivalent values for a normal length loading section.

In addition to plotting the mean, maximum and minimum capacities of each group of circuits for each loading section, a straight line representing the Average Mean M.E.C. per group per normal loading section of the whole cable should also be drawn. A specimen example of such a plot is given in Fig. **2**, which gives the results obtained for a group of 20 lb. circuits in a composite cable containing 20 lb. and 40 lb. circuits.

The results for the pair circuits are shown as wire-to-wire values, those for the phantom circuits as pair-to-pair values.

The straight full line represents the Average Mean M.E.C. per normal loading section. The dashed straight lines represent capacities 2% greater and 2% less respectively than the Average Mean M.E.C. per normal loading section.

The extent of the divergence of the mean line from the average mean line is indicative of the degree of uniformity of length distribution of M.E.C. of the circuits generally, large divergencies representing considerable non-uniformity and *vice versa*. In those cases where the divergencies are large, the causes are ascribable to non-uniform manufacture and ineffective grading.

grade manufacture or it may result from the special test jointing of less-perfectly manufactured factory lengths.

In the example given in Fig. **2** no attempts at M.E.C. equalisation were made during the

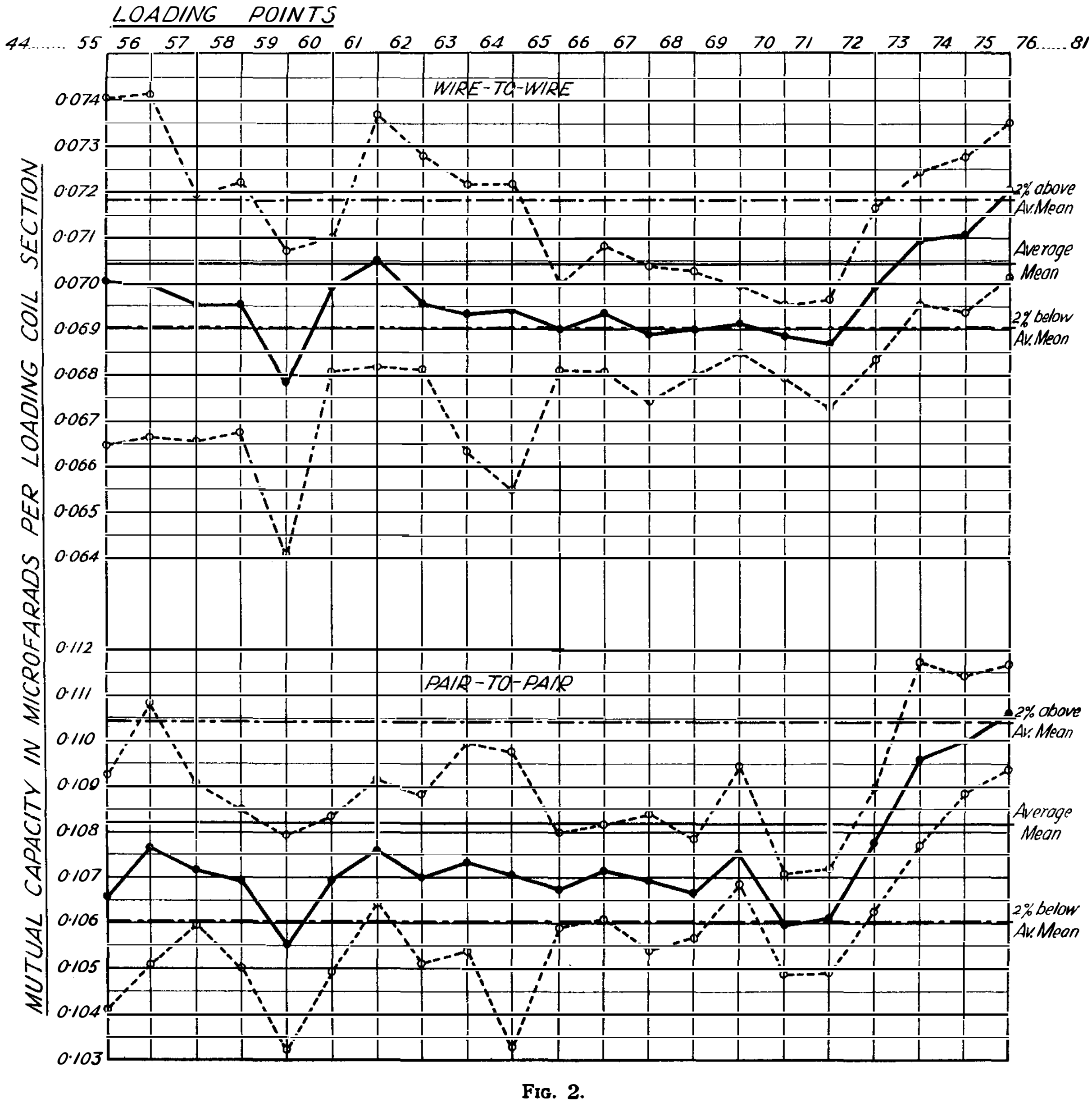


Fig. 2.

The distance between the maximum and minimum lines at any point is generally referred to as the "Band Width." Narrowness of "Band Width" is indicative of small circuit deviations; this may be achieved directly by high

construction of loading sections 45 to 65. The large circuit deviations and consequent large "Band Width" will be observed. The length deviations are also considerable. From loading section 66 onwards, attempts at M.E.C. equalisation were made. In the case of this cable no grading was undertaken. Thus the only result of the equalising operations was to reduce the circuit deviations, the length deviations remaining at essentially the same magnitude as for loading sections 45-65. This must be so since the Mean M.E.C. of the circuits of any loading section cannot be controlled by selection between the manufacturing lengths of that loading section. The only control, other than that of manufacture, over the Mean M.E.C. of the circuits of a loading section is that of grading.

tion of M.E.C. which has resulted from the more careful manufacture of the factory lengths of cable, supplemented by work in the field.

Selected Jointing of Loading Sections to ensure M.E.C. equalisation along the Length of Circuits comprising Repeater Sections.—Referring to the loading sections :—

(*a*) If both circuit and length deviations of M.E.C. are small, further selection will be unnecessary since the circuits are essentially uniform. This is the condition to be aimed at in telephone cables

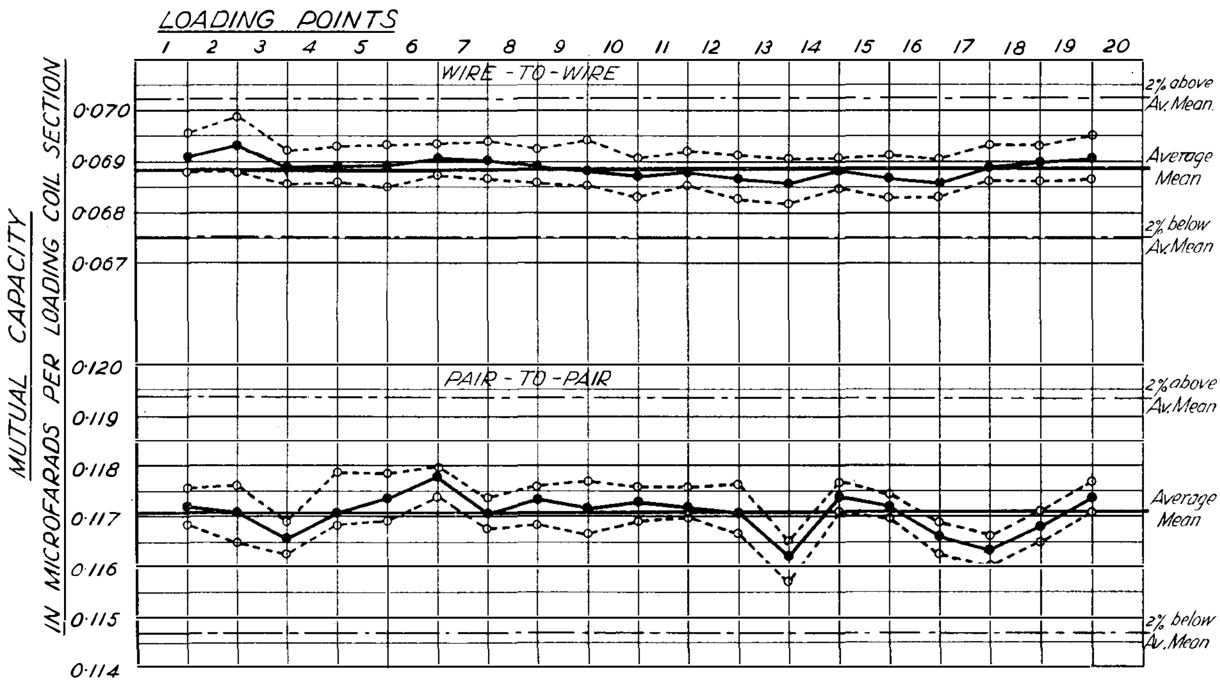


FIG. **3**.

Fig. **2** is a plot of the results obtained on load-coil sections in one of the first cases in this country of M.E.C. equalisation by means of field operations. A scheduled analysis of the plot is given in Table No. 2.

The results for the loading sections of a cable recently manufactured and whose factory length characteristics are given in Table No. 1 are shown plotted in Fig. **3**. A scheduled analysis of the plot is given in Table No. 3.

A comparison between Fig. **2** and Fig. **3** and Tables No. 2 and 3 shows at once the considerable improvement in the uniformity of distribu-

generally and can only be satisfactorily ensured by high grade manufacture and the exercise of the precautionary measures in primary field constructional work, already described.

(*b*) If length deviation is large and circuit deviation is small, practically no improvement is obtainable by selection between loading sections.

(*c*) If circuit deviation is large and length deviation is small, then in order to preclude the possibility of pairs of large capacity in one loading section being joined to pairs of low capacity in an adjacent loading section, test selected jointing of the loading sections is advantageous and desirable.

(*d*) If both the circuit deviations and length deviation are large, it will usually be possible by test-selected jointing between the loading sections to ensure uniformity of length distribution of M.E.C. in a proportion of the circuits of the complete cable. These selections are carried out with a view to ensuring a number of circuits (in certain groups) for satisfactory duplex repeater working. Such circuits will accordingly receive prior consideration. In these circumstances the remaining cable circuits will generally be more irregular than if test-selected jointing between the loading sections had not been resorted to. It is desirable, of course, to include both side and phantom circuits in these selections, but because of the additional complication involved and because such a procedure seriously limits the improvement possible in the side circuits besides limiting interference immunity adjustments which would otherwise be normally considered at this stage of the construction work, it is seldom attempted.

In the case of the example given in Fig. **2** it was necessary to select the joints between the loading sections, in order to obtain a number of circuits in which length deviation of M.E.C. would not be large. The circuits so obtained were used for special two-wire duplex repeater working and the repeaters in these circuits could be worked at a higher gain than those in the remaining circuits.

Impedance-Frequency Characteristics of a completed Cable manufactured to present day specifications for M.E.C.—Fig. **4** gives the impedance-frequency characteristics for a recently completed medium heavy coil-loaded cable. It will be seen by comparing Fig. **4** with Fig. **1** that the impedance frequency curves of Fig. **4** are much less irregular than those of Fig. **1**. In the case of the cable concerned in Fig. **4** all similar circuits, *i.e.*, similarly loaded circuits in the same group, had practically the same impedance-frequency characteristics. This is a decided advantage since if desired it is possible to design one type of balancing network for each type of circuit and the singing points of the repeaters will be but little different from those obtained by the construction of individual balances.

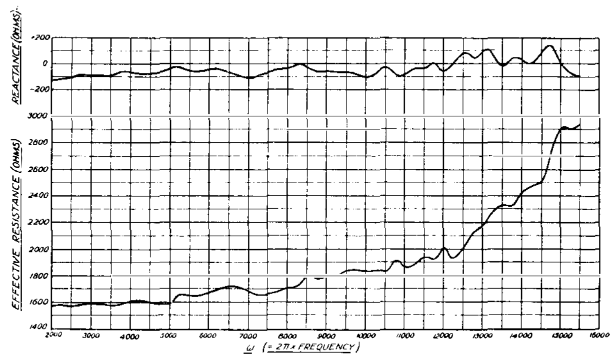


Fig. **4**.

Replacing a Factory Length of a Loading Section originally test-jointed for mutual capacity equalisation.—Cases will arise when owing to a fault or some other cause a new length of cable will require to be inserted in a loading section, originally test-jointed for mutual capacity equalisation. In such cases, in addition to capacity balancing for interference immunity, test-jointing for longitudinal uniformity of M.E.C. of the circuits of that loading section will also be required.

It has already been pointed out that the Mean M.E.C. of the circuits of a loading coil section cannot be controlled by selection between the various lengths of cable forming that loading coil section. Only circuit deviation of M.E.C. can be controlled by selection in such a case. Thus in the case of the replacement of a length of a loading section as soon as the particular replacing length has been decided upon, the only result which can be accomplished by subsequent selection is the reduction of the magnitude of the Circuit Deviations of the circuits over the reconstituted loading section.

TABLE No. 1.

ACTUAL CAPACITY DEVIATIONS OF THE FACTORY LENGTHS OF A REPEATER SECTION OF 60/40 M.T. CABLE.

Circuits.	Side.			Phantom.		
Layer.	C	1st	2nd	C	1st	2nd
Average Mean Mutual ... ... Capacity (μF. per mile)	0.0627	0.0614	0.0616	0.1004	0.1002	0.1039
Groups.	1st		2nd	1st		2nd
Average Mean Mutual ... ... Capacity (μF. per mile)	0.0615		0.0616	0.1003		0.1039
Circuit Deviations %.						
Average Mean	1.45		1.35	0.79		0.74
Maximum Mean	2.25		2.30	1.45		1.45
Average Maximum	4.00		3.50	1.80		1.70
Maximum Maximum	10.21		9.75	6.23		5.82
Length Deviations %.						
Mean	1.14		1.14	1.99		1.15
Maximum	3.74		5.03	3.50		6.94

TABLE No. 2.

ACTUAL CAPACITY DEVIATIONS OF THE LOADING COIL SECTIONS OF A GROUP OF 20LB. CONDUCTOR CIRCUITS OF A REPEATER SECTION OF A COMPOSITE CABLE CONTAINING 20LB. AND 40LB. CIRCUITS.

Circuits.	Side.	Phantom.
Layer.	4th	4th
Group.	3rd	3rd
Average Mean Mutual ... ... Capacity (μF. per mile)	0.0626	0.0962
Circuit Deviations %.		
Average Maximum	3.67	1.96
Maximum Maximum	7.02	4.44
Length Deviations %.		
Average	1.49	1.26
Maximum	3.69	2.68
Maximum Difference between Adjacent Normal Length L.C.S's. %	3.84	2.59
Ratio. Phantom Capacity ... ... / Side Capacity	1.54	
End Sections.		
Circuit Deviation %. Maximum	5.15*	3.26*
Length Deviation %. Maximum	11.2*	9.6*
Maximum Difference between Adjacent L.C.S's. %	14.6*	11.7*

* Indicates end section of short length, the results for which have been converted to the equivalent values for a normal length loading coil section.

Table No. 3.

ACTUAL CAPACITY DEVIATIONS OF THE LOADING COIL SECTIONS OF A REPEATER SECTION OF 60/40 M.T. CABLE.

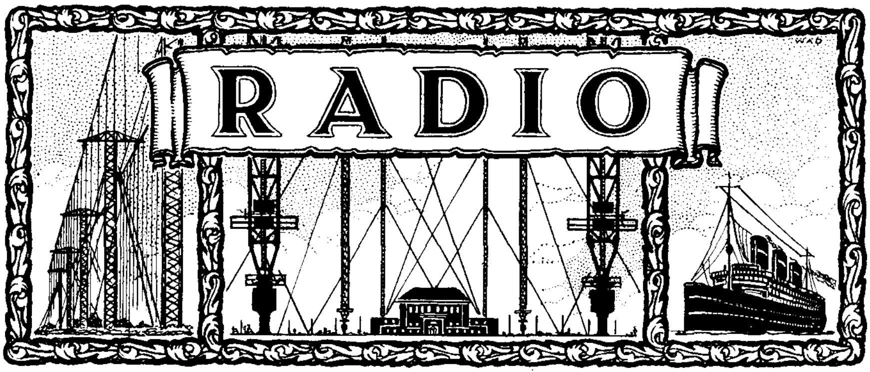
Circuits.	Side.		Phantom.	
Layer.	C, 1st	2nd	C, 1st	2nd
Groups.	1st	2nd	1st	2nd
Average Mean Mutual Capacity (μF. per mile) ...	0.06056	0.06121	0.09898	0.10404
Circuit Deviations %.				
Average Maximum ...	0.56	0.61	0.33	0.35
Maximum Maximum ...	1.61	0.99	0.48	0.61
Length Deviations %.				
Average ...	0.66	0.31	0.57	0.33
Maximum ...	1.48*	1.65*	1.20	1.50*
Maximum Difference between Adjacent Normal Length L.C.S's. % ...	0.94	0.67	1.18	1.07
Ratio. Phantom Capacity / Side Capacity ...	1.63	1.70		
End Sections. *Circuit Deviations* %. Maximum ...	1.77*	4.38*	1.60*	1.50*
End Sections. Maximum Difference between Adjacent L.C.S's. % ...	2.89*	2.00*	0.91*	1.38*

* Indicates end section of short length, the results for which have been converted to the equivalent values for a normal length loading coil section.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 31ST MAR., 1929.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
633,089	517	3,985	51,880	112	London	24,892	75,197	2,444,896	119,009
80,801	2,158	20,798	66,223	2,528	S. East	4,059	53,741	223,213	27,950
84,349	4,533	31,445	58,487	3,186	S. West	20,843	13,192	164,666	58,982
66,564	6,005	38,387	61,577	4,611	Eastern	24,175	40,999	128,542	66,788
99,726	8,457	45,265	60,190	3,890	N. Mid.	31,859	55,703	251,178	107,102
82,537	4,774	30,228	73,549	4,396	S. Mid.	12,233	24,799	204,340	86,992
59,401	4,850	29,909	54,115	3,348	S. Wales	6,599	26,584	125,947	71,504
107,747	8,011	26,411	51,091	4,463	N. Wales	13,897	40,309	284,746	62,042
162,580	1,473	15,672	43,881	3,157	S. Lancs.	14,178	81,079	487,843	49,467
95,180	6,212	30,445	47,311	3,438	N. East	12,485	44,924	247,127	75,319
65,685	3,913	23,819	38,520	2,835	N. West	8,860	35,084	173,716	31,065
48,536	2,565	16,133	25,823	2,672	Northern	5,350	18,838	113,733	45,230
22,039	4,557	8,516	13,657	538	Ireland N.	135	2,327	45,325	1,557
67,625	5,445	26,867	38,523	1,231	Scot. East	5,231	13,785	156,687	44,783
90,068	7,253	24,459	43,505	1,053	Scot. West	12,360	25,527	227,832	35,522
1,765,927	70,723	372,339	728,332	41,458	Total	197,156	552,088	5,279,791	883,312
1,727,680	70,604	373,013	720,356	39,941	Figures as at 31st Dec., 1928.	192,360	543,639	5,177,395	888,278



THE PRAGUE CONFERENCE.

A CONFERENCE was held at Prague, from the 4th to the 13th April, to discuss various radio questions affecting the Continent of Europe. All the European nations, with the exception of Lithuania, were represented and, in addition, delegations from Egypt and the United States of America were present.

Various minor questions affecting aeronautical, meteorological and police services were discussed, but the major question before the Conference was the Broadcasting situation in Europe.

In the early days of Broadcasting it became evident that the haphazard distribution of wave-lengths, which was then prevalent, caused a large amount of interference which considerably limited the service area of the Broadcasting stations in various countries. The principal Broadcasting interests combined to form the Union Internationale de Radiophonie, with headquarters at Geneva, with the object of endeavouring to straighten out the complex situation which had arisen. The first result of the work of the Union was the " Plan de Geneve," which was an attempt to divide the available wave-lengths between the Broadcasting Stations in Europe. This plan effected some improvement, but was only partially successful because the Union was not officially recognized in certain countries.

At a later stage a second attempt was made to divide the available wave-lengths, the result being known as the " Plan de Bruxelles." This plan suffered the same fate as its predecessor, and the Government of Czecho Slovakia offered to call an official conference to consider the matter.

The principal question before the Conference was the status of the Union Internationale de Radiophonie. After very long and heated discussions the Conference agreed to recognize the Union in its quality of a body of Broadcasting experts. Government representatives are to be allowed to take part in the discussions of the Union on technical questions, when they desire to do so, and the rearrangement of wave-lengths within the Broadcasting Bands is to be left to the Union. Failing agreement on any question, and provided a majority of the European States desire it, a major Governmental Conference would be called to endeavour to arrange the matter.

Once this knotty political problem had been settled all was plain sailing. A small sub-committee concentrated on a new plan, the " Plan de Prague." Using the Plan de Bruxelles as a basis, each nation stated its desires and its grievances and an endeavour was made to satisfy as many peope as possible. Naturally, everybody could not be satisfied because there are not enough wave-lengths to meet the demand, but the Conference as a whole approved the Plan de Prague and arranged for it to be put into operation on the 30th June, 1929.

The Conference at Prague marks a new step in European radio affairs. Formerly the policy of first come first served was the rule in wave-length distribution. This is the first time the Governments of European States have concurred in a wider, more humanitarian, view that the last comer, or the smallest State, is entitled to share in the artistic and cultural benefits of Broadcasting, and that a distribution of wave-lengths based on the essential needs of the countries concerned should take the place of the more crude policy of grab.

That an agreement on these lines was possible is a credit to the pioneer work done by the Union de Radiophonie, but also to the broad-minded policy of the delegates of the principal countries concerned.

It remains to be seen whether the policy, now established for Broadcasting, will be extended to the wider fields of commercial radio telegraphy and telephony.

Here follows a reprint of the "Plan de Prague":—

REDISTRIBUTION OF WAVE LENGTHS.

Following the "Plan de Prague," coming into force on the 30th June, 1929.

Frequencies in Kilocycles.	*Wavelengths in metres (approx.)*	*Name of Country.*	*Station.*
160	1875	Holland	Huizen
167	1800	Finland	Lahti
174	1725	France	Radio, Paris
183.5	1635	Germany	Zeesen
193.0	1553	Great Britain	Daventry
202.5	1481	Russia	Moscow*
207.5	1444	Aerial Services and Eiffel Tower	
212.5	1411	Poland	Warsaw
217.5	1380	Aerial Services	
222.5	1348	Sweden	Motala
230	1304	Russia	Kharkof*
250	1200	Turkey	Stamboul†
		Iceland	Reykjavik†
260	1153	Denmark	Kalundborg
280	1072	Norway	(X)†
297	1010	Switzerland	Bale†
320	938	U.R.S.S.	Moscow C.C.S.P.*
364	825	U.R.S.S.	Moscow*
375	800	U.R.S.S.	Kief*
385	778	U.R.S.S.	Petrozavodsk*
395	760	Switzerland	Geneva†
442	680	Switzerland	Lausanne†
527	572	Germany	Friburg†
		Serbia	
531.5	565	U.R.S.S.	Smolensk*
536	560	Germany	Augsbourg† Hanover†
545	550	Hungary	Budapest‡
554	542	Sweden	
563	533	Germany	
572	525	Littonia	
581	517	Austria	
585.5	511	U.R.S.S.	Archangel*
590	509	Belgium	
599	501	Italy	
603.5	497	U.R.S.S.	Moscow*
608	493	Norway	
617	487	Czechoslovakia	
621.5	483	U.R.S.S.	Gomel*
626	479	Great Britain	
630.5	476	U.R.S.S.	Simferopol*
635	473	Germany	
644	466	France	Lyons
653	459	Switzerland	
666.5	450	U.R.S.S.	Moscow S.P.*
662	453	Commune No. 1	
671	447	France	Paris P.T.T.
680	441	Italy	
689	436	Sweden	
698	429	Serbia	
702.5	427	U.R.S.S.	Kharkof*
707	424	Spain	
716	418	Germany	
725	413	Ireland	
729.5	411	U.R.S.S.	Odessa*
734	408	Poland	
743	403	Switzerland	
747.5	401	U.R.S.S.	Koursk*
752	399	Great Britain	
761	394	Roumania	
770	390	Germany	
779	385	Poland-Italy§	
783.5	383	U.R.S.S.	Dnepropetrovsk*
788	381	France	
792.5	379	U.R.S.S.	Artemovsk*
797	377	Great Britain	
806	372	Germany	
810.5	370	U.R.S.S.	Tver*
815	368	Spain	
819.5	366	U.R.S.S.	Nikolaief*
824	364	Norway	
833	360	Germany	
842	356	Great Britain	
851	352	Austria	
855.5	351	U.R.S.S.	Leningrad*
860	349	Spain	
869	346	France	Strasburg
878	342	Czechoslovakia	
887	339	Belgium	
891.5	337	U.R.S.S.	Ivan-Voznesensk*
896	335	Poland	
905	332	Italy	
914	329	France	Montpellier
923	325	Germany	
932	322	Sweden	
941	319	Bulgaria	
950	316	France	Marseilles
959	313	Poland	
968	310	Great Britain	
977	307	Serbia	
986	304	France	Bordeaux Lafayette
995	301	Great Britain	
1004	298	Holland	
1013	295	Esthonia	
1022	293	France and Czechoslovakia	Limoges
1031	291	Finland	
1040	289	Great Britain	
1049	286	France	Rheims
1058	283	Portugal	
1067	281	Denmark	
1076	279	Czechoslovakia	
1085	276	Germany	
1094	274	Italy	
1103	272	France	Rennes
1112	270	Greece	
1121	268	Spain	
1130	265	France	Lille
1139	263	Czechoslovakia	
1148	261	Great Britain	
1157	259	Germany	

Frequencies in Kilocycles.	*Wavelengths in metres (approx.)*	*Name of Country.*	*Station.*
1166	257	Sweden	
1175	255	France	Toulouse P.T.T.
1184	253	Germany	
1193	251	Spain	
1202	250	Czechoslovakia	
1211	248	Italy	
1220	246	Commune No. 2	
1229	244	Albania (provisionally Poland)	
1238	242	Great Britain	
1247	240	Norway	
1256	239	Germany	
1265	237	Monaco—Nice—Corsica (divided)	
1274	235	Norway	
1283	234	Poland	
1292	232	Serbia	
1301	231	Sweden	
1310	229	Spain	
1319	227	Germany	
1328	226	Roumania	
1337	225	Ireland	
1346	223	Luxembourg	
1355	221	Finland	
1364	220	France	
1373	218	Commune No. 3	
1382	217	Commune No. 4	
1391	216	Commune No. 5	
1400	214	Poland	
1410	213	Italy	
1420	211	Roumania	
1430	210	Hungary	
1440	208	Belgium	
1450	207	Commune No. 6	
1460	206	Commune No. 7	
1470	204	Commune No. 8	
1480	203	Commune No. 9	
1490	202	Commune No. 10	
1500	200	Free	

* Russia did not take part in the Washington Conference.

† The use of these waves, which are situated in a band not attached to Broadcasting by the Regulations added at the Washington Convention, is authorised with the express proviso that the stations which use them do not interfere with the services occupying this band.

In particular, it is necessary to ensure that the outputs from these stations do not render inoperative signals of distress, alarm, safety or urgency sent out on 500 Kc/s (600 m) and on 333 Kc/s (900 m).

In case of interference, the Administrations interested will endeavour to investigate every other suitable solution.

‡ The wavelength attached to Hungary will be brought back to the interior of the band attached exclusively to Radio Telegraphy on the first favourable occasion.

§ Exclusive wave kept in reserve in case there were mutual interference.

NOTE.—The Conference has noted the existence of the station of Kaunas (Lithuania), which has used different waves between 155 Kc/s (1935 m) and 151 Kc/s (1990 m) for a service of broadcasting. This station having interfered with the mobile services assigned to the station of Portishead (Great Britain) using the wave length 149 Kc/s (2013 m) and situated in the band kept exclusively for the mobile services, the Conference has asked the Administration of Great Britain to get in touch with that of Lithuania with a view to finding for the station of Kaunas a wavelength such that it may bring no interference to these mobile services.

A MACHINE TO DEMONSTRATE THE PROCESS OF MODULATING A CARRIER WAVE.

A. C. TIMMIS, B.Sc., A.M.I.E.E.

IF the amplitude of a sine wave is varied according to a sinusoidal law at a lower frequency than that of the original carrier wave, it is said to be modulated, and the envelope of the modulated wave is sinusoidal. In the case of complete, or 100% modulation, the amplitude of the carrier varies from ● to twice its normal amplitude. As the amplitude of the carrier wave is being changed continually, however, it ceases to be a true sine wave, and this distortion is exactly equivalent to the addition of the two sidebands. If a modulated wave be analysed into a Fourier series, it will be found to contain three frequencies: carrier, carrier + modulating frequency, and carrier − modulating frequency.

But the same result can fortunately be obtained by simple trigonometry—the analysis is given in the writer's article "Carrier Current Telephony" in the January, 1929, issue of this Journal.

If a carrier wave and the two sidebands be drawn in their correct relations of phase and magnitude and added together graphically or mechanically, the modulated wave will be synthesised. This addition can be very conveniently performed by means of a machine designed and made by the Marconi Company, in which the principle of Lord Kelvin's tide-predicting machine is employed.

The machine does not give a mechanical representation of what happens when modulation is carried out electrically, as, for instance, by varying the output of a carrier frequency oscillator in accordance with an audio frequency, and it occurred to the writer that a simple mechanical analogy to this process would be useful for instructional purposes, and as a complement to the Marconi synthesising machine.

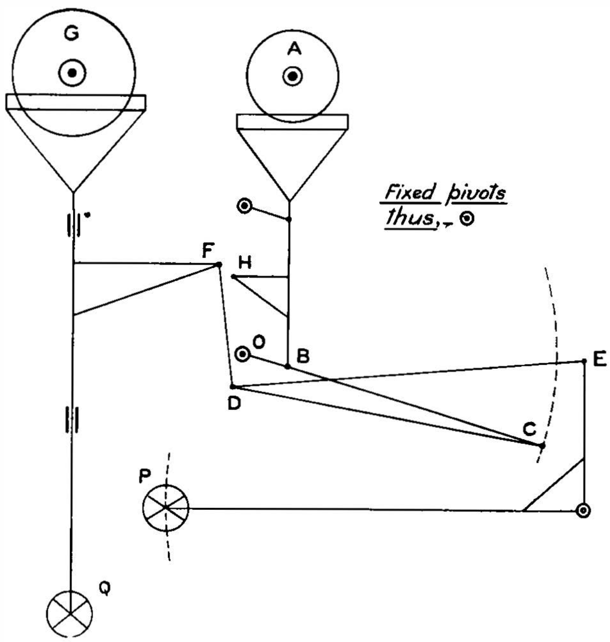


Fig. 1.

In Fig. 1 is shown the principle of a linkwork (designed originally as a multiplying mechanism for use in a measuring instrument) which enables the amplitude of a sine wave to be continuously varied in accordance with another motion. The crank and slot A impart—as regards vertical movement—a simple harmonic motion to the point B, on the link OC, which swings about the pivot O. The link CD is exactly the same length as OC. If the point F is fixed and OC swings through a fairly small angle the length OD is practically unchanged and may be regarded as one arm of a bell-crank lever BOD. The movement of D, which is transmitted to E and the pencil P, will therefore be a simple harmonic motion whose amplitude is proportional to the length OD, and whose frequency, which we will call the carrier frequency, is that of the crank A. Now suppose the length OD is made to vary from O to a maximum, by driving the point F from another simple harmonic motion whose frequency is determined by the crank and slot G. The amplitude of the motion of P will be proportional at any instant to the length OD which is proportional to the movement of F, and this is the condition for modulation of the " carrier " frequency of A by the " audio " frequency of G. The crank G may be geared, at various reduction ratios, and in any phase relation, to A.

In the actual machine, a view of which is given in Fig. 2, ratios of 2 : 1, 4 : 1, 8 : 1 and 16 : 1 may be used between A and G by means of gear wheels. The paper is traversed under the pencils by means of rollers, seen on the right of the photograph, which can be driven at a convenient speed through the adjustable friction gear seen above the rollers. This gear is driven by the handle on the left of the photograph and the crank A (the carrier movement) is driven at the same time through bevel gears underneath the plate. The audio movement has a pencil (Q in Fig. 1) which traces the audio wave, the lowest on the paper; and the carrier movement has a similar pencil on a swinging link which traces the middle curve. The top curve is the modulated wave.

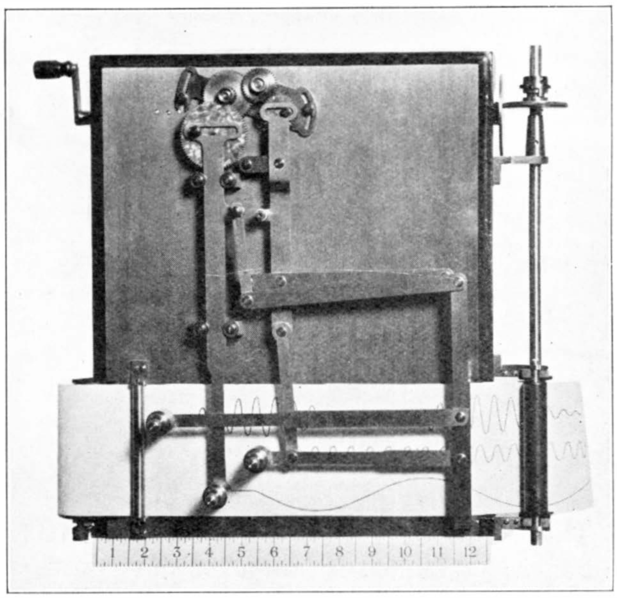


Fig. 2.

The link FD (Fig. 1) is slotted so that its length can be adjusted to vary the degree of modulation within limits. It can also be swung over to a pivot on the carrier movement (H in

Fig. 1). The pencil P then traces the result of modulating a carrier wave by itself.

Applying the usual sideband formula to this case we obtain the carrier frequency, double that frequency, and zero frequency or DC. The result of this modulation is therefore the same as square law rectification, and the wave drawn by P is the partially rectified carrier wave. The point may perhaps be more clearly seen by considering only the carrier motion, with the link FD attached to H. The vertical motion of the point B may be represented by: $y = 1 + \sin \omega t$, where ω is the angular velocity of the crank. But the action of the linkwork is such that the movement of P represents the product of the movements of F and B; hence the movement of P may be represented by

$$\begin{aligned} y^1 &= (1 + \sin \omega t) \times y \\ &= (1 + \sin \omega t)^2 \\ &= 1 + 2 \sin \omega t + \sin^2 \omega t \\ &= 1\tfrac{1}{2} + 2 \sin \omega t - \tfrac{1}{2} \cos 2\omega t \\ &= \text{DC} + \text{carrier} + \text{second harmonic.} \end{aligned}$$

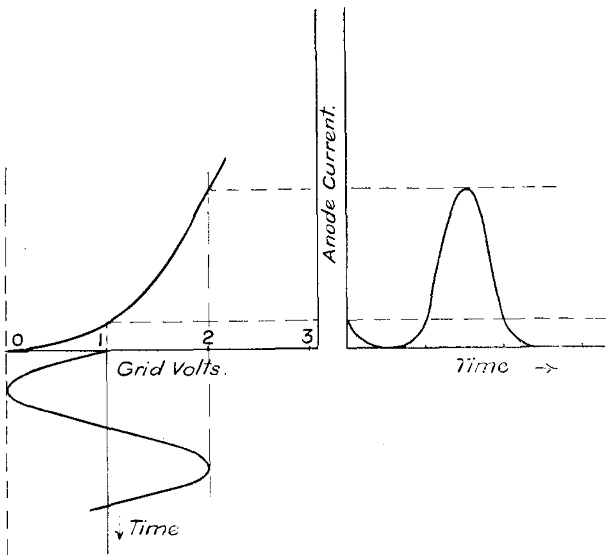


FIG. 3.

This is also the equation for square law rectification as performed by a valve whose grid is subjected to the sinusoidal voltage $1 + \sin \omega t$, measured from the bottom of the (parabolic) characteristic—Fig. 3.

The anode current is obviously

$$y = kx^2 = K(1 + \sin \omega t)^2$$

If the priming point is made lower than 1 the grid voltage wave will cross the axis. In an actual valve the anode current would remain zero, but the parabola assumed in the equation would continue. The linkwork corresponds to the equation, and cannot therefore be used to illustrate a more complete degree of rectification than that shown in Fig. 3.

The linkwork which forms the essential feature of the machine could be replaced by a dynamically equivalent set of cams, but link-work has the advantages that it is easy to make and practically frictionless. The slight error due to obliquity of certain links is of no consequence, seeing that the purpose of the machine is to demonstrate what happens during modulation. It is particularly interesting to generate a modulated wave in which the carrier is only a small multiple of the audio frequency, and to vary the phase relation between carrier and audio.

In this article the only system of modulation considered has been the straightforward one of which "anode choke modulation" is the usual form. There is another, quite apparently different, system, however. If two sine waves, a carrier and an audio frequency, for instance, are added together so that they heterodyne each other and are then passed through a square law rectifying device such as that of Fig. 3, a complicated wave is produced which contains, among other things, the carrier and the two sidebands in correct phase relation, *i.e.*, the modulated carrier wave. The other frequencies may be filtered out, leaving the modulated carrier. There is evidently a close connection between the two systems of modulation, because the same mechanism performs modulation according to the first system, and square law rectification, which is the essence of the second system.

The latter type of modulation occurs more or less in any circuit where two frequencies are present and non-linearity is introduced by the presence of iron, as in the filter coils of carrier telephone systems. When modulation occurs thus, as an unwanted effect, it is sometimes called "cross-modulation." It is hardly practicable to design a mechanism to illustrate this type of modulation completely.

NOTES & COMMENTS

THE Council of the Institution of Electrical Engineers has nominated Colonel Sir Thomas F. Purves, Engineer-in-Chief of the Post Office, to be President of the Institution for the forthcoming year. For the second time this year we have to offer our congratulations to the head of the engineering department upon an honour conferred. The position of president of the I.E.E. is no sinecure—it is rather in the nature of a whole time job, but, in spite of the heavy work of his own department, we feel certain that the new president will sustain worthily the prestige of the office, created and borne so successfully by the line of distinguished predecessors.

Mr. W. A. Valentine has retired on age limit from the post of Controller of the London Telephone Service, and has been succeeded by the Deputy Controller, Mr. W. H. U. Napier. Mr. Valentine has had a strenuous career, with the N.T. Coy. and for the past seventeen years with the P.O., and his many friends trust he will remain in good health to enjoy the rest he has so deservedly earned.

Speaking in the Newfoundland Legislative Assembly on 17th April, Sir R. A. Squires, the Premier, announced his intention of introducing a Bill during the present session to empower the American Telephone and Telegraph Co. to lay new Transatlantic cables, *via* Newfoundland, for telephone purposes between the two hemispheres. The cable, it is understood by Reuters, will be laid from America into Placent Bay, carried across the isthmus to Conception Bay and thence to Europe. It is understood that the European end of the cable will be landed in Ireland.

Messrs. Siemens Bros. have just completed and at the time of writing are engaged in laying a continuously loaded cable from England to the Isle of Man, and two cables from the island to Northern Ireland. In our next issue we hope to be able to give a detailed technical description of the construction and characteristics of these cables, which will provide a trunk service to the island and improve communication with Ireland.

The A.T.M. Coy. have sent us a copy of their pamphlet on "The A.T.M.-Doignon Multiplex Printing Telegraph System," which explains very fully, and with finely executed illustrations, the details of the system. The improvements claimed over the existing Baudot multiplex are as follows:—(1) The suppression of the Baudot governor. (2) Suppression of the moderator on receiver. (3) The use of a commercial type motor to drive the distributor with constant speed. (4) Automatic control of receiver speed and phase. (5) Alteration of distributor and receiver speeds, by simply turning one adjusting screw. (6) Suppression of all gear trains in the receiver units. As a result of the last mentioned, the keyboard can be mounted in the base of the receiver and readily locked and unlocked. An independent keyboard with cadence and lock can be fitted, if necessary. A description of the distributor governor is given, as well as a mathematical treatment of its action.

TELEGRAPH OR 'PHONE?

If the Rotarians, at their luncheon to-day, expected Mr. T. E. Herbert, of the Post Office engineering department, to answer some of the criticisms made against the Post Office, they were disappointed. He addressed himself wholly to the question whether the telegraph system will be superseded by the telephone. About this he was, as he remarked, an "incurable optimist" on the side of the telegraph, despite the fact that the system is being run at a loss of £1,500,000 a year. That does not necessarily say, though, that the telegraph is in a state of honourable yet inevitable decay. For Mr. Herbert believes that the system should be carrying a reasonable amount of the traffic which at present goes by mail. As he remarked, speeding up business increases profits, and it ought to pay the nation to expand the telegraph system by giving a cheaper, better, and quicker service.

Mr. Herbert incidentally brought forward one rather interesting criticism of the telephone. The telephone is obviously a blessing in many ways, but there are other times when it becomes extremely irritating. How many minutes are wasted every day by trivial inquiries? The delays due to these, at least, could be prevented by a greater use of the telegraphic service.

—*Manchester Guardian*, 12th April, 1929.

The Bell Telephone Quarterly for April gives the concluding part of an important article by H. S. Osborne on "Standardisation in the Bell System."

In concluding the article Mr. Osborne says this general outline of standardizing activities in the Bell System is sufficient to indicate the outstanding part which standardization has played in the building up of the Bell System. For many years, standardization based upon not only the present needs of the telephone system but also the best picture obtainable of future trends, has been an integral part of the programme of development of telephone service. One type of standardization increases both the possibility and the advantages of another type so that in such an organisation, standardization activities ramify through the entire structure and touch every part of the work.

The total economies resulting from standardization, of course, it would be impossible to closely estimate. Standardization as indicated above, has been productive of many advantages in addition to economy. The advantages from standardization may be summarized as follows:

1. Standardization makes the best available for all.
2. Standardization reduces the cost because, when all companies use the same things, they can be manufactured in the largest quantities and uniformity in output contributes to economies in production.
3. Standardization reduces the cost of carrying stocks of materials and the cost of maintenance and repairs, because fewer parts have to be carried and maintained.
4. Standardization reduces the cost of instruction of new employees because there are fewer things with which to get acquainted.
5. Standardization reduces accounting costs because there are fewer types and sizes of materials to keep track of.
6. Standardization minimizes complicated engineering and operating problems that might result from intercommunication between widely divergent systems and apparatus.
7. Standardization renders available large supplies of materials and labour in emergencies.
8. Standardization greatly facilitates development work, since improvement in, or development of, a new article involves a co-ordination with a smaller number of associated parts.

C.B. CLAY FOOTBALL CHALLENGE CUP.

The final tie in the C.B. Clay Challenge Cup was played on the Tufnell Park Football Ground on Tuesday evening, 16th April, between teams from the Post Office Stores Department (Holloway) and the Engineer-in-Chief's Office. The latter team won by five goals to three after extra time had been played. Col. C. B. Clay, the donor of the Cup, was unfortunately unable to be present owing to an attack of ptomaine poisoning, and in his absence the presentation of the cup, together with miniature cups to each member of the winning team, was made by Mr. H. Sparks, O.B.E., the Controller of Stores. Mr. Sparks paid a tribute to both teams for the excellent game they had played and also said he was sure all present would wish Col. Clay a speedy return to good health. It may interest readers of the Journal to know that this Football Challenge Cup was first instituted in 1898 and is still open to all teams representing the staff of any branch or section of the Post Office associated with the Telephone Service in London including the following departments:—

The Secretary's Office.
The London Telephone Service.
The Post Office Stores Department.
The London Engineering District.
The Office of the Engineer-in-Chief.

Entries for the competition are cordially invited and particulars can be obtained from the Hon. Secretary, Mr. C. J. Head (London Engineering District), Mr. A. E. Wild (London Telephone Service), or Mr. F. Woollard (Engineer-in-Chief's Office). The proceeds of all matches are devoted entirely to charity and the competition has been the means of raising over £200 during the past two or three years.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed:—

Exchange.	Type.	No. of Lines.
Gladstone (Advance portion) ...	New Auto.	M.D.F.
Linthorpe	,,	560
Marine (Southend)	,,	1430
Nottingham	,,	7255
Southbank	,,	185
Stockton	,,	1280
Temple Bar	,,	7900
Cwmbran	Auto Extn.	130
Leeds	,,	Modfns.
Newport	,,	400
Tandem	,,	Positions
Ashford	New Manual	500
Berkhampstead	,,	580
Deal	,,	860
Stanmore (Advance portion) ...	,,	M.D.F.
Upminster	,,	440
Bournemouth	Manual Ext.	680
West Bromwich	,,	420
Cardiff Corporation	P.A.B.X.	
Consett Iron Co.	,,	20
East African Society	,,	
Hazell Watson & Viney ...	,,	30
Shell Mex (Southampton) ...	,,	30
Taylor & Parsons	,,	30
Universal Grinding Wheel ...	,,	20
Uxbridge Guardians	,,	20
Woolwich Guardians	,,	20

Orders have been placed for the following works:—

Exchange.	Type.	No. of Lines.
Arnold	New Auto.	450
Beeston	,,	730
Bulwell	,,	540
Carlton	,,	635
Gladstone	,,	4860
Hampstead	,,	6666
Leytonstone	,,	2470
Pollards	,,	4000
Arkwright	Auto Extn.	760
Epsom	,,	300
Foleshill	,,	100
Grimsby	,,	530
Nottingham	,,	190
Sheffield Area Coin Box Equipt.	,,	—
Sherwood	,,	190
Sketty	,,	340
Hastings	New Manual	3410
Romford	,,	1780
Theydon Bois	,,	270
Crosly	Manual Ext.	900
East Grinstead	,,	240
Jesmond	,,	600
Consett Iron Co.	P.A.B.X.	20
East London Rubber Co. ...	,,	50
Hazell Watson & Viney ...	,,	30
Kent Education	,,	30
Preston Corporation	,,	30
Stalybridge Corporation ...	,,	20
Synthetic Ammonia	,,	100
Taylor & Parsons	,,	30
Woolwich Guardians	,,	20
Yarmouth Corporation ...	,,	30

LONDON DISTRICT NOTES.

Telephones.—The following figures show the changes in the number of exchange lines, extensions, and stations during the three months ending and the totals at 31st March, 1929:—

	Increase.	Total.
Exchange Lines ...	7,733	363,226
Extensions ...	7,243	308,596
Stations	13,274	611,588

External Plant.—During the same period the changes shown below have occurred in mileage:

Telegraphs.—A nett decrease in open wire of 2 miles and a nett increase of 164 miles in underground.

Telephones (Exchange).—A nett increase of 255 miles in open wire and nett increase of 40,734 miles in underground.

Telephones (Trunk).—A nett increase of 10 miles in open wire and nett increase of 2,268 miles in underground.

Pole Line.—A nett increase of 13 miles, the total to date being 5,908 miles.

Pipe Line.—A nett increase of 169 miles, the total to date being 10,429 miles.

The total single wire mileages at the end of the period under review were:—

Telegraphs	26,147
Telephones (Exchange) ...	2,497,551
Telephones (Trunk) ...	80,377
Spares	119,122

TELEPHONE EXCHANGE PROGRESS.

Manual.—Upminster C.B. No. 1 was opened on the 11th April equipped with 720 lines.

Automatic.—It is anticipated that the following Exchanges will open during the next three months:—

Exchange.	No. of Equipped Lines.	Manufacturer.
Beckenham	3,000	Siemens
Reliance	2,700	General Electric Co.
Maida Vale	7,500	Siemens
Edgware	1,300	General Electric Co.
Metropolitan	9,500	A.T.M.
National	9,500	A.T.M.
Fulham	7,500	Standard
Flaxman (Kensington)	9,900	General Electric Co.
Mitcham	1,480	Siemens
Hendon	4,200	A.T.M.

CALL OFFICES.

The work of converting Call Offices from Post Payment to Pre-Payment working is proceeding throughout the District. Arrangements are also being made to fit emergency calling apparatus in Kiosks.

The first of the new iron kiosks (No. 4) has now been erected in Euston Road, opposite Kings Cross Station. It is a post office in miniature combining as it does a telephone call office, with all the usual facilities, a letter box, and a stamp vending machine. These latter are placed on the outside at the back so that the sale of stamps and posting of letters does not interfere with the use of the telephone. The all-embracing nature of the facilities is shown by the various opal signs worded "Telephone," "Post Office" and "Stamps." The kiosk is very similar in design to the ordinary iron kiosk.

A new type of concrete kiosk (No. 3) to the design of Sir Giles Gilbert Scott, is now making its appearance in various parts of London.

The design corresponds somewhat with that of the familiar iron kiosk, but whereas this is coloured red the concrete kiosk is coloured cream, with the glazed frames picked out in red. The glazed portions extend much lower than in the original type of concrete kiosk (No. 1) and four opal signs are provided just below the domed roof. The structure is 8′ 7½″ in height by 3′ 1″ square overall and presents a very pleasing appearance.

CALL OFFICE CABINETS.

A suite of eleven oak cabinets has replaced standard cabinets at the Arcade, Liverpool Street; the attendance booth has been abolished and multiple coin boxes have been introduced.

A suite of cabinets, in teak, has been installed at Charing Cross Station.

EPSOM AUTOMATIC EXCHANGE.

This exchange, which is the oldest public automatic exchange in the country, was installed in an adapted dwelling house at Epsom in the year 1912. When the growth of lines necessitated more space for automatic switches arrangements were made for the manual portion of the Epsom traffic to be dealt with at Sutton. The growth of lines at Sutton, however, outgrew the available accommodation and, pending the construction of a new exchange at Sutton, it was necessary to transfer the Epsom Manual work to Streatham. The new Sutton exchange has now been opened and the 107 circuits which carry the manual traffic of the Epsom area have been transferred thereto.

Transfers of Subscribers' Lines.

The establishment of additional exchanges in a multi-exchange area necessarily involves the transfer of a number of existing subscribers' lines from one exchange to another. It is probable that very few persons, apart from those engaged in organising the transfers, realise the magnitude of these operations in the London area. For example, in March, 1929, over 17,000 lines were transferred and arrangements are being made for the transfer of 18,200 lines in September. It is probable that a similar number will be transferred at each Directory issue for the next two or three years. It is needless perhaps to say that subscribers dislike to be given a change of exchange name and number and their reasons for this dislike are appreciated. Every effort is therefore made to reduce the inconvenience to a minimum. When investigations are being made to determine how relief can best be given to an exchange which is approaching the limit of its capacity the necessity to cause as little disturbance as possible to existing subscribers is a prominent consideration. Nevertheless, just as it is impossible to make an omelette without breaking eggs, so it is impossible to make a satisfactory lay-out in a growing telephone system without breaking up the existing groups of subscribers which form exchange areas and forming fresh groups in which there is room for expansion. The only alternative would be one so expensive as to be altogether impracticable. It would involve an estimate of the magnitude and distribution of the subscribers' lines for several decades which would have to be more accurate than is at present considered practicable in this or any other country, a statement of what the calling rate would be and the community of interest between the various areas, and also a lifting of the veil to indicate what improvements in apparatus and cable will take place. Buildings of suitable size and with the right type of apparatus might then be provided at once in all the areas which it may ultimately be necessary to form, to which would be connected all lines in those areas. It will be readily grasped that during the earlier years many of the buildings would have very few lines connected to them and the ratio of the expenditure due to the annual charges on buildings, equipment and line plant, and the cost of operating, to the income from subscribers' rentals and fees would be exceedingly high. If the service is to be kept self-supporting such a policy would involve the raising of fees to subscribers in order to compensate for the increased expenditure, and although this might not kill the goose that lays the golden eggs, it would probably put it off its feed and thus reduce its laying capacity.

The necessity for transfers must therefore be faced, and the fact that such large blocks are transferred with so little inconvenience to the subscribers indicates how carefully those officers of the Traffic and Engineering Departments who are directly concerned work out the details of what is necessarily a very intricate piece of organisation. A tribute must also be paid to those telephonists whose duty it is to divert calls to the new channels and smooth over the irritation which is felt by the transferred subscribers during the first few weeks after the transfer. Notwithstanding the magnitude of the transfers the complaints are remarkably few.

Emergency Charging Sets for Telephone Exchanges.

A portable Emergency Charging Set mounted on a trailer and operated by a 4 Cylinder Crude Oil Deisel Engine is being tried experimentally in the L.E.D. The rated output of the machine is 1,000 amperes at 60 volts. The complete unit weighs approximately 8 tons, and is transported by means of a tractor.

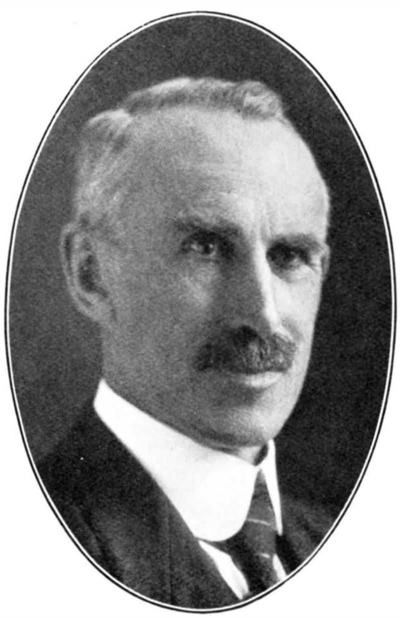
Telegraphs.

One of the Multiplex telegraph sets has been superseded by Teleprinters with voice frequency transmission.

A double duplex Baudot set has been installed on a Berlin circuit for experimental purposes.

At certain racing centres near London, Teleprinters have been introduced to replace Wheatstone apparatus and the change is regarded as a considerable improvement. Unfortunately, however, the majority of Race-course Grandstands have no motive power facilities for driving the Teleprinters, and the cartage of batteries is thus involved. The matter is being investigated with a view to minimizing the inconvenience thus caused.

RETIREMENT OF MR. R. McILROY, I.S.O.



ROBERT McILROY, I.S.O.
Late Superintending Engineer, London Engineering District.

ROBERT McILROY entered the service of the Post Office at Belfast where he was appointed as Telegraphist on 6th July, 1885; and for six years he was an apt pupil in a school of experience which, though it awarded no diplomas, was very successful—if the metaphor may be permitted—in sifting grain from chaff. Mr. McIlroy can recount many amusing episodes of that period, including some relating to happenings whilst "on hire" to Railway Companies for whom the Post Office provided Telegraphists; but the number of those episodes was restricted by the sifting process, which transferred him to the Engineering Department as a Junior Clerk in 1891, and thence early in 1893 to the Engineer-in-Chief's Office in the capacity of Draughtsman and Shorthand Writer.

It was not long before Mr. McIlroy's obvious abilities led to his selection for the post of personal assistant to the late Mr. James Hookey, then Assistant Engineer-in-Chief, and subsequently Engineer-in-Chief, which post he filled with conspicuous success until Mr. Hookey's retirement in 1902: during those years he carried a load of administrative work to which, whether judged from the standpoint of variety or of magnitude, there have been few parallels in the history of the Post Office Engineering Department.

In September, 1907, he was appointed to a Staff Engineership, First Class, and took charge of the Section of the Head Office which had been formed to deal with all matters concerning the construction of external plant and the protection of plant from power circuits, and also the scrutiny of all works estimates; and in April, 1909, he succeeded the late Mr. W. Vyle as Superintending Engineer of the South Wales District with headquarters at Cardiff, where he remained for 12 years.

On 1st August, 1921, at the age of 52, Mr. McIlroy was promoted to the Superintending Engineership of the London Engineering District, and in that position found full scope for a rare combination of administrative ability and practical experience. Under the most favourable conditions the headship of the London Engineering District, with a rapidly expanding staff which now numbers more than 8,000, would be a severe test of quality; and the briefest consideration of the numerous problems arising out of post-war conditions, supplemented by those incidental to engineering development, including the adoption of the "Director" system of automatic telephones, will furnish some idea of the responsibility of the position during the past 8 years. It would have been no small achievement merely to have maintained the efficiency of the District:

Mr. McIlroy may claim much more than this without fear of question. He will be remembered as one who led his staff by trusting them and who, in everything he undertook, set them the example of producing a finished piece of work.

So much for the official aspect of Mr. McIlroy's career; what of the man behind the official? Those who have been privileged to know the man have found a strong straightforward and, in many respects, unconventional character, to which a keen sense of justice and a deep sympathy for those in trouble and misfortune make equal contributions: many paths have been smoothed by the kindly insight of the man, and very often the travellers have not known either the extent or the direction of their indebtedness.

Mr. McIlroy has earned his leisure: may he and Mrs. McIlroy long be spared to enjoy it together. J.W.A.

POST OFFICE ENGINEERING AND STORES DEPARTMENTAL WHITLEY COUNCIL.

REPORT OF COMMITTEE ON RECRUITMENT.

Membership.

THE Committee on Recruitment was reconstituted in July, 1928, to review the Recruitment Scheme, and the following were appointed to it:—

Official Side—

Mr. E. Raven, C.B. *(Chairman).*
Col. Sir T. F. Purves.
Mr. E. H. Shaughnessy.
Mr. W. H. Weightman.
Dr. R. V. Hansford *(Secretary).*

Staff Side—

Mr. E. H. Williams *(Vice-Chairman).*
Mr. F. Edwards.
Mr. A. Grierson.
Mr. G. E. Harding.
Mr. T. Hargreaves.
Mr. L. S. Summers.
Mr. G. Balchin *(Secretary).*

Mr. C. H. Smith acted as Vice-Chairman for the first meeting only. The Committee has held seven meetings.

At the first meeting the Official Side pointed out that a review of the Recruitment Scheme for Assistant Engineerships and Inspectorships was considerably overdue, and that the matter had been brought to a head by the Report of the Leech Committee on Engineering Organisation, which expressed the definite opinions that there should be a considerable reduction in the percentage of Assistant Engineerships filled by promotion and that there should be a substantial increase in the percentage of Inspectors recruited by the Limited Competition. These opinions had been accepted by the Department; the Official Side must therefore be regarded as approaching the matter from this point of view. Other aspects of the Recruitment Scheme to be discussed were the age limits for the Competitions, the eligibility of certain classes for appointment to Engineering posts, and the re-institution of a "Certificate Qualification" as a condition of promotion to the rank of Inspector.

The recommendations of the Committee in regard to these questions and certain minor modifications to the existing Recruitment Scheme are detailed in this Report. An Appendix is attached which summarises the proposed conditions of recruitment.

Percentage of Vacancies to be Filled by Competition.

The Official Side stated that it was considered that the present scheme needed modification for two main reasons. In the first place, the ages at which men are promoted to Assistant Engineerships under the ordinary procedure are so high as to make it a matter of serious difficulty to find an adequate supply of Engineers of suitable age for the higher controlling posts. A substantial lowering of the promotion age is hardly to be expected; there is therefore good ground for advancing more men to the Assistant Engineer grade by means of the Competitions, so as to reduce the average age of the grade.

In the second place, it is the view of the controlling officers of the Engineering Department that candidates from the Competitions possess, on the average, greater potentialities for further advancement than men promoted through the ordinary procedure; and that from this point of view also there is a strong argument for extending the scope of the Competitions.

In the opinion of the Official Side, the only alternative to an increase in the proportion of posts to be filled by competition would be a very much more drastic selection of junior men for promotion; apart from the great difficulty attendink the selection, the Official Side would expect to find that such a procedure would produce a more acute sense of grievance than if the posts were filled by competition. The Staff Side admitted the force of the latter contention, but stated that the immediate adoption of drastic alterations to the present scheme of percentages must necessarily react unfavourably on the interests of the members of the existing classes and would unduly favour youth as compared with age and experience. The Staff Side also contended that even if changes were necessary in the methods of obtaining recruits every effort should be made to get them from within the Department.

After considerable discussion the Committee agreed to recommend an increase in the percentages of vacancies allocated to the Limited Competitions, but, in order to conserve the interests of the existing personnel as far as possible, it proposes that the changes should be made in three stages of two years each. Accordingly it recommends that the vacancies be allocated as indicated in the following table for an experimental period of six years, and that the question be reviewed at the end of that period:—

	1928	1929-30	1931-2	1933-4
Assistant Engineers:				
Open Competition ...	20	20	20	20
Limited Competition ...	20	25	30	40
Promotion	60	55	50	40
Inspectors:				
Open Competition ...	10	10	10	10
Limited Competition ...	10	20	30	40
Promotion	80	70	60	50

The Committee recommends that shortages in any one source of supply should be made good from the other sources. Any departure from these percentages which is found to be necessary should be the subject of prior discussion on the Departmental Whitley Council.

Age Limits for Competitions.

Experience has shown that the upper age limits for the Open Competitions are somewhat low and tend to debar suitable candidates who have not completed their course of study while still within the age limits.

Under the terms of the previous Reports an upper age limit for both the Limited Competitions of 40 years was recommended for a limited number of years, after which the upper age limits for Assistant Engineers and Inspectors were to be 30 and 25 years respectively. The reduced upper limits of age have not been brought into force, pending the review of the scheme.

The Committee considers that the upper age limits for the various Competitions might with advantage be somewhat higher than the final limits recommended in the Fourth Report and recommends that the following age limits for the Competitions be brought into operation forthwith:—

(1) *Assistant Engineers.*
- (*a*) Open Competition—20 to 25, with 2 years' extension for approved Works experience.
- (*b*) Limited Competition—23 to 32.

(2) *Inspectors.*
- (*a*) Open Competition—17 to 23.
- (*b*) Limited Competition—20 to 30.

Reinstatement of Technical Certificates as a Condition of Eligibility for Promotion to Inspectorships.

The Official Side stated that in view of the advances in complexity and technique of the work of the Engineering Department, and of the increased facilities now available for technical education, it was considered not unreasonable to revert to the pre-war practice of making the possession of technical certificates one of the recognised normal qualifications for promotion to the supervising grade of Inspector. In the absence of certificates there should be some other countervailing qualifications of a special order. The Official Side therefore proposed that an officer promoted to the rank of Inspector should be required to possess, as a minimum, certificates equivalent to those which are at present recognised as a qualification for a full technical allowance to workmen. The Official Side, however, did not suggest that every candidate for promotion should possess certificates in *both* Telegraphy and Telephony, if a higher certificate is obtained in one subject only.

The Staff Side did not challenge the contention of the Official Side, provided that the reinstitution of the "Certificate Qualification" was coupled with reservations in favour of the existing staff, who had acted on the assumption that there would be no change in the present Regulations.

The Committee accordingly recommends that a "Certificate Qualification" should be instituted forthwith as one of the normal qualifications for promotion to the rank of Inspector. The Certificates recognised should be those issued by the City and Guilds of London Institute, and the requisite qualifications should be as follows:—

A First-Class Certificate in Magnetism and Electricity, together with one of the following alternatives:—

(1) Certificates in two of the subjects Telephony, Telegraphy, and Radio Communication, which should be either a First Class in the Ordinary Grade or a Second Class in Grade II. or the Final Grade in each case.

(2) One certificate in Telephony, Telegraphy, or Radio Communication, which should be a First Class in Grade II. or the Final Grade.

The Committee also recommends that the possession of these prescribed certificates should not be an essential condition for promotion in the following cases:—

(*a*) Officers born before the 1st January, 1894.

(*b*) Officers of the grades normally eligible for direct promotion to the rank of Inspector who "qualified" in either a Limited or an Open Competition for Inspectorships but did not obtain an appointment.

(*c*) Officers who have countervailing qualifications of a special order.

Limited Competition for Inspectorships. Syllabus of Examination.

The Committee recommends that a subject entitled "Radio Communication" should be included as an optional subject in the Limited Competition for Inspectorships.

Eligibility of Draughtsmen for Promotion to Rank of Inspector.

While Draughtsmen are not regarded as in the normal line of promotion to Inspectorships, the Committee recommends that they should be eligible for exceptional promotion to that rank if they possess the necessary practical and technical qualifications.

Eligibility of Clerical Staff for an increased outlet to Supervising Engineering Grades.

The Committee discussed this question with the Staff Side of the Clerical Committee of the Departmental Whitley Council and has given careful consideration to the suggestions made by the Staff Side of the Clerical Committee.

These suggestions were to the effect that Clerks in the Engineering Department should be eligible for nomination to probationary posts as Assistant Engineers and Chief Inspectors, the necessary training being given during the probationary period. At the end of the period the appointment to the engineering grade would be confirmed if a certificate of efficiency could be given: otherwise the officer would revert to his clerical post.

After careful consideration the Committee is unable to recommend this plan for adoption. Under the present scheme of organisation, Assistant Engineers are normally employed either as second in command of an Engineering Section, or upon high-grade technical work at Headquarters or in the District Technical Sections. The Committee does not consider that clerical work in the Engineering Department would be likely to fit a man to fill either of these types of posts, even after a probationary period.

As regards Chief Inspectorships, the primary function of this grade is the control of groups of Inspectors, who in their turn are in control of large bodies of workmen. In the opinion of the

Committee the performance of clerical duties is not a suitable preparation for work of this nature.

The Committee is therefore of the opinion that it would not be in the interests of the Engineering Department that Clerical Classes should be granted an avenue of advance either to Assistant Engineerships or to Chief Inspectorships. The Clerical Classes are already eligible to compete in the Limited Competition for Inspectors; and the facilities for Clerks to become Inspectors will be substantially increased by the proposed increase from 10 per cent. to 40 per cent. in the percentage of appointments allocated to the Limited Competition and by the extension of the age limit.

The Committee recognise the stagnation of promotion which exists on the clerical side of the Engineering Department and would have been glad if it could have recommended measures which would relieve this stagnation; but in view of the growing complexity of engineering work, and the urgent importance of maintaining a high standard of efficiency, it does not feel able to recommend the admission of Clerks to grades above that of Inspector.

Eligibility of Assistant Traffic Superintendents for an Increased Outlet to the Supervising Engineering Grades.

The Committee discussed with a representative of the Association of Assistant Traffic Superintendents (Provinces) the question of providing an increased outlet for Traffic Officers to the Supervising Engineering grades.

The Committee recommends that Assistant Traffic Superintendents who are otherwise eligible, or who, after three years' approved service in the Traffic Branch, receive a nomination by the Engineer-in-Chief, to compete at the Open Competition for Assistant Engineerships should be granted an extension of age in respect of the period employed on traffic work in the Post Office, plus any period claimable in respect of engineering works experience, up to a maximum of five years.

The Committee is unable to recommend the admission of Assistant Traffic Superintendents to the Limited Competition for Assistant Engineerships.

12st March, 1929.

APPENDIX TO REPORT OF COMMITTEE ON RECRUITMENT.

Summary of Conditions of Recruitment of Assistant Engineers, Chief Inspectors, and Inspectors.

I.—PERCENTAGE ALLOCATION OF VACANCIES

(i) *Assistant Engineerships*

Method of Recruitment.	Year			
	1928	1929-30	1931-32	1933-34
Open Competition	20	20	20	20
Limited Competition	20	25	30	40
Promotion	60	55	50	40

(ii) *Chief Inspectorships*

Method of Recruitment.	
Promotion	100

(ii) *Inspectorships*

Method of Recruitment.	Year			
	1928	1929-30	1931-32	193-34
Open Competition	10	10	10	10
Limited Competition	10	20	30	40
Promotion	80	70	60	50

Note.—Shortages in any one source of supply to be made good from the other sources, subject to discussion on the P●st Office Engineering and Stores Deparmental Whitley Council.

II.—GRADES ELIGIBLE

(i) *Assistant Engineerships*

Open Competition	Limited Competition	Promotion.
(*a*) Graduates in Engineering who have taken complete engineering course. (*b*) Whitworth Scholars. (*c*) Holders of Diploma of Membership of Imperial College in Physics or Engineering, or Diploma of Associateship of City and Guilds Institute; or in exceptional cases, others who satisfy Civil Service Commissioners in regard to training and qualifications. (*d*) P.O. employees nominated by the Engineer-in-Chief.	(*a*) Chief Inspectors, Inspectors Repeater Officers with 3 years' approved Post Office Service at the date fixed for the examination. (*b*) Draughtsmen, Wayleave Officers, Skilled Workmen with 5 years' approved service in the Engineering Department at the date fixed for the examination. All candidates to be nominated by the Engineer-in-Chief.	Chief Inspectors. Inspectors. Repeater Officers.

(ii) *Chief Inspectorships*

By promotion from—

(*a*) Inspectors
(*b*) Repeater Officers } in exceptional circumstances.
(*c*) Draughtsmen

(iii) *Inspectorships*

Open Competition	Limited Competition	Promotion.
No restrictions.	(*a*) Clerks, Draughtsmen, Wayleave Officers, and Skilled Workmen in the Engineering Department. (*b*) Telegraphists (including Wireless Telegraphists), Sorting Clerks and Telegraphists with manipulative ability. All candidates to have five years' approved Post Office service at the date fixed for the examination and to be nominated by the Engineer-in-Chief.	Skilled Workmen, Draughtsmen (in exceptional circumstances). Subject to Certificate Qualification. (See VI).

III.—AGE LIMITS FOR COMPETITIONS

Assistant Engineerships		Inspectorships	
Open Competition	Limited Competition	Open Competition	Limited Competition
20 to 25 with extension as stated below.	23 to 32	17 to 23	20 to 30

NOTE.—The following extensions of age are permitted to candidates in the Open Competition for Assistant Engineerships :—

(*a*) Two years' extension for practical experience in approved Engineering Works.

(*b*) Assistant Traffic Superintendents who are otherwise eligible, or who, after three years' approved service in the Traffic Branch receive a nomination by the Engineer-in-Chief, may be granted an extension in respect of the period employed on traffic work in the Post Office, plus any period claimable under (*a*) up to a maximum of five years.

IV.—SYLLABUSES FOR COMPETITIONS.

(A) OPEN COMPETITION FOR POST OFFICE ASSISTANT ENGINEERSHIPS.

Subjects of Examination

(1) Mathematics
(2) Electro-Technology
(3) Materials
(4) Theory of Machines
} Compulsory. Candidates must " pass " in all these subjects.

(5) Personal Qualities

(6) Alternating Currents
(7) Electrical Machines
(8) Heat Engines
(9) Telegraphy and Telephony
} One subject to be taken.

NOTE. The subjects have been chosen with the object of providing a syllabus suitable without additional training for Engineering graduates of any of the principal Universities. The detailed syllabus for each subject, the grade of marking and the " pass " standard will be specified by the Civil Service Commissioners.

After the examination, personal qualities (Subject 5) will be judged by an Advisory Board and the marks awarded will be added to the examination totals.

(B) LIMITED COMPETITION FOR POST OFFICE ASSISTANT ENGINEERSHIPS.

Subjects of Examination

(1) Mathematics
(2) Electro-Technology
(3) Elementary Materials and Structures
} Compulsory. Candidates must " pass " in all these subjects.

(4) Personal Qualities

(5) Telegraphy and Telephony
(6) Physics (*a*)
(7) Chemistry (*a*)
} Two subjects only to be taken.

NOTE.—The detailed syllabus for each subject, the grade of marking and the " pass " standard will be specified by the Civil Service Commissioners, the standard for the subjects marked (*a*) being appropriate to intermediate University examinations.

After the examination, personal qualities (Subject 4) will be judged by an Advisory Board and the marks awarded will be added to the examination totals.

(C) OPEN COMPETITION FOR POST OFFICE ENGINEERING INSPECTORSHIPS

Subjects of Examination

(1) Pure Mathematics
(2) Applied ,,
(3) Electricity and Heat
(4) Engineering Drawing and Design
} Compulsory. Candidates must " pass " in all these subjects.

(5) Personal Qualities

(6) Sound and Optics
(7) Chemistry
(8) Telegraphy and Telephony
} One of these subjects only to be taken.

NOTE.—The detailed syllabus for each subject, the grade of marking and the " pass " standard will be specified by the Civil Service Commissioners.

After the examination, personal qualities (Subject 5) will be judged by an Advisory Board and the marks awarded will be added to the examination totals.

(D) Limited Competition for Post Office Engineering Inspectorships

Subjects of Examination

Subjects	
(1) Pure Mathematics (2) Applied Mathematics (3) Electricity and Heat (4) Engineering Drawing and Design	Compulsory. Candidates must " pass " in all these subjects.
(5) Personal Qualities	
(6) Telegraphy (7) Telephony (8) Radio-Communication (9) Sound and Optics (10) Chemistry	One of these subjects only to be taken.

Note.—The detailed syllabus for each subject, the grade of marking and the " pass " standard will be specified by the Civil Service Commissioners.

After the examination, personal qualities (Subject 5) will be judged by an Advisory Board and the marks awarded will be added to the examination totals.

V.—PROBATIONARY SERVICE AND SCALE OF PAY

Probationers selected through any examination will be paid a salary commencing at least two and not more than four incremental points below the minimum of the Assistant Engineers' or Inspectors' scale and will normally serve as probationers for two years with tests at six monthly intervals; they will be appointed Assistant Engineers or Inspectors respectively normally after two years' satisfactory probationary service, but probationers certified to possess adequate qualifications and practical experience may be appointed to the substantive rank before the end of two years when so certified, seniority in that rank counting from the date of this certificate. (Appointment is in every case subject to not less than twelve months' probation).

VI.—" CERTIFCATE QUALIFICATION " FOR INSPECTORSHIPS

A recognised normal qualification for promotion to Inspectorships is the possession of technical certificates issued by the City and Guilds of London Institute. The required certificates are as follows :—

A First-Class Certificate in Magnetism and Electricity, together with one of the following alternatives :—

(1) Certificates in two of the subjects Telephony, Telegraphy and Radio Communication which should be either a First Class in the Ordinary Grade or a Second Class in Grade II of the Final Grade in each case.

(2) One Certificate in Telephony, Telegraphy or Radio Communication which should be a First Class in Grade II or the Final Grade.

The possession of these certificates is not an essential condition for promotion in the following cases :—

(*a*) Officers born before 1st January, 1894.

(*b*) Officers of the grades normally eligible for direct promotion to the rank of Inspector who " qualified " in either a Limited or an Open Competition for Inspectorships but did not obtain an appointment.

(*c*) Officers who have countervailing qualifications of a special order.

TELEPHONE FINANCE AND STATISTICS OF THE AMERICAN BELL CO. AND THE BRITISH POST OFFICE.

W. J. MEDLYN, M.I.E.E.

AN article on the growth and finance of the British Telephone Service was published in the *P.O.E.E. Journal*, Volume 13, Part 2, in July, 1920, and a further article on the same subject appeared in Volume 18, Part 3, issued in October, 1925. A brief note on the Post Office Commercial Accounts for the year ending 31st March, 1928, was published in this Journal in April last.

The annual report of the American Telephone and Telegraph Co. for the year ending 31st December, 1928, which was issued in New York on March 1st, is now available. This report includes the operations of the American Bell Telephone Co., and it is possible therefore to make some interesting comparisons between the British and the American Telephone systems. The methods of keeping the accounts vary in detail, but, from the descriptions given in the American Report, it is possible to assemble the figures relating to the main heads of income and expenditure so that the financial results can be approximately compared. In dealing with finance, dollars are converted to sterling at the par rate of exchange. Of course, to get a real comparison it would be necessary to take into account the relative value of the currency, and its purchasing power in the two countries, as regards the standard of living in general, and the prices of the main items of telephone plant in particular. These complexities are outside the scope of this article.

Table 1 conveys a good idea of the extent and general lay out of the two systems. For the last years shown in the Table, the Bell Telephones consisted of approximately 78% manual and 22% automatic instruments, as compared with the British 87% manual and 13% automatic. (Bringing the British telephones up to the level date of 31st December, 1928, the total telephones had increased to 1,722,583, of which 85% were manual and 15% automatic). The number of Bell Telephones increased 5.8% in the year, as compared with the British 8.1%. The Bell average mileage per telephone was 4.28 and the British 4.40, including spare telephone wires in both cases. The Bell underground mileage was 66% of the total, and the British 84%. The Bell total mileage increased 9.5%, compared with 5.8% increase in the number of telephones, the corresponding British figures being 9.4% and 8.1% respectively.

A curious arithmetical discrepancy appears in the American report. The statistical table shows that 798,592 telephones were added during the year. In the body of the report it is stated that 4,235,000 telephones were connected and 3,485,000 disconnected, a net increase of only 750,000. The reason for such a considerable difference is not explained.

Finance.—Financial comparisons under the main heads of income and expenditure are given in Table 2 for the year 1928, and skeleton figures are shown for some of the corresponding American and British items in 1924 and 1925 respectively. In the Bell system, current maintenance covers " Cost of inspection, repairs and rearrangements required to keep the plant and equipment in operating condition." In the Post Office accounts re-arrangements are charged against the depreciation fund, and for this reason the figures are not exactly comparable.

The average daily exchange calling rate in the Bell System was 3.98 as compared with the British 2.39; the toll rate was .21 for both systems.

The American report states that about one-fifth of all telephones receive service through private branch exchanges which are operated by employees of subscribers. Of the 14,524,648 telephones in December, 1928, therefore, approximately 2,904,930, (20%), were extensions on branch exchange switchboards, and the remaining 11,619,718, (80%), were simple telephones directly connected with the public exchanges. Of the 1,631,191 British telephones in March, 1928, approximately 523,338, (32%), were extensions on private exchange switchboards, and the remaining 1,107,853, (68%), were directly connected with the public exchanges. Only the calls passing through the public exchanges are counted in the statistics, and, based on these percentages, the Bell 4.19 local and toll calls represent about 5.25 per direct telephone per day, as compared with the British 3.8. The average calling rate for extension telephones is not known, but it is no doubt much higher than the rates for direct exchange lines. Taking this into account, together with the higher percentage of extension telephones in this country, the actual number of calls per telephone in the two countries probably does not differ so much as might appear from the published statistics.

The average income from the local exchange and toll services was £14.1 in the Bell system, as compared with the British £12.

The Bell maintenance cost was £2.2 per telephone, and the British £1.7, but when these costs are combined with the charges against the depreciation fund, the figures are—Bell £3.7 and British £2.7. As previously stated, the methods of allocation as between Maintenance and Depreciation are not quite the same with the two systems.

There is a wide difference between the Bell £46.3 prime cost value of plant and equipment per telephone, as compared with the British £77.3. In both cases the cost of land and buildings is included. It is not possible to explain this difference without full knowledge of the purchase price of materials and equipment, and this again is linked up with the complex question of relative taxation of industries in the two countries. (The cost of land and buildings is shown separately in the Bell figures for 1924 in Table 3).

In this country the great bulk of the exchange equipment has been provided and installed by contractors, and the same arrangement also applies to a considerable proportion of the underground plant. Assuming equal conditions in the matter of prices, the greater percentage of automatic telephones would tend to make the Bell system more expensive as regards the average cost per telephone. In America there is an extensive system of party line services which has some effect on keeping down the average cost per telephone, owing to the use of cheaper line plant and exchange equipment. Party lines are not popular with the public in this country. A large proportion of the British telephone plant was provided during the years of peak prices after the end of the War, and of course the cost of that inflation still remains as a standing charge. The growth of these capital charges over a period of years is well illustrated in Table 3. During the period from 1919 to 1924 the British total cost of telephone plant was doubled, and the cost per telephone increased from £49 to £66, a difference of £17 or 35%. During the same period the cost of the Bell plant was also nearly doubled, while the cost per telephone increased from £32 to £41, a difference of £9, or 28%. The Table shows marked increases in the cost per telephone with both systems in succeeding years since 1914. Increased density of development has therefore had the effect of increasing the cost per unit of plant, instead of reducing it as is so often suggested.

So far as the British figures are concerned, the increased costs are partly attributable to the great extension of the underground system which has taken place in recent years. The establishment of telephone repeater stations has been an expensive item, but this is off-set by a consequent cheapening of main cables, although the full effect of the latter has probably not yet been felt. During recent years also there has been a considerable increase in the number of telephone kiosks, which would have some effect on average costs. In March, 1928, there were 24,054 public call office stations, including 4,687 kiosks. The average capital costs are also increased by the extension of the automatic system owing to the more expensive exchange equipment which is required. No doubt these factors have also had their effect in increasing the average costs of the Bell system.

In the latest accounts the British depreciation reserve fund for telephone plant, land and buildings, amounted to £30,556,300 or £18.7 per telephone, and the American total was £133,680,159 or £9.2 per telephone. In addition to the depreciation reserves the Bell balance sheet shows £19,173,209 reserves for contingencies, and an accumulated surplus of £76,802,516.

Apart from prime cost values, it is remarkable how closely the figures agree in the American and British systems. If, however, we assume that sterling has twice the purchasing value for ordinary commodities in this country as compared with America, the analysis gives cause for some disquiet. Anything that can be done to reduce costs is bound to improve the prospects of developing the service, and an important factor affecting this question is the price of materials used and the manufacturers' charges for equipment. The economic organisation of the work, and the lay-out of the plant to the best possible advantage in the public interest are matters which are receiving very close attention both in this country and in America.

Table 4 shows the balances in the telephone net revenue accounts for the various years since 1912, after charging interest on capital, and after allowing for the depreciated value of the plant, and all other charges.

The heavy losses in the two years ending 31st March, 1921, were due to delay in raising the cost of service to correspond with the increased cost of materials and labour, pending the findings of the Select Committee appointed by Parliament to enquire into the organisation and administration of the Telephone Service and the method of making charges. This Committee reported in March, 1922, but the table shows that successful steps had been taken before that to stem the losses. More rapid progress was made after the charges were adjusted as a result of the Committee's recommendations.

Owing to the abnormally high prices prevailing, the revenue was debited with a special depreciation allowance of £200,000 annually from 1919 to 31st March, 1923, making a total of £800,000 for the four years; the deficit shown in the Table is increased by this amount.

The revenue accounts have been debited with a total sum of £2,181,954 in respect of Civil pay to telephone staff released for service with the Army and Navy during the War. It will be seen therefore that, apart from this sum, the losses and gains over the whole period to date nearly balance.

It is the policy of the Post Office to give back to subscribers the benefits resulting from profits, and large reductions of rates were made in July, 1922, July, 1923, and July, 1924. It is interesting to observe from a statement published by Sir Henry Bunbury, the Comptroller and Accountant General, that had these reductions not been made, and assuming that there would have been the same amount of business at the higher rates as in fact there was at the reduced rates, the surplus would have been:—

In 1922-23	£1,800,000	instead of	£1,244,000	difference	£556,000
,, 1923-24	£3,400,000	,, ,,	£1,718,000	,,	£1,682,000
,, 1924-25	£4,100,000	,, ,,	£852,000	,,	£3,248,000
Totals	£9,300,000	,, ,,	£3,814,000	,,	£5,486,000

These benefits have been continued since 1924-25.

After making provision for the payment of reasonable dividends to the stock-holders to ensure the necessary flow of capital, and after the payment of other expenses, the policy of the American Company is similar to that of the Post Office, viz.:—to furnish the best possible service at the least cost. The result of this policy is well expressed in the words of the 1928 report (dollars converted to sterling) as follows:—

"Effective February 1, 1929, there was a reduction in toll and long distance rates amounting to a saving to the users of about £1,026,000 annually. Also during 1928 the basic trans-oceanic telephone rate was cut from £15 to £9. Effective at the beginning of 1929 the American Telephone and Telegraph Company reduced its charge to its Associated Companies, under its contracts for services, from 2 per cent. to 1½ per cent. of the gross telephone revenues of those companies. This reduction amounts to about £940,000 annually, and is in accord with the practice of the American Telephone and Telegraph Company to do everything possible to aid its Associated Companies in keeping down the cost of telephone service. The Western Electric Company, Incorporated, reduced prices in 1928 by about £4,000,000 on the present annual volume of purchases by Bell System companies. This was accomplished largely by increased efficiency and improved methods of manufacture."

TABLE 1.

EXCHANGE AND TRUNK SYSTEM.

	AMERICAN BELL SYSTEM.								BRITISH TELEPHONE SYSTEM.					
	Dec., 1924	%	Dec., 1925	%	Dec., 1928	%	Increase during 1928	Incr. %	Mar., 1925	%	Mar., 1928	%	Increase during 1927-28	Incr. %
Telephones Manl. ...			10,538,935	87.6	11,377,632	78.3	201,746	1.8	1,223,243	96.0	1,4427,384	87.5	42,204	3.0
Telephones Auto. ...			1,496,289	12.4	3,147,016	21.7	596,846	23.4	50,557	4.0	203,807	12.5	80,201	64.7
Telephones Total ...	11,242,318		12,035,224	100	14,524,648	100	798,592	5.8	1,273,800	100	1,631,191	100	122,405	8.1
Exchange (British working). Miles of Wire														
Underground	24,760,252		28,425,392		37,843,154		2,681,198	7.6	3,101,556		4,719,708		546,026	13.1
Submarine	—		—		—		—	—	326		309		(39)	—
Aerial Cable ... } Open ... ... }	10,052,769		9,462,213 / 1,953,235		13,503,157 / 2,069,381		1,381,573 / 73,542	10.3	615,689		700,085		32,970	4.9
Total ...	34,813,021		39,840,840		53,415,692		4,136,313	8.4	3,717,571		5,420,102		578,957	12.0
Toll or Trunk (British working).														
Underground	1,893,660		2,057,196		3,237,550		512,505	18.8	326,725		507,932		38,256	8.1
Submarine	—		—		—		—	—	2,696		5,014		1,454	40.8
Aerial Cable ... } Open ... ... }	3,186,938		1,209,332 / 2,366,172		2,947,233 / 2,592,269		625,376 / 95,655	15.0	340,332		377,269		10,958	3.0
Total ...	5,080,598		5,632,700		8,777,052		1,233,536	16.4	669,753		890,215		50,668	6.0
Exchange and Toll (Working and Spare).														
Underground	26,653,912	66.81	30,482,588	67.0	41,080,704	66.1	3,193,703	8.4	3,891,808	79.6	6,048,318	84.4	572,328	10.4
Submarine	—	—	—		—	-	—	—	3,755	.08	6,604	.09	1,154	21.2
Aerial Cable ... } Open ... ... }	3,239,707	33.19	10 671,545 / 4 319,407	33.0	16,450,390 / 4,661,650	33.9	2,006,949 / 169,197	11.5	993,851	20.3	1,115,358	15.5	43,307	4.0
Total ...	39,893,619	100	45.473,540	100	62,192,744	100	5,369,849	9.5	4,880,414	100	7,170,280	100	616,789	9.4
Miles per Telephone (Working and Spare).														
Underground	2.37		2.53		2.83				3.05		3.71			
Submarine	—		—		—				.003		.004			
Aerial Cable ... } Open ... ... }	1.18		1.25		1.45				.78		.68			
Total ...	3.55		3.78		4.28				3.83		4.40			

NOTE.—In the British system, low gauge spare cable wires weighing 20lbs., or less, per mile, and open 40lbs. per mile are included in the "working" mileages.

Table 2.

TELEPHONE FINANCE AND STATISTICS OF THE AMERICAN BELL CO., AND THE BRITISH POST OFFICE.

	American Bell. 31 Dec., 1924.	American Bell. 31 Dec., 1928.	British Post Office. 31 Mar., 1925.	British Post Office. 31 Mar., 1928.
Revenue :—		£		£
Local Exchange Service		132,362,656		18,695,371
Toll ,, ,, ...		63,557,499		
Advertising and Miscellaneous		4,496,287		135,844
Net value of Telegraph, Telephone Services		—		69,330
Total Revenue		200,416,442		18,900,545
Deduct bad debts		1,271,760		25,729
Total Income		199,144,682		18,874,816
Expenditure :—				
Current Maintenance	£20,874,651	31,735,214	£2,404,637	2,687,910
Traffic Expenses		43,568,130 }		
Commercial Expenses		18,245,839 }		5,011,878 }
General, Miscellaneous and Pension liability		10,454,127 }		925,676 }
		(72,268,096)		(5,937,554)
Rents, Rates, Taxes, etc.		19,329,432		1,008,484 }
				264,101 }
Depreciation charges	£20,483,483	31,616,131	£3,258,957	4,775,177
Total Expenses		154,948,873		14,673,226
Interest and Dividends		35,131,171		4,094,199
		190,080,044		18,767,425
Plant, Prime Cost	£465,774,289	673,040,240	£88,453,207	126,087,712
,, Depreciated Value		539,360,081		95,531,412
Reserves in Depreciation Fund		133,680,159	£21,910,111	30,556,300
Telephones at end of year	11,242,318	14,524,648	1,273,800	1,631,191
Increase in year	836,163	798,592	115,308	122,405
Mean number of telephones...	10,824,236	14,925,352	1,216,146	1,569,989
Direct Exchange lines at end of year		—		1,041,543
Proportion of lines to Stations		—		10 : 16
Telephone Calls :—				
Exchange daily per telephone	4.07	3.98	2.46	2.39
Toll do.	.17	.21	.26	.21
Costs per telephone :—		£		£
Annual Income		14.1		12.0
,, expenses		11.0		9.3
,, maintenance	£1.9	2.2	£2.0	1.7
,, traffic, etc., expenses		5.1		3.8
Depreciation expenses	£1.9	2.2	£2.7	3.0
Plant, prime cost	£41.4	46.3	£69.4	77.3
,, depreciated value		37.1		58.6
Depreciation Fund		9.2	£17.2	18.7
Renewals and Plant displacement charged to Depreciation Fund :—		£		£
Amount		21,351,556		1,564,896
Cost per telephone		1.5		1.0
Maintenance as above		2.2		1.7
Renewals, etc., and Maintenance		3.7		2.7

Table 3.

PRIME COST OF TELEPHONE PLANT, LAND AND BUILDINGS.

Years ending—British Post Office, 31st March; American Bell, 31st December.

Year.	Telephones. British	British Plant, etc.	Amount. £	Cost per Telephone. British. £	Cost per Telephone. American Bell. £
1913	730,763	Plant	27,513,814	37·65	
		Land and Buildings	3,100,000 (Estd.)	4·24	
		Total	30,613,814	41·89	
1914	774,821	Plant	30,137,043	38·89	
		Land and Buildings	3,538,673	4·57	
		Total	33,675,716	43·46	31·44
1915	796,348	Plant	33,208,845	41·70	
		Land and Buildings	3,544,786	4·45	
		Total	36,753,631	46·15	30·55
1919	797,218	Plant	35,057,431	43·97	
		Land and Buildings	3,658,802	4·59	
		Total	38,716,233	48·56	32·40
1923	1,050,672	Plant	62,648,362	59·62	
		Land and Buildings	4,409,631	4·20	
		Total	67,057,993	63·82	39·25
1924	1,158,492	Plant	71,801,538	61·98	37·40
		Land and Buildings	4,967,187	4·29	4·00
		Total	76,768,725	66·27	41·40
1925	1,273,800	Plant	83,050,253	65·20	
		Land and Buildings	5,402,954	4·24	
		Total	88,453,207	69·44	43·32
1927	1,508,786	Plant	106,882,126	70·84	
		Land and Buildings	7,050,616	4·67	
		Total	113,932,742	75·51	45·37
1928	1,631,191	Plant	117,935,820	72·30	
		Land and Buildings	8,151,892	5·00	
		Total	126,087,712	77·30	46·30

Table 4.

STATEMENT OF THE BALANCES SHOWN IN THE BRITISH TELEPHONE INCOME AND EXPENDITURE ACCOUNTS SINCE 31ST MARCH, 1912, AFTER CHARGING INTEREST ON CAPITAL.

Year ended 31st March.	Surplus. £	Deficit. £	Net Total to date. Surplus. £	Net Total to date. Deficit. £
1913	303,343	—	303,343	—
1914	239,111	—	542,454	—
1915	—	111,018	431,436	—
1916	—	118,177	313,259	—
1917	201,729	—	514,988	—
1918	355,468	—	870,456	—
1919	—	36,261	834,195	—
1920	—	1,961,710	—	1,127,515
1921	—	4,721,970	—	5,849,485
1922	—	559,132	—	6,408,617
1923	939,009	—	—	5,469,608
1924	1,596,917	—	—	3,872,691
1925	463,006	—	—	3,409,685
1926	550,830	—	—	2,858,855
1927	283,375	—	—	2,575,480
1928	107,391	—	—	2,468,089
Totals	5,040,179	7,508,268		2,468,089

SOME MODERN ASPECTS OF ELECTRICAL COMMUNICATION.

ADVANCES IN TELEPHONY AND TELEGRAPHY.

AT the Royal Society of Arts on Wednesday, April 10, a lecture was given by Mr. George Howard Nash, C.B.E., M.I.E.E., on "Some Modern Aspects of Electrical Communication." The Chair was taken by Sir Richard A. S. Paget, Bt. Mr. Nash observed that the Society had encouraged electrical communication from its earliest stages. The word "telephony" had appeared in the Journal of the Society as long ago as 1856, when it was applied to a method of transmitting musical sounds. Submarine telegraphy, the Hughes type-printing telegraph, and the D'Arlincourt method of transmitting writing, had all found a place in the Journal. The most important contribution to the subject that the Society had furnished, however, was the account on November 30, 1877, by Professor A. Graham Bell himself, of the articulating telephone, on which occasion the harmonic character of alternating electric currents was for the first time revealed and enthusiastically recognised. Since that time, in successive Cantor Lectures, the story of the development of Hertzian Wave telegraphy had been told in that room, and the advances in telephony had there been recorded. The present purpose was to make known to those who were not yet conversant with modern developments, some of the problems that arise on very long telephone connections, the means adopted for reducing or for overcoming difficulties, and to explain how, by modern methods of telephony and telegraphy, a number of communications can be made simultaneously, over a single pair of wires, without mutual interference.

The lecture was illustrated by a large diagram that indicated the main links — in a long telephone connection between two subscribers—over two continents, with an intermediate transoceanic link. An improved form of subscribers' set was shown, more convenient and more comfortable to use than the familiar pedestal type. The difficulty here to be surmounted was the variable distance between mouth and mouthpiece, owing to diversity of size of human heads. Entire freedom of movement of a speaker or listener during conversation by telephone was also a point to be gained by correct design of the set. Mr. Nash then proceeded to describe and to demonstrate a modern automatic system of telephony, and to distinguish this from a trunk exchange, *i.e.*, from an exchange designed for operating long-distance traffic. He explained that long lines are costly, and that consequently they cannot be increased indefinitely in number without raising the price of a call beyond what a subscriber is prepared to pay. The result is that the number must be reduced, with consequent occasional "delay," while subscribers await their turn. Service is thus provided on what is termed a "delay basis," the delay depending upon the number of calls waiting for a free line. This requires that calls shall be recorded at the trunk exchanges, and that the proper rotation shall be maintained by a system of tickets to operators. A recording switchboard with a belt conveyor for these tickets was shown. Where long distance telephony is more highly developed, a sufficient number of lines can be provided to supply a "no delay" service. The recording switchboard is then abandoned and a method of operation known as "the combined line and recording method" is introduced. In this method the trunk-line operator receives the call from the subscriber and makes out the ticket, but the subscriber does not hang up and wait to be called. Instead, the line operator completes the call to the required subscriber and connects the two with little or no delay. The ticket is then stamped. This saves recording positions and a good deal of ticket distributing equipment, and gives much faster service. From the various Trunk Exchanges, the circuit might, for example, now pass by means of "loaded" lines and "repeaters" to a Main Trunk Exchange, similar to an ordinary exchange, except that calls originating for a transoceanic radio link are received at a special position where they are dealt with by a technical control operator.

The arrangements at the Rugby Radio Station were then briefly explained by the lecturer, who referred to the fact that, as a supplement to the Long Wave Transatlantic Link, a Short Wave Circuit is now in operation, *i.e.*, two circuits are available during most hours. For purposes of demonstration it was assumed that, at the receiving station, links of communication with subscribers were installed similar to those on the transmitting side of the ocean.

Attention was then directed to certain effects that manifest themselves on long-distance telephone connections, which may involve aerial and cable circuits. On shorter connections these effects are present, but in less degree. They are:—(*a*) Attenuation distortion. (*b*) Phase distortion. (*c*) Echoes. (*d*) Interference.

(*a*) *Attenuation distortion,* sometimes called "frequency distortion," refers to the variation of the attenuation, or to the change of power efficiency, with frequency. An unloaded cable is a prolific source of such distortion, the attenuation increasing rapidly with frequency. The method of loading cables, commonly practised, by the insertion of lumped inductances, at intervals of about 6000 feet, causes the attenuation to remain relatively low over the most important part of the speech range, after which it rises to a value higher than in the absence of the loading. This results in a reduction of distortion over the essential part of the speech range, but in certain cases the residual distortion may still be intolerable. Attenuation distortion may be removed by the association of suitable resistance-reactance networks with the circuit; these are usually referred to as "attenuation equalisers" and introduce loss at the frequencies where the line loss is low, so that the sum of the line and equaliser loss approximates to a constant value for all frequencies transmitted. In certain cases, the reactance and capacities associated with the transformers of the amplifiers constituting part of a telephone repeater may be adapted to supply the necessary equalisation; this method has found favour in toll cable practice on account of its obvious economy. Long distance circuits are of course not exclusively confined to the transmission of speech and may be used for broadcasting or other purposes, such as picture transmission.

(*b*) *Phase distortion* is introduced by the difference in time of travel for different frequencies; it derives its name from the fact that the time of travel depends upon the way in which the phase shift of the complete system varies with frequency. The statement by Helmholtz that relative phase shift of different frequencies is not important, applies only to steady tones; it breaks down when the conditions are so extreme that parts of a finite wave-envelope starting at the same time arrive at the receiving end at different times, and when the difference in the time of arrival is greater than 30 milliseconds. In practice, for long distances, phase distortion is automatically eliminated by the fact that the repeaters normally used do not pass the frequency range above 2400 cycles. For two-wire circuits, high cut-off cables have the additional advantage that their speed of propagation is greater, which makes echoes less harmful. The fact that their impedance is more uniform within the pass-range, facilitates the construction of balancing networks; and as their attenuation distortion is small, very little correction is necessary. As an alternative to high cut-off circuits, the use of time delay correcting networks in an analagous manner to that of attenuation equalisers, has been proposed. These networks are either of the lattice or bridged T type, arranged so that they build up the time of travel of the fastest frequencies (*i.e.*, the low frequencies in this case) to be as nearly as possible equal to the time of travel of the slowest frequency in the pass-range of the system.

(*c*) *Echoes* are caused either by the return of part of the speech energy to the talker after an odd number of reflections, or by subsequent repetitions of the speech arriving at the receiving end after an even number of reflections. The term "reflection" is here intended to include any event during the process of which the original speech currents give rise to currents having the direction of propagation reversed. The type of long-distance circuit known as a "four-wire" circuit—in which a separate pair of wires is provided, respectively, for talking in each direction—was described. It was explained that, in practice, exact balance is never obtained. Consequently an indefinite number of separate echoes may arise, but these may be reduced so as to be of little importance. In the case of a "two-wire" circuit, each individual repeater has two balancing circuits associated with it, each of which affords the possibility of reflection taking place; but the reflection occurring at the terminals of the system is the most serious, because the balance there is always worse than at any other point in the circuit. This is on account of the fact that the end of the system has to be connected to a variety of circuits varying comparatively widely in impedance. To eliminate terminal echoes, it is usual to provide some means by which speech currents travelling through the circuit in one direction block the circuit operating in the other direction. This can only be done at a point in the circuit where four-wire operation occurs. In the case of a two-wire system the circuit is, in effect, converted to a four-wire circuit at every repeater in order to permit the insertion of one-way amplifiers. For this reason, and because the highest levels are obtained in the output of repeaters, echo suppressors, whether of the relay type or grid jamming type, are always associated with repeaters.

A typical arrangement for echo suppression used by the International Standard Electric Corporation on four-wire systems was then exhibited. It is in two halves, identical in function and differing only in the arrangement of their filament circuits to afford the most economical disposition. Within the working range, the behaviour of the apparatus is substantially independent of speech level in the line. In connection with the Transatlantic circuit, a special type of voice-operated switching device is employed which differs from a normal echo suppressor in that it is capable of suppressing an echo having zero delay. This is made necessary because of the desirability of operating transmitting and receiving stations on the same wave lengths, so that the receiving system is capable of amplifying the relatively weak signals received from the distant station and yet rejects the much stronger signals received from the local transmitting station. For this purpose, to avoid clipping of the speech, it is necessarry to introduce delay networks to retard the speech while switching operations are in progress.

The receiving circuit is normally through, and the transmitting circuit is normally blocked. Outgoing speech from the toll board arrives first of all at the amplifier detector bridged across the upper circuit it operates one relay which blocks the incoming circuit, and another relay which removes the short-circuit from the outgoing path. In this condition, incoming speech or noise has no effect on the circuit. With the cessation of outgoing speech, the circuit returns to normal. Incoming speech blocks the outgoing circuit and thus prevents any unbalance currents that pass the terminating set from operating the amplifier detector associated with the outgoing circuit. In every case the delay network is of such a length that the switching processes are complete before the speech arrives at the output of the delay network.

(*d*) *Interference* in telephone circuits may be inductive or may be introduced by the charging and floating machines associated with the power plants of the amplifier stations. In the case of radio links, the question of atmospherics has also to be considered. Inductive interference is introduced either by neighbouring power circuits, by telegraph circuits on the same route, or by speech circuits on the same route, in which case it is referred to as " crosstalk." Power induction is guarded against by careful survey of the route before laying the cable, by suitable transpositions in the power lines themselves, by bonding on electrified railways, and by selective interconnection of the conductors of the cable at joints, to balance the conductor capacities to earth. Interference from power plants is reduced to a minimum by separating power supply circuits from speech circuits and by the insertion of filters on the power supply leads. Reduction of telegraph interference is effected by the use of " noise killers " which are sometimes referred to as " shaping circuits." They consist of low-pass filters to suppress the high frequency components of the telegraph wave which are most serious in causing interference. Crosstalk is reduced to a minimum by careful adjustment of the speech levels, by balancing the internal capacities in each quad, and by special attention to the inductance and resistance balances of loading coils as well as by taking care to keep the conductor resistance of the cable itself balanced. Special care has to be taken in the lay-out of repeater stations and in the design of repeating coils, as well as in the arrangement of supply circuits both low tension and high tension, since these are always common to a large number of repeaters.

The question of atmospheric interference has been left to the last, since it is a very special problem in itself. During certain periods of the day and year, the interference by atmospherics coupled with fading in the signal strength, is sufficient to render the circuit entirely inoperative. To reduce this inoperative period to a minimum, special precautions are taken in the choice of wave lengths, in the location of the transmitting and receiving stations, in the type of antennæ, in the type of modulation process and in the operation of the circuit, to ensure that the maximum ratio of signal to noise is always obtained. Generally speaking it is always possible at any one time to choose such a wave length that satisfactory communication can be established, and this with a total use of only two or three wave lengths. The removal of the receiving station in England from Wroughton, Somersetshire, to Cupar, Scotland, was brought about purely on account of the better reception; and for the same reason the receiving station in America was located at Houlton, Maine.

Directional antennæ are used both for transmission and reception, and are an important factor in increasing signal strength and in reducing noise. The single side-band system of transmission in use at Rugby, in conjunction with complete carrier elimination, enables the highest degree of selectivity to be used in the receiving system, combined with maximum radiation of energy at the frequencies carrying the speech characteristics. In the operation of the circuit, precautions are taken to ensure that the radio transmitter is always fully loaded, irrespective of the strength of the speaker's voice, so that the maximum received field strength is always obtained.

Mr. Nash said that the evolution of radio links had now reached such a stage that the terminals of such a connection could be regarded in exactly the same way as the terminals of a land line connection—both from a technical and from an operating point of view. It was of course evident that, since radio links are usually costly, they should be operated on a similar basis to a high price long distance circuit, with maximum economy in line time. From a technical aspect, no two points on the earth are so remote from one another that it is impossible to connect them by long distance telephone. Obvious economic limitations of supply and demand up to now have prevented the installation of many very long circuits. The circuit which was recently set up between Stockholm and New York is an example of the possibilities of long distance communication. This circuit was 22,400 kms. long and was made up as follows:—

10,400 kms.		of Extra Light Loaded Cable.
4,700	,,	Radio Link.
6,850	,,	of Open Wire Line.
314	,,	of Submarine Cable.

It was equipped with 138 four-wire repeaters, 24 carrier repeaters, six cord-circuit repeaters and eight echo suppressors, including the special voice-operated switching device at London and New York.

He proceeded to consider how many simultaneous communications could be made over a single pair of wires. In any available telephone circuit of a type consisting either of aerial lines or short cable lines there is available for transmission purposes a frequency range extending from zero, or a few cycles per second, up to 30,000 cycles per second. Various communication systems have been designed to enable the maximum use to be made of this frequency range. These systems comprise:—(1) The Composite Telegraph System, which is superimposed on the telephone system and occupies the frequency range from 0—80 cycles. (2) The Carrier Telegraph System which occupies the frequency range from 3000 to 10,000 cycles. (3) The Carrier Telephone System which occupies the frequency range from 5000 to 30,000 cycles.

(1) *The Composite System*, on an open wire telephone circuit, provides two independent earth return telegraph channels. The speed of transmission over each channel may be up to 25 cycles per second, or approximately 60 words per minute, Morse, and by the use of the ordinary telegraph duplex balance, the transmission may be in two directions simultaneously.

As the use of telephone ringing current falls within the range 0 to 80 cycles, it is not permissible over a Composited circuit, since it would interfere with the telegraph; therefore it is necessary to insert special Composite Ringer apparatus on the Exchange side of the line repeating coils in all cases where the telephone signalling is by 16 cycle currents. The Composite Ringer translates the outgoing 16 cycle ringing current from the exchange to a higher frequency, frequently 135 or 500 cycles, and transmits this over the line. Similarly, it translates incoming calling signals from the line and transmits 16 cycle current to the exchange.

(2) *The Carrier Telegraph System* provides 10 independent telegraph channels in both directions, each channel being capable of transmission at a telegraph speed of 40 cycles per second. In carrier telegraphy, the currents are more severely attenuated than in the case of direct current telegraphy, and carrier telegraph repeaters must be provided to compensate for the increased attenuation. These repeaters have been designed so that their spacing will correspond with the telephone repeater spacing on the line, and it is thus possible to accommodate the telegraph repeaters in buildings already housing telephone repeaters.

(3) *Carrier Telephone Systems* provide one, three, or more channels over an open wire line or short underground or submarine cable which may be already in use for the usual purposes, *e.g.*, voice frequency telephony and composite telegraphy. From a trunk exchange operator's point of view there is no difference between a carrier circuit and any ordinary trunk circuit. The subscriber will notice only that the carrier circuit is free from the noise usually found on open wire trunk lines. The carrier equipment required can be classified roughly as carrier terminal equipment or carrier repeater equipment. At carrier terminals, the speech frequencies received from a subscriber's set are used to modulate the carrier frequency. Modulation has the effect of converting the speech frequencies to higher frequencies, and it is the latter which are transmitted along the line. At the receiving terminal, the high frequencies are " demodulated " or detected and thus brought back to their true place in the frequency scale. By moving the frequencies resulting from several subscribers' lines to different parts of the frequency scale, it is possible to provide several conversation channels on the same pair of wires. Separation between the frequencies resulting from the different conversations is effected by means of electric wave filters, each designed to pass a band of frequencies and to eliminate all others.

Carrier repeaters are used on lines where the attenuation is too great to permit of the use of terminals only. They have been designed so that their spacing corresponds with the usual spacing of voice frequency repeaters.

Although it might be thought that carrier apparatus must be comparatively expensive, it is found in practice to be otherwise. In many cases, particularly for distances greater than 200 miles, it is cheaper to instal and maintain carrier systems than to provide and maintain additional pairs of wires to give the same facilities. Indeed, a single channel system has proved to be the more economical for distances as short as 40 or 50 miles.

The following cases were then described :—

Case 1.

One normal telephone circuit.
Two composite telegraph circuits.
Three carrier telephone circuits.

A total of four telephone and two telegraph circuits.

Case 2.

One normal telephone circuit.
Two composite telegraph circuits.
Ten carrier telegraph circuits.

A total of one telephone and twelve telegraph circuits.

Case 3.

One normal telephone circuit.
Two composite telegraph circuits.
Three carrier telephone circuits.
Two carrier telegraph circuits.

A total of four telephone circuits and four telegraph circuits.

All the above telegraph circuits can be worked duplex.

In the first two cases these services can be operated at the same time without much difficulty, but in the third case careful consideration is necessary to ensure the location of the carrier telegraph channels in a range where they will not interfere with or be interfered with by the carrier telephone channels, and it is probable that they will be restricted to the range 3000 to 5000 cycles per second.

In the lecture room were set up two terminal equipments connected by a pair of wires and equipped with ordinary telephone sets, two composite telegraph channels, one carrier telephone channel and one carrier telegraph channel. By operating them all separately and then simultaneously, but only receiving one at a time, their simultaneous operation without interference was demonstrated.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

THE Annual General Meeting of the Institution was held at the Institution of Electrical Engineers, London, on Tuesday, May 14th, 1929. The Chair was taken by the President, Col. Sir Thomas F. Purves, M.I.E.E.

The Secretary read the report of the Council for the year 1928-29 and the reference to the honour of Knighthood recently conferred on Sir Thomas F. Purves by H.M. the King was received with enthusiasm. The Annual Statement of Accounts was presented by the Hon. Treasurer, Mr. C. J. Mercer. Mr. P. J. Ridd moved and Mr. A. O. Gibbon seconded that the Annual Report and Statement of Accounts be accepted and the meeting carried the resolution unanimously.

Mr. B. O. Anson moved that a vote of thanks be passed to the retiring members of Council and drew attention to the fact that this resolution was tinged with more than the usual regret as Mr. A. L. DeLattre was retiring from the Chairmanship of the Council after seven years of office. On behalf of the Council he thanked Mr. A. L. DeLattre for the skill, courtesy and leadership which had characterised his occupancy of the chair. Mr. W. A. Satchwell seconded the resolution which was carried with acclamation, and Mr. A. L. DeLattre replied.

The President then presented the medals for the Session 1927-28 as follows:—

Senior Silver Medals to Mr. A. H. Jacquest, A.M.I.E.E., and Mr. L. H. Harris, M.Sc. (Lon.), A.C.G.I., for their Paper on "Sparking and Arcing at Relay Contacts and the use of Spark Quench Circuits."

Senior Bronze Medal (in absentia) to Mr. C. Robinson, B.A., A.M.I.E.E., for his Paper on "The Submarine Link in International Telephony."

Junior Silver Medal to Mr. C. W. Brown, A.M.I.E.E., for his Paper on "The Director in Automatic Telephony. Its Application and the functions performed."

Junior Bronze Medal to Mr. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E., for his Paper on "Satellite Working in Automatic Telephone Areas."

The President then presented the Booth-Baudot Award of £5 and Certificate for the year 1928 to Mr. R. L. Ryan, Portishead Radio Station, for his suggestion "Method of Keying Tuning Fork Controlled Radio-telegraph Transmitters."

The meeting closed with the announcement by the President of the names of the Chairman and Vice-Chairman of the London Centre for the year 1929-30 as follows:—

Chairman—Mr. A. B. Hart, M.I.E.E.
Vice-Chairman—Mr. T. Cornfoot, M.I.E.E.

The Annual Meeting was followed by a meeting of the London Centre at which a very interesting lecture, illustrated by many slides, was given by Mr. F. Addey, B.Sc., F.R.A.S., entitled "The Royal Observatory, Greenwich."

LIST OF PRINTED PAPERS ISSUED DURING YEAR 1928-29.

No. 116. "The Director in Automatics. Its Application and the Functions performed," C. W. Brown, A.M.I.E.E.

No. 117. "The Submarine Link in International Telephony," C. Robinson, B.A., A.M.I.E.E.

No. 118. "Sparking and Arcing at Relay Contacts and the use of Spark Quench Circuits," A. H. Jacquest, A.M.I.E.E., and L. H. Harris, M.Sc. (Lond.), A.C.G.I.

No. 119. "The Problem of the P.B.X. connected to an Automatic Public Exchange," C. W. Brown, A.M.I.E.E., and R. J. Hines, B.Sc.

No. 120. "Satellite Working in Automatic Areas," F. I. Ray, B.Sc., F.H.D., A.M.I.E.E.

COUNCIL FOR THE YEAR 1929-30.

The constitution of the Council for the year 1929-30 is as follows:—

Chairman—Mr. E. H. Shaughnessy.
Honorary Treasurer—Mr. C. J. Mercer.
Representing Staff of the Engineer-in-Chief's Office—
Mr. B. O. Anson and Capt. J. G. Lucas.

Representing Executive Engineers—
London: Mr. J. Cowie.
Provinces: Capt. N. F. Cave-Browne-Cave.

,, Asst. & Second Class Engineers—
London: Mr. P. G. Hay.
Provinces: Mr. A. E. White.

,, Chief Inspectors—
London: Mr. J. N. Hill.
Provinces: Mr. W. A. Satchwell.

,, Clerical Staff—
London: Mr. E. H. M. Slattery.
Provinces: Mr. A. C. Smith and Mr. H. Willcock.

,, Inspectors—
London: Mr. N. Layton.
Provinces: Mr. Thos. Davidson.

,, Draughtsmen—
London and Provinces: Mr. R. J. Stewart.

Secretary—Dr. R. V. Hansford.

ESSAY COMPETITION, 1928-29.

The Judges have reported to the Council that the Prize Winners in the recent Essay Competition, arranged in order of merit, are as follows:

1. G. Franklin, E.-in-C.O.
   "Modern Theories of Electricity and Magnetism."
2. F. E. Wright, Repeater Station, Marks Tey.
   "Telephone Transmission Measurement on Repeater Circuits."
3. C. H. Hartwell, Brighton.
   "Maintenance of Subscribers' Apparatus in Automatic Areas."
4. N. V. Knight, E.-in-C.O.
   "Radio Methods in Telegraphy and Telephony."
5. W. H. Owens, Holborn Exchange.
   "General Analysis of Faults in a Director Automatic Exchange."

The Council has decided to award Certificates of Merit to the following four competitors who were next in order of merit:—

6. R. E. Gray, Reading.
   "Photo Copying and the Post Office Eng. Dept."
7. S. B. Iles, Manchester.
   "The Preparation of Development Schemes."
8. W. E. Everson, Repeater Station, Aldeburgh.
   "Landing the Shore End of a Submarine Cable."
9. H. Chapman, Testing Branch, Fordrough Lane, Birmingham.
   "The Study of the Oak."

There were 45 entries, and the Judges reported that although the number of essays submitted is smaller than in previous years the quality of the essays recommended for prizes and certificates is fully up to former standards.

R. V. Hansford,
Secretary.

May, 1929.

LOCAL CENTRE NOTES.

LONDON CENTRE.

The final meeting of the Session was held on May 14th, when Mr. Frederick Addey, B.Sc., F.R.A.S., gave a lecture on "The Royal Observatory, Greenwich." This lecture, specially arranged in connexion with a visit to the Observatory two days later, was most delightful and instructive. By means of an excellent series of lantern slides and lucid exposition Mr. Addey conducted his audience over the Observatory.

The hearty vote of thanks at the close of the meeting was a well-deserved tribute to the excellence of the lecture.

Informal Meetings.

The fifth Informal Meeting was held on March 26th, when Messrs. H. T. Bines and D. C. Maddocks gave an illustrated lecture entitled "Tandem and Holborn; Construction and Maintenance" before a large audience. The many problems of "Tandem and Holborn" were very ably dealt with and a good discussion ensued.

The final Informal Meeting was held on 23rd April, when Mr. B. Lynn gave an illustrated lecture on "Straightforward Junction Working." Mr. Lynn showed that he was thoroughly conversant with the development of "Straightforward Junction Working" and the large audience and subsequent discussion proved the keen interest that was aroused. Mr. Lynn ably replied to the many points raised and a hearty vote of thanks closed another successful Session.

Visits.

The Royal Observatory, Greenwich.

A visit was made on May 16th, the party being met and addressed in the Octagonal Room by the Astronomer Royal, Sir Frank Dyson. The party was then divided into groups and conducted over the Observatory.

The visit was interesting and instructive and this, together with the lecture two days earlier, made one more able to appreciate the value of the Observatory to us as a maritime nation.

T.H.

SCOTLAND EAST CENTRE.

Session 1928-29.

At the November meeting, Mr. E. J. Woods, A.M.I.E.E., read a paper on "The Main Underground System of Great Britain." The paper has already been referred to in the Journal. Mr. Woods, in a masterly reply dealing with various points raised in a keen discussion, furnished much useful information outlining Departmental policy.

At the January meeting, Mr. J. H. Douglas read a paper entitled "Notes on Battery Course—May, 1928." Included in the points dealt with were:—The necessity for a Technical Instruction on the subject; Diversity of opinion as regards theory and actual maintenance of lead accumulators; Future growth of secondary cell plant and training of staff; Necessity for complete discharge of cells; Oil on Electrolyte; Cadmium Test; Installation by direct labour; Standardisation of Secondary Cells; Distribution of current in cells; Cause of buckling of plates; Wood separators; Discharge frame; Counter E.M.F. batteries; Plantè and Faure plates; Details of faults, and visit to Messrs. Harte's Works. Mr. Douglas provided some valuable notes on Secondary Cell Maintenance for use by men in charge of small battery plants. The various points raised in the discussion were suitably answered.

Mr. H. Burgher's paper at the February meeting dealt with "Cabling and Cable Jointing." The paper was of a thoroughly practical nature and contained many useful suggestions and much constructive criticism. The improved results obtained from the fuller use of motor transport facilities during cabling operations were described, and the necessity for adhering to instructions relating to cable jointing was emphasised. In the evening, members visited "The Scotsman" Office. Much interest was taken in the power plant recently installed for petrol, paraffin or gas as an alternative to the City Electricity Supply, and in the tele-photo apparatus of M. Bélin, and also the Murray Multiplex column printing telegraphs, as well as in the general work of the production of an important daily newspaper. The skilful guidance of Mr. W. P. Morris, of "The Scotsman," was greatly appreciated.

An informal meeting was held in March, when short papers introducing the following subjects were read:—

"Electrolytic Testing," by Mr. J. T. Gillespie, A.M.I.E.E.

"Changing Ideas on Costing," by Mr. J. Lomax.

"Works Order Excesses," by Mr. E. J. Fraser.

Mr. Gillespie described the various tests, the apparatus used, the different conditions met with, and the points to be observed when preparing a record of the observations and the results obtained.

Mr. Lomax reviewed the faults and weaknesses of the old system and indicated the advantages of the costing system now in force.

Mr. Fraser directed attention to the detection and treatment of excesses and the necessity for the timeous formulating of applications for authority to enable the altered conditions to be considered and approved before any additional cost is incurred.

The concluding meeting of the Session was held in April, when Mr. R. Goodfellow contributed a paper on the "Training of Youths." The problem had been engaging the attention of educationists and employers of labour for a number of years and it was one always bristling with difficulties and generally difficult of solution. The real necessity for "Earnestness" on the part of youths was essential to success, and the cultivation of useful habits and the desirability of avoiding distraction were emphasised, The policy pursued by the Department was explained and it was felt that the modifications recently introduced would provide an organised scheme of education enabling any student starting at the lowest educational grade to proceed as far as his ability would take him. The new scheme was undoubtedly a step in the right direction.

The meetings were all well attended and hearty votes of thanks were accorded the lecturers.

SOUTH LANCS. CENTRE.

The 1928-29 Session was opened on the 15th October, 1928, with an address by the Chairman, Mr. W. J. Medlyn, in which, under the title of " Progress and Development in the Engineering Department," an interesting account was given of the activities of the Post Office, and the latest development in engineering practice. The address, which was greatly appreciated, was followed by a cinematograph film entitled " Voices across the Sea," giving an interesting description of the Anglo-American Telephone services.

At the second meeting, held on 12th November, 1928, a paper entitled " Automatic Telephony—Trunking and Grading " was read by Mr. H. P. Clyma. The paper opened with a very clear and concise explanation of the economic necessity of grading, and, with the aid of an excellent series of lantern slides, the lecturer gave an instructive description of the way in which trunking and grading are carried out in an Automatic Exchange.

The third meeting of the Session was held on 17th December, 1928, and Mr. H. M. Turner read a paper on " Secondary Cells." In view of the rapid increase in the amount of secondary battery plant, consequent upon the introduction of automatic switching and repeater working, the paper proved to be of exceptional interest and value. The author's presentation of the main points of his paper, illustrated by numerous lantern slides, was greatly appreciated. A valuable discussion followed in which representatives of several battery manufacturers also took part.

At the fourth meeting, held on 14th January, 1929, Mr. E. J. Woods, of the Engineer-in-Chief's Office, read a paper entitled " The Main Underground Trunk Cable System of the British Isles." This paper, which gave a very comprehensive summary of the growth of the main underground system and concluded with a survey of the recent changes of practice and policy in main cable design, evoked an interesting and useful discussion.

At the fifth meeting, held on 11th February, 1929, a paper was read by Mr. R. G. De Wardt on the " Wireless Beam System." The paper, which was illustrated by a number of lantern slides of the Grimsby Beam Radio Station, gave a clear outline of the principles of beam working, and the various practical problems which had to be dealt with in their application. A good discussion resulted.

The sixth meeting was held on 11th March, 1929, when Mr. E. S. Ritter, of the Engineer-in-Chief's Research Section, read a paper on " Picture Telegraphy." This gave a very clear description of the development of the various systems of electrical transmission of pictures, and the application of the photo-cell to such systems was demonstrated in an interesting manner. From the excellent series of lantern slides shown, and photographic prints displayed, members were able to see the wonderful strides made in this branch of Telegraphy during the last few years.

At the final meeting of the Session, which was held on 8th April, 1929, Mr. A. J. Aldridge, of the Engineer-in-Chief's Research Section, read a paper entitled " The Measurement of Sound and its application to Telephony." On account of its length, the paper had to be presented in a somewhat abbreviated form, but the main features were given by the author in a very interesting and instructive manner. Many important points were raised in the discussion which followed, and to these points the lecturer adequately replied.

SCOTLAND WEST CENTRE.

The fourth meeting of the Session was held in the Societies' Room, Royal Technical College, Glasgow, on 4th March, when a paper entitled " Notes on Battery Course, May, 1928," was read by Mr. J. H. Douglas, of the Edinburgh Central Automatic Exchange. The subject was dealt with in a clear and exhaustive manner and the questions raised indicated that it was of considerable interest to the members.

H.C.M.

NORTH WESTERN CENTRE.

The discussion of Mr. C. Coward's paper on "Unit Construction and Maintenance Costs (External) from Fundamentals," which was read on the 25th February, was resumed in St. George's Hall, Preston, on the 18th March, 1929.

The Chairman of the Centre (Mr. J. M. Shackleton, M.I.E.E.) presided.

The proceedings were opened by the Vice-Chairman (Mr. S. Upton, M.I.E.E.), who reviewed the salient points of the paper and suggested lines on which the discussion might usefully proceed. There was no lack of speakers, and although the meeting lasted for over three hours there were clear indications that the subject had by no means been exhausted when the meeting terminated. Mr. Coward suitably dealt with the points raised in the discussion.

The closing meeting of the 1928-29 Session was held on the 22nd April, 1929, when a paper entitled "Petrol Engines with special reference to the Electrical Circuits" was read by Mr. H. Horrocks.

Mr. J. M. Shackleton presided.

The paper was divided, broadly, into two parts; the first part dealing with the mechanical, and the second part with the electrical aspect of the subject.

Mr. Horrocks opened with a review of the evolution of the petrol engine, especially as applied to road vehicles. He then described the internal combustion engine on the four-cycle principle and passed on to a detailed description of the modern engine. The methods of ignition, etc., were given prominence and the general electrical details described at length.

LOCAL ORGANIZATION, 1929-30.

Chairman—Mr. J. M. Shackleton, M.I.E.E.
Vice-Chairman—Mr. S. Upton, M.I.E.E.
Committee—Messrs. A. S. Carr, R. A. G. Chambers, W. H. Lane, W. G. Morris, H. F. Perry and A. W. Whittaker.
Librarian—Mr. H. Howarth.
Secretary—Mr. D. Barratt, Superintending Engineers' Office, Cross Street, Preston.

D.B.

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8, Wellesley Place,
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A. T. Kingston, Esq., M.B.E., A.M.I.E.E.,
Office of the Chief Engineer,
Telegraphs & Telephones,
C.T.O.,
Colombo,
Ceylon.

A. J. Kellaway, Esq.,
Department of Posts and Telegraphs,
P.O. Box 366,
Pietermaritzburg,
South Africa.

CURRENT LITERATURE.

The Journal of the Instiution of Electrical Engineers. Vol. 67. No. 387. March, 1929.

Electrical Equipment of the Singapore Floating Dock. Ernest T. Williams, O.B.E., Member.

Note on Sheath Losses in Single-Core Single-Phase Cables. Professor W. Cramp, D.Sc., Member, and G. M. Harvey, Associate Member. Eddy current losses in pair of sheaths undergo a change as sheaths are removed from position of intimate contact.

A Critical Study of a Three-phase System of Unarmoured Single-Conductor Cables, from the Standpoint of the Power Losses, Line Constants and Interference with Communication Circuits. E. B. Wedmore, Member, P. D. Morgan, B.Sc. (Eng.), Associate Member, and S. Whitehead, M.A., Associate Member. Technical Report from the British Electrical and Allied Industries Research Association, with seven Appendices in which the problems are tackled mathmatically. In their conclusions, the authors state that on account of the complexity of specific problems, such as the separation to render negligible any interference between power and communication circuits, they are best solved experimentally, so that co-operative research between telephone and power engineers will no doubt be needed shortly. [*Certain tests in this direction have been carried out on the Bedford-Little Barford length of the power grid now erected.—Eds., P.O.E.E. Jnl.*]

Vol. 67. No. 388. April, 1929.

The Electrical Equipment of X-Ray Apparatus. L. G. H. Sarsfield, M.Sc., Associate Member.

The Continuously-Loaded Submarine Telegraph Cable. A. E. Foster, P. G. Ledger, Member, and A. Rosen, B.Sc. (Eng.), Ph.D., Associate Member. The earlier non-loaded type is referred to briefly and the more recent loaded type is treated in somewhat greater detail, special reference being made to the Fanning Island-Suva (Fiji) section of the Pacific Cable (1926). In the non-loaded cable, distortion and attenuation of signals may be reduced and the speed of signalling increased by increasing the section of the conductor, but there is a limit to this procedure. The discovery of high permeability alloys with low magnetising forces has made possible the loading of telegraph cables with consequent increase of signalling speed. A description is given of the method of treatment during manufacture and the method of applying the loading material to the conductor is described. The theory of transmission of impulses through loaded cables is briefly discussed and some details of the methods of testing during manufacture and after laying are given.

The Design of Transmitting Aerials for Broadcasting Stations. P. P. Eckersley, Member, T. L. Eckersley, B.A., B.Sc., and H. L. Kirke.

Thermal Transference in Transformer Coils. Report (Ref. E/T 27) of the British Electrical and Allied Industries Research Association.

Discussion on " A Generalised Analysis of the Triode Valve Equivalent Network." Paper by Mr. F. M. Colebrook, given in earlier issue, page 157 of Volume.

Precautions in the Use of Electrical Instruments. W. H. Lawes, B.Sc., Associate Member. Paper summarises precautions to be adopted in purchase, installation and use of electrical instruments, the errors to be expected and their control.

The Institution Annual Dinner, 1929. Report of.

The Part played by Mr. St. George Lane Fox Pitt in the Invention of the Carbon Incandescent Electric Lamp and the Modern Method of Electric Lighting. A. A. Campbell Swinton, F.R.S., Member.

Vol. 67. No. 389. May, 1929.

An Introduction to Researches on Circuit Breaking. E. B. Wedmore, Member, W. B. Whitney, Ph.D. (Eng.), Member, and C. E. R. Bruce, M.A., B.Sc. Report (Ref. G/T 34) of the British Electrical and Allied Industries Research Association.

The Anticipation of Demand and the Economic Selection, Provision and Lay-out of Plant (Telephone Systems). Captain J. G. Hines, Member. A description of the methods employed by the British Post Office in making telephone development studies, framing lay-out schemes and determining the economic period for which to provide plant. The paper was read in conjunction with another paper with the same title but applying to Power Systems, and the points of similarity and dissimilarity are discussed.

The Mathematical Theory of the Magnetic Field round a Circular Current and Allied Problems. Alexander Russell, M.A., D.Sc., L.L.D., F.R.S., Past-President.

Electric Lifts. L. Burdes, B.Sc. (Eng.), Student.

Control Equipment for Direct-Current Trains. J. W. Gibson, B.Eng.

Carrier Telephone Systems. J. A. H. Lloyd, M.Eng., Student. The paper outlines the trend of development in carrier telephone systems in the past, the practical application of these systems, and the working of carrier terminal, repeater and associated equipments, and then summarises the uses and advantages of these systems.

Phase Advancing, with particular reference to the Scherbius Shunt-Wound Advancer. C. J. O. Garrard, M.Sc., Student.

Journal of the American Institution of Electrical Engineers. March, 1929.

Study of Noises in Electrical Apparatus. T. Spooner and J. P Foltz. Descriptions of resonance types of sound analysers for the study of noises in gears, motors, etc.

A New High-Accuracy Current Transformer. M. S. Wilson.

Anomalous Conduction as a Cause of Dielectric Absorption. J. B. Whitehead and R. H. Mardin.

Telemetering. C. H. Linder, C. E. Stewart, H. B. Rex and A. S. Fitzgerald. The problem of transmitting instrument readings or their equivalents from one point to another.

Revolving Field Theory of the Capacitator Motor. Wayne J. Morrill.

Electrical Aids to Navigation. Robert H. Marriott. Electrical and magnetic aids to navigation by water and air are outlined.

Two - Reaction Theory of Synchronous Machines. R. H. Park.

Corona Ellipses. V. Karapetoff. A mathematical theory of the cyclograms of Corona obtained by a cathode ray oscillograph.

Losses in Armoured Single Conductor Lead-Covered A.C. Cables. O. R. Schurig, H. P. Kulhni, F. H. Buller.

Power Transmission and Distribution. Concluding report of the 1927-8 Sub-Committee, giving the latest data of the sub-committee on protection of transmission lines against lightning.

Carrier Current and Supervisory Control on Alabama Power Coy's system. W. I. Woodcock and E. W. Robinson. The experience of the company with carrier current telephony over power lines.

Flux Linkages and Electro-magnetic Induction in Closed Circuits. L. V. Bewley.

Decibel. The Name for the Transmission Unit. W. H. Martin. Summary tracing the evolution of the " Neper " and the " Bel."

Separation of Stray Load Losses in A.C. Generators. M. C. Holmes.

Insulation Tests of Electrical Machinery, before and after being placed in service. C. M. Gilt and B. L. Barnes. Ratios of test to working voltages are recommended for tests made on site after installation and periodically throughout the life of the plant.

Line-Start Induction Motors. C. J. Koch.

April, 1929.

Oscillographs for recording Transient Phenomena. W. A. Marrison. Two instruments and their performances are described and illustrated for recording very short or very long transients; they may be used in combination.

Vector Presentation of Broad-Band Wave Filters. R. F. Mallina and O. Knackmuss. Function of a broad-band wave filter of the iterative ladder type explained in terms of two characteristic vectors. Diagram shows the relationship between a mid-series and a mid-shunt structure.

Short-Circuit Testing on Alabama Power Coy.'s System. H. J. Scholz and C. B. Hawkins.

Transient Analysis of A.C. Machinery. Yu H. Ku.

The Condenser Motor. Benjamin F. Bailey.

Theoretical and Field Investigations of Lightning. C. L. Fortescue, A. L. Atherton and J.

H. Cox. A review of some recent methods of studying lightning phenomena. Theory of travelling waves along transmission lines with reflections at open and earthed ends is discussed. How surges are produced by lightning and the effect of earth resistance.

Power Factor and Dielectric Constant in Viscous Dielectrics. Donald W. Kitchin.

No-Load Induction Motor Core Losses. T. Spooner and C. W. Kincaid.

The Predominating Influence of Moisture and Electrolytic Material upon Textiles as Insulators. R. R. Williams and E. J. Murphy.

South Eastern Power and Light System. A. T. Hutchins.

Automatic Re-closing High-Speed Circuit Breaker. A. E. Anderson.

Automatic Mercury Rectifier Sub-stations in Chicago. A. M. Garrett.

Lightning. Progress in Lightning Research in the Field and in the Laboratory. F. W. Peek, Jnr.

Bushing - Type Current Transformers for Metering. A. Boyajian and W. F. Skeets.

The Post College Education of Engineers Edward Bennett, Chairman of the Committee on Education. Recommendations.

132-KV Shielded Potentiometer, for determining the accuracy of Potential Transformers. C. T. Weller.

Illumination Items. Centre fixture in residence lighting. Traffic Control. Industrial lighting practice. Helen G. McKinlay, W. T. Dempsey and A. D. Bell.

May, 1929.

Operating Experience with the Low Voltage A.C. Network in Cincinnati. F. E. Pinckard.

Electrical Equipment of Bar Plate and Hot Strip Mills. J. B. Ink.

Effect of Transient Voltages on Power Transformer Design. K. K. Palueff.

Street Railway Power Economics. J. A. Noertker.

Recent Development in Telephone Construction Practice. B. S. Wagner and A. C. Burroway. An abridgement of the paper in which are described recent developments in telephone construction practice which react to preserve the integrity of the sheath of lead-covered cable, thus decreasing insulation troubles due to moisture seeping through armour breaks and warding-off service interruptions.

Iron Losses in Turbine Generators. C. M. Laffoon and J. F. Calvert.

Cathode Ray Oscillograph Study of Artificial Lightning Surges on the Turners Falls Transmission Line. K. B. McEachron and V. E. Goodwin.

Lighting of Airways and Airports. H. E. Mahan.

The Fabrication of Large Rotating Machinery. H. V. Putman.

Electrical Features of the Kansas City New Water Works. Albert L. Maillard.

Fused Arcing Horns and Grading Rings: Design, Construction and Operating experience on 66,000 volt Transmission Lines of the Union Gas and Electric Co. Philip Stewart.

Arc Welding of Steel Buildings and Bridges. Frank P. McKibben.

Illumination Items. The present status of Light Sources and Window Material. A device for measuring Average Voltage.

BOOK REVIEWS.

" Alkaline Accumulators." By J. T. Crennel, B.A., and F. M. Lea, M.Sc. 132 pp. 10/6 nett. Longmans Green & Co.

The alkaline or so called nickle iron accumulator has developed rapidly of late years and is now proving a serious rival of the lead acid cell in some branches of industry. Very little technical information has hitherto been available regarding this type of cell and the publication of this book which the authors claim represents a summary of all the available information on the subject is therefore very welcome. The development, construction, manufacture, theory, characteristics, operation and maintenance are dealt with, much of it in a manner which makes it understandable to the purely practical man. A very fair comparison is also made of the relative merits and deficiencies of the lead acid and alkaline cell.

Although the book contains a large amount of very useful information one is left with the impression that there is still much to be learned before our knowledge of the alkaline cell is as extensive as that of the lead acid accumulator.

H.C.J.

" The A.B.C. of Storage Battery Management." By Ernest C. McKinnon, M.I.E.E. 121 pp. 3/6 nett. Chloride Electrical Storage Coy., Ltd.

Although some 70 years have elapsed since Plante commenced the classic experiments which were the nucleus of modern storage battery design, it is surprising to find that to many people with extensive knowledge of other branches of electrical engineering the behaviour of the secondary cell is shrouded in complete mystery. This is no doubt due to the paucity there has been of suitable literature on the subject, but Mr. McKinnon's publication should go a long way to remove any deficiency there may have been in this direction. The book treats the whole subject of secondary cell maintenance in a very understandable yet comprehensive manner and can be confidently recommended to all those in any way interested in secondary cells. It is of course confined to cells of the lead acid type.

H.C.J.

" Operational Circuit Analysis." Vannevar Bush, Eng.D. New York: John Wiley & Sons, Inc., 1929. London: Chapman & Hall, Limited. 22/6 nett.

The author of this book is to be congratulated on producing a work which contains, not only a general discussion, *ab initio,* of the Heaviside Operational Calculus, but also brings together in one text the modern developments of the subject, which can be found only in scattered papers and there accompanied by formidable mathematical difficulties.

It is now over forty years since Oliver Heaviside first began to publish his classical *Electrical Papers* and with them his operational methods of solving the differential equations of electric circuit theory. His methods met with a certain success—the kind that the French term a *succès de scandale.* Many engineers regarded his conclusions as absurd, whilst mathematicians were bewildered by the eruption in his proofs of mysterious operators such as $\sqrt{\frac{d}{dt}}$. The result was that Heaviside's great work was nearly forgotten and unused for many years. But, as the author points out in his first chapter, the modern developments of electrical engineering have resulted in circuit and field problems becoming inherently more difficult to analyse and requiring for their solution mathematical methods similar to those invented by Heaviside.

The first part of the book deals with the mathematical theory of the direct operational method, where the Heaviside operational equation is interpreted as a solution of an infinite integral equation of the Laplace type. Heaviside was the first to recognise this equivalence; he did not, however, make much use of it in his researches. The author developes the subject rigorously and produces a delightful looking theory. Trouble arises, however, as soon as this theory is applied to practical circuit or field problems. The infinite integral equations which arise can only be evaluated by advanced mathematical methods—methods which are, through human fallibility, as likely as not, to give the wrong answer. Of course, one may follow the author's advice of referring to a table of infinite integrals and then transforming into the desired form. But for the reader to use a formula without understanding it, or without ever having understood it, and then to transform this formula, savours very much of an unintelligent faith in Mumbo Jumbo. Heaviside made no pretence to rigorous formalism, but allowed only physical, geometrical and analytical ideas to guide him. This is the essential difference between his methods and those of the " Infinite Integralists." This is a point that the author has apparently overlooked.

The author then deals with the application of the Fourier integral to electric circuit theory. The general method of solution is by contour integration in the complex plane and the calculus of residues. By this process it has been successfully applied to the solution of special problems. The author then discusses very briefly the theory of functions of a complex variable and shows the connection between the Fourier analysis and the operational method.

The reader will, no doubt, think it strange that the author when dealing with real variables finds it necessary to use the complex variable. Complex integration was introduced into operational theory by Bromwich and the idea has gained ground that the operational method is only an easy way of writing contour integrals. This, however, is not the case; the complex integral forms a convenient method of evaluating the Heaviside operators that apparently satisfies the æsthetic taste of the mathematical rigorist.

The book can be thoroughly recommended to readers. Te author has handled his subject in an able manner with the result that the book is very readable and in places even entertaining.

"Electrical Transmission and Distribution." Edited by R. O. Kapp, B.Sc. Sir Isaac Pitman & Son. Volumes V. and VI. 6/- each.

These volumes form part of a series of eight, of which Volumes I. and II. were reviewed in the last issue of this Journal, on the extensive subject of Electrical Transmission and Distribution.

The two volumes under review cover sub-station work, the first dealing with the construction and maintenance of the machinery used in modern practice, the second with the various types of sub-stations with a section on testing, maintenance and operation. Both volumes are divided into sections each written by an expert on the particular subject dealt with.

Volume V. comprises four sections on the following subjects: "The Construction of Transformers," "Converting machinery," "Mercury Vapour Rectifiers" and "The Handling, Care and Protection of Transformers" respectively. The theoretical side of the subject is not stressed in any section, the book being chiefly concerned with what are usually termed "practical" matters. The diagrams and illustrations, especially the latter, are very clear and are more profuse than is usual in technical books.

Volume VI. is divided into three sections, the largest dealing with "The Testing maintenance and operation of Sub-stations." This subject is dealt with more fully than the others and, forming the main part of the book, gives a lucid description of the latest methods employed.

The "Design and Lay-out of Sub-stations" is the title of a brief section, whilst the third section deals more fully with automatic sub-stations and their operation.

The clear diagrams and illustrations are a noteworthy feature of this volume also.

Both volumes are indexed.

J.B.

Kempe's Engineer's Year-Book for 1929. Crosby Lockwood & Son, London. 30/- net.

This year's issue, which forms the thirty-sixth edition, contains 3,264 pages, with over 3,000 illustrations, has a cubic content of 7″ × 5″ × 4″ and weighs about 5 lbs. avoirdupois. The mass is very considerable, but it is doubtful whether any part could be omitted if the opinion of the engineering world on the subject could be obtained and summarised. The book needs no introduction nor commendation to Post Office engineers, who have grown up in the knowledge and esteem of the author and who know the amount of skilled and classified labour that has been given to the compilation of the work.

There are some fifty sections which cover all branches of engineering practice, including one containing legal notes for engineers and an appendix of trade terms in English, French, Italian, Spanish and Russian. A very complete index is furnished, by means of which data on any subject can readily be found. A copy of the book should be on the shelves of every engineer whose interests are wider than his own immediate job; even the specialist will find some information on his own subject which he cannot carry in his head.

"The A.T.M. Telegraph Engineers' Handbook." The Automatic Telephone Manufacturing Coy., Ltd. Price 2/6.

This handbook is packed full of formulæ and figures and it will be found very useful to telegraph engineers as a book of reference.

The book is divided into nine sections, the first two of which deal with telegraph transmission theory. The third section deals with transient phenomena and is arranged in an attractive manner, the formulæ being deduced and not merely quoted. The fourth section deals with the theory and application of the A.T.M. Gulstad Relay. This is followed by a section dealing with Relay Testing sets. Sections 6 and 7 are technical descriptions of the A.T.M. Universal Duplex Unit and the Vyle Polarised Sounder respectively. Section 8 consists of a table of Exponential and Hyperbolic Functions. The last section is a list of the A.T.M. Telegraph products. The theoretical matter in the book has been ably dealt with, and the formulæ and illustrations are clearly reproduced.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Promotions.

Name.	Grade.	Promoted to	Date.
Hansford, R. V., D.Sc.	Acting Assistant Staff Engineer, Radio Section, E.-in-C.O.	Assistant Staff Engineer, Radio Section, E.-in-C.O.	17-4-29
Blight, W. O.	Executive Engineer, Equipment Section, E.-in-C.O.	Acting Assistant Staff Engineer, Equipment Section, E.-in-C.O.	1-4-29
Aspinall, H. O.	Assistant Engineer, N.W. (Extl.) Section, London District.	Executive Engineer, Centre (Extl.) Section, London District.	1-8-29
Smith, J. I.	Assistant Engineer, Middlesboro' Section, N. District.	Executive Engineer, Middlesboro' Section, N. District.	2-7-29
Ireland, W.	Assistant Engineer, Equipment Section, E.-in-C.O.	Executive Engineer, Inverness Section, Scotland East District.	5-9-29
Gray, H. C.	Assistant Engineer, Centre (Intl.) Section, London District.	Executive Engineer, Technical Section, S. Mid. District.	1-9-29
Hill, S. F.	Assistant Engineer, Equipment Section, E.-in-C.O.	Executive Engineer, Birmingham (Intl.) Section, N. Wales District.	1-7-29
Watkins, J. H., M.C.	Assistant Engineer, Technical Section, London District.	Executive Engineer, Bangor Section, N. Wales District.	1-7-29
Frost, P. B.	Assistant Engineer, Equipment Section, E.-in-C.O.	Executive Engineer, Equipment Section, E.-in-C.O.	24-4-29
Jacquest, A. H.	Assistant Engineer, Telephone Section, E.-in-C.O.	Executive Engineer, N. Ireland District.	26-5-29
Jones, L. J.	Assistant Engineer, Radio Section, E.-in-C.O.	Executive Engineer, N.E. (Intl.) Section, London District.	1-8-29
McKichan, J. J., O.B.E.	Assistant Engineer, Telephone Section, E.-in-C.O.	Executive Engineer, Lines Section, E.-in-C.O.	24-4-29
Banks, A. E.	Assistant Engineer, Manchester (Intl.) Section, S. Lancs. District.	Executive Engineer, Leicester Section, N. Mid. District.	1-7-29
Legg, Capt. J.	Assistant Engineer, Test Section, E.-in-C.O.	Acting Executive Engineer, Testing Branch, London.	24-4-29
Keyworth, F.	Skilled Workman, Class I., Telegraph Section, E.-in-C.O.	Inspector, Telegraph Section, E.-in-C.O.	
Sturges, A.	Skilled Workman, Class I., Testing Branch.	Inspector, Testing Branch.	To be fixed later.
Bull, R. S.	Unestablished Skilled Workman, Testing Branch.	Inspector, Testing Branch.	

Appointments.

Name.	From	To	Date.
Ackerman, H. M. W.	Probationary Assistant Engineer, S. Lancs. District.	Asst. Engineer, S. Lancs. District.	
Potts, E.	Probationary Assistant Engineer, E.-in-C.O.	Assistant Engineer, E.-in-C.O.	
Hibberd, W. A.	Probationary Assistant Engineer, E.-in-C.O.	Assistant Engineer, E.-in-C.O.	1-4-29
Luxton, W. G.	Probationary Assistant Engineer, E.-in-C.O.	Assistant Engineer, E.-in-C.O.	
Dallow, J. C.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	
Birch, S.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	
Joyce, R. M.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	
Stevens, E. C. C.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	
Wootten, L. G.	Probationary Insp., London District.	Inspector, London District.	
Partridge, F. V.	Probationary Insp., London District.	Inspector, London District.	
Lee, A.	Probationary Insp., London District.	Inspector, London District.	
Challinor, W.	Probationary Insp., London District.	Inspector, London District.	1-4-29
Collett, W. A.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	
Evans, T.	Probationary Insp., S. Lancs. Dist.	Inspector, S. Lancs. District.	
Sharpe, H. T. A.	Probationary Insp., London District.	Inspector, London District.	
McDougald, F. M.	Probationary Insp., N. Mid. Dist.	Inspector, N. Mid. District.	
Pengelly, R. H.	Inspector, Radio.	Postmaster, Helston.	4-4-29
Chandler, R. W.	Inspector, Grimsby Radio.	Assistant Traffic Superintendent.	14-4-29
Simpson, C.	Inspector, N. Ireland District.	Assistant Superintendent of Traffic.	28-4-29

Transfers

Name.	Rank.	From	To	Date.
Harding, R. W.	Executive Engineer	S. Mid. District.	E.-in-C.O.	1-9-29
Deane, W.	,,	N. Mid. District.	London, C.T.O. Section	1-7-29
Wanless, G. G.	Inspector	Scot. E. District	E. District.	2-3-29
Prosser, G.	,,	N. Wales District.	E.-in-C.O.	17-3-29
Wilson, G.	,,	S. Wales District.	,,	18-4-29
Dalton, A. W.	,,	N.W. District.	S.E. District.	14-4-29

Retirements.

Name.	Grade.	Districts.	Date.
Gwilliam, W. J.	Executive Engineer.	Testing Branch.	30-3-29
Appleby, C. W.	,,	London.	31-7-29
Peck, G. A.	,,	Northern.	1-7-29
Patrick, J.	,,	Scot. E.	31-8-29
Chandler, A. E.	,,	E.-in-C.O.	31-8-29
Richardson, G.	,,	N. Wales.	30-6-29
Dickson, J.	,,	N. Wales.	30-6-29
Laslett, G.	,,	N. Ireland.	1-7-29
Wells, R. A.	,,	London.	31-7-29
Steed, H. P.	,,	,,	30-6-29
Hansard, A.	Assistant Engineer.	S. Mid.	31-5-29
Latimer, F. D.	,,	S. East.	14-3-29
Holland, C. G.	Chief Inspector.	N. West.	31-3-29
Stevenson, R.	Inspector.	Scot. West.	27-3-29
Wells, R.	Inspector (Wireless Overseer).	Scot. West.	15-4-29
Lynch, F. F.	Inspector.	London.	19-4-29
Lambert, R. B.	,,	S. East.	23-4-29
Patrick, D.	,,	Scot. East.	3-5-29

Deaths.

Name.	Rank.	District.	Date.
Knox, W. G.	Inspector.	S. Mid.	28-2-29
Brackley, L. P. A.	,,	S. East.	21-4-29
Jones, J. C.	,,	N. Wales.	16-4-29

CLERICAL ESTABLISHMENT.

Promotions.

Name.	Grade.	Promoted to.	Date.
Knapman, W. C.	Clerical Officer, London District.	Higher Clerical Officer, London Dist.	1-4-29
Paine, F. J.	Clerical Officer, London District.	Higher Clerical Officer, London Dist.	1-4-29
Adams, W. F.	Clerical Officer, London District.	Higher Clerical Officer, London Dist.	1-6-29
Peck, H. W.	Clerical Officer, S. Mid. District.	Higher Clerical Officer, N. Ire. Dist.	1-5-29

Retirements.

Name.	Grade.	District.	Date.
Copp, S.	Higher Clerical Officer.	London.	31-3-29
Swansborough, R.	Higher Clerical Officer.	London.	31-3-29
Jenkins, W. A. S.	Higher Clerical Officer.	London.	31-5-29
Bell, J. G.	Higher Clerical Officer.	Scotland East.	19-5-29

APPOINTMENTS.

Name.	From	To	Date.
Petche, E. A.	Clerical Officer, E.-in-C.O.	Asst. Supt. of Traffic, L.T.S.	16-3-29
Wilderspin, G. H.	Clerical Officer, E.-in-C.O.	Asst. Supt. of Traffic, L.T.S.	16-3-29

DRAUGHTSMEN ESTABLISHMENT.

PROMOTIONS.

Name.	Grade.	Promoted to	Date.
Payne, R. P.	Draughtsman, Cl. I., E.-in-C.O. (acting).	Draughtsman, Cl. I., E.-in-C.O. (substantive).	29-9-28
Wakefield, E. T. R.	Draughtsman, Cl. II., E.-in-C.O.	Draughtsman, Cl. I., E.-in-C.O.	14-2-29
Dale, R. A.	,, ,,	,, ,,	14-2-29
Ackland, W. E.	,, ,,	,, ,,	14-2-29
Lipscombe, C. A. D.	,, ,,	,, ,,	21-4-29
Horne, F. H.	,, ,,	,, ,,	14-2-29
Deacon, T. A. F....	,, ,,	,, ,,	14-2-29
Shipley, E. C.	,, ,,	,, ,,	14-2-29
Gill, O. W.	,, ,,	,, ,,	14-2-29
Allport, A. W.	Draughtsman, Cl. II., N. Wales Dist.	Draughtsman, Cl. I., N. Wales Dist.	1-1-28
Turver, S. C.	Draughtsman, Cl. I., Ldn. Engr. Dist.	Senior Draughtsman, Ldn. Engr. Dist.	14-2-29
Tait, W. D.	Draughtsman, Cl. II., Scot. E. Dist.	Draughtsman, Cl. I., Scot. W. Dist.	21-5-29
Grierson, A.	Draughtsman, Cl. II., N.E. Dist.	Draughtsman, Cl. I., N.E. District.	5-5-29
Thorpe, W. R.	Draughtsman, Cl. II., London Engineering District.	Draughtsman, Cl. I., Ldn. Engr. Dist.	14-2-29
Faulkner, L.	Draughtsman, Cl. II., S.E. Dist.	Draughtsman, Cl. I., Ldn. Engr. Dist.	22-5-29
Thomas, E. W.	Draughtsman, Cl. II., S. Wales Dist.	Draughtsman, Cl. I., S. Lancs. Dist.	16-6-29

APPOINTMENTS.

Name	From	To	Date.
Craft, L. W.	Draughtsman, Unestd., E.-in-C.O.	Asst. Supt. of Traffic, Cl. II., L.T.S.	25-8-28
Tyzack, W. E.	Draughtsman, Unestd., E.-in-C.O.	Asst. Supt. of Traffic, Cl. II., L.T.S.	18-3-29
Hill, F.	Draughtsman, Cl. I., E.-in-C.O.	Architectural Asst., Grade II., Secretary's Office.	29-9-28
Devey, G. B.	Draughtsman, Cl. II., E.-in-C.O.	Probationary Inspector, London Dist.	1-1-29
Stevens, P. F.	Draughtsman in Training, E.-in-C.O.	Probationary Inspector, E.-in-C.O.	20-1-29

COMMUNICATIONS.

All Remittances and Communications should be addressed to the MANAGING EDITOR, P.O.E.E. JOURNAL, Engineer-in-Chief's Office, Alder House, London, E.C.1.

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