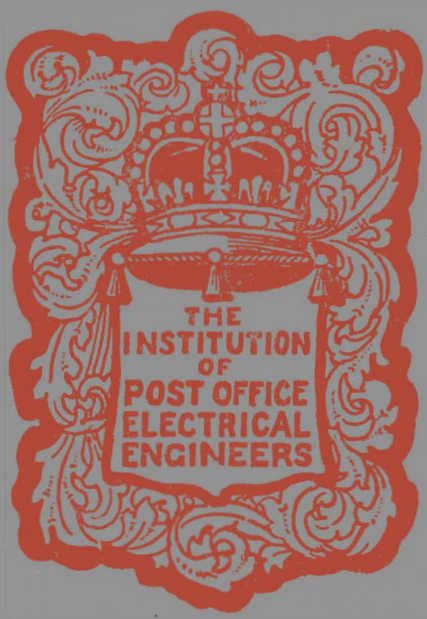
THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL



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OCT: 1925

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The Post Office Electrical Engineers' Journal.

A QUARTERLY JOURNAL.

CONTENTS FOR OCTOBER, 1925.

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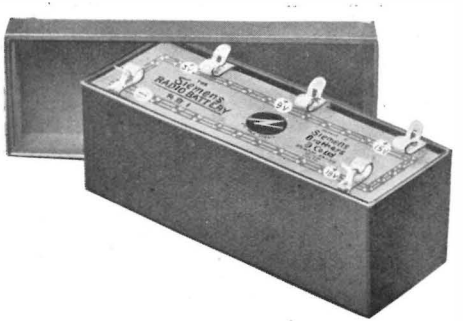

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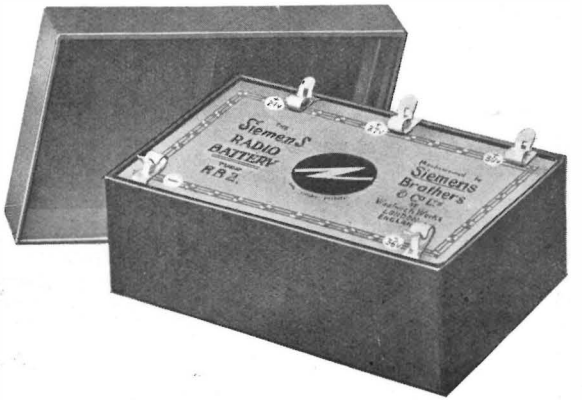

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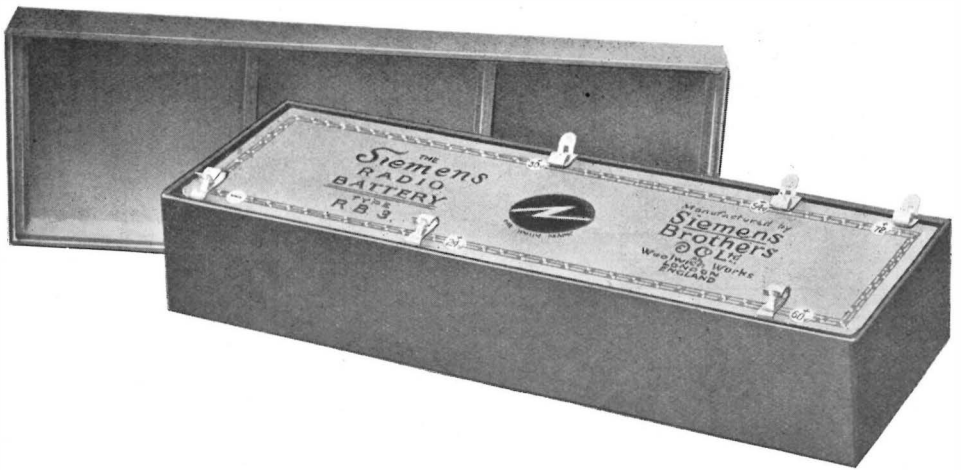

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A VOICE FREQUENCY TELEGRAPH SYSTEM.

By W. D. Hamilton.

In view of the development of underground networks much attention has been given of late to systems of telegraphic transmission designed for use over small gauge conductors, loaded or unloaded, in lead-covered paper-core cable.

A satisfactory system of this sort would enable aerial trunk telegraph routes to be replaced by cable and secure for telegraphs the benefits of the greater stability of the cable circuits. The use of cable pairs as loop telegraph lines would also reduce immensely the liability to inductive disturbance from high-voltage and heavy-current circuits.

To be successful such a system must meet the following requirements:—

(1) Offer efficient transmission to existing types of telegraph, such as Morse, Wheatstone, Creed, Baudot, etc.

(2) Heavy current impulses, with steep rises and falls, should not be used on the cable loop line.

(3) It is desirable, if the cable is to be shared by telegraph and telephone circuits, that the telegraph signals over the cable should consist of alternating-current of the same order of amplitude and frequency as used in the telephonic pairs.

(4) If the telegraph pairs are loaded with the same loading as the telephone pairs, requirement (3) becomes essential to secure efficient transmission.

Many names have been used to designate systems devised on these lines, such as—High-frequency telegraphy, Tone (or Tonic) telegraphy, Speech-frequency telegraphy and Voice-frequency telegraphy. The first term is indefinite and, in view of the frequencies used in Wireless, it cannot be regarded as properly

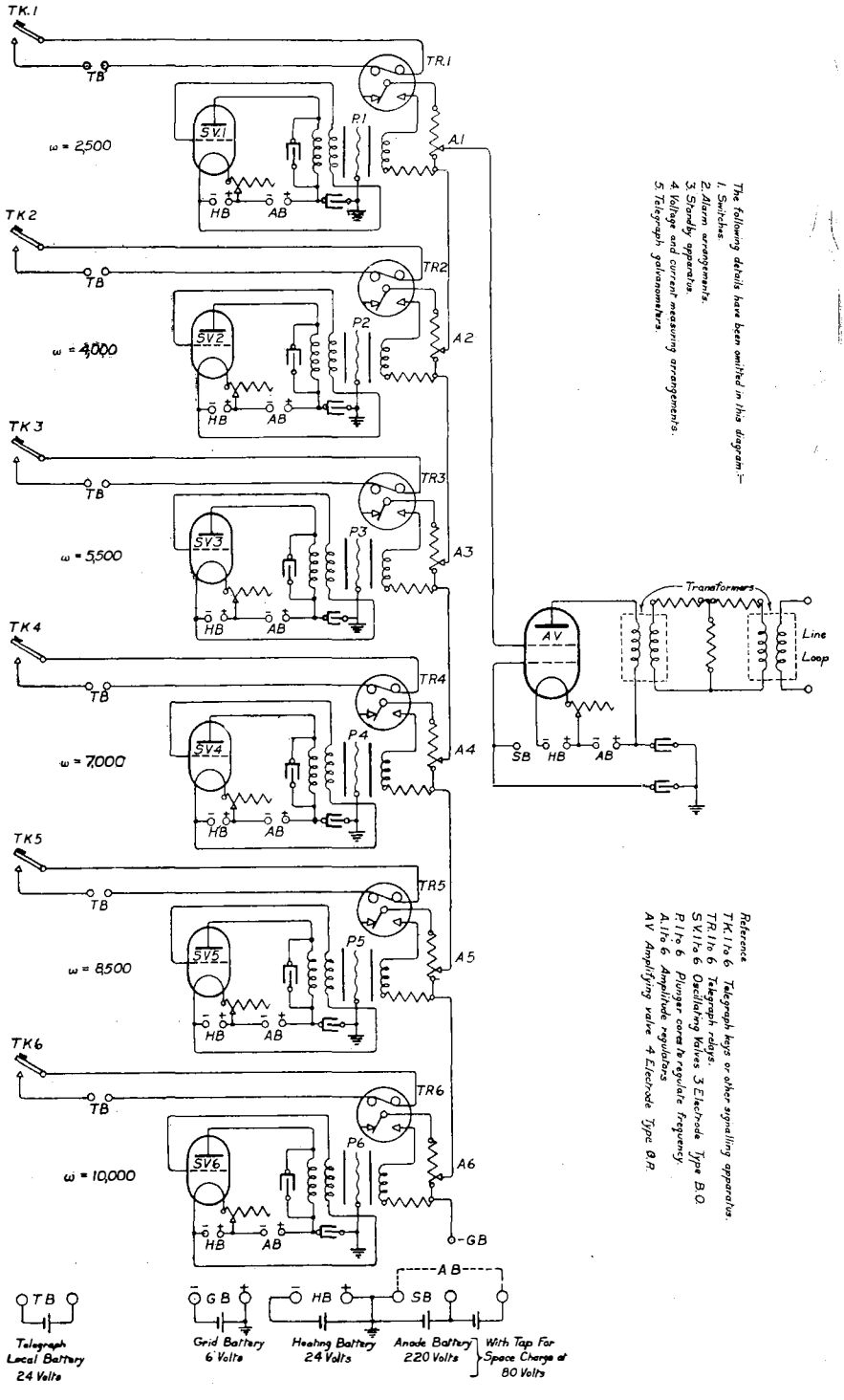


Diagram Ex. 20340.– TRANSMITTING END.

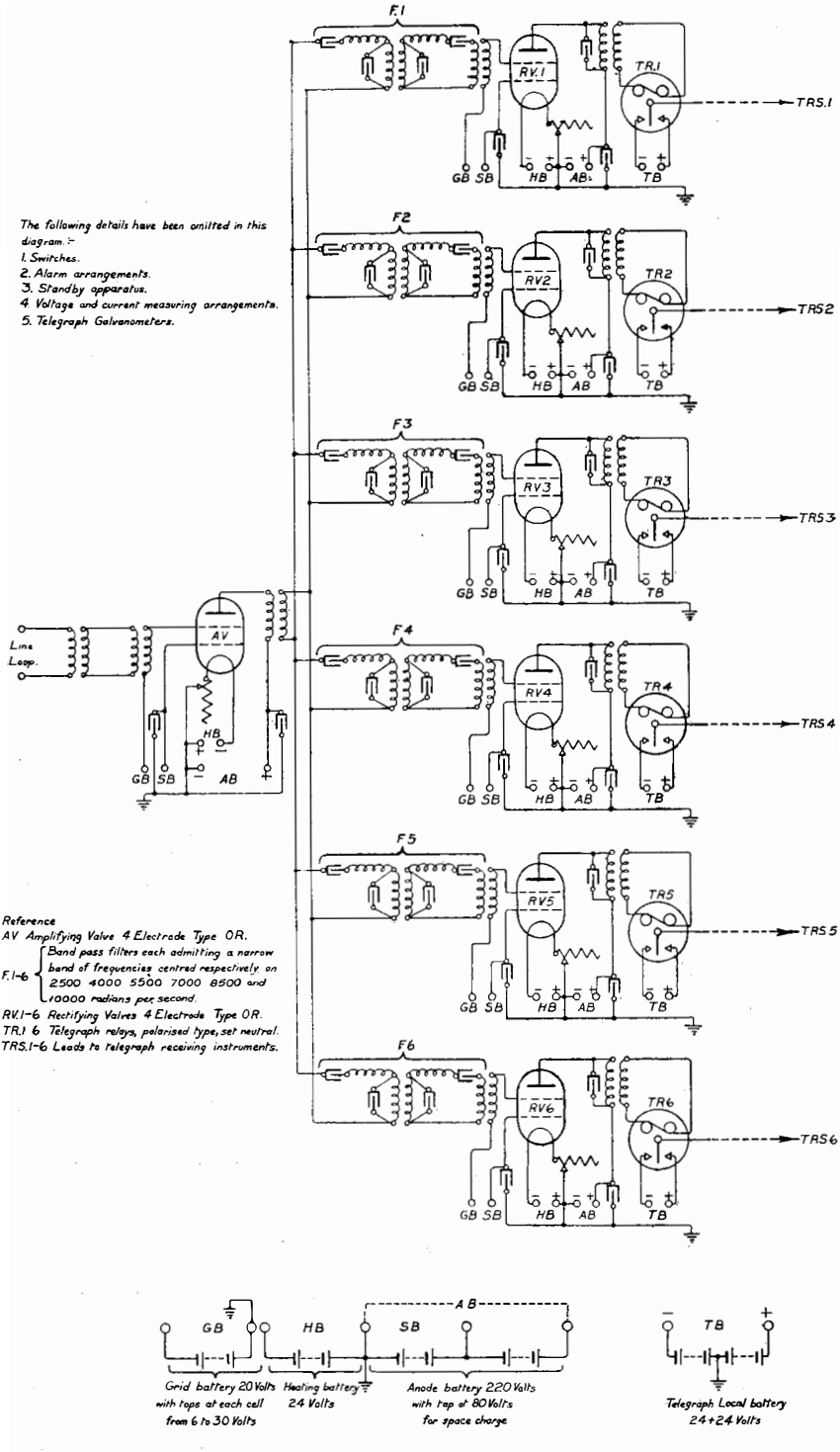


Diagram Ex. 20341.— Receiving End.

applicable to the frequency-range used in transmitting speech by normal methods of telephony. The last-named—Voice Frequency—is favoured in this country and may be accepted as likely to become the standard term in the British Post Office.

Messrs. Siemens & Halske have developed a voice-frequency system on these lines. One sender rack and one receiver rack, which, together with the battery equipment, form a complete unit of the system were obtained early this year for trial in the Telegraph Section, Engineer-in-Chief's Office. Thermionic valves are utilised as generators, as amplifiers and as rectifiers. Three-electrode valves serve as oscillators (generators) and four-electrode valves, having a high amplification factor and a low internal impedance, are employed as amplifiers and as rectifiers.

Although a figure of approximately 800 cycles per second is regarded as the average of the alternating currents of telephony, it is well known that these currents vary over a considerable range on both sides of that average. The upper and lower limits in speech do not call for discussion here, but it will be agreed that frequencies from half (400) to twice (1600) the average cycles per second are well inside the voice-frequency range. Within this band Messrs. Siemens & Halske's system provides six separate channels on one pair of cable wires. As arranged, these channels only work one way and another pair of wires are needed to give six channels in the opposite direction.

A general idea of the operation of the system may be gained from a consideration of the diagrams on pages 214 and 215.

Transmitting End.—See diagram Ex. 20340. A key, transmitter or other telegraph sender, TK_1, in the telegraph instrument room is connected by a local line or loop to a polarised telegraph relay TR_1 on the transmitter rack of the voice-frequency installation. This rack may be located with the receiving rack in the Test room, the Exchange basement or other convenient position where the alarm system with which it is fitted can command skilled attention.

A 3-electrode valve, SV_1, mounted on the transmitter rack, has a reactance coupling between its plate and grid circuits. The constants of the coupled circuits are selected so that the valve, when the heating and plate batteries are switched on, oscillates continuously at a frequency of

$$f = \frac{2500}{2\pi} = 400 \text{ cycles per second (approx.).}$$

The elements of the reactance coupling are not variable, but it is necessary to allow for a slight divergence between the point of maximum admittance of the corresponding filter at the receiving end and the frequency generated. To effect this an adjustable iron plunger, P_1, projects into the hollow centre of the reactance coils. Its movement is controlled by a knob on the front of the

rack, and by increasing or diminishing the extent of its projection into the coils the frequency generated may be slightly lowered or raised. The output coil of the oscillator completes its circuit *via* two resistances and the tongue and marking stop of the polarised telegraph relay TR_1. It follows that the output circuit is broken and takes no current unless the tongue of the relay is against the marking contact. One of the resistances A_1, termed the Amplitude resistance, forms part of the circuit between the grid battery and the grid of a 4-electrode amplifying valve AV. The amount of the amplitude resistance A_1 actually in the grid circuit may be adjusted by a sliding connection controlled by a knob on the front of the rack. By these means the frequency continuously generated by the oscillating valve SV_1 may be delivered to the grid of the amplifying valve AV in series of impulses corresponding to the " marks " from the telegraph key and the consequent closure of the tongue—marking stop circuit of the relay TR_1; the frequency generated may be varied with narrow limits and the amplitude of the alternating current input to AV may be controlled. In addition to the channel described there are five similar channels controlled by TK_2, TK_3, TK_4, TK_5 and TK_6 respectively. Each of these channels has, from telegraph relay to amplitude resistance inclusive, equipment on the transmitter rack similar to that on channel one. The constants of the reactance couples differ, however, and are of such value that valves SV_2, SV_3, SV_4, SV_5 and SV_6 give oscillations of 4,000, 5,500, 7,000, 8,500 and 10,000 radians per second respectively. The amplitude resistances A_2, A_3, A_4, A_5 and A_6 are in series with A_1 in the grid lead of the amplifying valve AV. Thus the depression of one or any combination of the telegraph keys closes the corresponding relays and results in a frequency, or an amalgamation of all or several of the frequencies being delivered to the grid of AV. On the release of any key the corresponding relay opens. The frequency or amalgamation of frequencies reaching AV is amplified and passes *via* an output transformer and a line transformer to the loop line and thence to the receiver rack of the distant Voice Frequency station, either direct, or, if necessary, through an intermediate valve repeater station.

Receiving End.—See diagram Ex. 20341. The frequency or amalgamation of frequencies arrives, attenuated, at the receiver rack, passing from the loop line *via* a line transformer and an input transformer, to an amplifying valve AV. The amplified output passes through an output transformer, across the secondary of which are teed six band-pass filters F_1, F_2, F_3, F_4, F_5 and F_6, each constructed to admit respectively a narrow band of frequencies centred respectively on the frequency generated by the oscillating valves SV_1, SV_2, SV_3, SV_4, SV_5 and SV_6 at the sending end.

Each filter terminates on the primary of an input transformer.

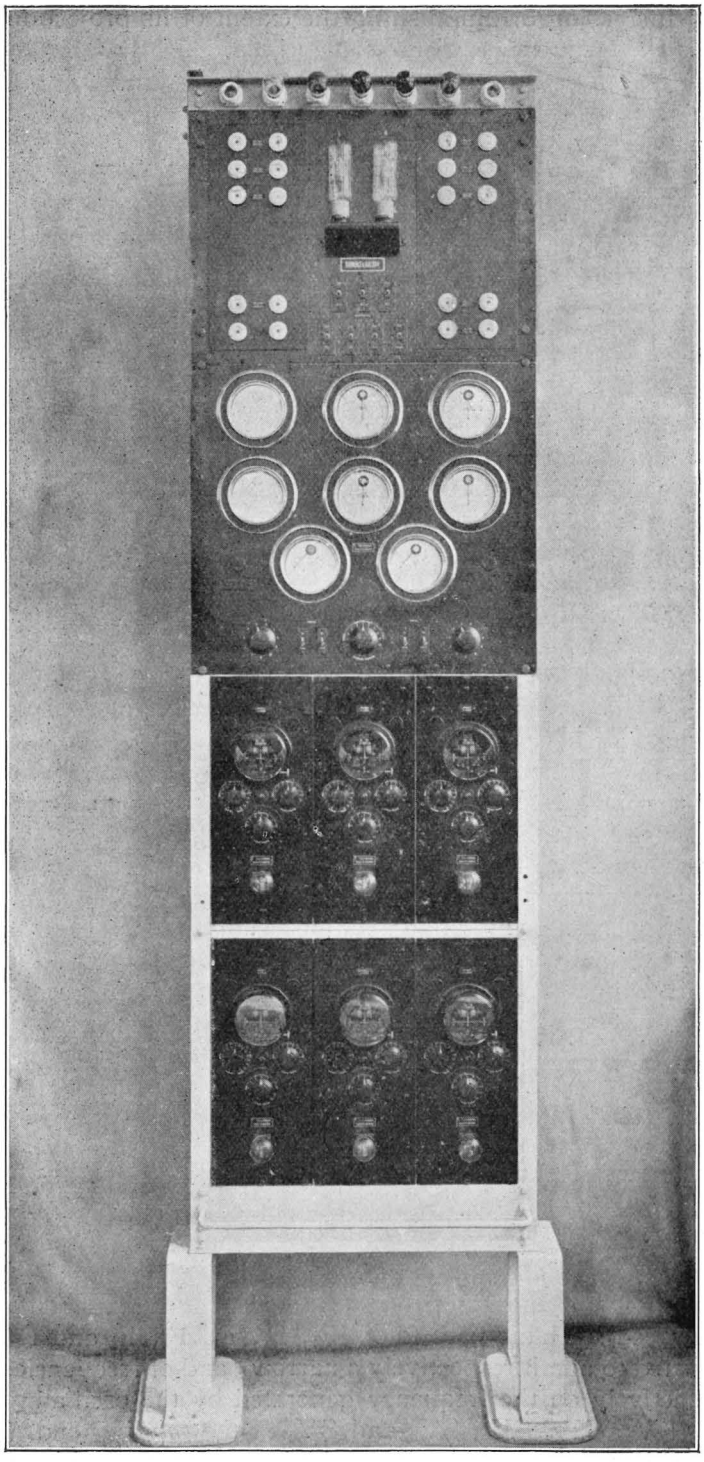
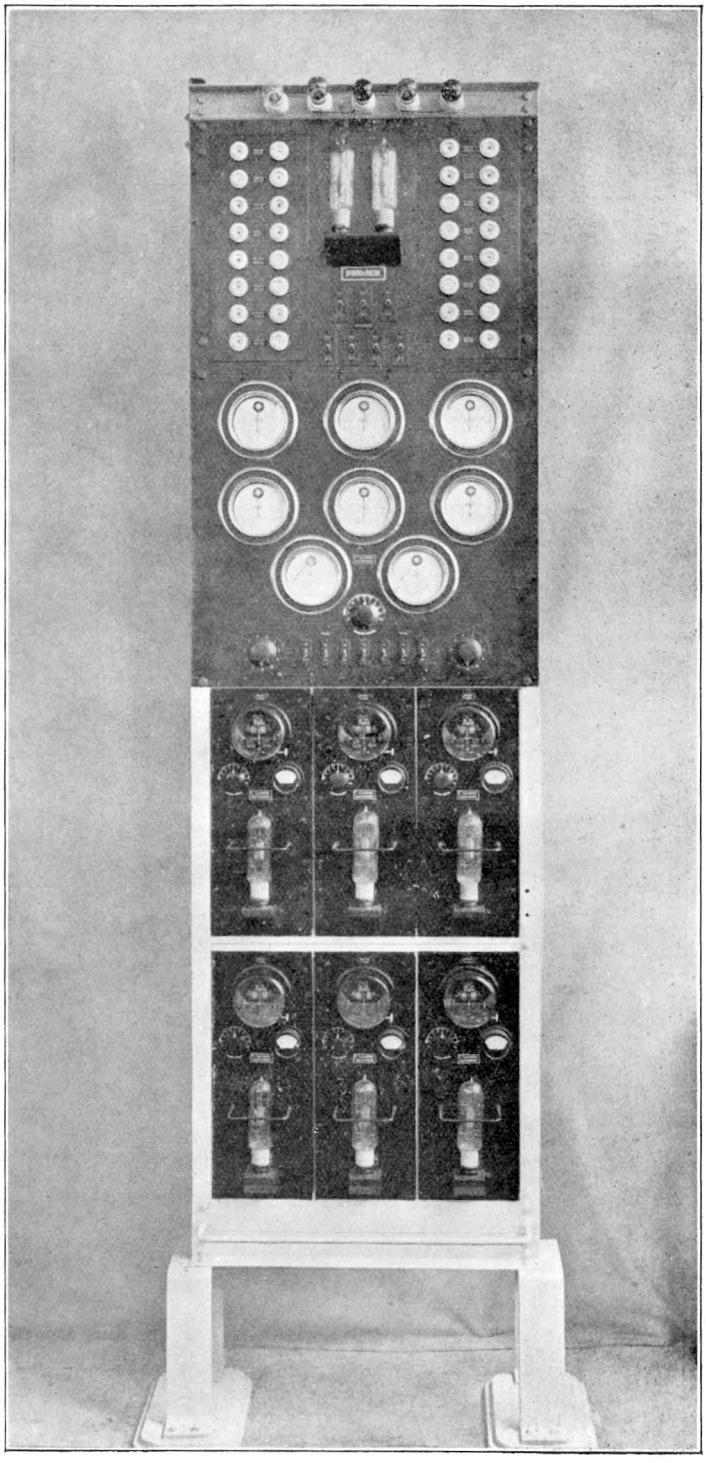


FIG. 1.—FRONT OF TRANSMITTER FRAME.



See Fig. 1.

Telegraph Relays.

Valve controls and Milliameter.

Rectifying Valves.

See above.

FIG. 2.—FRONT OF RECEIVING FRAME.

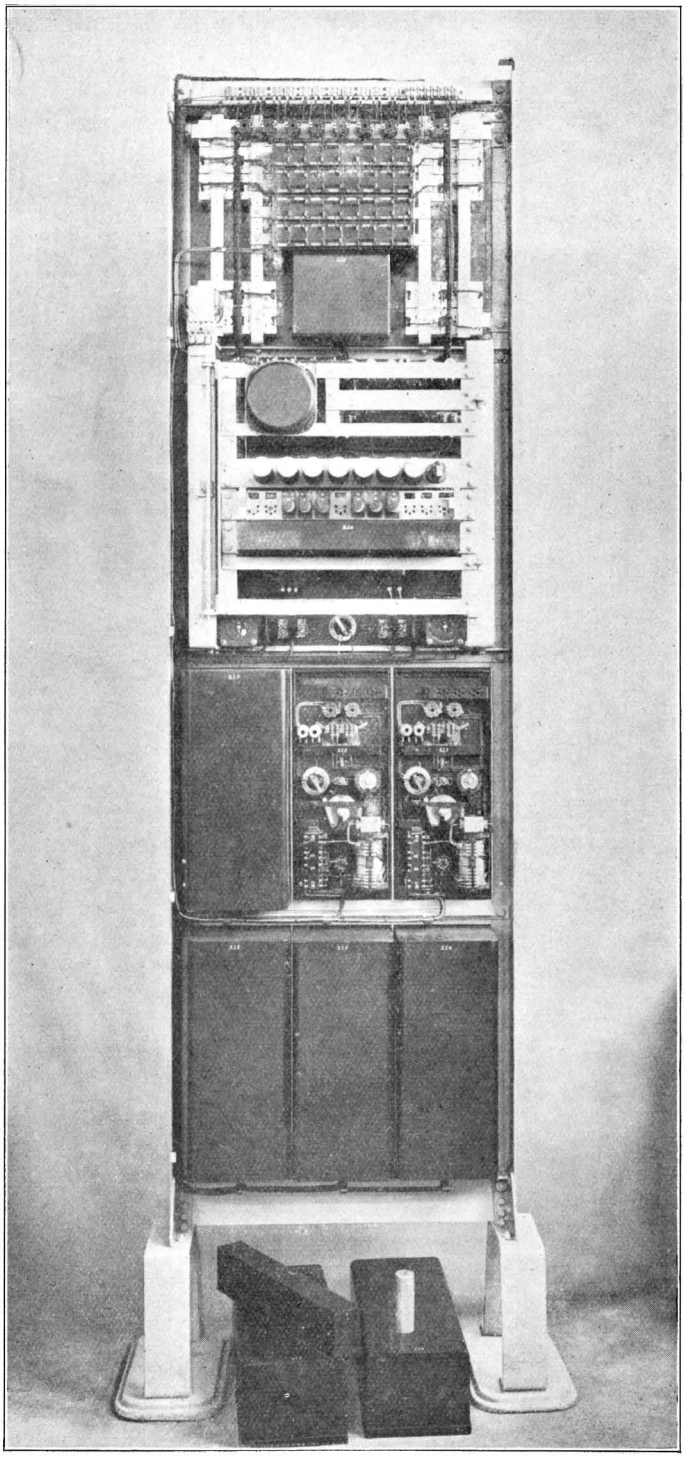


FIG. 3.—BACK OF TRANSMITTER FRAME.

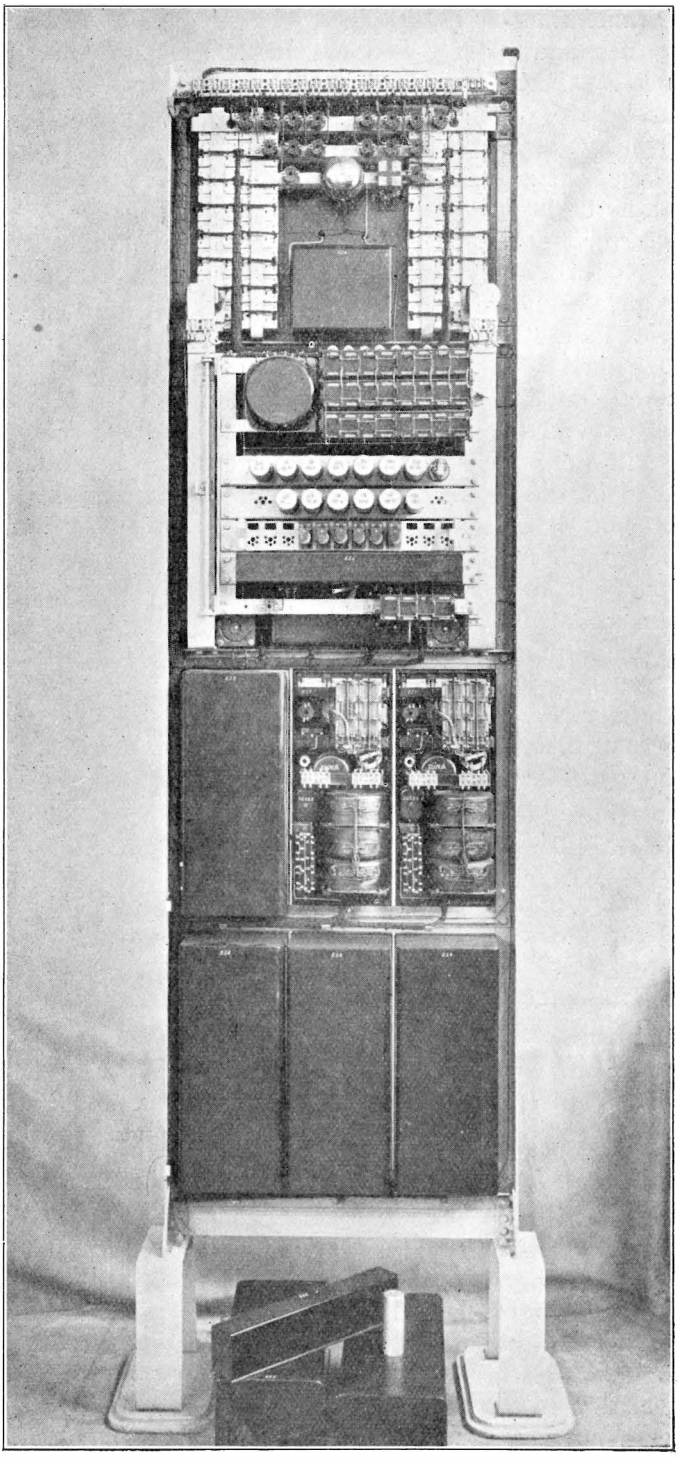


FIG. 4.—BACK OF RECEIVER FRAME.

Each transformer is thus open to receive one of the six filtered frequencies and pass it to the grid of the particular rectifying valve RV_1, RV_2, RV_3, RV_4, RV_5 or RV_6 connected to the secondary.

By means of a grid battery the grids of these rectifying valves are primed negatively to a point on the Characteristic Curve, where any additional voltage reaching the grid will be amplified, if positive, but suppressed, if negative. By this means the "gushes" of A.C., corresponding to the depression of, say, TK_1, which have been admitted by F_1 are rectified to undulatory current impulses in the output circuit of RV_1. The output transformer has its primary coil shunted by a condenser, the effect of which is to smooth out the undulations of current in the primary coil, leaving only a D.C. element to affect the secondary. Consequently there will be a single short impulse in the secondary at the initiation of the rectified current impulse in the primary and a single short impulse in the reverse direction at its termination. The telegraph receiving relay TR_1 is in series circuit with the secondary; its armature is set neutral and the relay is so connected that the initial impulse carries its tongue to the marking contact, while the terminal (reverse) impulse restores the tongue to the spacing side. The tongue of the relay is joined, by means of a local line, to the appropriate telegraph receiving apparatus TRS in the instrument room. The working of the other five channels is similar to that of the one described.

The appearance of the voice-frequency apparatus may be seen from the reproduced photographs. The top of the frames is approximately 9 feet 6 inches from the ground. Referring to Fig. 1 the top sections contains (1) a horizontal row of coloured lamps for alarm indicators; (2) 2 valves—the AV valve and its stand-by; (3) immediately below the valves 7 switches for connecting the anode voltage to each valve; (4) four vertical rows—two on right and two on left—of fuse mountings.

The second section of the frame carries six telegraph galvanometers, one ammeter and its rotary switch, one voltmeter and its rotary switch, a rotary switch (middle) for adjusting the filament current of the amplifying valve AV, and four keys for connecting up the heating circuits. The third and fourth sections each consist of three units of the oscillators. Each unit consists of (1) telegraph relay; (2) a rotary switch for regulation of the amplitude of the output; (3) a rotary switch for regulating the heating current of the adjacent valve; (4) a rotary handle for adjusting the frequency generated; (5) a three-electrode valve connected as an oscillator.

Referring to Fig. 2, the two top panels are similar to those of Fig. 1 save that there are more fuses and heating circuit switches. This is due to all valves on this frame being heated independently,

whereas the oscillator valves are heated with pairs in series. The third and fourth panels consist of the six rectifying units. The apparatus on each is (1) telegraph relay; (2) a rotary switch for heating current regulation; (3) a milliammeter for measuring the

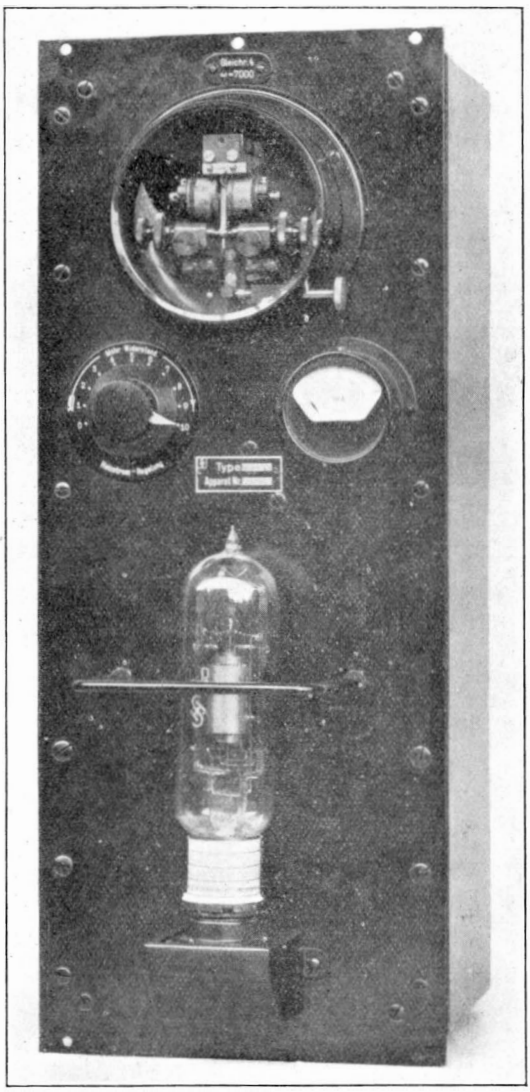


FIG. 5.—ONE UNIT FRAME OSCILLATING RACK OF TRANSMITTER FRAME.

output of the rectifying valve adjacent; (4) a 4-electrode valve functioning as a rectifier. Back view of the frames are shown on Figs. **3** and **4**, and views of a single oscillator unit and a single rectifier unit on Figs. **5** and **6**.

Wheatstone speeds of 100 words per minute have been attained on all six channels simultaneously over an artificial line equivalent to 24 s.m. of loaded cable. Using a repeater unit in the centre of the line similar results were obtained over 48 s.m. Unfortunately

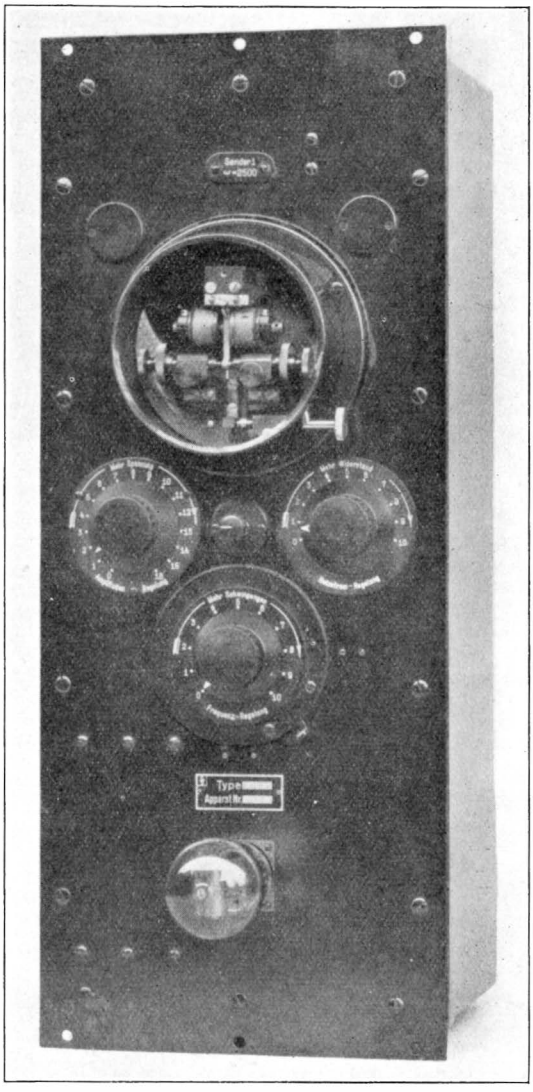


FIG. 6.—ONE UNIT FRAME RECTIFIER RACK OF RECEIVING FRAME.

building operations in T.S. made it necessary to vacate the Experimenting Room when the experiments were on the point of being carried to real lines. A new room is being provided and fitted and it is hoped to resume trials shortly.

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 30TH JUNE, 1925.

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.
454,727	617	4,186	55,954	461	London	22,547	50,112	1,553,613	46,882
54,392	1,897	19,414	54,858	1,714	S. East	3,825	20,069	87,735	14,764
57,381	4,386	25,536	43,612	1,671	S. West	13,314	4,460	85,403	26,499
45,076	8,390	30,618	39,994	5,527	Eastern	13,950	22,630	47,101	46,431
76,918	8,590	41,299	50,785	3,258	N. Mid.	19,034	31,580	134,309	78,995
54,471	4,802	25,790	54,959	4,416	S. Mid.	11,892	13,861	105,844	81,649
50,331	5,099	28,255	44,346	1,887	S. Wales	5,237	15,120	81,600	54,441
80,886	8,464	23,379	41,670	5,240	N. Wales	12,206	29,641	146,233	46,880
126,280	2,953	16,598	46,658	3,453	S. Lancs.	12,392	58,730	327,554	35,599
75,811	6,411	29,706	42,042	2,501	N. East	8,074	29,450	165,500	24,812
50,789	3,828	23,788	37,451	2,203	N. West	8,561	28,853	95,390	6. 25,935
39,192	2,547	15,334	23,565	2,076	North	2,792	8,392	63,307	25,168
17,900	4,781	5,942	11,502	241	Ireland N.	139	84	28,750	73
52,232	5,575	21,050	31,722	1,231	Scot. East	1,629	6,380	95,933	11,356
74,828	7,467	22,634	39,252	903	Scot. West	12,627	22,445	185,176	23,873
1,311,214	75,807	333,529	618,370	36,782	Totals.	148,219	341,807	3,203,448	543,363
1,280,725	75,841	331,447	612,204	36,711	Figures on 31st Mar. 1925.	143,783	326,725	3,101,556	523,527

JUNCTION WORKING BETWEEN AUTOMATIC AND MANUAL EXCHANGES. NON-DIRECTOR AREAS.

By I. H. JENKINS, A.M.I.E.E., and J. S. PATERSON, E.-in-C. Office.

THIS article describes the method of interconnecting automatic and manual exchanges in non-director areas. The method of working Director areas (*i.e.*, large areas like London) was dealt with in the articles on the "P.O. Exhibit at the British Empire Exhibition," by Messrs. W. E. Hudson and F. I. Ray, in the July and October issues of this Journal last year.

The principles employed in automatic systems for signal control differ fundamentally from anything existing in manual exchanges. This has given rise to circuit problems of considerable difficulty and the following is an attempt to indicate how these have been solved:—

A subscriber connected to an automatic equipment is provided with means, under the control of his dial, of setting up a connection within the local fee area. During the transition period, however, some of the exchanges within the local fee area will be of the manual type and the subscriber's dialling puts him into communication with the manual exchange operator, who completes the connection; these calls are known as dialled-out calls. Calls originated by automatic subscribers for exchanges outside their local fee area are handled on the automatic exchange manual positions and obtained by the subscriber dialling "0." This is a permanent feature of an automatic system and is necessary for accounting reasons, the subscriber's meter being designed to record one local call fee unit only for each call.

Conversely, calls originated by subscribers on manual exchanges are set up by the manual operator, who is provided with

a dial, or its equivalent, for obtaining the automatic subscriber direct through the automatic switches; these calls are known as dialled-in calls. Within this category are included calls from manual exchanges or from manual positions at automatic exchanges inside and outside the local fee area. The provision of dialling-in junctions is determined only by traffic requirements and engineering considerations governed usually by the length of line.

The principle of standard junction signalling between manual exchanges provides that a current is sent on the " B " wire from the outgoing end to an earthed calling relay at the incoming end and that the supervising signal is given by current sent on the " A " wire from the incoming end to an earthed supervisory relay at the outgoing end.

In the case of outgoing junctions to Automatic, signalling can be either direct to a selector line relay or *via* an incoming repeater at the automatic exchange. Where repeaters are used, the signalling is the same as in manual to manual junctions and this will be dealt with later. Where the junction is connected to a selector direct, the line relay associated with the selector is double-wound, one coil being connected to a battery and the other to earth. It will be seen therefore that a loop made at the manual exchange will operate the selector line relay and if this loop is made through a dial, impulses can be transmitted to the auto system.

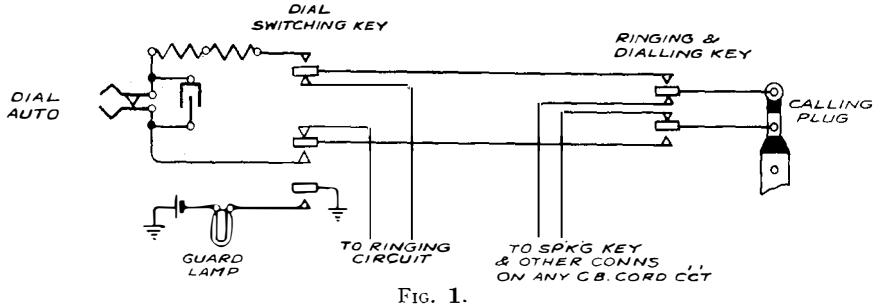


FIG. 1.

" LOOP " DIALLING-IN FROM C.B. EXCHANGES.

Where line limits permit, the adopted practice is to terminate the junction direct on a selector and provide the operators with the means of dialling from any cord circuit, one dial being common to a position. The standard method is to connect the dial through a switching key to the commons of the ringing keys of the cord circuits, so that the position of the switching key determines whether the calling plugs will be connected to the ringing or to the dialling circuit (see Fig. 1).

Where most of the connections made by the operators will

require ringing a guard lamp is necessary to indicate when the dial switching key is left in the position for dialling.

The most important precaution to be made is to suppress false impulses.

If a selector be connected direct to an outgoing junction jack, it will be seen from Fig. **2** that during the process of inserting the

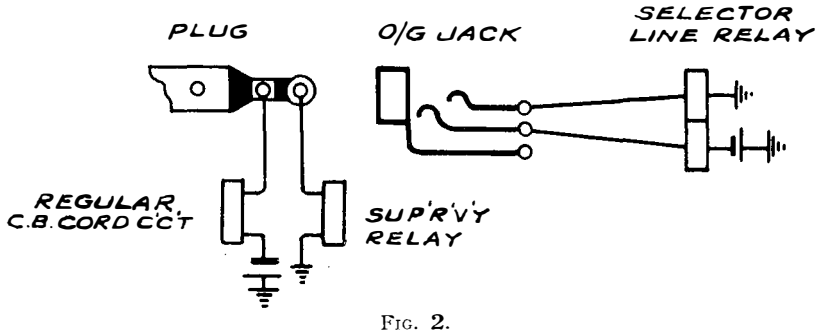


FIG. 2.

plug in the jack, the tip of the plug, to which is connected an earthed supervisory relay, will invariably touch the " B " spring of the jack and energise the selector line relay momentarily, thus producing a false impulse.

To avoid this defect it is necessary to keep the selector line relay off the outgoing jack until the plug is fully home in the jack. This equipment is shown in Fig. **3**. It is so arranged that the line

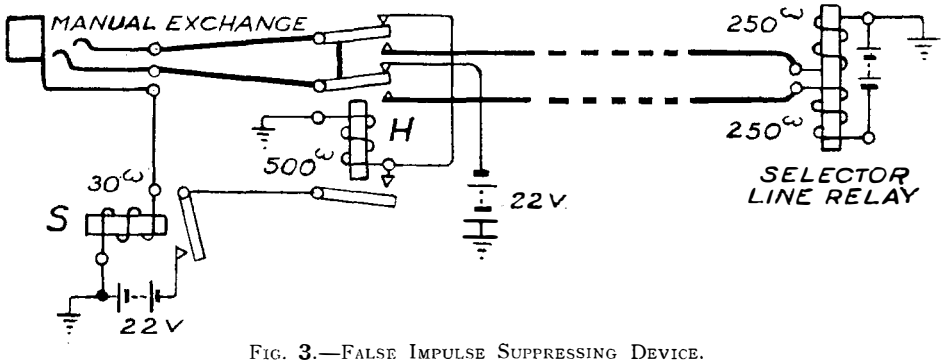


FIG. 3.—FALSE IMPULSE SUPPRESSING DEVICE.

is not connected until the plug is home and the dial connected to the plug. The operation is as follows :—

The operator inserts plug in jack and relay S is actuated by current from sleeve of plug. The operation of S prepares a holding circuit for relay H.. The dial switching key is thrown, which connects the dial circuit to the commons on the outer spring of " ringing and dialling " key. The latter is then held over and

the loop from the dial circuit operates relay H, which connects up the line and holds in *via* contact of relay S. The operator dials the required number and then releases the " ringing and dialling " key.

At this stage the junction is through to the wanted subscriber, but it is necessary that the circuit should be held by the cord circuit until and after the called subscriber answers.

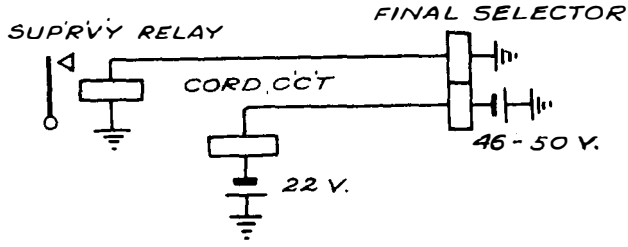


FIG. 4.

A reference to Fig. 4 will show that the auto exchange equipment is held only on one coil of the relay and that there is battery connected to each end of that one coil. The holding current is therefore determined by the *difference in voltage between the batteries* at each of the two exchanges concerned. Fig. 5

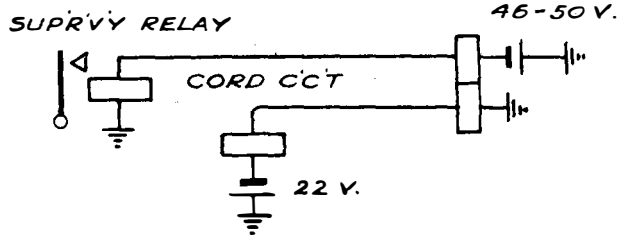


FIG. 5.

shows that a reversal takes place when called party answers. The batteries at both exchanges are now assisting each other and the supervisory relay in cord circuit is actuated by current from auto exchange. It is the condition shown in Fig. 4, however, that limits the resistance of the junctions for " loop " dialling.

At 40-volt exchanges dialling-in direct to a selector line relay is impracticable, because the voltages at each end are too nearly equal to permit of holding the switches prior to and after dialling. For a similar reason, single-battery 22-volt exchanges are limited to 100 ohms loop, because in these exchanges the voltage may rise to 28 or 30 during charging.

22-Volt and 24-volt exchanges with two sets of cells can dial in direct to selector, subject to the limits shown below, but where

30-volt transmission circuits are installed, *e.g.*, Jack-ended Junction cord circuits, " Loop " dialling will be restricted to the lowest holding limit quoted below, *i.e.*, 100 ohm loop.

Line limits for " Loop " dialling.

22-volt exchanges,	double	battery.	350 ohm loop res.
24-volt ,,	,,	,,	280 ,, ,, ,,
22-24-volt ,,	single	,,	100 ,, ,, ,,
,, ,,	with 30-v. jct. cord circuits.		100 ohm loop res.

Battery Dialling from C.B. Exchanges.

Battery dialling is necessary at all C.B. exchanges where the cord circuit voltage exceeds 30 and at other exchanges where the line resistance of the junctions exceeds the limits for holding given under the heading of " Loop " dialling.

" Battery " dialling is effected by inserting a repeater circuit at the automatic end between the junction line and the selector.

The repeater provides for regular junction signalling as in the manual to manual practice already referred to.

In addition, it has to repeat the dial impulses and hold the selector, as in the case of " Loop " dialling.

Fig. **6** shows the conditions on the junction side of the repeater.

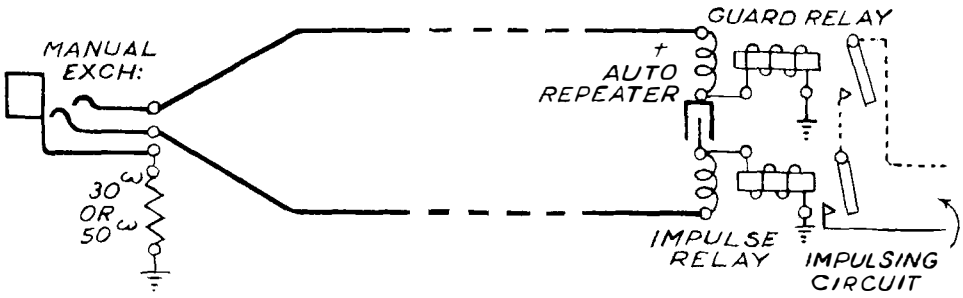


Fig. 6.—Outgoing Junction Working to Repeater.

Unlike the " Loop " dialling junctions, there is no false impulse-suppressing equipment required at the outgoing end, for the reason that the impulsing circuit is not connected until the plug is fully inserted and the dial and ringing key thrown. The circuit conditions just after the plug has been inserted in the outgoing jack are shown in Fig. **7.**

The guard relay is not operated and the impulsing relay is operated, but the impulsing circuit is not connected until the guard relay is operated.

Fig. **8** shows the conditions when the dial circuit is joined up by the operation of the keys as described for " loop " dialling.

The operation of the dial circuit keys connects battery in

parallel over the A and B wires and both " guard " and " impulsing " relays are operated. The latter responds to the impulses from the dial, but the former is kept steadily operated. Figs. **6**, **7** and **8** are only schematic and do not show the actual connections at the auto repeater.

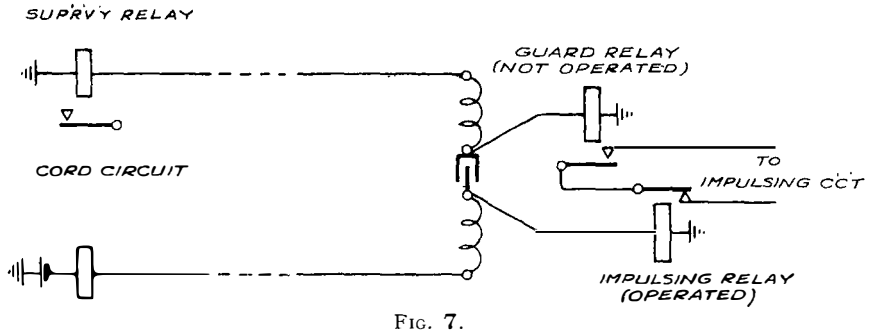


FIG. 7.

Fig. **9** shows a repeater in detail.

The insertion of a plug in the outgoing jack actuates relay " A." This performs no function with regard to the call meantime, but is used to make the outgoing portion busy (at auto end) in the case of a bothway line. The operation of the dial circuit keys (see Fig. **8**) actuates relay "L " (relay " A " remains operated), then relay G and GB operate in turn. G cuts off the

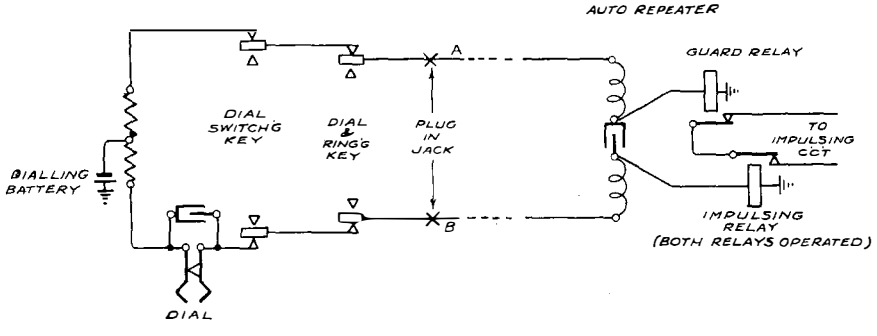


FIG. 8.—" BATTERY " DIALLING CIRCUIT CONDITIONS.

repeating coil and therefore relays D and DD. It also removes the earth connection from impulsing circuit and provides a loop of 250 ohms across the selector relay (not shown) *via* contacts of relay A. Dialling is commenced and impulses sent to selector. When dialling key is restored, L and G release, but GG being slow is held in by the earth on A contact, which has been restored by the release of G. The selector is now straight through to the repeating coil.

The 0.5 m.f. condenser placed in shunt with D by DD is to improve the volume of tone when " Busy Back " is received on an engaged line, the impedance of D being too great to allow of satisfactory busy tone being transmitted to the calling party. If circuit be disengaged, relay DD is released and D actuated when the calling party replies. D substitutes battery for earth through

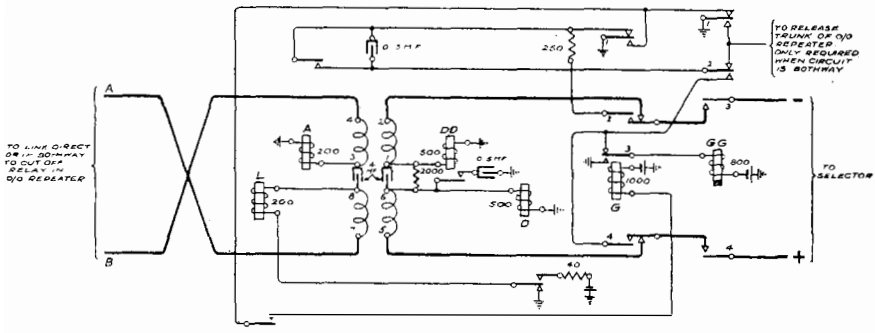


FIG. 9.—INCOMING REPEATER AT AUTO EXCHANGE (WITH REPEATING COIL).

L and sends the supervisory current, out on the A line, to the calling exchange.

The repeater just described is suitable for lines subject to noisy conditions.

(1) Fig. **10** shows a circuit which has been designed to reduce

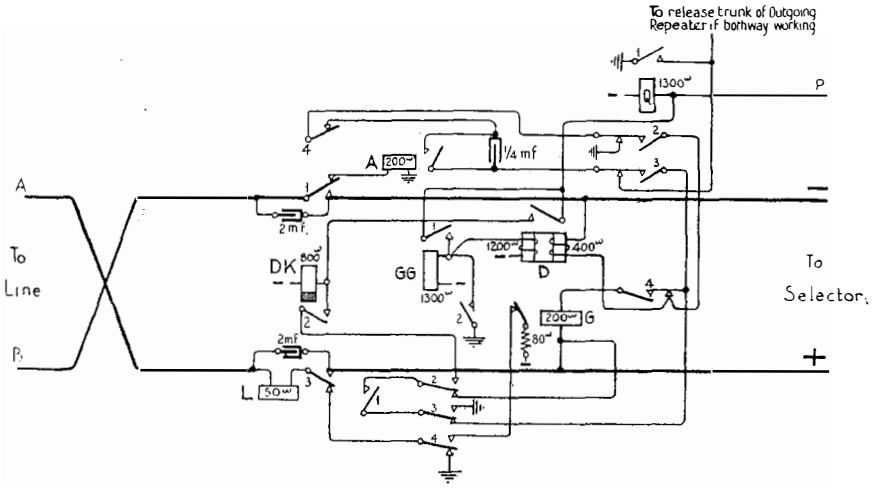


FIG. **10.**—INCOMING REPEATER AT AUTO EXCHANGE (WITHOUT REPEATING COIL).

the transmission losses by the omission of a repeating coil in the transmission circuit.

(2) Provison is made for :—

(*a*) Engaging on the insertion of the plug at the manual end the outgoing multiple bank in the case of bothway working.
(*b*) Seizing the selector on throwing the dialling key.
(*c*) Conversion of battery dialling impulses to loop impulses.
(*d*) Transmitting the busy back flash.
(*e*) Transmitting through signalling from the called subscriber.
(*f*) Vesting the control of the switches in the originating manual operator.

Operation.

(3) *Relay A* operates on the insertion of the plug. Its functions are: first, to engage the outgoing multiple bank and, second, to act as an impulsing relay after the operation of Q, and on release to disconnect the loop.

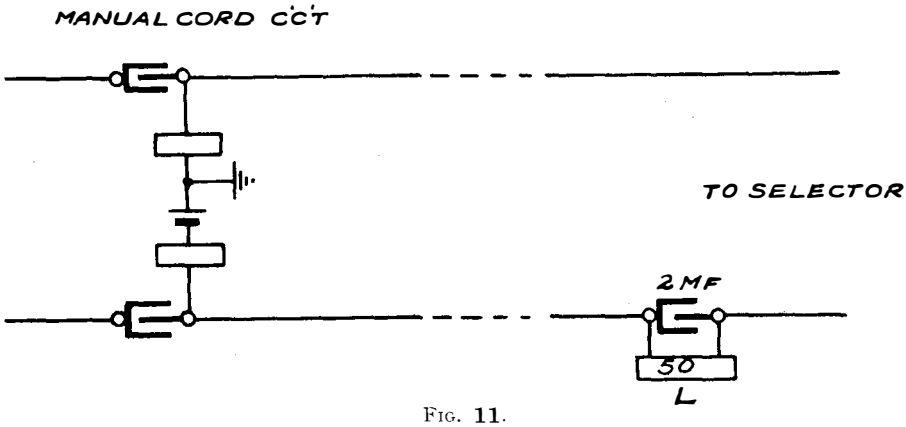


FIG. 11.

(4) *Relay L* operates on the throw of the dialling key. Its functions are: first, to complete the loop and seize the switch and, second, to short-circuit Relay G and, third, to provide a holding circuit for relay DK. Relay G is short-circuited whilst the dialling key is thrown to maintain the control of the switches by the calling operator in the event of the called subscriber replying before the dialling key is released.

(5) *Relay Q* operates on the seizure of the switch. Its functions: are (1) to maintain earth on the outgoing multiple bank, (2), (3) and (4) to transfer spring of Relay A to the loop for impulsing.

(6) *Relay G* operates on the release of the dialling key. Its functions are: (2) to energise Relay GG, (1) to connect battery to the A line to flash the cord circuit supervisory lamp when busy back has been dialled into.

(7) *Relay GG* operates when G operates. Its functions are: (1) to lock through earth on the private, (2) and (3) to transfer the spring of Relay L to DK for holding, (4) to connect A line to G for busy back flashing.

(8) *Relay D* operates when the called subscriber answers and energises Relay DK.

(9) *Relay DK.* DK is operated by D. Its functions are: (1) to disconnect Relay A and connect the B line through to negative, (3) to connect the A line to positive through Relay L, (2) to provide a holding circuit for itself, (4) to sever the signalling bridge.

The circuit conditions during conversation are as shown in Fig. **11.**

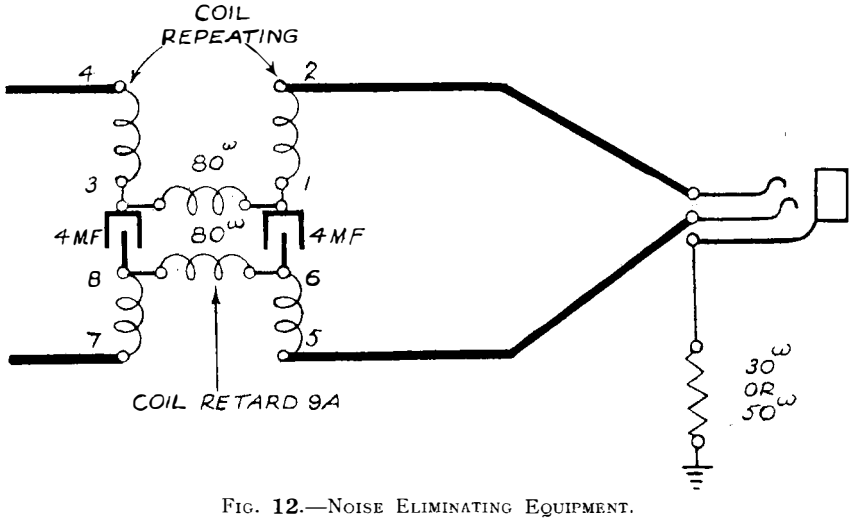


FIG. **12.**—NOISE ELIMINATING EQUIPMENT.

"BATTERY" DIALLING THROUGH NOISE ELIMINATING EQUIPMENT.

Figs. **12** and **13** show the auxiliary equipment required for "noisy" lines over which dialling is required.

"Battery" dialling only is provided for, because, owing to the low line limits for "loop" dialling from C.B. exchanges, it is not anticipated that such short lines will require noise eliminating equipment, but Fig. **12** could be used for loop dialling with the addition of a false impulse-suppressing relay equipment as in Fig. **3.**

In Fig. **12** the 80 + 80 ohms retardation coil provides a physical path for holding and impulsing through the repeater at the auto exchange.

Fig. **13** is an adaptation of what was the standard noise eliminating equipment with an additional relay and connections for dialling through. The insertion of the plug in the jack operates relay C by the current from the "ring" of the cord circuit, the repeater at auto exchange is then seized. The operation of the dialling keys, as already described, actuates relay D, which releases relay C and connects the line through direct to the exchange side of the repeating coil. Impulses are transmitted from the dial over the B line, whilst battery is kept steadily applied to the A line to operate the "guard" relay.

The restoration of dial keys re-operates relay "C," and the relay S responds to the supervisory current on A line when the called subscriber answers, closing terminals 1 and 6 of repeating coil through the 200-ohm spool.

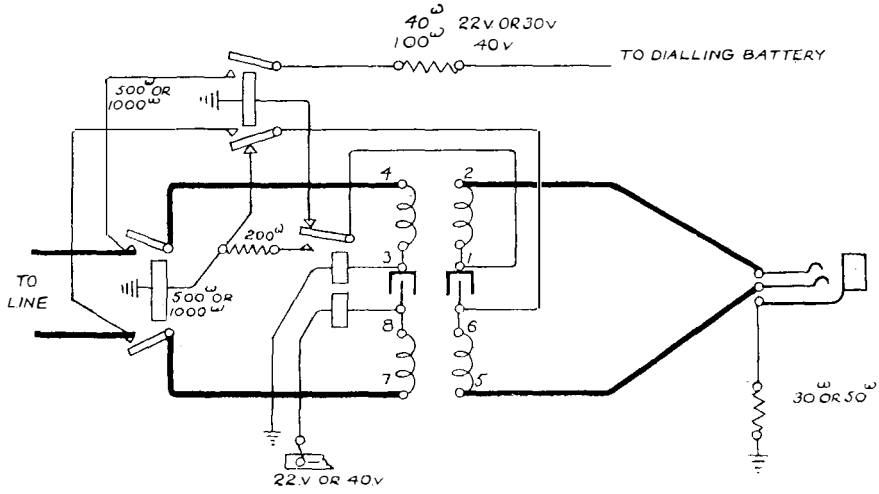


FIG. **13**.—LONG LINE AND NOISE ELIMINATING EQUIPMENT.

Tests made on these circuits by the Research Section proved that dialling conditions through equipment to Fig. **13** were improved slightly as compared with direct dialling on a cable line. The disadvantage of additional resistance in circuit is rather more than compensated for by the capacity and inductance tending to lengthen the "make" period, thus correcting the distortion of impulses due to a long line.

The arrangement in Fig. **12** is not so efficient as Fig. **13** for dialling, and gives an average loss of approximately 3.5 miles standard cable. The line limits for battery dialling through equipments to Fig. **13** are approximately the same as shown below. Dialling through equipments to Fig. **12** is 15% to 20% less.

Line Limits for Battery Dialling.

Dialling Battery,	Loop Resistances in Ohms.	
22 v.	1200	Speed of dial interruptions at 10 per second.
24 v.	1600	
30 v.	2000	
40 v.	3000	

The foregoing figures are approximately correct, but are dependent (*a*) on the insulation and capacity of the line, (*b*) the speed of the dial impulses. A dial slower than 10 per second decreases the line limits.

Mixed Dialling.

It has been found necessary to provide for cases where junctions exist from a manual exchange dialling from cord circuits to two different automatic exchanges, one where the conditions permit of "Loop" dialling and the other where "Battery" dialling is required.

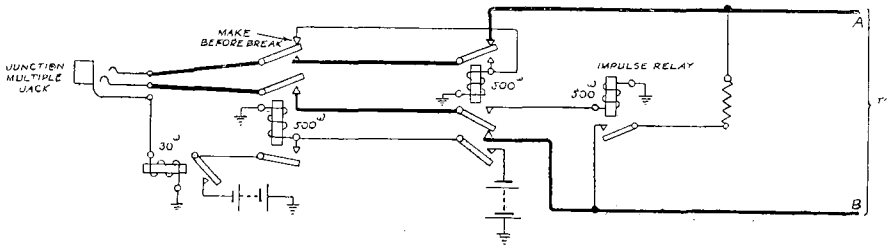


Fig. **14**.—Equipment for Converting "Battery" Impulses to "Loop" Impulses.

To meet such cases, two auxiliary equipments have been designed, one to convert "Loop" impulses from the cord circuits into "Battery" impulses on the line and the other to convert "Battery" impulses from cord circuit into "Loop" impulses on the line. The adoption of one or the other of these equipments will be determined by local conditions, economy in apparatus being one of the chief decisive factors.

Fig. **14** shows the auxiliary equipment for converting "Battery" impulses to "Loop" impulses. A portion of this equipment includes the "false impulse-suppressing" feature, shown in Fig. **3**, and in addition a change-over relay (CO) and an impulsing relay (A). The operation of S, by the insertion of the plug, prepares a holding circuit for H. The throwing of the dial switching and dialling keys sends battery over the tip and ring of plug in parallel, as shown in the left portion of Fig. **8**. Relay H is not yet operated and current flows only over the tip side to

relay CO, which operates and (1) locks in through its own contact, (2) connects " A " to ring side, and (3) actuates H. Relay H locks in over contact of S and joins the armatures of CO through to jack. Relay A operates and " loops " the line. Dialling commences and " A " breaks the loop in response to the dial impulses. When dialling is completed, the release of the dialling key takes battery off the tip and CO releases. H and S are retained until the plug is withdrawn, A is released by CO and the cord circuit is through to the auto exchange.

The line limits for junctions connected to this equipment are the same as already quoted for " Loop " dialling.

Fig. **15** shows the equipment for converting " Loop " impulses

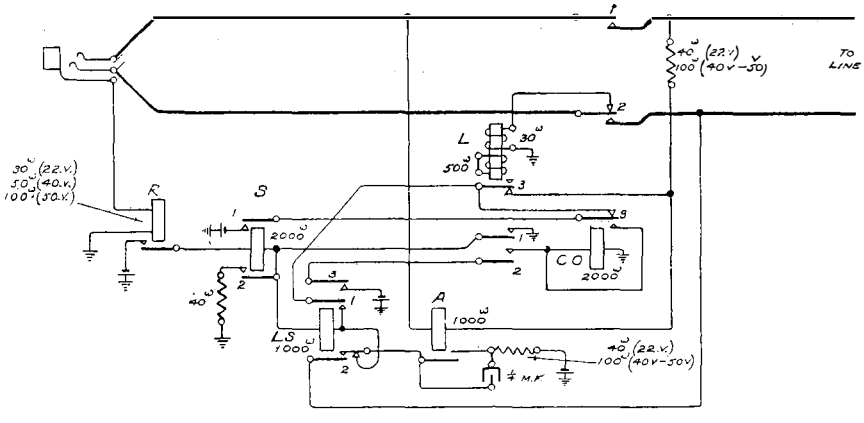


FIG. **15**.—EQUIPMENT FOR CONVERTING " LOOP " IMPULSES TO " BATTERY " IMPULSES.

from dial in cord circuit to " Battery " impulses, the conditions at auto exchange end being shown in Figs. **9** and **10**.

When the plug is inserted in the jack, relays R and L operate. Contacts L1 and R1 complete the circuit for relay S, which operates and locks. The dialling key is now thrown and relay L is disconnected from battery and releases, thus completing the circuit for relay A *via* battery, S1, CO3, L3, A1000, through the dialling loop in cord circuit, CO2 to earth through relay L. Relay L is marginal and does not operate when in series with 1000 ohms relay A. Contact A1 completes the circuit for relay LS, which operates and locks up through contacts LS1, CO3 and S1. The " A " line is now connected to battery through 40 ohms, L3, CO3 and S1, while the " B " line is connected to battery through 40 ohms, contacts A1 and LS2. When the dial is operated A will respond to the interruptions and send impulses over the " B " line. On the completion of dialling, the dialling key is released and relay L operates from battery on the cord

circuit. Relay CO operates by battery through LS3 and L2 and locks through contacts CO3 and S1. Relay LS is now disconnected at the back contact of CO3 and releases. Relay L also releases, being disconnected by contact CO2, and the circuit is left with relays R, S and CO operated during the talking period.

"Loop" Dialling-in from Magneto Exchanges.

The conditions for dialling-in from these exchanges differ fundamentally from those associated with C.B. exchanges, in that the dial on each position is connected to a special dialling plug instead of being associated with the connecting cord circuits.

Two jacks are provided for each outgoing junction, one jack for dialling and the other for connecting.

The dialling plug circuit is shown in Fig. **16**. This circuit is used both in Magneto and C.B.S. No. 1 Exchanges with more than one position.

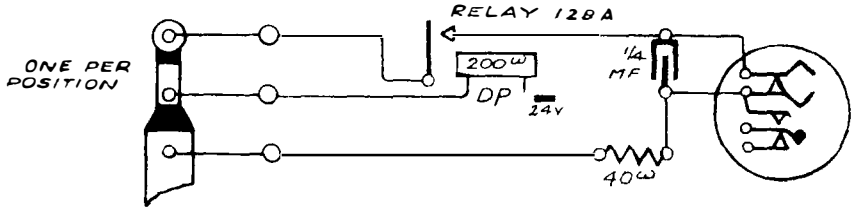


Fig. **16**.—Dialling Plug for Magneto and C.B.S. No. 1 Exchanges.

The function of relay DP is to delay the connection (through dial) between the tip and sleeve until the plug is fully home. This is to prevent false impulses due to contacts between tip, ring and sleeve while the plug is being inserted in dialling jack.

The .25 mf condenser and 40-ohm spool are provided to quench sparking across the dial contacts during impulses.

Multiple Magneto Exchanges (Condensered).

The circuit for unidirectional lines to auto exchanges is shown in Fig. **17**. (Bothway working will be referred to later).

Operations, Loop Dialling.—On getting a demand from a subscriber for a number in auto exchange the operator inserts the calling plug of connecting cord into the outgoing jack of line to auto exchange. Relay CO operates and the selector is "seized" *via* LA to earth. D operates round the loop of waiting magneto subscriber's telephone, by current from DI.

The dialling plug is then inserted. Relay DB operates and CO is released. The required number is then dialled and dialling plug withdrawn. Relay CO re-operates. When auto subscriber replies, LA operates, then C, through contact D (operated) and

contact of DB (normal). C locks in through auxiliary spring 4 to earth at spring 3 of outgoing jack. The control of CO is now transferred from the jack to the contacts of LA and D. Relay LA is controlled by auto subscriber and D by magneto subscriber. When both hang up, CO is released and the line is free. This arrangement is to guard against the auto equipment being held up due to slow clearing, owing to the failure of magneto subscriber to " ring off."

In the case of bothway working, it allows a call in the other direction to be made even if a plug be left in outgoing jack. Fig. **17** is designed for either Loop or Battery dialling outgoing only, or for Battery dialling on bothway junctions.

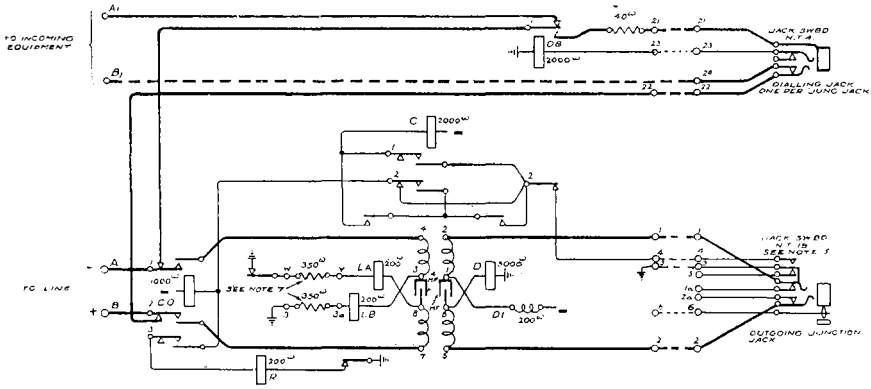


FIG. **17**.—MAGNETO EXCHANGES WITH CONDENSERS. OUTGOING: LOOP OR BATTERY DIALLING; OR OUTGOING PORTION OF BOTHWAY BATTERY DIALLING.

The Battery dialling is similar to that described in connection with Fig. **8**, the plug, dialling jack and relay DD performing the functions of the dialling keys. The conditions for Battery dialling at auto end are the same as described for Figs. **9** and **10**.

BOTHWAY JUNCTION—LOOP DIALLING.

In bothway working, the incoming portions at each end are normally on the line, the outgoing portions being switched in only when a call is begun, and released again at the end of the call. The connections have to be so arranged that the earthed calling relay on the incoming portion of the junction at the manual exchange is not on the same side of the line as the selector coil at auto exchange which is normally to battery. The normal circuit conditions are as in Fig. **18**.

Assuming a call set up by the manual exchange on the outgoing portion and the plug withdrawn before the auto subscriber has replaced the receiver, the reversal would persist and a false call

given to the incoming end at the manual exchange. In addition, the selector would be held through the earthed line relay.

Fig. **19** shows the arrangement designed to guard against this probability. It is similar to Fig. **17**, except that LB is a relay instead of a retard coil. An additional contact has been provided on relay CO and an additional relay R has been inserted.

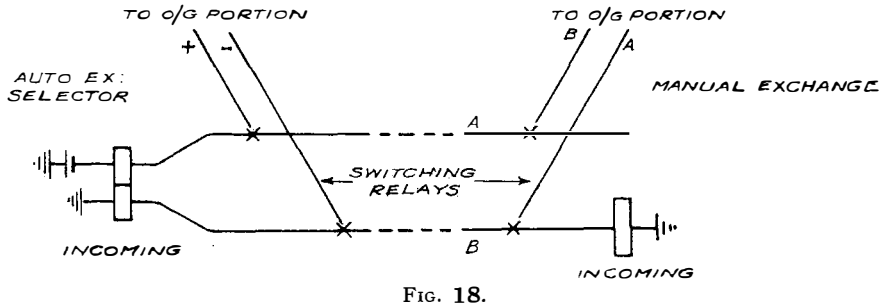


FIG. **18.**

When auto subscriber answers, LA is operated, but LB restores. Relay R is short-circuited by the earth in spring 3 of jack. If the operator withdraws the plug from outgoing jack while the reversal is still on, CO is held in *via* its own contact 3, coil of R to earth at resting contact of LB. Relay R operates in series with CO and disconnects earth from LA. The selector is then released and the reversal is removed. LB operates, R and CO are released and the circuit is at normal.

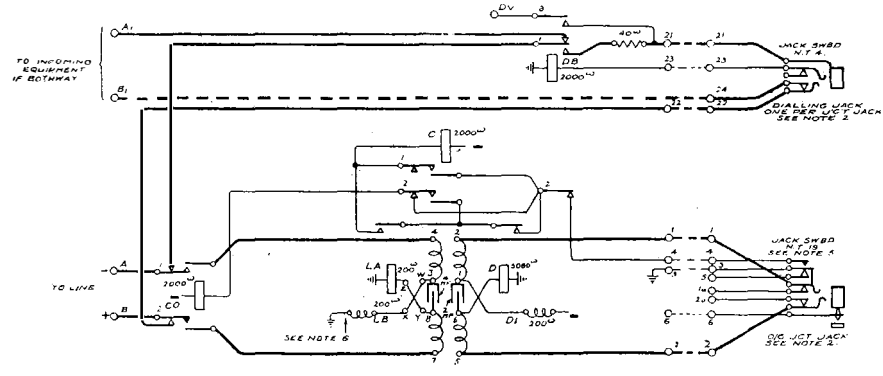


FIG. **19.**—MAGNETO EXCHANGES WITH CONDENSERS. OUTGOING PORTION OF BOTHWAY JUNCTION. LOOP DIALLING.

LOOP DIALLING-IN FROM NON-MULTIPLE MAGNETO EXCHANGES.

Figs. **20** and **21** show the circuits for use in non-multiple exchanges and are similar to Figs. **17** and **19**, except that the magneto subscriber does not control the release. These circuits

are entirely plug-controlled and are designed for exchanges where, owing to the absence of a multiple, there is space for clearing signals associated with the outgoing jacks. These circuits do not require the subscribers' bell circuits to be condensered.

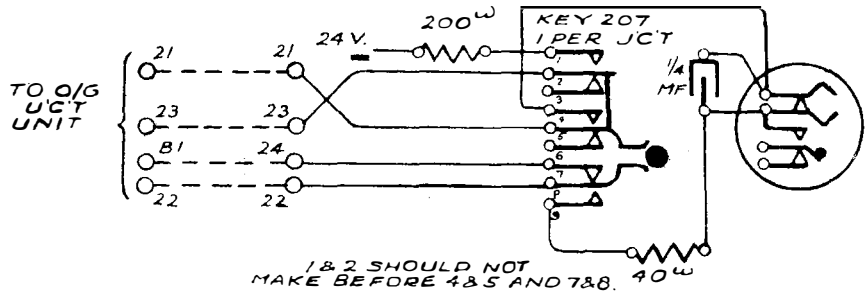


FIG. 20.—NON-MULTIPLE MAGNETO EXCHANGES. OUTGOING LOOP OR BATTERY DIALLING OR OUTGOING PORTION OF BOTHWAY. BATTERY DIALLING.

In the case of exchanges with one position only, where it is practicable to provide a key per junction, the arrangement shown in Fig. **22** takes the place of the dialling plug and dialling jack.

LOOP DIALLING-IN FROM C.B.S. NO. 1 EXCHANGES.

These are similar in principle to Figs. **20** and **21**, except that as the operator gets a clear on the cord circuits, there is no need to provide a clearing signal per junction.

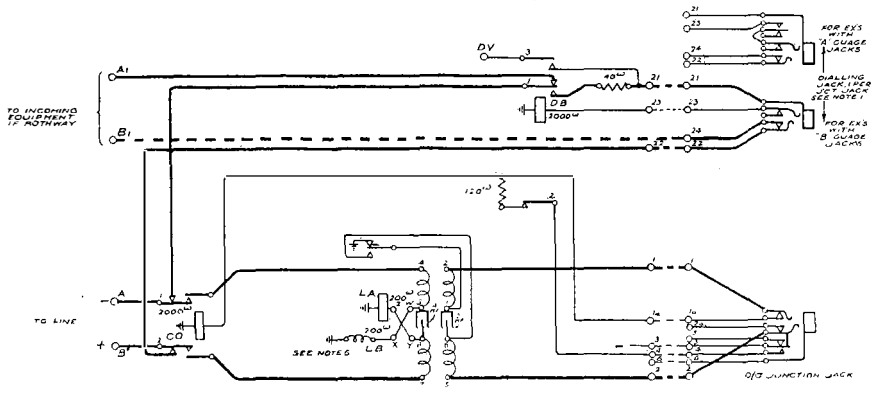


FIG. **21**.—NON-MULTIPLE MAGNETO EXCHANGES. OUTGOING PORTION OF BOTHWAY. LOOP DIALLING.

The circuits are shown in Figs. **23** and **24**. The necessity for the special connections on "A" gauge jacks is to avoid false impulses caused by the tip and ring springs being short-circuited by the tip of dialling plug during insertion.

Fig. **22** can also be applied to C.B.S. exchanges with single positions.

The line limit for "loop" dialling from Magneto and C.B.S. No. 1 exchanges is approximately 1,200 ohms. The limits for battery dialling are the same as already given for C.B. exchanges.

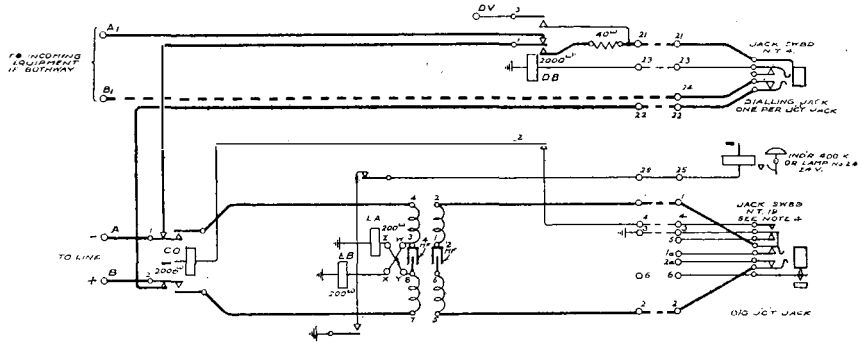


Fig. 22.—Magneto and C.B.S. No. 1 Exchanges. Dialling Key per Junction.

Loop Dialling-in from C.B.S. Nos. 2 and 3 Exchanges.

No auxiliary equipment for dialling-in is provided for these exchanges. Dialling will be done from the cord circuits as in C.B. exchanges, and the conditions laid down for C.B. exchanges apply also to C.B.S. Nos. 2 and 3.

As many of the C.B.S. Nos. 2 and 3 exchanges are worked by primary batteries, the voltages may vary from 15 to 35. In such cases, battery dialling only is practicable.

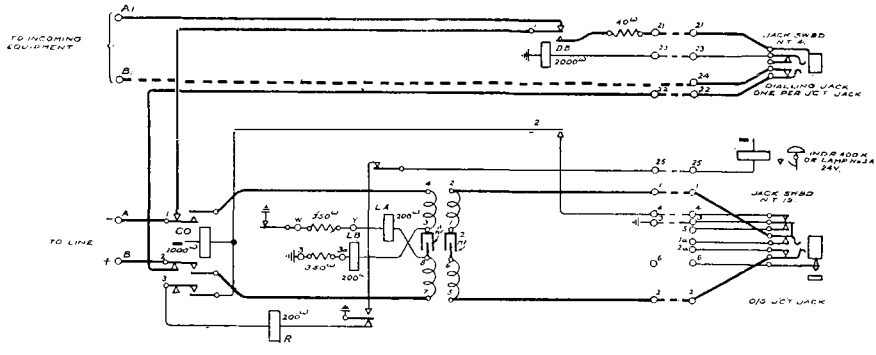


Fig. 23.—C.B.S. No. 1 Exchanges. Outgoing; Loop or Battery Dialling or Outgoing Portion of Bothway, Battery Dialling.

Battery Dialling from Magneto and C.B.S. No. 1 Exchanges.

In the case of dialling-in to systems where the line relay is connected to earth or where dialling-in repeaters, as shown in

Figs. **9** and **10**, are used, it is necessary to connect the coils or relays LB, in Figs. **17**, **20** and **23**, to battery instead of earth as shown.

In such cases the dialling battery is connected to the point DV, shown in Figs. **17**, **20** and **23**.

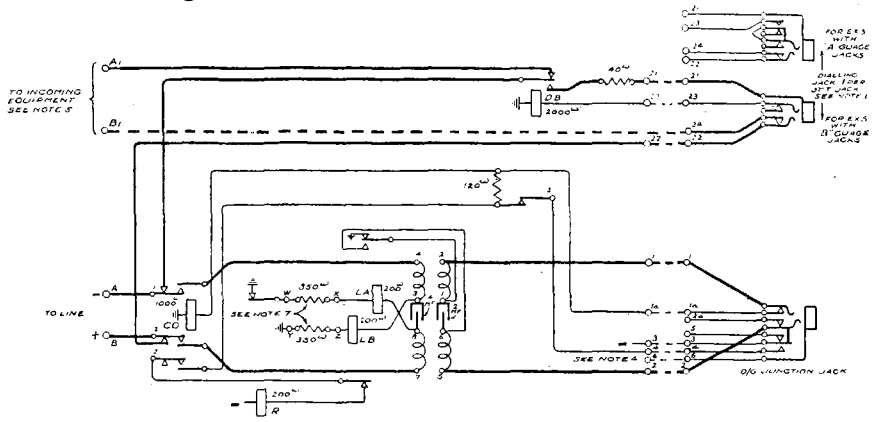


FIG. **24**.—C.B.S. NO. 1 EXCHANGES. OUTGOING PORTION OF BOTHWAY, LOOP DIALLING.

DIALLING-OUT TO C.B. AND C.B.S. NOS. 1, 2 AND 3 EXCHANGES.

Dialling-out from auto subscribers direct to a manual exchange is limited for traffic reasons to exchanges within 5 miles radius from the auto exchange.

The circuit conditions are as shown in Figs. **25** (auto end) and **26** (C.B. end).

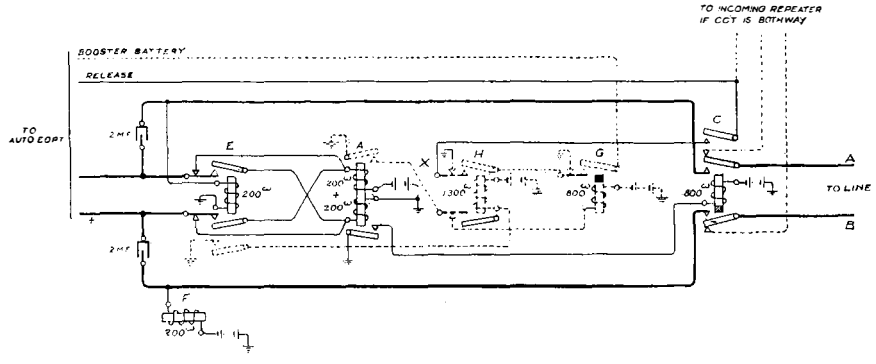


FIG. **25**.—REPEATER CIRCUIT. DIALLING OUT TO C.B. EXCHANGES.

Repeaters to Fig. **25** are connected to selector levels allotted to the manual exchange to be dialled-out, and this equipment takes the place of the final selector on an auto to auto connection.

Operation.—Subscriber dials level required and operates L and G, then CO, which switches the line through. Coil F sends

battery over B line of junction and relay D is on A line waiting for called supervisory. When distant subscriber answers, a current is sent on A line and operates D, which reverses the feeding current through L and meters the calling subscriber if the metering circuit is connected for operation on the reversal.

In Booster battery metering, the operation of L also operates the slow release relay G, which prepares the Booster battery to H contact. When D operates, H is actuated and locks in through its own contact 2 and contact 1 of L. The operation of H connects the Booster battery to the release trunk on which the subscriber's meter stands and a call is registered. H also disconnects G and Booster is therefore only applied for the time taken by G to release.

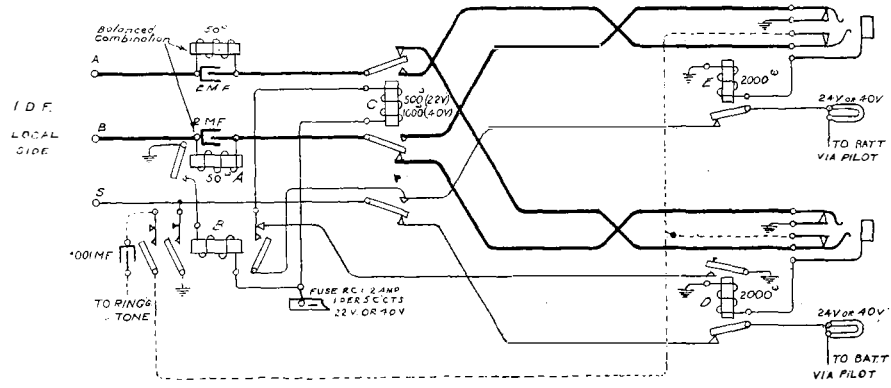


FIG. 26.—C.B. EXCHANGES. INCOMING CIRCUIT DIALLED OUT FROM AUTO EXCHANGES.

Fig. **26** is designed to free the junction when auto subscriber hangs up and to switch a following-on call to lamp and jack 2, at the same time maintaining a clear on the answering cord connected to jack 1.

Operation.—Relay A responds to current sent over B line; then relay B operates, which sends ringing tone over line, and cuts off the connection from relay S1 to relay C.

Operator gets glow on lamp 1 and plugs into jack 1, which cuts earth off relay A, but that is now in series with the supervisory relay in cord circuit and therefore remains operated. The ringing tone is also cut off at jack.

A jack-ended junction cord circuit is used for connecting this circuit, but is so arranged that current is not sent over A line by the entry of the operator into circuit, otherwise false metering would occur. The metering condition is therefore not set up until called subscriber replies. When auto subscriber hangs up, relays L and CO (Fig. **25**) release, the repeater is freed and a clear given to manual exchange cord circuit.

While the plug is still in jack 1 relay S1 applies earth to relay C, when B releases and C changes over the circuit to jack and lamp 2. A second call following immediately on the release of the first will come up on lamp 2 and will be connected on jack 2, C retaining through test wire T, which is earthed by relay B. The circuit to Fig. **26**, although primarily designed for working from auto exchanges, may also be used for manual to manual working.

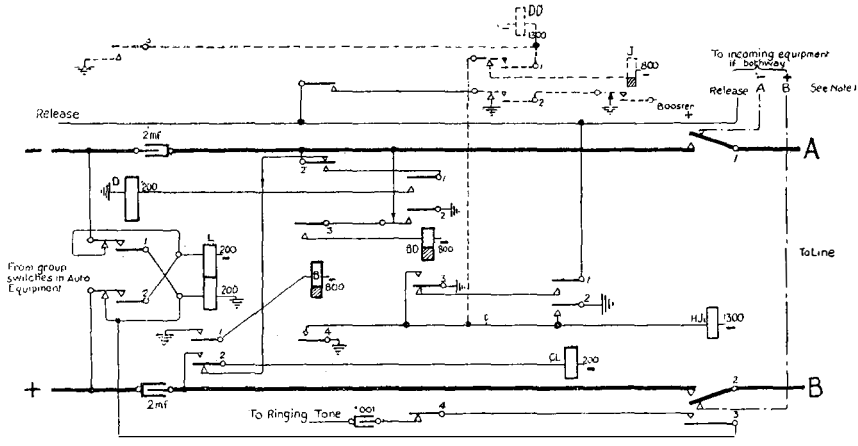


FIG. **27**.—REPEATER CIRCUIT. DIALLING OUT TO MAGNETO AND C.B.S NO. 1 EXCHANGES.

DIALLING-OUT TO MAGNETO AND C.B.S. NO. 1 EXCHANGES.

Fig. **27** shows the repeater used at the automatic exchange end for dialling-out to Magneto and C.B.S. No. 1 exchanges.

It is the same in principle as the dialling out repeater shown in Fig. **25**, but differs in that the repeater is "held" until operator at manual exchange withdraws the plug. No following-on calls are possible as in Fig. **25**. The "ringing tone" is applied at the auto end because the distant exchanges are not generally provided with ringing machines.

Fig. **28** shows the connections at a Magneto exchange.

Relay LB operates from battery on B line *via* relay F (Fig. **27**) and gives the calling signal. Operator plugs in and sends earth on A line *via* spring 11 of jack, contact M2 and coil of LA. In Fig. **27** relay B had connected relay BD to A line and BD operates by earth from A line on insertion of plug. BD locks and transfers D to A line in preparation for the reply of the Magneto subscriber. Reverting to Fig. **28**, the operator extends the calling plug to the wanted subscriber and rings. The meter key is then depressed. Relay M operates and is locked to earth *via* jack spring 11. M1 connects relays LA and LB together,

but earth is still connected at this point *via* contact S1. When the Magneto subscriber replies, S operates, earth is removed from LA and LB and current on B line is looped round *via* A line to relay D on Fig. **27**. The calling subscriber is then metered as described for Fig. **25**.

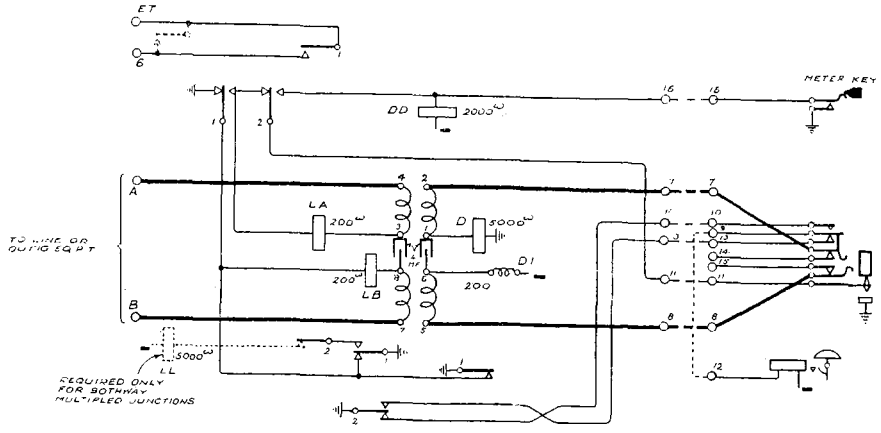


FIG. **28**.—MAGNETO EXCHANGES. INCOMING CIRCUIT DIALLED OUT FROM AUTO. EXCHANGES.

Fig. **29** shows the connections for C.B.S. No. 1 exchanges and the operation is the same, except that relay S operates when calling plug is connected to called subscriber and operates DM *via* earth at LB1.

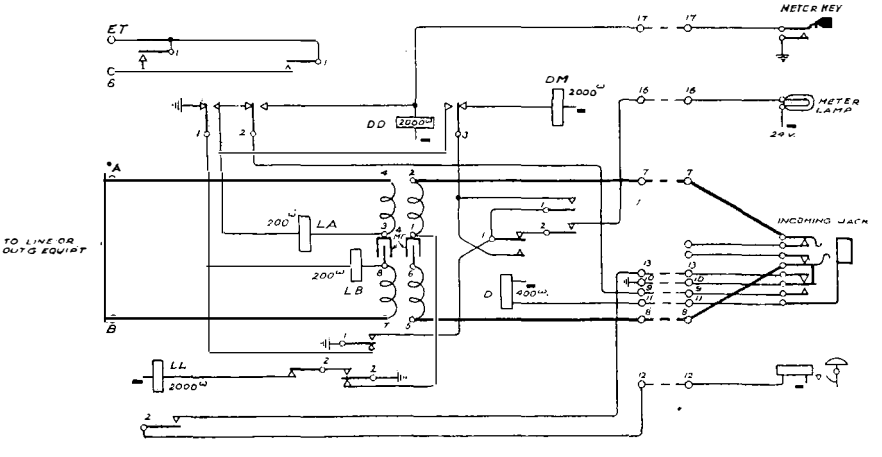


FIG. **29**.—C.B.S. NO. 1 EXCHANGES. INCOMING CIRCUIT DIALLED OUT FROM AUTO. EXCHANGES.

When called subscriber answers, S releases, then DM meter lamp glows, operator depresses meter key, relay M operates and in held *via* contact M2 to earth *via* jack springs 11 and 9.

Relays LA and LB are looped through and calling subscriber is metered as in Fig. **27.** Clearing signals from the auto end are given by the release of LB due to the removal of relay F (Fig. **27**) to the A line. The current on A line keeps LA operated and the outgoing jacks (if bothway) busy until the plug is withdrawn and the consequent release of M disconnects LA and the circuit restored to normal.

PORT OF LONDON AUTHORITY: PRIVATE AUTOMATIC BRANCH EXCHANGES.

By ALEC. B. EASON, M.A., A.M.I.C.E.

Section. *Summary.*

SECTION A.

THIS article gives a short description of the Port of London Authority's automatic telephone system throughout the various Docks and Offices. The automatic and manual equipment was manufactured to Post Office Specification upon plans and data furnished by Mr. G. F. Preston, C.B.E., M.I.E.E., and installed in 1925 by Messrs. Siemens Bros., Ltd., Woolwich. The following schedule gives briefly an outline of the general scheme:—

Name of P.L.A. Office or Dock.	Equipment for extensions Init.	Ult.	Manual positions provided initially.	Extensions dial out to public exchange.	Inc. calls received *via*
Head Office	200	400	8	Royal	Royal
Tilbury	60	100	1	Tilbury	Tilbury
London & Katherine's	70	120	Nil	Royal	Royal
India and Millwall ...	130	200	Nil	East	,,
Victoria and Albert...	160	250	Nil	Albert Dock	,,
Surrey Commercial ...	120	200	Nil	Hop	,,
Gravesend	Manual P.B.X. with a dial for dialling into the P.L.A. system.				

A detailed description is given of some of the special circuits used in the exchanges, but no attempt is made to describe the ordinary preselector and selector circuits which are of the standard Siemens No. 16 type as used for Swansea, Sheffield, Edinburgh, etc.

The allocation of lines and junctions between the various exchanges is shown in Fig. 1. The figures quoted against exchange lines and junction lines are only approximate; the precise number of channels to and from the public exchanges and

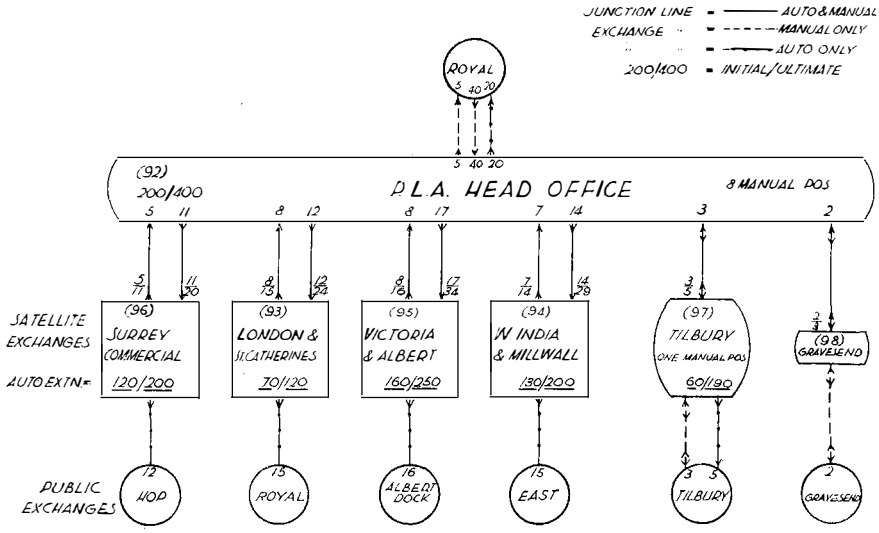


Fig. 1.—P.L.A. Exchanges and Tie Lines.

between the P.A.B.X.'s will depend upon the requirements at a particular date. The figures given, however, show the general relationship between the various lines and extensions.

The multi-office numbering scheme differs from that used for public exchanges, in that only three figures need to be dialled for local calls, whereas five figures are required for inter-exchange calls. This scheme saves the provision of certain plant, and can be adopted because the persons using the telephone are all officials in the one organisation.

Section B.—Traffic and Numbering Scheme.

The traffic to be dealt with falls under the following categories:

Outward calls, an extension calling the following:—

Type.	*Direction.*	*Type.*	*Level used.*
Local,	to an extension on same Exchange.	Auto	2, 3 or 4
Inter-Ex.,	to an extension on a Satellite.	ditto	92 to 97
,,	to an extension at Gravesend.	Auto-manual	98
Public,	to a member of the public, *via* a local or junction call.	ditto	0
,,	to a member of the public, *via* Trunk or Toll exchange.	ditto	91
Local,	to the P.L.A. manual board for an enquiry.	ditto	91

Incoming calls.

Incoming from the public; any type, trunk or local, etc.	to an extension at the Head Office or Tilbury.	Manual	The P. L. A. operator plugs into the extension line multiple on the Manual positions.
Ditto.	to an extension at a Satellite.	Manual-auto	The P. L. A. operator plugs into o/g junc. and dials the No. required.

The difference in procedure between day and night calls is described in Section C.

A typical numbering scheme, to give the above mentioned facilities is given below. This refers to Surrey Commercial Docks; at other exchanges the numbering is similar.

Level.	*Purpose.*
1	Spare: N.U. tone.
200—299	Extensions: Surrey Commercial: local calls.
300—399	,, ,, ,, ,,
4	Spare: N.U. tone.
5	,, ,, ,,
6	,, ,, ,,
7	,, ,, ,,
8	,, at Surrey Commercial. (At Tilbury, 8 calls Tilbury Manual board).
91	P.L.A. Manual board at Head Office.
92200—92599	Extensions at Head Office.
93200—93319	,, ,, London and St. Katherine's Docks.
94200—94399	,, ,, India and Millwall Docks.
95200—95449	,, ,, Victoria and Albert Docks.
96200—96399	,, ,, Surrey Commercial (when called from other exchanges).
97200—97299	,, ,, Tilbury Docks.
98	Gravesend manual P.B.X.
99	Spare: N.U. tone.
90	,, ,, ,,
0	Public Exchange.

If the caller wants some information, or some enquiry is to be made, the procedure at first is the same as for trunks; "91" is dialled and the PLA operator will give the required information.

The PLA operator can complete local calls to the extensions, if the caller finds it difficult to get the extension required; the caller dials 91 and asks the PLA operator to dial the number and complete the call for him; or the call can be completed later when the wanted extension becomes free. In the case of Head Office extensions the operator can repeatedly test the multiple jack, until she finds it free and can then plug in and call the line which has been busy, and then recall the extension which originated the call.

Incoming Calls from the Public System circulate either from Royal Exchange to the PLA Head Office or from Tilbury Exchange to the PLA, Tilbury Docks. At the Head Office manual board, the local extensions are multipled and if the call is for a Head Office extension the operator plugs in direct, no automatic plant being used for the call. For calls to the satellites the operator plugs into a disengaged line in the outgoing junction multiple of the inter-office junctions which radiate from the Head Office to the various docks. These junctions also come from the levels of the 2nd selectors and terminate upon 3rd selectors at the satellite exchanges.

The method of busying junctions so that a 2nd selector will not pick up a junction which an operator is using, and so that the operator will find the engaged test upon the outgoing junction multiple jack, if an automatic call is in progress is explained in Section E, dealing with a *bothway* junction. In that case there are four channels which have access to the one line, viz., auto extensions at either end, and operators at either end; anyone of these which takes possession of the line must busy it to the other three.

We shall discuss the handling of calls in more detail.

Local Calls circulate *via* 1st and 2nd preselectors to 1st selectors and then *via* final selectors to the required extension.

If the call is to a *satellite*, it reaches a 2nd selector at the Head Office, when 9 is dialled, and reaches a 3rd selector in the exchange required *via* a two-wire junction, or *via* a direct three-wire trunk in the case of calls to the Head Office when the 2nd digit is dialled: the remaining three digits of the extension wanted are then dialled and pick up a final selector and the required extension.

Calls to Gravesend are completed manually after the P.B.X. operator at Gravesend has been reached by dialling 98; the manual board taking the place of 3rd selectors at the other docks.

Local and Fee Junction Calls to the public can be made by dialling "0"; junctions from this level go direct to the relative public exchange and the public exchange operator makes the connection and meters the call, as in the case of an ordinary subscriber.

Trunk and Toll Calls to or from any extension must be dealt

with by the PLA operator so that the payment may be controlled, and the call when it matures may be circulated to the calling extension. As all inward traffic comes into the Head Office, except in the case of Tilbury, naturally outward trunk traffic must take the same route. The caller dials 91 and gets the attention of the PLA operator.

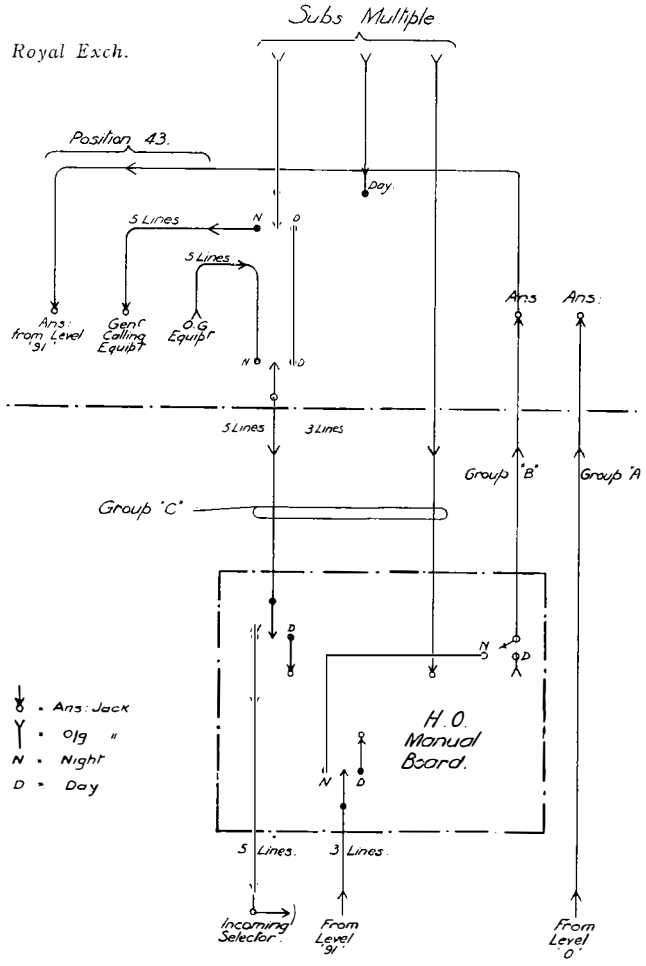


FIG. 2.—P.L.A. HEAD OFFICE LINES TO ROYAL EXCHANGE.

SECTION C.—NIGHT SERVICE ARRANGEMENTS. (FIG. 2).

The night arrangements at the Head Office and at Tilbury are similar and only those at the Head Office will be described. The main feature is that the P.O. operator at Royal will dial PLA extensions when the subscriber's PABX operators are not on duty.

The lines from the PLA to Royal Exchange consist of three groups, A, B and C.

Group A consists of lines carrying outward local and junction traffic from the Head Office extensions to Royal Exchange, obtained by dialling "o."

Group B consists of lines worked manually from the Head Office to Royal.

Group C consists of lines from Royal to the Head Office, several of which are switched to apparatus at night to carry night traffic.

An extension wanting a trunk call at night dials 91, as is done during the day, but the call arrives at a special position at Royal, having been transmitted over one of Group B lines to answering equipment on a special position at Royal. The Royal operator completes the Trunk call in the ordinary manner.

Calls being made to the PLA at night are put through on the subscribers' multiple as during the day, but as the lines are now intercepted the call is received on answering equipment at the special position in the same exchange, where the Department's operator can complete them by dialling into the PLA system. She plugs into special outgoing jacks at Royal which are connected to the lines of group C, arriving at PLA Head Office on incoming selectors: she then dials the five digits of the required extension number whether it be at the Head Office or at one of the Docks. The caller must be in a position to ask for the particular dock and particular extension number required.

Section D.—Plant and Traffic Routes at Tilbury Docks.

This exchange has one manual board and 60 extensions. The local calls are dealt with as in other exchanges.

The junction traffic is dealt with *via* three routes:—

1. *Via* "o" level circuits *to* the Tilbury Public Exchange.
2. *Via* manaul bothway junctions to and from Tilbury Public Exchange.
3. *Via* manual and auto junction lines to the Head Office for traffic in the PLA system.

There are three "o" level lines, which are not allowed trunk facilities. If an extension wants a trunk call, 8 will be dialled and the call will arrive at the PLA manual board. The operator will book and pass the call to the Tilbury Public Exchange over a bothway manual exchange line.

Incoming trunk calls to Tilbury Docks will come over the trunk lines to Tilbury Public Exchange and be passed *via* the bothway exchange lines to the PLA board.

When extensions require information from their own operator, they will dial "8," and the call will arrive at the manual board.

Fig. **3** shows, schematically, the grouping of plant at Tilbury.

The 60 auto extensions come to break-jacks on the manual board and thence to 1st Preselectors. The banks of 1st Preselectors go to 1st Selectors. On level 2 are the final selectors for auto calls incoming to auto extensions. Manual calls are connected direct *via* the break-jack on the manual board.

On level " 0 " is the auxiliary equipment for calling the Tilbury Public Exchange.

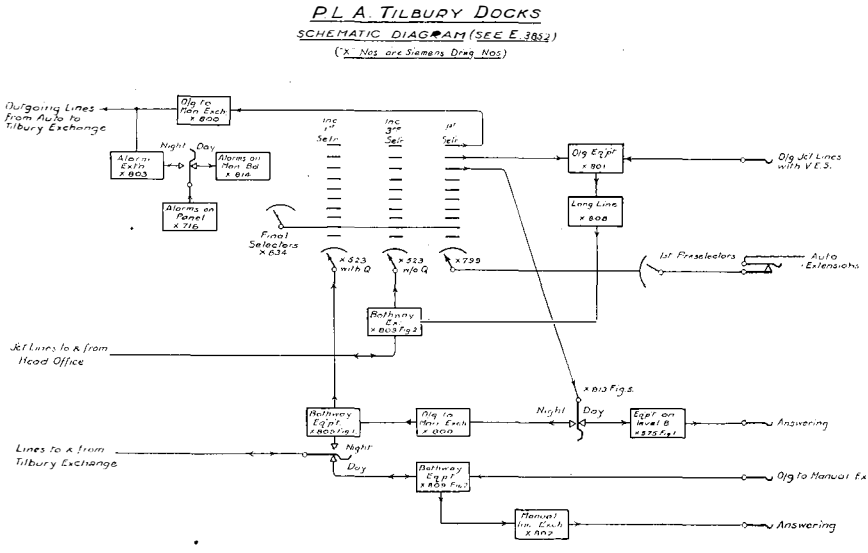


FIG. 3.—P.L.A. TILBURY DOCKS. SCHEMATIC DIAGRAM.

On level " 9 " is the equipment for calling the other PLA exchanges, *via* the tie lines: the manual board operator has access to these same tie lines *via* o/g jacks equipped with manual engaged signals. The bothway equipment busies the manual board jacks and relative bank when the tie line is being used for an incoming call.

On level " 8 " during the day, the call goes *via* auxiliary equipment to the answering jack on the manual board, and at night to the Public Exchange. (See below).

The exchange (manual) lines terminate on ordinary bothway equipment and answering jacks at the PLA manual board.

The traffic arrangements at night are as follows:—

The PLA operator before she leaves will throw night switching keys which

(1) Change over the manual exchange lines to (*a*) incoming 3rd selectors for incoming calls, and to (*b*) circuits from level 8 so that when extensions dial " 8 " for trunk

calls, the call will be received by a special operator in the public exchange who will control inward and outward calls for the PLA.

The routing is as follows: from level 8 *via* key to equipment for calling the public exchange, *via* bothway equipment to cut off the incoming selector *via* the other key to the public exchange.

Incoming calls come from Public Exchange *via* key and bothway equipment to an incoming selector.

The public exchange operator must dial the three figures of the extension number required.

(2) The night keys also throw over an alarm circuit so that faults occurring at night will give the alarm by lighting lamps at Tilbury Public Exchange instead of lighting lamps on PLA manual board.

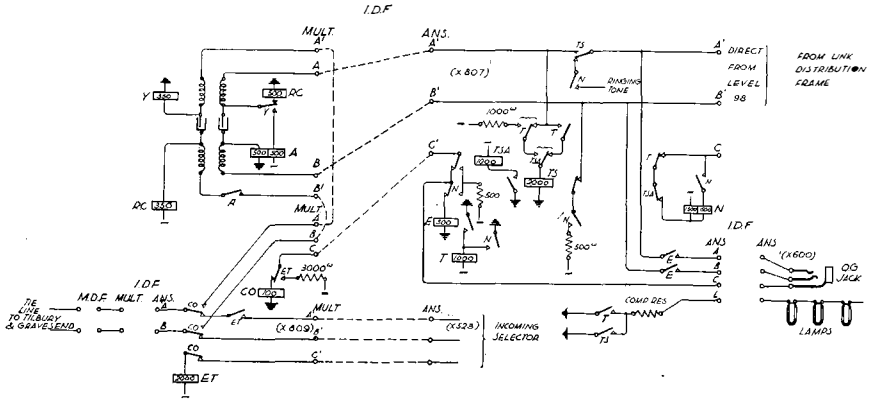


FIG. 4.—P.L.A. BOTHWAY EQUIPMENT ON TIE LINES. HEAD OFFICE.

SECTION E.—BOTHWAY JUNCTION LINE CIRCUIT.

The bothway junction line circuit between the Head Office and Tilbury or Gravesend is shown in Fig. 4. Its circuit operation is as follows:—

The Gravesend operator making a call takes possession of an incoming selector and dials the number required. The outgoing junction multiple and the banks of the 2nd selectors on level 98 are made busy so that the junction cannot be taken up simultaneously for calls from the Head Office to Gravesend.

The PLA operator making a call to Gravesend plugs in on the outgoing junction multiple, engages the banks on the level 98 and cuts off the incoming selector. Similarly, an automatic call to Gravesend will engage the outgoing junction multiple and cut off the incoming selector.

We shall first describe the operations for a *manual call* from the PLA operator to *Gravesend*.

(*e* = energised, *d* = de-energised, *h* = held, T′ = *via* a contact of T energised, ′T = *via* a contact of T unenergised or normal).

The operator plugs into the outgoing junction multiple

E *e* from the sleeve circuit.

CO *e* ,, ,, ,, ,,

T *e* *via* E and lights the visual engaged lamps and also cuts off battery from private of bank contact which is therefore busy.

The incoming selector is cut off at CO′.

A *e* in long distance equipment, by battery sent out on B line from cord circuit.

Battery is sent out on B line to Gravesend from the retard RC (350), *via* A′ and the Gravesend operator is called.

The Gravesend operator replies : and puts

Y *e* Battery on the A line and operates Y.

TS *e* Battery *via* A (500), Y′, repeater, A line, T′, ′TSA, TS (2000), earth.

TSA *e* *via* TS′.

TS joins the A line through to the cord circuit and extinguishes the supervisory lamp.

TS *h* Battery, 1000 ohm resistance, T′, TSA′, TS (2000), earth.

TSA keeps the battery from the private of the banks and keeps them engaged and TS keeps the visual engaged lamps alight.

The banks and outgoing junction multiple are thus kept engaged as long as either the Gravesend operator or the PLA operator has a plug in the line jacks.

Now consider the operations for an *automatic call to Gravesend* when the tie line is picked up automatically at the Head Office when someone has dialled 98.

The wipers of the 2nd selector wipe over the banks marked A′, B′, C′, and if the tie line be free, battery N (1500) operates the test relay.

N *e* the 2nd selector and relay N operates.

M *h* by earth on the private wire of 2nd selector.

T *e* *via* N′.

T lights the visual engaged lamps.

CO *e* Battery, 500 ohms, N′, ′TSA, ′ET, CO (100), earth.

CO cuts off the incoming selector.

N puts battery *via* 500 ohms on to B line and N puts ringing tone to the caller.

A *e* operates A.

A joins battery *via* RC (350) to the B line to Gravesend.

When Gravesend operator replies the actions of TS and TSA are as previously described.

The relays and retards energised during a conversation automatic call to Gravesend and supplied with battery from the Head Office are :—

Relay.	*Ohms.*	*Amperes.*
CO	500 + 350 ohms	0.0706
RC	350 + 23 + 800 line + 50 Gravesend	0.0490
A	500 + 23 + 500	0.0686
N	1500 + 1500	0.0200
T	1000	0.0600
TS	1000 + 2000	0.0200
TSA	1000	0.0600
Lamps,	150 (in circuit)	0.2500
	Say 0.60 Amp.	0.5982

Current will also be used in the 2nd Selector originating the call to Gravesend and Gravesend will supply battery *via* A wire to hold Y (350).

Now consider a call *from Gravesend.* When the Gravesend operator plugs in, battery on the B wire operates on a relay in the incoming selector: A relays pulls up V, which earths the C wire. This pulls up ET.

ET puts the A line through.

ET puts the engaged test on the *o/g* jack.

E *e* from ET and lights the visual engaged lamps.

T *e* from E, and engages the bank on level 98 by cutting off battery so that no auto call can be received.

Gravesend then dials in the ordinary way and the call will go through automatically to its destination.

During a call from Gravesend the current used is:—

Relay.	*Ohms.*	*Amperes.*
ET	2000	0.0300
E	3000 + 500	0.0171
T	1000	0.0600
Lamps	150	0.2500
		0.3571

Current used in incoming selector (X523):—

A	from Gravesend	
HA	500 + 23 + 800 + 50	0.0435
V	500 + 1000	0.0400
V	500 + 300	0.0750
RA	350 + 500	0.0706
T	1500	0.0400
		0.2681

Section F.—Alarms at H.O. and Tilbury.

When a fault occurs a lamp glows to indicate its position and type, and a pilot relay causes a lamp on the manual board to glow. The various faults are grouped under two headings, "urgent" an "non-urgent," and actuate either an "urgent" pilot or a "non-urgent" pilot relay. Fig. **5** shows the circuits which are used for extending the alarm to the manual board and the public exchange.

During the day any fault simply causes a lamp to glow on the manual board and the operator advises the maintenance staff of its occurrence.

At night time the existence of urgent faults is made known to the public exchange operator over a junction used ordinarily for traffic, but which can be taken up, if idle, by the fault signalling arrangements.

At night time the existence of non-urgent faults is not *signalled* to the public exchange.

If an operator wishes to find out whether or not a non-urgent fault exists, she can dial a particular number allocated for "faults," and if the number is busy a fault exists.

If everything is in order the operator would receive N.U. tone on that particular number: the busy condition is put on by the break in the C wire, due to operation of either H or B relays.

During the day the key is normal and the operation of a pilot relay lights the lamp on the manual board.

When the PLA operators leave the manual board the key is thrown. A non-urgent fault will then actuate H and put busy on the particular "fault" number.

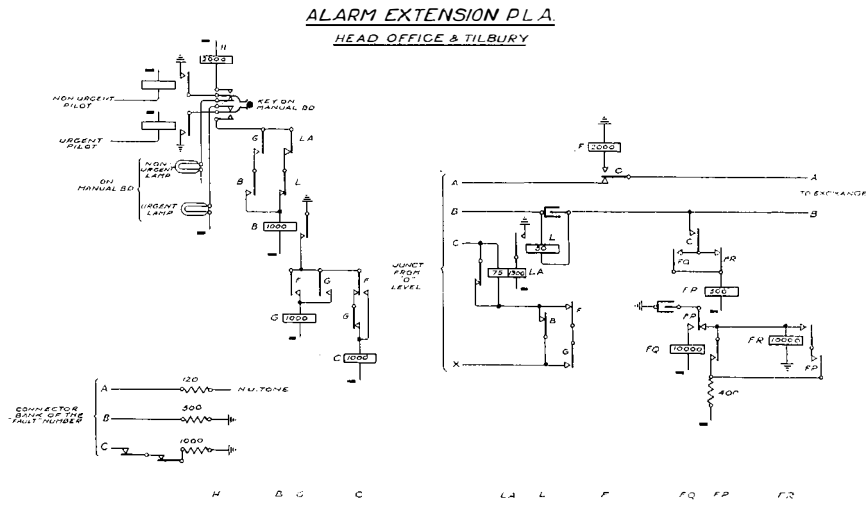


FIG. 5.—ALARM EXTENSION P.L.A. HEAD OFFICE AND TILBURY.

The circuit description of an urgent fault at night is as follows:—

(*e* = energised, *d* = de-energised, V = battery 'L = *via* L armature, normal, L' = *via* L armature operated).

Urgent Alarm. Fig. 5.

Assuming the junction to public exchange is idle.

B *e* V, B 1000, 'L, 'LA, contact of Alarm relay, earth B relay disconnects private of cct. allotted for fault discrimination at B' making it test busy to the operator when she tests.

C *e* V, C 1000, 'G, 'F, B', earth.
C relay disconnects A line to auto. equipment and connects the A line to F 2000.

FP *e* V, FP 500, 'FR, C', B line, Exchange earth.

FQ *e* By condenser charge.

FR *e* When FP is operated, relays FW and FR are operated alternately *via* FR', 'FQ and 'FR, FQ', thus giving an intermittent flash at the exchange.

F *e* When the operator answers she puts battery on the A line and operates F.

The lamp in the B side of the cord circuit will flash.
F relay brings in G relay.
G *e* V, G 1000, F′, B′, earth.
G *h* G relay locks itself; *via* G′ B′, earth.
C *h* C relay is now held *via* F′ instead of ′G.
When the operator withdraws her plug, the lamp flash stops because,
F *d* at withdrawal of plug
C *d* at ′F and this cuts FP off the B line.
The A line is re-connected to the Auto. equipment at ′C: and the junction is available for ordinary traffic.
Relay G is now held operated *via* G′ and B′.
Relay B is operated all the time the fault exists, *i.e.*, whilst the "urgent" Pilot Alarm relay is operated.
The operator can test if the fault is still on, by testing the predetermined extension number which will test busy whilst the fault exists.
Should the junction be engaged when the Alarm originates, then
L *e* *via* the junction loop
LA *e* V, LA 1300, L′, earth: now B relay cannot operate until the junction is free.

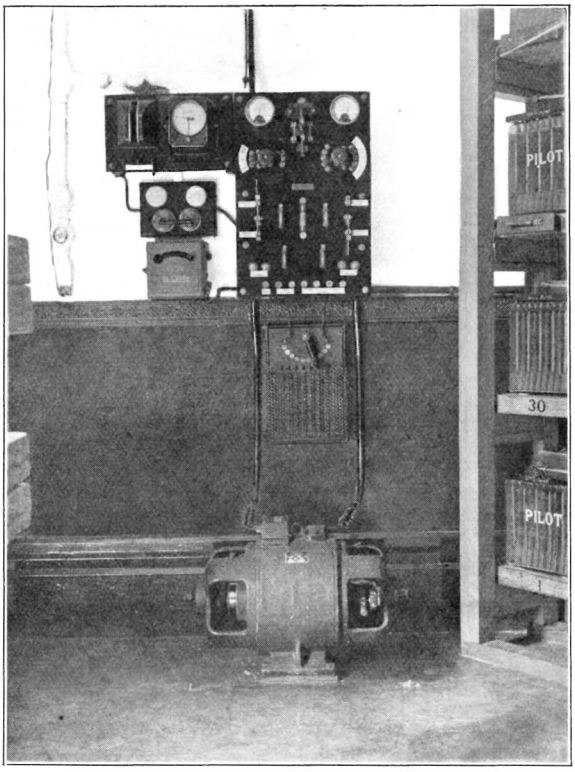


FIG. 6.—CHARGING PLANT AT SURREY COMMERCIAL DOCKS.

SECTION G.—POWER PLANT.

The Power Plant provided for the satellite exchanges is of the standard Post Office type. Fig. **6** shows the installation at Surrey Commercial Docks. It comprises (*a*) the charging machines con-

sisting of a 230-volt motor coupled to a generator giving 20 amperes at 60 volts with voltage regulation from 60 to 82 volts: (*b*) the charging panel, and (*c*) the ampere-hour meter which cuts off the charge when the requisite charge has been given to the cells. The pointer of the A*h* meter is set at a certain point by the officer who starts up the charging machine; when the full charge has been given to the cells, the pointer makes an electrical contact which actuates the no-volt release of the starter and the charging machine stops running.

In every exchange there are duplicate ringing machines, arranged so that if one fails to supply the current, the other machine will start up and supply the ringing current. The machines comprise (*a*) the ringer, (*b*) the interrupters for giving the busy back and number unobtainable tone, and (*c*) the interrupters for supplying impulses at 60 and 30 per second for driving the preselectors and selectors.

It is Messrs. Siemens' usual practice in small exchanges to provide one machine to give all the interrupted currents needed. In large exchanges they provide separate machines to give ringing interruptions and switch drive interruptions.

Section H.—Current Consumption.

This section gives the current consumption for some typical calls, during conversation period. Dialling and ringing periods are not considered.

Consider four types of calls from a satellite, say, Surrey Commercial Docks:—

(*a*) To Public Exchange, "o."
(*b*) To a local extension.
(*c*) To an extension at Head Office.
(*d*) To an extension at India and Millwall Docks.

Consider three types of call at the Head Office:—

(*e*) Incoming from the Public Exchange to Head Office extension.
(*f*) Incoming from the Public Exchange to a Satellite (IM).
(*g*) From a Head Office extension to a Satellite (IM).

The first selector supplies currents backwards to feed the calling extension: the amount of current fed forwards depends upon whether the current goes (*a*) to the Public Exchange, (*b*) to feed another extension, (*c*, *d*) over a junction line to the Head Office.

For (*a*) the exchange line is taken as 100 ohms, and relay to earth in cord circuit as 200 ohms, total resistance is 700 ohms (86 *m*A).

For (*b*) the extension loop is taken as 150 ohms, giving a total 850 ohms (70 *m*A).

For (*c*, *d*) the junction line resistance is taken as 100 ohms, giving a total 973 ohms (62 *m*A), with a 23 ohm repeater in series with 500 ohms.

The C wiper circuit differs in the various cases: for calls going outside the exchange the wiper has to find battery to prove that the junction is idle: battery through 1000 ohm, C wire resistance, is put on the private, which becomes earthed when a selector picks up the junction. For local calls the battery is supplied *via* the private wire of the final selector.

The ampere-hours for 2 minutes duration calls are thus:—

At	*a* SC to Ex.	*b* SC to SC	*c* SC to HO	*d* SC to IM	*e* Ex. to HO	*f* Ex. to IM	*g* HO to IM
Head Office	0	0	.014	.017	.010	.018	.021
Surrey Commercial ...	.013	.015	.012	.012	0	0	0
India & Millwall ...	0	0	0	.012	0	.012	.012

A MODERN TELEPHONE REPEATER STATION.

THE principal members of the net-work of modern high efficiency telephone cables connecting all the important towns of Great Britain have now been completed, and as far as these towns are concerned insurance against total interruption of communication by storm and tempest is as complete as modern scientific methods can make it. The general design of the cable network was described by Sir William Noble in his paper before the Institution of Electrical Engineers in 1921. The routes of the main cables and the location of the repeater stations are given in Fig. 1.

The time required for building and equipping the Repeater Stations has proved to be longer in nearly every case than the time taken to complete the cables converging on them. In addition to the delays unavoidably connected with the purchase of sites and the placing of building contracts there have been several periods of delay due to strikes in the building trade. Where, however, it has not been possible to complete a main Repeater Station by the time the converging cables were ready for service a temporary installation of repeaters has been provided to avoid loss of revenue. The temporary installation has generally consisted of one or more emergency sets which are kept normally in readiness at convenient points in the country for use in case of fire and other contingencies.

The purpose of the present article is to describe one of the modern permanent Repeater Stations which constitute a new

feature in any considerable network of underground telephone cables. These stations are located at average intervals of 50 miles along the cable routes. The actual location of any station has been dependent on several factors, the primary considerations being the maintenance of a uniform power level along the cable lines, the focussing points of cable routes and the availability of a reliable source of public power supply. The locations of stations

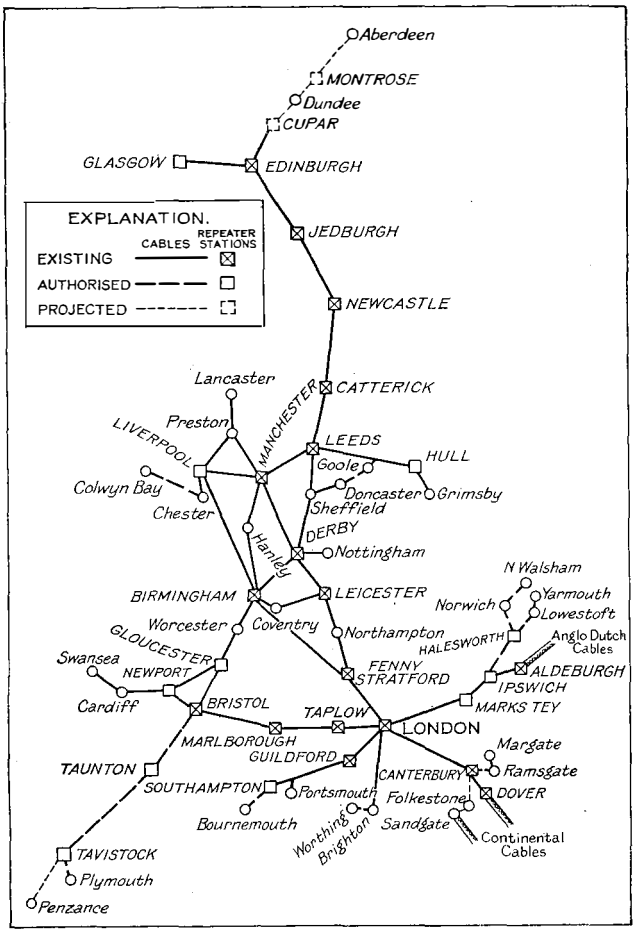


FIG. 1.—TELEPHONE REPEATER STATIONS—PLAN OF SYSTEMS.

such as Derby, Leeds, or Birmingham is evidently fixed by their position on the cable routes; whereas stations such as Marlborough or Jedburgh have been located by the first condition mentioned. In cases such as the two last named the stations are necessarily self-dependent as regards power supply and have their own prime movers. Otherwise they conform to the general design which has

been standardised for the whole system. The stations to which the following description applies in detail are those at Taplow and Marlborough on the London-Bath main road. These were the first of the series of permanent stations to be completed and may be taken as fully representative of the whole series.

Taplow station stands on a plot of about two-fifths of an acre, with a frontage of 85 feet to the main road. The buildings, which were designed by and erected under the supervision of H.M. Office of Works, are plain brick structures of two floors in fireproof construction throughout. The roof is flat. The ground floor accommodates the prime movers, generators and batteries; the upper floor is taken up almost entirely by the repeater room. Ample staff accommodation is provided on both floors. A low pressure water heating system is installed, with the boiler in a basement alongside the cable entrance chamber. In spite of its

FIG. 2.—MARLBOROUGH STATION.

not altogether prepossessing external appearance, the well-lighted and ventilated interior presents a very pleasing effect, and it would be difficult to imagine more pleasant conditions in which to work. Figs. **2** and **3** are photographs of the Marlborough and Taplow Repeater Stations. In some of the later and more isolated stations residential accommodation in the form of a 5-roomed flat has been added. Continuous attendance will be given in all the main line repeater stations.

The site of the Taplow station is large enough for a building of sufficient proportions to accommodate all the repeaters needed for operation of the cables for which ducts have been laid along the route. In general along the main routes 3 ducts have been laid for long distance cables. Taking the average circuit capacity per cable (including phantoms) as 330, an ultimate of 1,000

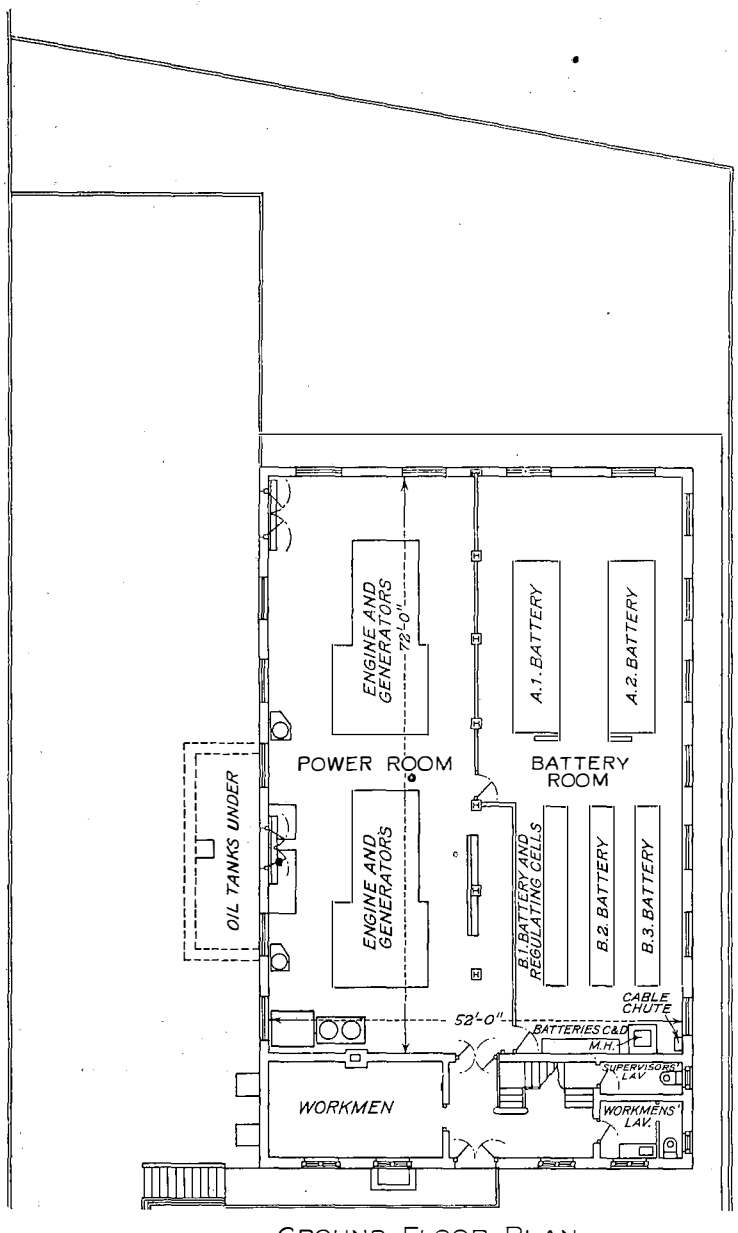
repeaters is arrived at. The proportions of the initial buildings were determined primarily by examination of traffic estimates which resulted in a standard layout for 520 repeaters, sufficient in most cases for a 10-year period.

The standard lay-out of the two floors is indicated in Fig. **4**.

It will be convenient in the first place to trace the course of a two-wire cable circuit through the Repeater Station by reference to Fig. **4** and photographic illustrations.

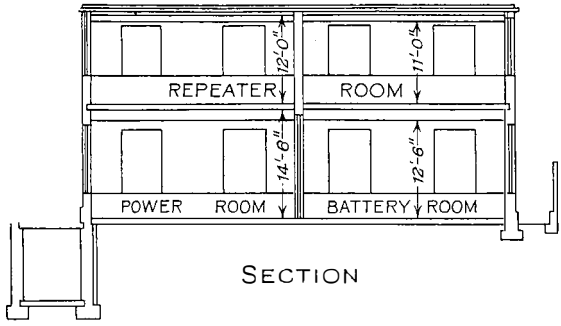
FIG. **3**.—TAPLOW STATION.

The main cables are turned into the building from a roadway manhole astride the duct line and enter the cable turning chamber in the basement. They rise from this chamber vertically to the Repeater Room to a point 2 or 3 feet above floor level (Fig. **5**). At this point, each main cable (in this case each cable contains 154 quads, multiple-twin formation) is divided by means of a pothead into 7 subsidiary cables for convenience in handling. The air space and paper insulation of the main cable is unchanged in the extension cables. The extension cables are carried along above the Terminal Test Tablet Racks, where each cable in its turn is terminated in a pothead from which emerge a corresponding number of V.I.R. tails. These tails are led down to the back of the Test Tablets and soldered to pillar terminals. The cable

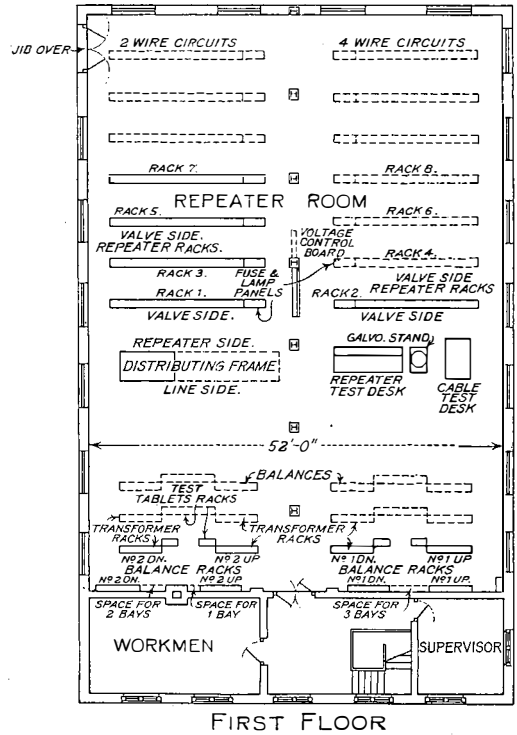


GROUND FLOOR PLAN

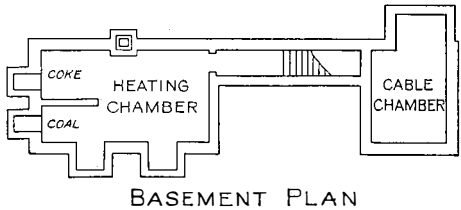
FIG. 4.—STANDARD LAY-OUT OF THE



SECTION



FIRST FLOOR



BASEMENT PLAN

TWO FLOORS AT THE REPEATER STATION.

conductors are thus completely sealed between the Test Tablet Terminals of successive stations along the cable route, and an insulation resistance of 10,000 megohms per mile is the minimum admitted.

The cable circuits are extended from the Test Tablets to the Terminal Transformers, seen at the bottom of the rack in Fig. **5**, by means of V.I.R. The Test Tablets are to be seen at the right of the Transformer Rack.

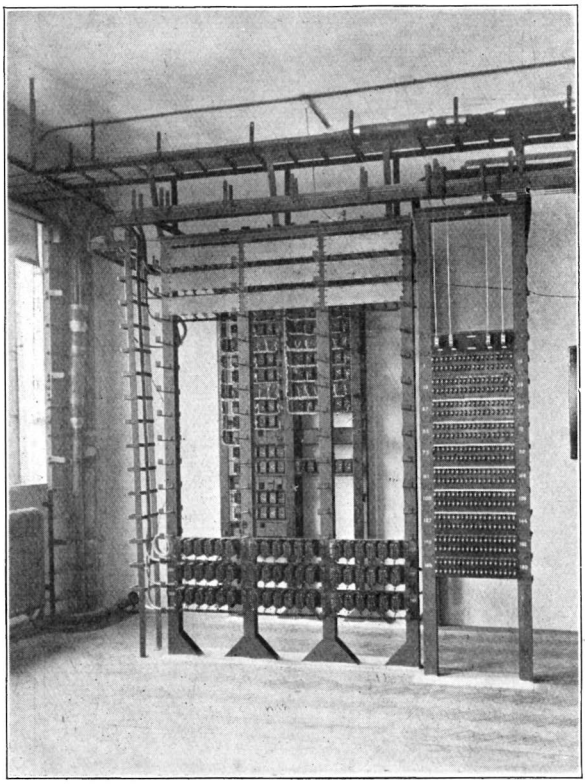


FIG. **5**.—ENTRY OF MAIN CABLES TO REPEATER ROOM AND TERMINAL TEST TABLETS.

Two-Wire Working.—A group of 3 pairs of transformers is allotted to each cable quad; one pair for each physical or side circuit and one pair for the superposed or phantom circuit.

Of each pair of transformers one takes the line circuit and its companion the balance circuit. The object of pairing the transformers, which is done by careful selection after manufacture, is to ensure that the line and balance transformers present the same impedance characteristics at speech current frequencies, that is, between 300 and 2,000 cycles per second, this being the

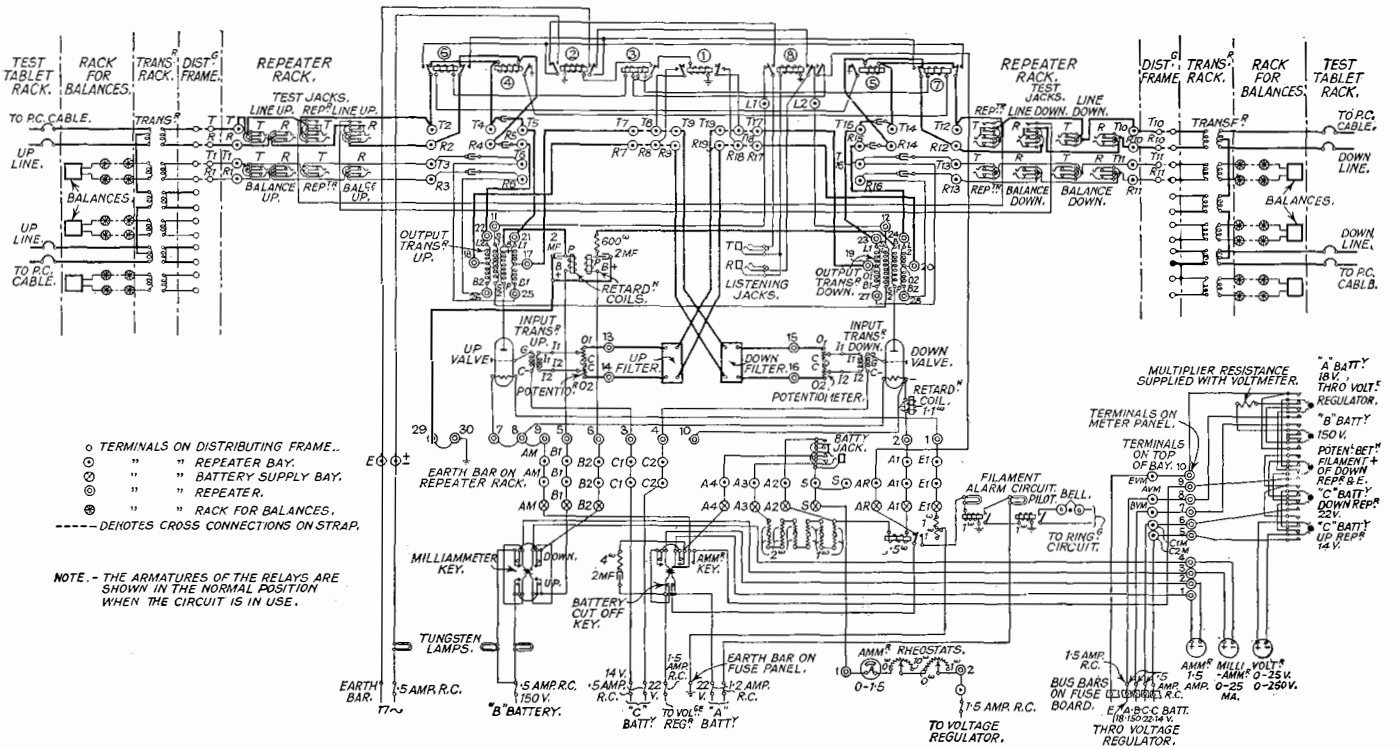


FIG. 6.—TELEPHONIC REPEATER STATIONS: 2 WIRE, 2 VALVES, 1 STAGE WITH REPEATER NO. 10 COMPLETE CIRCUIT DIAGRAM.

maximum range normally provided for in 2-wire circuits. The wiring arrangement of the transformers is clearly shown in the diagram Fig. **6**. From the Transformer Rack the cable circuits, physical and phantom, are carried to the Distribution Frame (Fig. **7**) in lead-covered silk and wool insulation cables, each cable carrying 9 circuits.

The wiring diagram (Fig. **6**) shows one of the physical circuits of a quad through the station, but physical and phantom circuits are precisely similar inside the station. The circuits are dis-

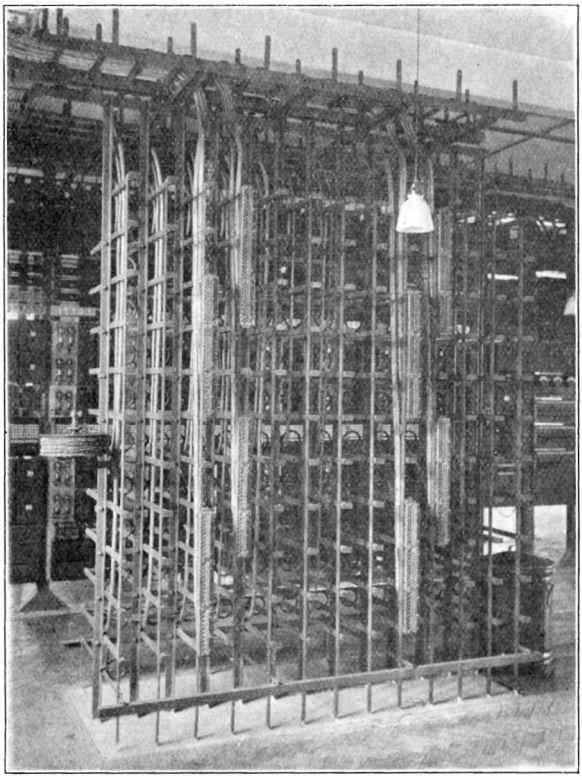


FIG. **7**.—DISTRIBUTION FRAME.

tributed from the D.F. to the various Repeater Racks in small lead-covered cables, terminating on tags at the head of each bay (Fig. **8**). From this point we must consider separately the speech and signalling circuits. The former can be traced along the heavy lines in the wiring diagram. The 2-wire repeater is illustrated separately in Figs. **9**, **10** and **11**.

It will be seen that it is necessary to take the speech circuit through the contacts of ringing relays before it passes *via* the

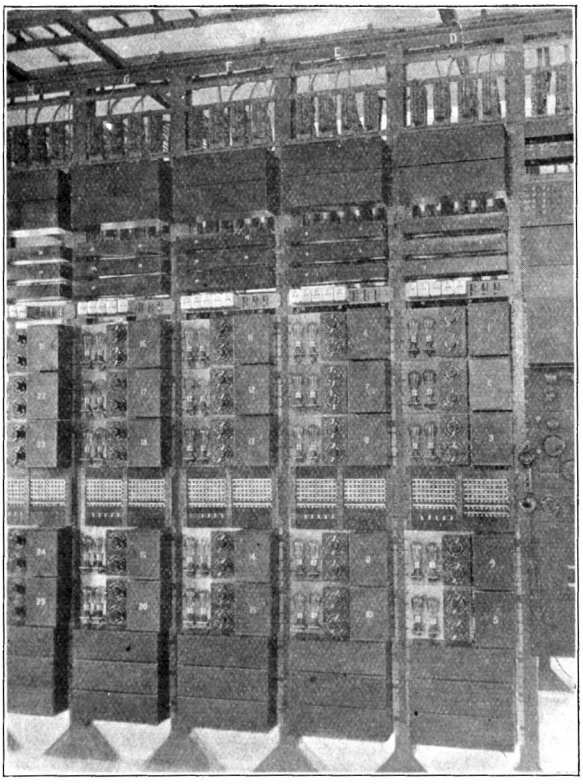


FIG. 8.—REPEATER BAYS.

Differential Output Transformer to the opposite Input Transformer.

The balancing network, which consists of a network simulating as closely as possible the impedance characteristics of the actual

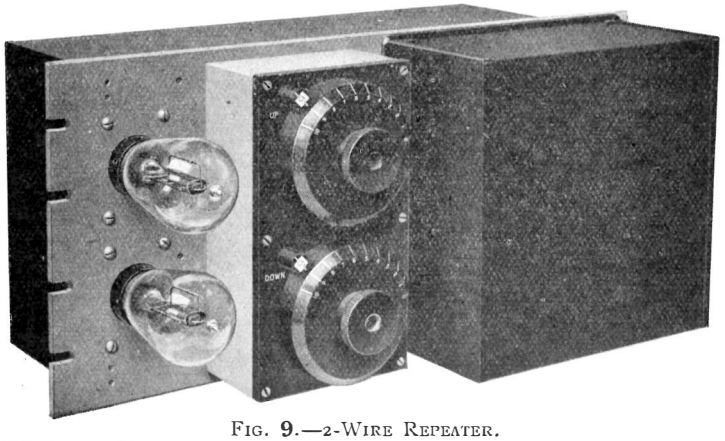


FIG. 9.—2-WIRE REPEATER.

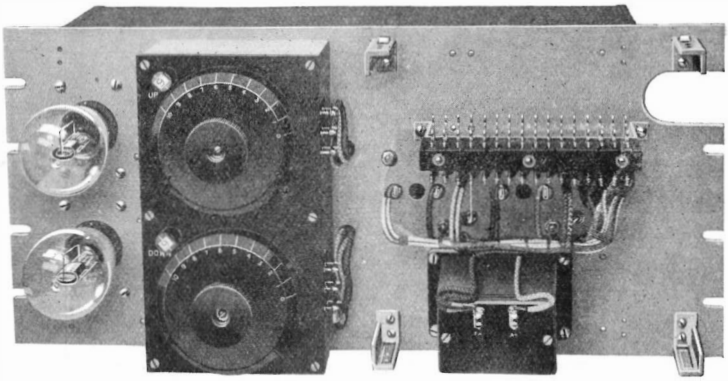


FIG. 10.—FRONT VIEW WITH DUST COVER REMOVED.
2-WIRE REPEATER.

cable line, is connected in series with the line windings of the Differential Transformer. The networks are accommodated on a rack fitted close up to the Terminal Transformer Rack and the

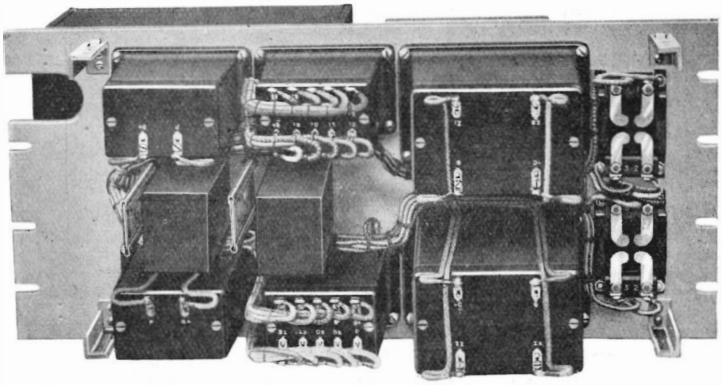


FIG. 11.—REAR VIEW WITH DUST COVER REMOVED.
2-WIRE REPEATER.

whole arrangement is so designed that the line and balance circuits are electrically identical between the Repeater Rack and the Terminal Rack.

A typical balancing network for a physical circuit in the

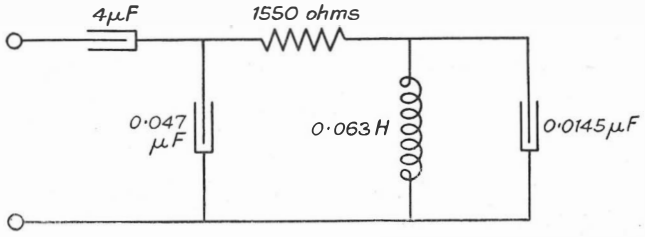


FIG. 12.—BALANCING NETWORK FOR SIDE CIRCUIT—TAPLOW REPEATER STATION.

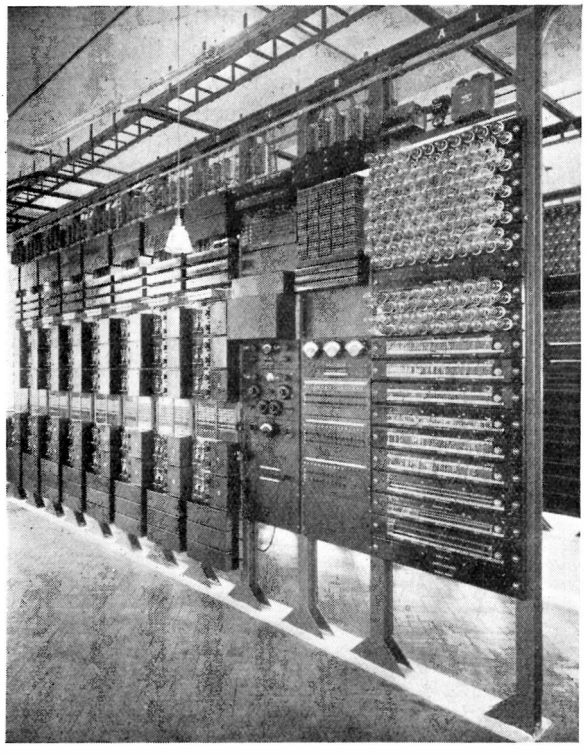


FIG. 13.—REPEATER RACK FRONT.

London-Bristol cable at Taplow is shown diagrammatically in Fig. **12.** These networks are designed on the basis of actual measurements of the line impedances.

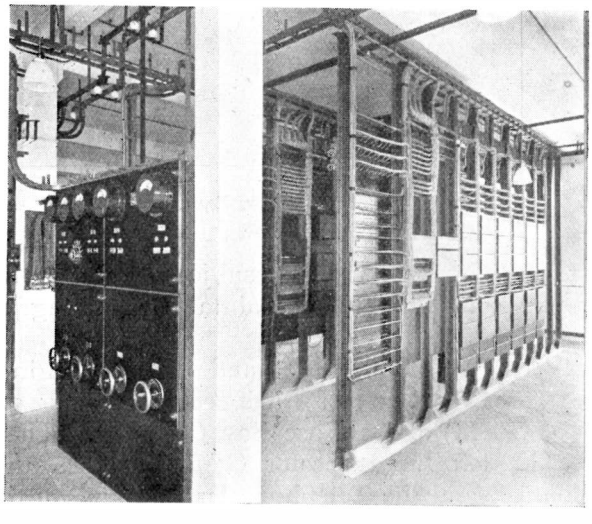


FIG. 14.—REPEATER RACK REAR.

From the middle points of the Up differential transformer the speech circuit passes through the Down filter to the potentiometer controlling the grid circuit of the Down Valve. The plate circuit of this valve transmits amplified speech currents to the Down line *via* the Down Differential Output Transformer, the wiring from this point to the cable Terminal Transformers being precisely similar to the wiring of the Up line side.

The theory and performance of a 2-wire Telephone-Repeater having been frequently described in the pages of this journal, it is

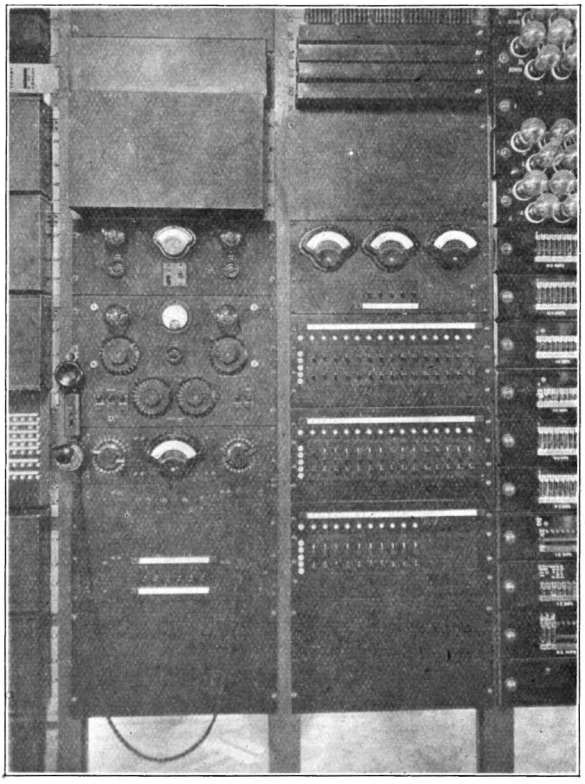


FIG. **15**.—TEST BAYS.

not necessary to enlarge on the subject in this article. Some details of the controlling and maintaining arrangements may, however, be of interest.

Each Repeater Rack, Figs. **13** and **14**, includes in addition to 7 (in some cases 8) Repeater Bays, each carrying 5 Repeaters, Test Bays (Fig. **15**) and a Fuse Bay (Fig. **16**). The Test Bays include on the left the Repeater Gain Test Set, the Filament Current Control, and the Telephone Panels, and on the right the Battery Supply Bay (Fig. **17**).

The Repeater Gain Test equipment consists of a single frequency valve oscillator, a rectifier-amplifier measuring circuit and an adjustable artificial cable. By means of this equipment the Repeater attendant can make a rapid check test of the amplification of any repeater under his charge. The circuit arrangement is shown in Figs. **18** and **19**.

The Filament Current Control apparatus is used in setting up a repeater for service, and when valves require to be renewed or changed. On the repeater rack the filament current is controlled

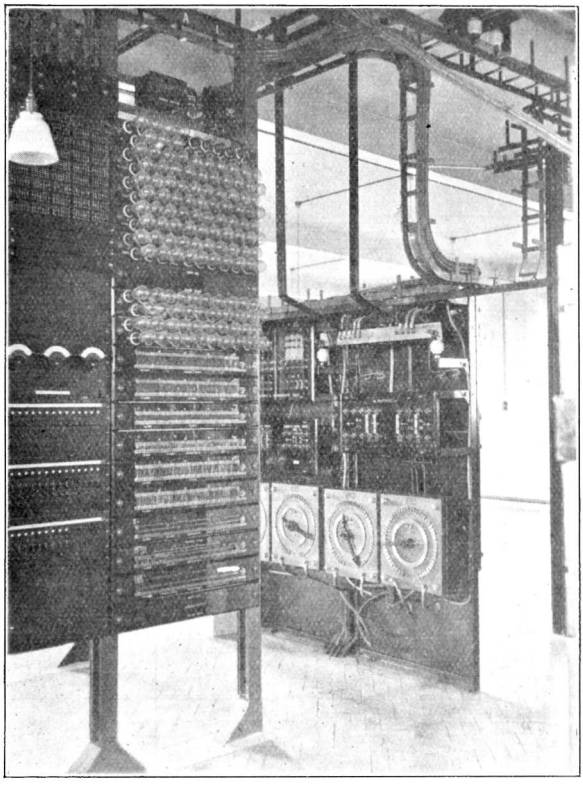


FIG. **16**.—FUSE BAY AND NEAR VIEW OF VOLTAGE CONTROL BOARD.

by a series of small fixed resistance spools, seen in Figs. **6** and **16**. The values of these resistances are determined by means of the rheostat and ammeter of the Filament Current Control circuit. As the average life of these valves exceeds one year's continuous running (in fact some of them have reached 15,000 hours life) the changing of resistance spools is an infrequent operation.

The Telephone Panel provides means for speaking and monitoring on any repeatered circuit in the rack. The valve

circuits of each repeater are led through the Battery Supply Bay and the arrangements of keys and meters provides means for measuring the filament current and the plate current of any repeater in the rack.

REPEATER RACK ASSEMBLY.

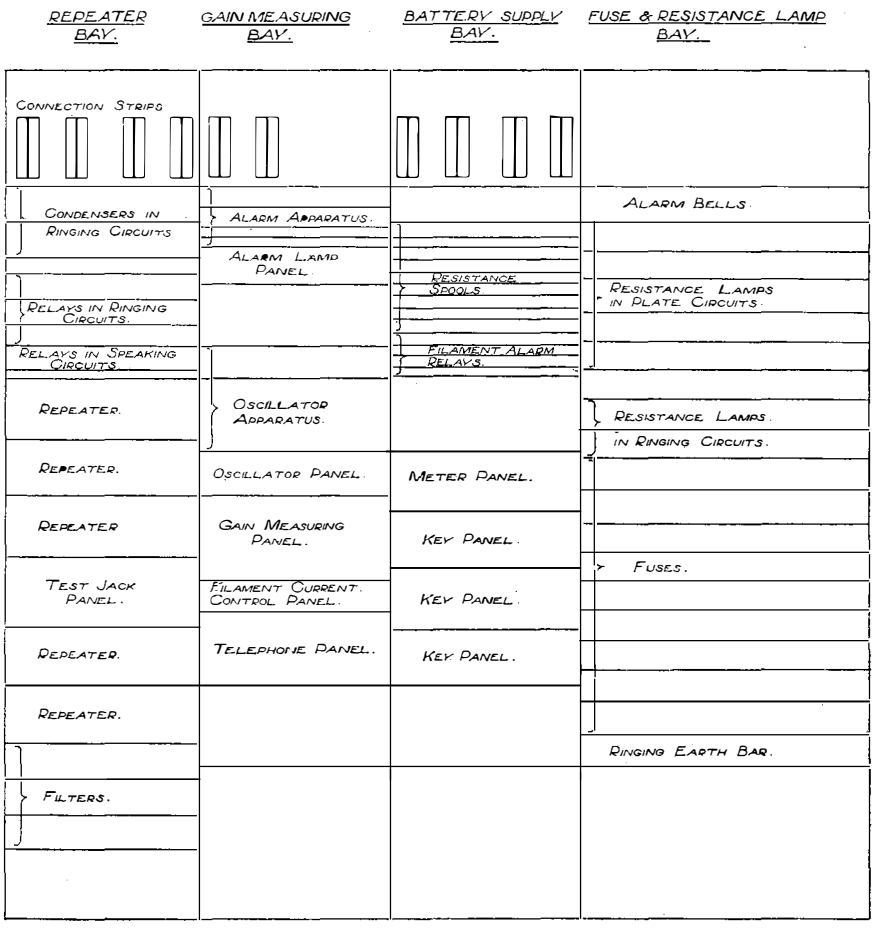


FIG. 17.—REPEATER RACK ASSEMBLY.

The purposes of the Fuse Panel will be seen by reference to the general circuit diagram, Fig. **6.**

It will be seen in Fig. **8** that each Repeater Bay carries a Test Jack Panel, which gives ready access to any part of a repeater circuit and also provides means for crossing out a faulty repeater and extending it to the main Test Desk for special attention.

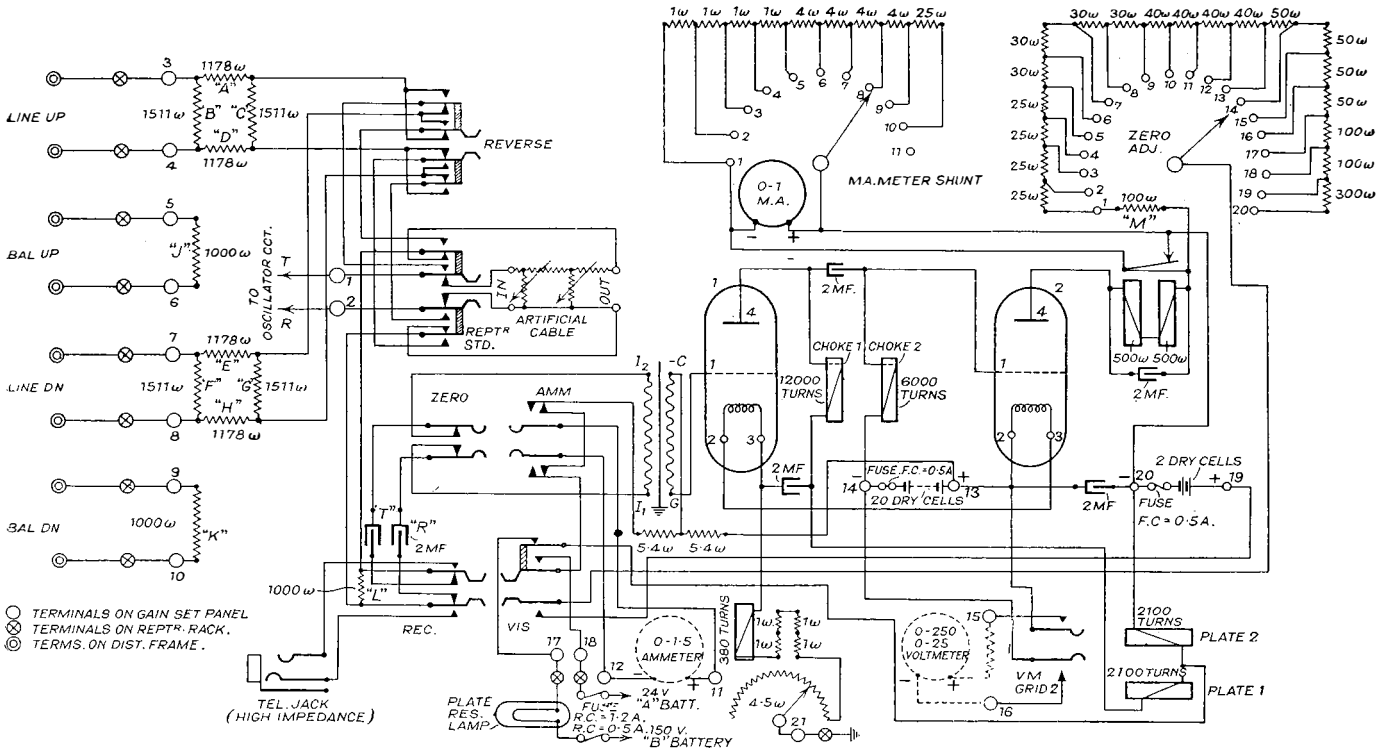


FIG. 18.—GAIN SET CIRCUIT (RECEIVER AND VISUAL) RACK TYPE FOR TELEPHONE REPEATER STATIONS.

The signalling repeater, which relays the 16-cycle currents used normally on trunk lines, is an arrangement of relays which conforms to telephone exchange practice. The various components of the repeater are shown in the general wiring diagram and as their respective functions will be clearly seen no special description is necessary. It may be mentioned here, however, that the necessity for relaying the 16-cycle signalling currents of a trunk line constitutes one of the limiting conditions to the number of 2-wire repeaters which can be operated in a " through " line. The fact that the speech current circuit must be passed through the contacts of the cut-off relays introduces a variable and, at times,

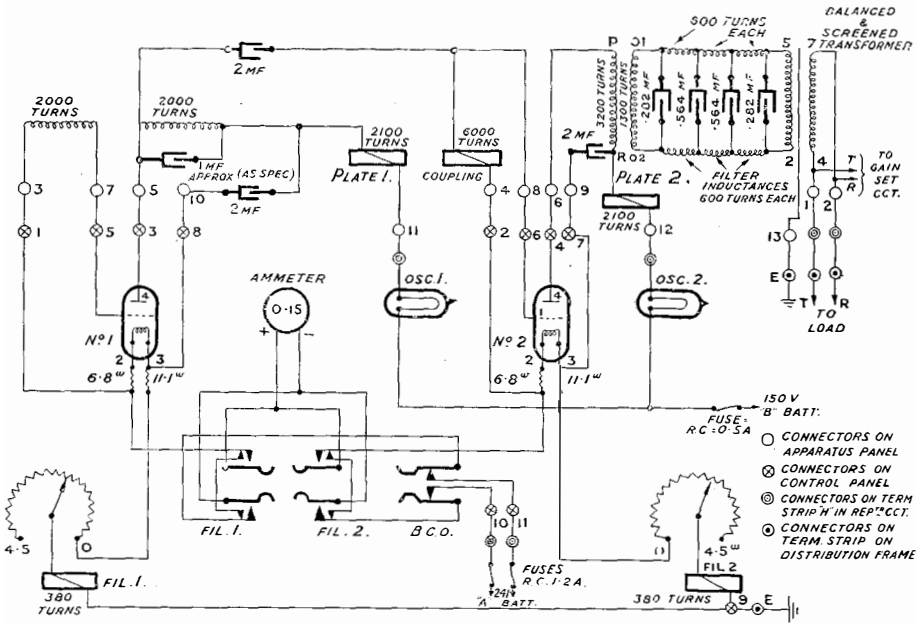


FIG. 19.—CIRCUIT OF FIXED FREQUENCY OSCILLATOR.

troublesome feature in the impedance of the line circuit, resulting in the risk of fleeting " out-of-balance " conditions. Experience has proved that where it is necessary to exceed 3 repeaters in a 2-wire through circuit, it is desirable to transform the 16-cycle signalling current at the terminal stations into a higher frequency, preferably 500 cycles, at speech current amplitude which can be dealt with at the repeaters without mechanical relays. Under service traffic conditions, however, a higher overall transmission efficiency than is possible with 2-wire working is generally demanded on long circuits exceeding 3 repeater sections, that is to say, 150 to 180 miles, and 4-wire working is resorted to.

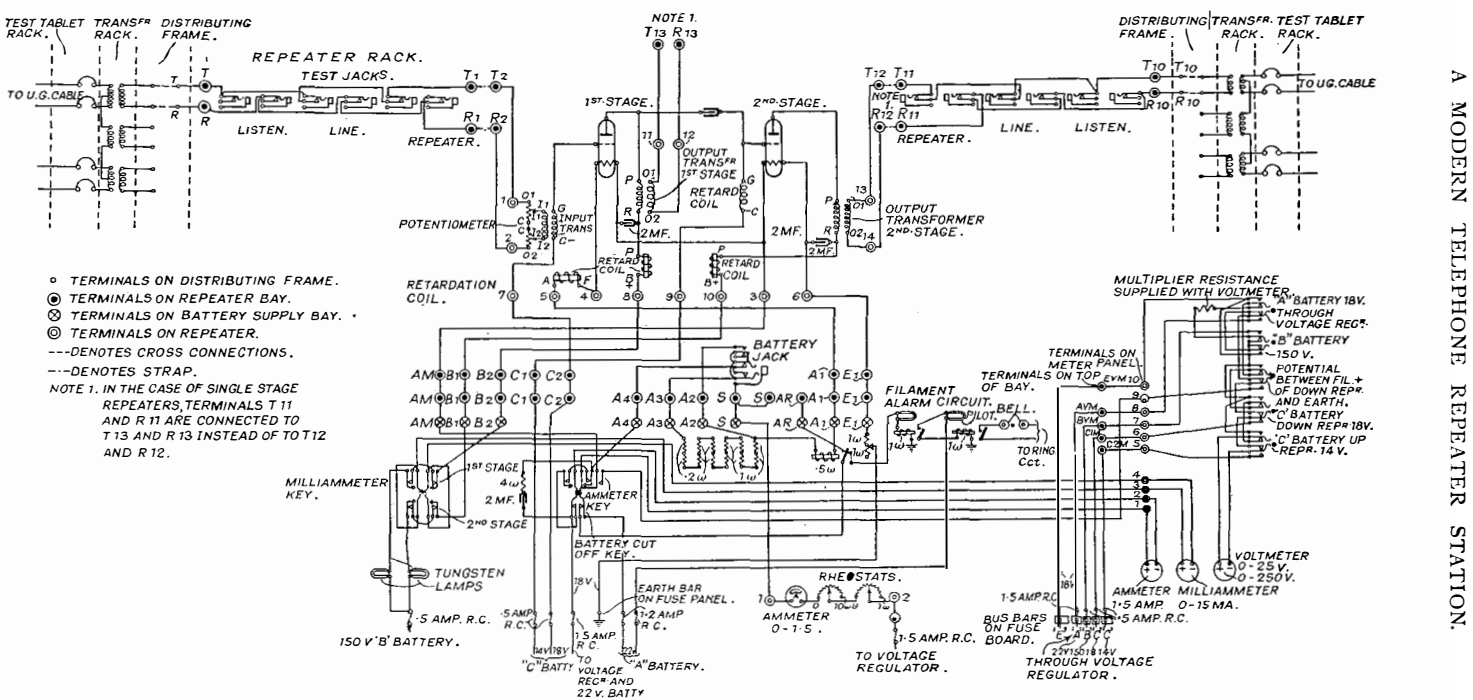


FIG. **20**.—TELEPHONIC REPEATER STATIONS—FOUR-WIRE REPEATER CIRCUIT WITH TELEPHONIC REPEATER NO. 11. MARLBOROUGH AND TAPLOW.

4-*Wire Working*.—The station cabling arrangements are the same as for 2-wire working up to the Transformer Rack, but from this point the cabling makes provision for efficient separation of the " goes " and " returns " of 4-wire circuits. Fig. **20** illustrates in schematic form the wiring of one side of a 4-wire circuit in the Station. The other side of the circuit is precisely similar. It will be seen that the controls of the valve circuits are arranged in the same manner as for 2-wire repeaters.

Fig. **21** is a photographic illustration of a 4-wire repeater unit.

As indicated above, the 500-cycle signalling system used for 4-wire working requires no relays at intermediate repeater stations and in this respect the wiring of 4-wire circuits is simpler than that of 2-wire circuits. As a matter of interest a schematic diagram of the signalling circuit for terminal stations on 4-wire circuits is given in Fig. **22**.

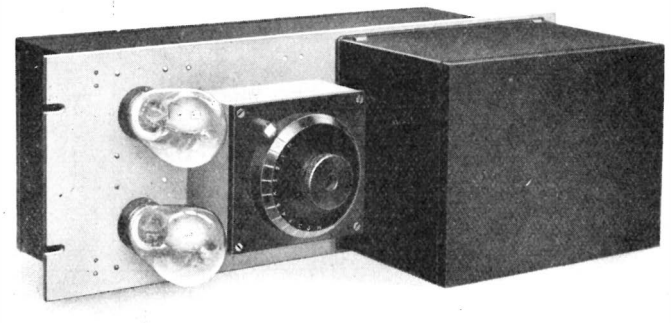


FIG. **21**.—FOUR-WIRE REPEATER.

The Test Desk equipment of a modern Repeater Station comprises a small laboratory of high grade testing instruments. The equipment is in two sections, namely, the Repeater Test Desk and the Cable Test Desk (Fig. **23**).

The former is divided into 5 panels as indicated in the sketch shown in Figs. **24** and **25**.

The telephone and jack panel provides means for speaking to any point in the station or along the line, accommodation for the standard telephone is also provided in this portion of the Desk. The transmission measurement apparatus and the condenser associated with the filter in the oscillator circuit are in the second panel. The variable frequency oscillator, which covers a range from 200 to 2,500 cycles per second with an average output of 25 milliamperes through 1000 ohms, is in the third panel. The oscillator supplies energy for the Transmission Measurement Set and to the alternating current bridge in the fourth panel. The

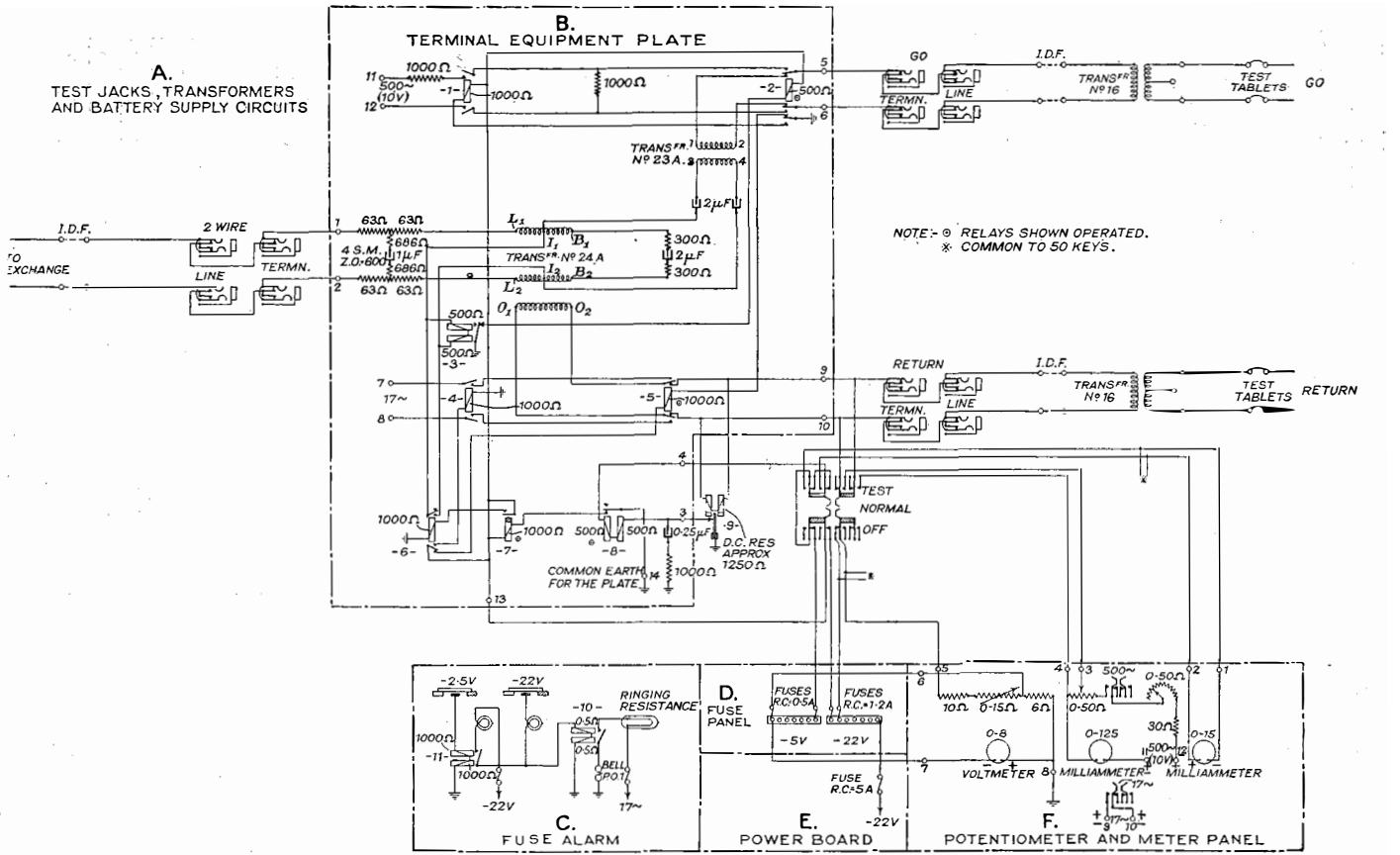


FIG. 22.—DIAGRAM OF CONNECTIONS OF TERMINAL EQUIPMENT FOR FOUR-WIRE REPEATER CIRCUITS.

switches in the alternating current bridge panel connect the apparatus for calibration of the oscillator or measuring the impedance of circuits with positive or negative angles. Leads to various positions in the repeater station from which impedance measurements are required terminate on the fifth panel.

The transmission measurement apparatus comprises the variable frequency oscillator already referred to and means for measuring the current sent out, together with a valve amplifying and detecting equipment for measuring the received current. In addition an artificial cable is provided for comparison purposes.

In making a transmission measurement a current of known value (usually 3 MA) and of the desired frequency is sent into one end of the circuit and the reading of the milliameter in the receiving apparatus connected to the other end of the circuit is noted. An

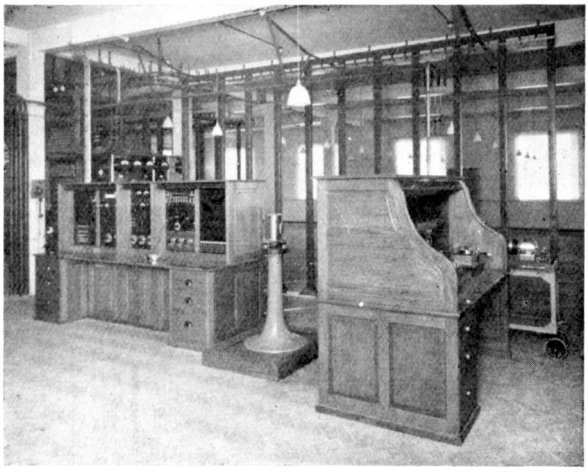


FIG. 23.—REPEATER AND CABLE TEST DESKS.

artificial cable is then substituted for the circuit under test and the cable is adjusted until the same reading as that recorded on the first test is obtained. The reading on the artificial cable will then indicate the transmission efficiency of the circuit under test.

If the two ends of the circuit are not in the same station, one station will send out the standard current (3 MA) and the other station will note the reading obtained on the milliameter of his receiving apparatus. The latter station will then substitute his own oscillator and an artificial cable for the distant station's oscillator and the line and will adjust his artificial cable until the reading obtained on the test of the line is reproduced.

The artificial cable reading will then, as before, indicate the transmission efficiency of the circuit.

The Cable Test Desk, Fig. **26**, provides facilities for insulation measurements, both inside the station and outside on the " line," and means for localisation of faults.

The Sullivan Reflecting Galvanometer, seen behind the desk in Fig. **23**, is carried on a heavy cast-iron base fixed to a large stone slab. A 3-inch pad of " Sorbo " is placed under the galvanometer, which throws its beam through a window in the back of the desk. The fact that this galvanometer can be used when either of the engine generator sets is running in the power room below speaks for the design of the buildings and in no less degree for the quality of British prime movers.

Standard Telephone.	Galvanometer Panel.	Meter Panel.	Switching Panel for A.C. Bridge.	Spare.
	Transmission Measuring Set.	Oscillator Panel.	Rheostat for A.C. Bridge.	
Telephone & Jack Panel.	Filter Tuning Condenser.	Anode Tuning Condenser for Oscillator Cct.	Condenser for A.C. Bridge.	Leads to Testing Points.

FIG. 24.—ARRANGEMENT OF EQUIPMENT ON REPEATER TEST DESK.

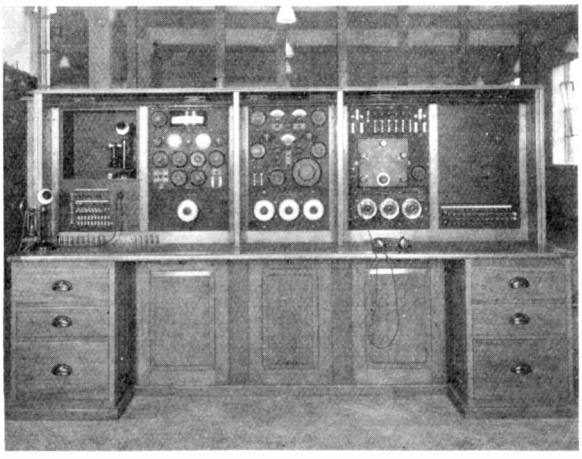


FIG. 25.—REPEATER TEST DESK. CLOSE UP.

The Cable Desk equipment includes also a motor-driven megger of special design (seen mounted on a perambulator carriage in the picture), which supplies current at 500-volts for insulation measurements.

A portable 250-volt motor-driven bridge megger is also supplied as part of the normal equipment of a Repeater Station.

The Power Plant of a large Telephone Repeater Station corresponds in the main to the power plant of a large modern Telephone Exchange. The fact that the former in many cases is located in an isolated position involves some addition to the normal requirements of a large Exchange, *e.g.*, prime movers, lighting and, in some cases, pumping. It will probably be sufficient, therefore, to describe in detail only those features peculiar to a Repeater Station.

When the first group of stations on the main cable network was designed the standard thermionic valve used by the Post Office

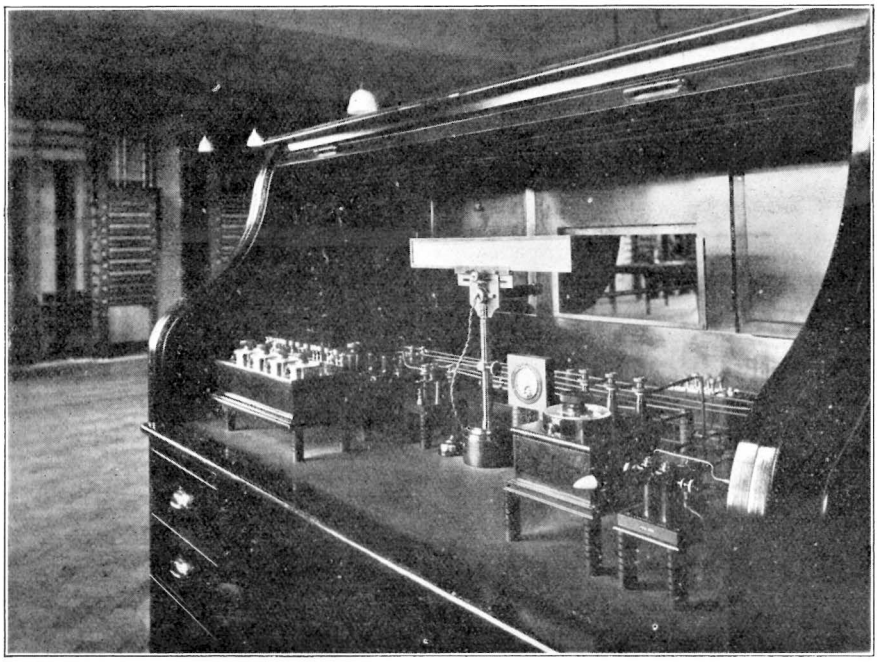


FIG. 26.—CABLE TEST DESK.

for repeater service required a supply of about 6 watts in its filament circuit, approximately 1.2 amperes at 5 volts. It was found convenient and economical to run the filaments of the two valves of a 2-wire repeater or the 2 valves of one side of a 4-wire repeater in series. An allowance for a drop of 3 to 4 volts was necessary for filament control resistances, filament alarm relays, etc. Voltage drop in cabling brought the total up to 15 volts and an 8-cell filament battery was indicated. The desirability of using standard types of telephone ringing relays designed primarily for 22-volt C.B. Exchanges, and the probability of being able to run 4 valves in series at a later date led finally to the provision of 11 cells in the A battery. The initial repeater room layout

provided for a maximum of 520 repeaters; the ultimate for the route was taken as 1000 repeaters and the average daily run for a trunk circuit on a main cable route is 13 hours. It will not be necessary, therefore, to detail the figuring which led to the provision of filament battery cells having a maximum tank capacity for 10,000 ampere hours, and an initial plated capacity for 5,000 ampere hours, nor to explain how a charging generator rated at 1000 amperes 22-30 volts is arrived at. The filament battery is known in the station as the "A" battery. The "A" battery is provided in duplicate.

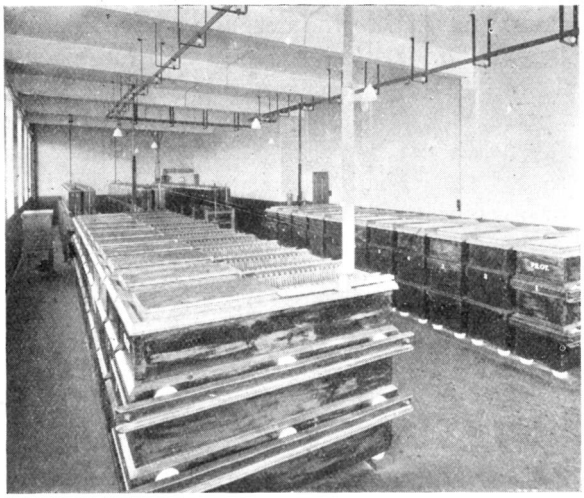


FIG. 32.—BATTERY ROOM.

The "B" battery supplies the valve plate circuits, auxiliary motors on pumps, air compressors, ringing machines and vacuum cleaners, and the lighting circuits. The valve plate circuits require approximately 0.010 amperes at 150 volts. Provision for motor and lighting circuits indicated a battery with a maximum plated capacity of 300 ampere hours. This battery is provided in triplicate, one on "charge" and two on "discharge," as the running of motor and lighting circuits in parallel with the valve plate circuits introduces objectionable disturbance effects in the latter.

The "C" battery is a 10-cell 20 ampere hour battery used for "priming" the grids of the valves.

The problem of prime movers for Telephone Repeater Stations presented some interesting difficulties when the first stations were designed.

Considerations of economy in building costs and maintenance staff charges indicated a building of two floors with all the generat-

ing plant and batteries on the ground floor. The requirements of the valve filament circuits pointed to a layout which involved the shortest possible cable run from the battery to the repeater racks *via* the repeater room voltage control board. The same arguments applied to the distance between charging generators and batteries. It was obviously not a case for steam engines. Producer gas engines were ruled out, principally on account of possible difficulties with fuel supplies in certain emergency conditions. Petrol engines were not viewed with favour. The fact that oil fuel storage is a comparatively easy problem and that a supply of fuel oil could be guaranteed by the authorities even in periods of emergency led to the decision to provide oil engines as prime movers. The choice lay between engines running on paraffin and the lighter petroleum products and those running on the heavier petroleums. The engineers of several of the leading oil-engine firms were consulted and this opportunity may be taken to put on record the valuable assistance afforded in solving the repeater station engine problem by the engineers of Messrs. Crossley Brothers, Manchester and London, Messrs. Ruston & Hornsby, Lincoln and London, and Messrs. Vickers, Petter, Ipswich and London.

At the time the early consultations took place, 1920-21, the most economical combinations (from the capital cost point of view only) of engine and generators were the 4-stroke high speed vertical paraffin engine and the 2-stroke medium speed vertical engine of so-called semi-Diesel type running on light residual oil of s.g. 850 or thereabouts, the generators 22-30 volt and 150-200 volts being coupled direct in tandem to the engine shaft in both cases.

Taking into account the requirements to be met if the engine room were to be located beneath the repeater room, neither of those combinations was considered to be free from objection in respect of noise and vibration. Undue noise meant interference with testing and monitoring in the repeater room, and vibration would cause rapid destruction of valve filaments and in certain conditions interference with circuit working. In addition there were objections to the storage of paraffin, and the 2-stroke vertical engine had, at that time at any rate, certain inherent defects that could cause much maintenance trouble. Both types, moreover, required rather generous head-room provision.

The alternative to the high speed vertical engine was the 4-stroke horizontal slow speed engine; many types of horizontal engine were on the market, and at this time development of the modern heavy oil engine which will start from cold was well advanced and several specimens of this type were available for inspection. The first cost of this type of engine was higher than

that of the vertical types; it required a much larger floor space and on account of its relatively slow speed the generators, especially for 23-30 volts supply, were necessarily heavy and costly. On the other hand, fuel consumption was low, and a very low grade of fuel could be used if necessary.

The floor space requirement was not a serious one in the circumstances of a two-storey Repeater Station, as the floor area of the Repeater Room is the determining factor and in a large station is always greater than the space needed for generating plant.

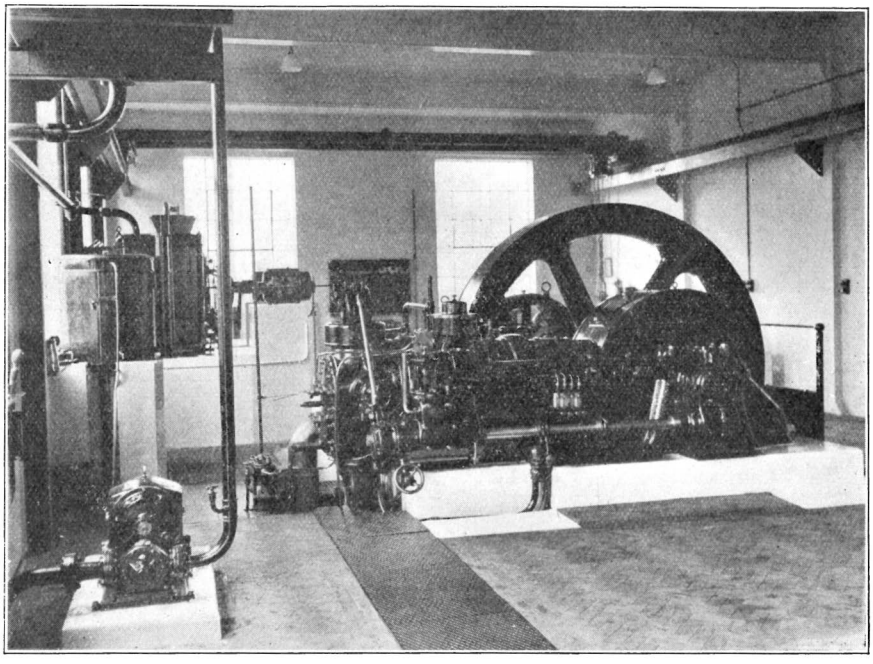


FIG. 27.—MESSRS. RUSTON & HORNSBY COLD STARTING ENGINE MARK 11 H.

After careful study of the whole matter a decision was reached to adopt the horizontal 4-stroke engine and a general specification embodying the following requirements was drawn up:—

(*a*) Engine to start from all cold without the aid of blow lamp or other heating device.

(*b*) Cyclic speed variation not to exceed 1.25%.

(*c*) Engine to run normally on the fuel sold as Diesel oil, but able to run in emergency on Admiralty furnace oil or on paraffin.

(*d*) Efficient silencing arrangements.

(*e*) Engine to be able to maintain a continuous output from the generators of 40 K.W.

Quotations were invited from several firms and, after rejecting those which did not fully comply with the requirements indicated, the final decision was given in favour of the Ruston & Hornsby engine.

The engine illustrated in Fig. **27** was made and installed by this firm and is the standard type for the first series of large repeater stations. Its nominal output is 76 B.H.P.

In this type of engine the fuel is injected into the combustion space by a pump, no compressed air being needed for this purpose. The pressure in the cylinder is high enough to ensure instantaneous ignition and combustion. The inlet and exhaust valves

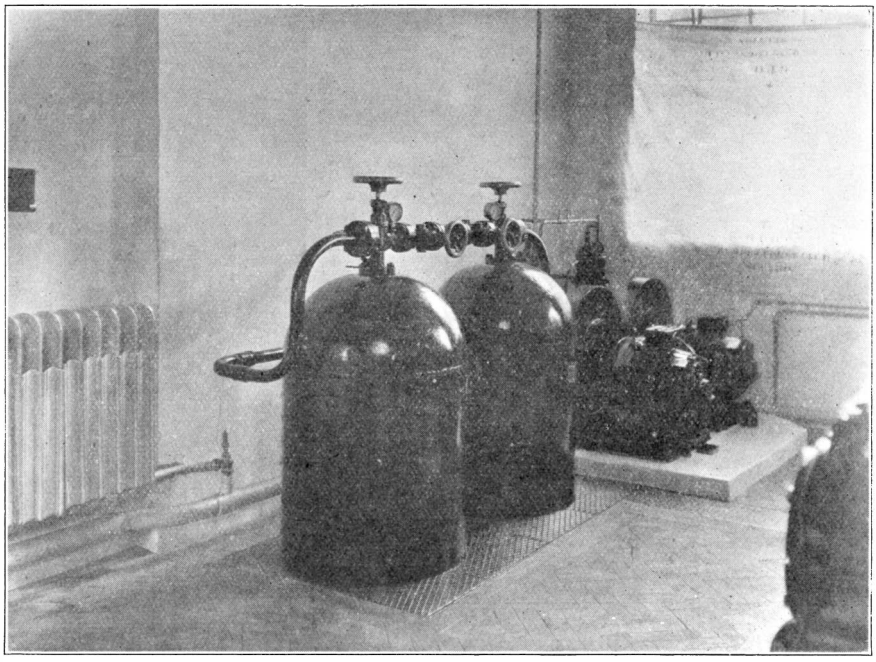


FIG. 28.—AIR RECEIVER AND COMPRESSORS.

are operated by eccentric gear, a feature which makes for smooth and quiet running.

Motion is imparted to the fuel pump plunger by a cam on the lay shaft and the whole of the gear is enclosed in oil baths. Governing is effected by by-passing a greater or less proportion of the oil pumped back to the service oil tank. The fuel oil leaving the pump passes to the atomiser arranged in the cylinder head. The atomiser cannot deliver a charge until the pressure of the oil from the pump is sufficient to overcome the resistance of a

spring-loaded needle valve. The oil enters the combustion space in the form of a very finely divided spray so that it is instantly ignited and effectively consumed.

The engine is started by compressed air which is admitted by a mechanically controlled valve.

The compressed air reservoirs (normally filled up to a pressure of 300 lbs. per spare inch) are seen with their motor-driven compressors in Fig. **28**. The motor circuits are arranged so that they may be connected either to the 150-volt battery circuit or direct to the 200-volt generators.

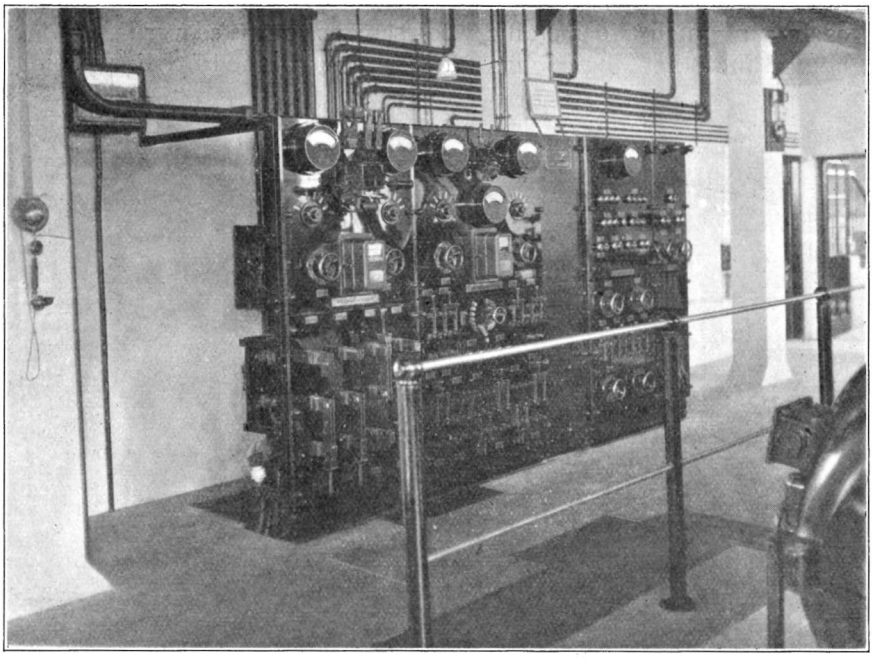


FIG. **29**.—POWER BOARD.

Even in frosty weather these engines start from cold, after 5 or 6 revolutions under compressed air, without hesitation on any fuel oil which is not too viscous at low temperature. Provision has been made in the main oil fuel tanks for connection with the central hot water heating system, so that in the event of necessity to use a low grade viscous fuel in very cold weather the temperature of the fuel may be increased. Alternative provision has been made so that the engine may be started on a small supply of light fuel oil until the heavier oil becomes warmed by the heat of the exhaust.

An important feature of this type of engine is the very low fuel consumption at light loads. The normal fuel consumption obtained under every day working conditions are:—

Full Load.	*¾ Load.*	*½ Load.*	
0.44	0.45	0.53	lbs. per B.H.P. per hour.

Provision is made for the storage in two tanks, placed in an underground concrete chamber of 5,000 gallons of fuel oil.

The array of large tanks for cooling water, usually in the past associated with engines of this size and type has been dispensed with in favour of the Heenan Cooling System.

The cooler seen in Fig. **27** consists essentially of a cast-iron casing in which two metallic wool screens are fitted vertically one behind the other, the cooling effect being obtained by distributing

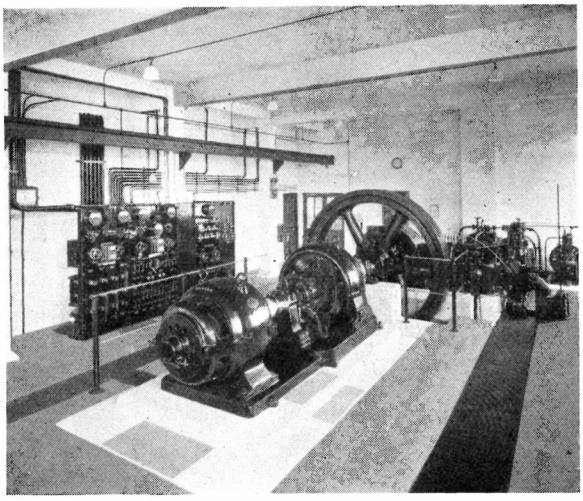


FIG. **30**.—GENERAL VIEW OF POWER ROOM.

the hot water over these screens, and at the same time forcing a current of air through them by means of a propeller type fan bolted to the front of the casing. The hot water from the engine jackets is delivered to a trough formed in the top of the casing, and after passing through a detachable strainer is evenly distributed over the screens through perforated brass plates fitted in the bottom of the trough. The cooled water collects in the base of the cooler from whence it is re-circulated to the jackets by means of a small positive-gear type pump bolted direct to the casing.

The air after passing through the screens is discharged

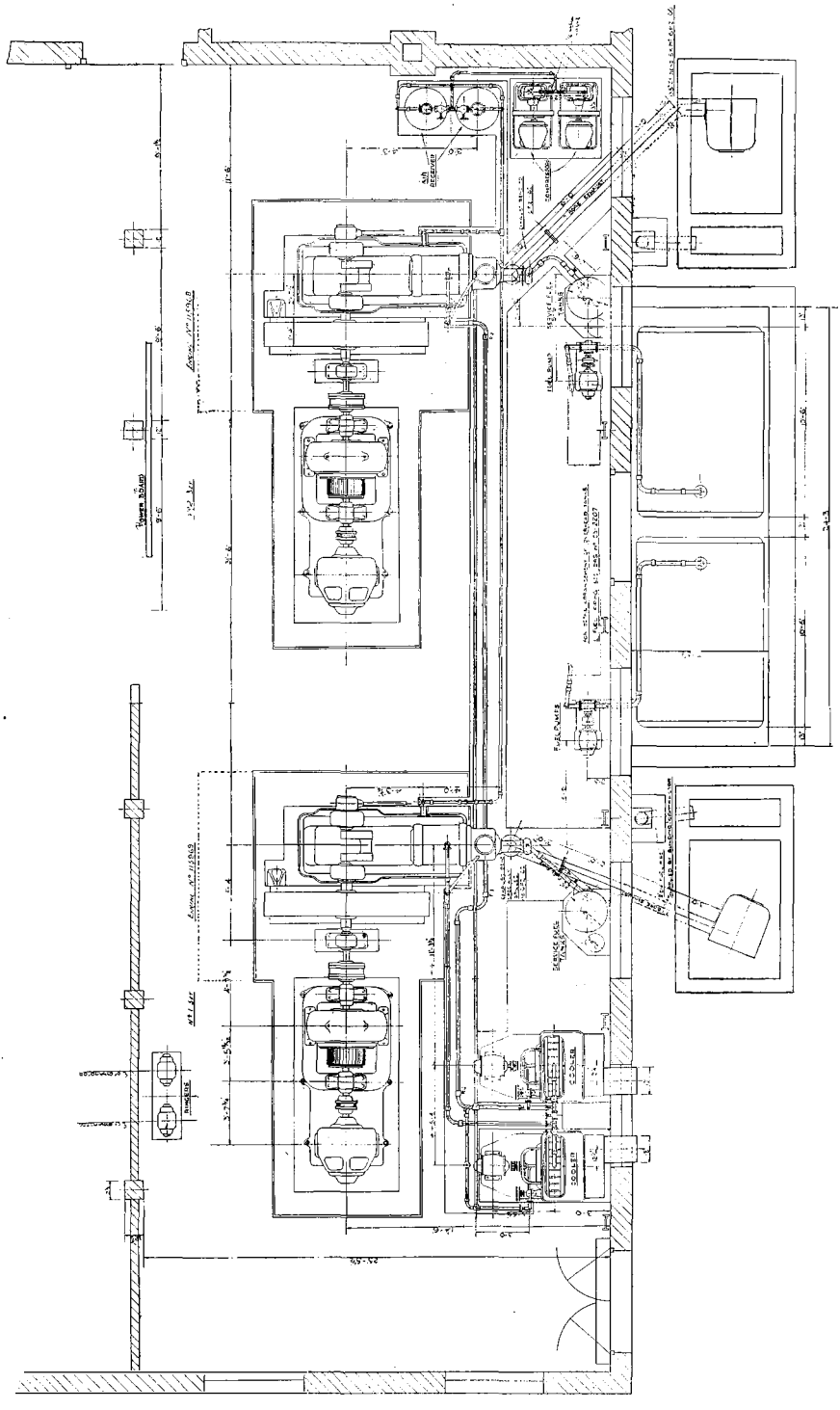


FIG. 31.—LAY-OUT OF ENGINE ROOM.

through a duct to the outside of the building. To prevent drops of water being carried away by the current of air, an eliminator consisting of a series of vertical iron blades mounted in a separate framework is fixed immediately inside the cooler outlet. The eliminator is removable so that access may be gained to the make-up ball-float valve and to the screens.

The fan is driven by a direct-coupled motor and the pump is belt-driven by the same motor. The motor is connected to the 150-200 volt generator, no starting switch is provided, and the motor starts and stops automatically with the engine.

A " Monitor Valve Safety Device " is provided in the cooling water supply of each engine as an additional precaution against failure of the cooling water supply. The monitor valve controls three electrical contacts. While the engine is running and the water-cooling system is in order the monitor valve closes the circuit of an electric lamp connected to the generators and placed in a conspicuous position. Should the cooling water supply fail the valve opens the lamp circuit and closes that of an electric bell, thus giving a visible and audible indication of the failure.

The question has been asked, and may be asked again: how is the engine started up for the first time after installation as there is no battery supply available for the compressed air starter motor? The answer is that one of the air reservoirs (they are in duplicate and are interconnected) has to be sent to the station already filled, although it is said that a reservoir could be filled by a manual pump.

The Main Switchboard controlling the generator, motor and battery circuits is illustrated in Fig. **29** and requires no detailed description. It carries the usual switchgear, fuses, circuit-breakers and alarms.

Fig. **30** is a general view of the Power Room, and Fig. **31** shows the layout.

The A battery supply to the Valve circuits is led from the Main Switchboard to the Repeater Room.

Voltage Control Board. Figs. **14** and **16**.

The 50-stop regulating switches with their associated resistance and alarm contact voltmeters give the station supervisor a means of holding the voltage of the valve filament circuit within very close limits.

In practice a limit of $\pm$ 0.4 volt is worked to.

The General Electric Co., Ltd., London, were the contractors for the whole of the equipment of these stations with Messrs. Ruston & Hornsby, Ltd., and the Premier Accumulator Co. as subcontractors for the engines and batteries respectively.

A.B.H.

GROWTH AND FINANCE OF THE POST OFFICE TELEPHONE SERVICE.

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

SIR W. MITCHELL-THOMSON, the Postmaster-General, in introducing the Post Office Estimates in the House of Commons on the 20th July, 1925, made some very interesting observations on the growth and finance of the telephone service. He said that it was the general policy of the Government that the telephone service should pay its way, and, since the introduction of the new tariff to correspond with the increased working costs due to inflation of values, in 1922, this policy had been successfully carried out. At the same time a pledge which had been given that, when circumstances permitted, rates should be reduced, had already been fulfilled, and it was estimated that the concessions made in the last three years represented a sacrifice of revenue of about £3,000,000, of which the telephone users were reaping the benefits. The net increase in the number of telephones last year was 115,308, or 10%, bringing the total up to 1,273,800 stations; this had beaten all previous records. Special attention was directed to the fact that the finance of the telephone service depended very largely on the call revenue, and a more extensive use of the telephone would tend not only to a better service, but to a further reduction of charges in the future. One extra call per day originated from each telephone would represent nearly £2,000,000 additional revenue. Notwithstanding, and no doubt to some extent in consequence of, the reduction in rates during the past three years the telephone revenue was steadily rising, and, in round figures, it was estimated that the receipts, amounting to £14,500,000 in 1923-24, would increase to something over £16,200,000 next year.

In referring to the magnitude of the Post Office work the Postmaster-General said the nearest figure he could get to represent the total value of transactions backwards and forwards with the public was £785,000,000. In such a business it was inevitable that mistakes should occur and things go wrong. He asked the public to keep a sense of proportion in these matters, and he assured them that he recognised the value of criticism as a help towards greater efficiency.

In opening the discussion, Mr. Hartshorn, who was Postmaster-General in the late Government, said that he went to the Post Office with a bias against it, but left it with the conviction that it was the most wonderful piece of business organisation that had ever been constructed in this world. He did not at all agree with the adverse criticisms sometimes urged against the Post Office on the ground that its staff was inefficient from a business

point of view. From the Permanent Secretary down through all the branches he found, as the heads of departments, men and women of outstanding ability. He regretted that the Post Office seemed to be regarded in this country as a sort of secondary department. The present Postmaster-General was the sixth occupant of that office in two years. He thought there was no more important Department in the State. Considering the magnitude of the business, it was surprising that there were so few complaints.

The report was well received by the House, and the Estimates were passed.

The present position of the telephone service is a gratifying change from the dark days of 1920, when, during a period of soaring prices, a large section of the public demanded from the Post Office the miracle of providing improved facilities at pre-war rates. Even in these days when a pre-war pennyworth of private enterprise costs the purchaser a penny three farthings, or more, there are many people who feel aggrieved because they cannot yet revert to the penny post, thus showing a lack of appreciation of the good bargain they are actually getting. The partial remedy for such a grievance is to get the telephone installed, when the subscriber can not only send out his local communications for the much desired fee of a penny, but can receive his correspondent's reply as well, without further charge.

The overtaking of arrears of work resulting from the unavoidable conditions arising out of the war (so that new lines can now be promptly joined up), and the improvement in telephone finance, as well as improvement in facilities and in quality of service, is an achievement of which the Post Office staff may well be proud. These results have been accomplished not only by the good management of the higher officers of the Post Office, but by the close co-operation and team work between the different departments and the zealous enterprise of the rank and file of the staff. It is also a fortunate thing for the Post Office, as well as for the wider interests of the community, that we have a Postmaster-General who is not only convinced of the success and future possibilities of the telephone industry in this country, but who is able to assemble his facts in such a way as to carry public opinion with him. At the same time public appreciation of success achieved has the natural effect of stimulating the staff to effect further improvement.

It is curious how old traditions tend to persist—sometimes in the most unexpected quarters. For example, at a recent publicity luncheon under the auspices of the Telephone Development Association, the Chairman, while admitting that the telephone service was making good progress, expressed

the view that still better progress might be obtained by private enterprise, and he put forward the suggestion that it would be a good thing if the Postmaster-General could have the assistance of a committee of able business men. On the first point, we are, of course, not unaware of the troubles which beset some of the large private enterprises, such as the railways and the coal mines, or the textile trades, which are of such a character as to intimately affect the life of the community; although, with the close knowledge of our own organisation, we are able, sympathetically, to appreciate the difficulties of their boards of management. On the second point, one would naturally expect the Telephone Development Association to have knowledge of the fact that the Postmaster-General *is* assisted by a committee of business men who are able to render effective help by constructive criticism and to secure the best interests of the public service. Moreover, in all the more important centres throughout the country, Advisory Committees connected with the local Chambers of Commerce have been established, and there is close contact between those committees and the local Post Office officials with a view to the maintenance of a high standard of efficiency. The management of the Post Office is in fact, in some respects, similar to that of the many highly successful municipal trading departments which are run by a trained business staff subject to the over-all control of experienced business men, who are elected to represent and to serve the local communities. The work of the Post Office is gradually becoming better known and better appreciated as a result of publicity methods, and it should be added that much useful work in this respect is being done by the Telephone Development Association.

Summary of Post Office Telephone Accounts.

In the "P.O.E.E. Journal," volume 13, part 2, published in July, 1920, an analysis was given of the financial working of the telephone system from the time of purchase of the National Telephone Co.'s undertaking in 1912, up to the financial year ending 31st March, 1919. From the Commercial Accounts for the year ending 31st March, 1924, further interesting information is now available. The following Table shows the balances in the Telephone Net Revenue Accounts for the various years after charging interest on capital, and after allowing for the depreciated value of plant, and all other charges:—

Year.	*Surplus.*	*Deficit.*	*Net Total to Date.*	
			Surplus.	*Deficit.*
	£	£	£	£
1912-13	303,343	—	303,343	—
1913-14	239,111	—	542,454	—
1914 15	—	111,018	431,436	—
1915-16	—	118,177	313,259	—
1916-17	201,729	—	514,988	—
1917-18	355,468	—	870,456	—
1918-19	—	36,261	834,195	—
1919-20	—	1,961,710	—	1,127,515
1920-21	—	4,721,970	—	5,849,485
1921-22	—	559,132	—	6,408,617
1922-23	939,009	—	—	5,496,608
1923-24	1,596,917	—	—	3,872,691
Totals ...	3,635,577	7,508,268	—	3,872,691

The surplus for the year ending 31st March, 1925, amounted to approximately £865,000 : the full accounts for the year have not yet been published. The net deficit to date, which at one time stood at £6,408,617 has thus been reduced to approximately £3,000,000 and the Postmaster-General estimates there will be a further reduction of about £500,000 in the current year's working. The deficit is therefore being gradually worked off; but, even under present conditions, the shortage of £3,000,000, with a capital value of £55,000,000, compares not unfavourably with the depreciated share values of many important industrial undertakings.

The heavy losses in 1919-20 and 1920-21 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 Telephone Committee.

Owing to the abnormally high prices prevailing, the revenue was debited with a special depreciation allowance of £200,000 annually from 1920 to 31st March, 1923, making a total of £600,000 for the three years; the " deficit " is increased by this amount in the above figures.

The Revenue Accounts have been debited with a total sum of £1,787,102 in respect of civil pay to telephone staff released for service with the Army and Navy during the War. Further payments in respect of arrears of War Bonus will be chargeable under this head as a result of the Sutton judgment in the House of Lords.

Notes on the Accounts for the Year ended 31st March, 1924.

Capital and Interest.

As a general rule, interest is calculated at 3 per cent. on all capital expenditure prior to 1st April, 1912; and, for all subsequent expenditure, at the average Bank rate appropriate to the year in which it was incurred.

The capital of the Telephone Service has been raised mainly by means of Loans under the Telegraph Acts, by Exchequer

Bonds, and by advances provided by the Exchequer out of Voted moneys. On the Loans the interest actually paid is the amount included in the account; on the Bonds the charge is calculated at 3 per cent., the rate at which the Bonds were issued; and on the Exchequer advances the charge is at the average Bank rates for the years in which the advances were respectively made. In financial calculations the present allowance is $4\frac{3}{4}$ per cent. As compared with this relatively low rate of interest, the Select Committee on the Telephone Service, 1922, found that private companies had to pay dividends at the rate of from 8 to 9 per cent. in order to attract the necessary capital for development purposes. The lower rate of State borrowing is, of course, to the advantage of the telephone users, since the charges on capital have to be met out of the revenue.

In all the accounts, interest on outstanding capital is charged before the balance of profit or loss is determined.

From the 1st April, 1893, to 31st March, 1924, loans amounted to £57,199,482. Of this amount £20,658,607 had been repaid, leaving a balance of £36,540,875 outstanding.

Exchequer Bonds to the value of £7,380,000 had been issued. After allowing for redemption, the balance of the Bonds outstanding amounted to £2,577,400.

The principal items in the Capital Account are shown in the following statement:—

	£
Liabilities.	
Balance of outstanding Loans	36,540,875
Exchequer (Telephone) Bonds	2,577,400
Exchequer advances, &c.	19,359,560
Total	£58,477,835
Less, Expended on Land and Buildings as per separate account	3,562,030
	£54,915,805
Assets.	
Total prime cost value of plant as at 31-3-24	65,367,125
Less, Balance at credit of Depreciation Account	12,725,776
	52,641,349
Value of Stores in stock	2,441,403
	£55,082,752

The cost of Renewals and Displaced Plant is charged to the Depreciation Fund. It is interesting to note that the balance of this fund (shown above) is practically the same as at 31st March, 1919, and approximately twice the amount shown in the accounts for 31st March, 1913. During the year the sum of £2,881,760 was charged to Renewals, and £3,032 to the value of plant permanently displaced. The amount transferred from Net Revenue Account to the Depreciation Fund for the year was £2,843,167. Since 1919 the cost of Renewals has kept nearly level with the amounts set aside for the Depreciation Fund.

The gross revenue for the year was £14,470,049 as compared with £13,918,594 for the previous year. These figures include rentals, fees, trunk calls and value of services to other Departments.

The average number of telephone stations in service during the year 1923-24 was 1,104,582, and the average gross revenue per telephone, therefore, amounted to about £13.

Government Telephone Services. — From 1st April, 1923, Government Departments have, with certain minor exceptions, paid in cash at public rates for the telephone services used by them; prior to that date the value of the services was recorded year by year and credited in the Telephone Accounts.

FEDERATED MALAY STATES.

THE Annual Report for the year 1924 of the Acting Director of the Posts and Telegraphs Department—Mr. T. A. Melville—is a very interesting record of progress. (The Report was published as a Supplement to the "F.M.S. Government Gazette" of 26th June, 1925).

Before 1st January, 1905, each of the States comprised in the Federation (Perak, Selangor, Negri Sembilan and Pahang) had its own postal and telegraph organisation, but on that date the State Departments became merged in the Federal Department, the object being to secure uniformity of procedure throughout the country backed by a common purse.

The year 1924 was noteworthy chiefly for the extensive telephone developments, ten new exchanges being opened and a large number of trunk lines being provided to connect them with the main system and to meet the requirements of the rapidly increasing traffic.

The only retrogression of importance in the Department's statistics was in the number of inland telegrams, which is attributed

to the readiness of the public to avail themselves of the trunk telephone service, the fees for which, it is stated, are low compared with those in many other countries.

The following paragraphs of the Report will appeal to many of our readers:—

TELEPHONES.

70. The number of subscribers to the telephone exchange system on the 31st December, 1924, was 2,436, an increase of 226 during the year. In addition there were 1,249 extension lines, extension bells and private circuits maintained by the Department, as compared with 1,093 in 1923.

77. Some press criticism appeared during the year regarding the telephone trunk charges in the Federated Malay States and it was pointed out by the Department that the fees were amongst the lowest in the world. The fee for an ordinary day call between Ipoh and Penang for example, a distance of 117 miles, is only 65 cents. For a similar call in Java the fee would be the equivalent of $1.75, in Denmark 96 cents, in the United States and Canada $1.50, in Australia 80 cents, in New Zealand 93 cents and in Ceylon 76 cents.

ENGINEERING.

84. On the 31st December, there were 2,463 miles of telegraph and telephone lines and 17,373 miles of overhead wire, of which 14,083 miles were telephone wires. In addition there were 55 miles of underground cables containing 5,502 miles of wire, single line. These figures do not include the pole and wires maintained by the Railway Department for their own use. The Posts and Telegraphs Department also owns and maintains 122 miles of line and 367 miles of wire in Johore. It also maintained in addition to its own lines 1½ miles of pole line for Kedah and 211½ miles of wire for Johore.

WORKSHOP.

104. A great variety of work was performed in the workshop, including general repairs and upkeep of all classes of Departmental apparatus and mechanical transport (15 motor vehicles). New classes of work undertaken were cabinet making and joinery, including the construction of wooden arms, office requisites and postal, telegraph and telephone stores and apparatus.

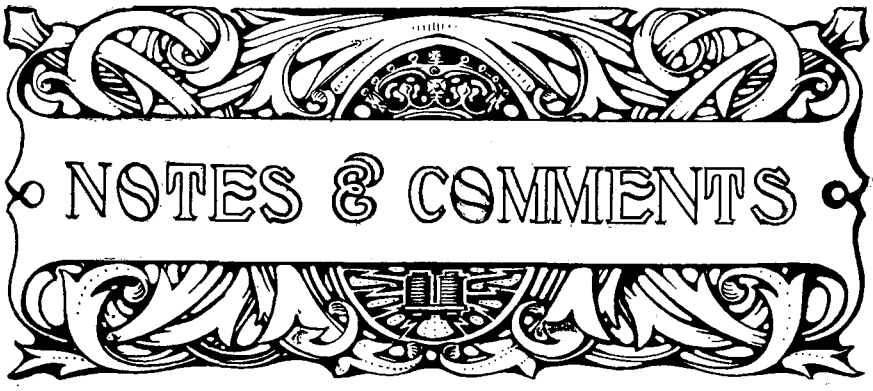
EMPLOYMENT OF MALAYS.

144. In accordance with the policy of the Government, special action was taken during the year to encourage Malays to seek employment in the Department; all branches had instructions to do their utmost in this direction and the co-operation of District

Officers and Inspectors of Schools was invoked. The result was that 76 Malays were appointed during the year as clerks, telephone operators, linesmen, compositors, chauffeurs, postmen, messengers and peons. There is also a long waiting list of applicants, particularly for the post of telephone operator, grade II., all the new exchanges now being opened being operated entirely by Malays.

WIRELESS.

150. The Malayan Wireless Committee met in Singapore on several occasions during the year and submitted reports to Government on the subject of broadcasting, the licensing of wireless receiving stations, of experimental transmitting stations, etc. The reports were forwarded to the Imperial authorities and, after making all necessary adjustments arising out of comments of those authorities, a final report has since been submitted. Arrangements have been made to issue receiving licenses against payment of a small fee. . . . .



NOTES AND COMMENTS.

OWING to the demands upon our space for the elaborate description of the new telephone repeater stations, which will play a very important part in the operation of long distance communications in the immediate future, and a detailed outline of the schemes whereby automatic exchanges can be sandwiched into local telephone networks in non-director areas, we are unable to publish in this issue the promised summary of the Engineer-in-Chief's Institution paper on Automatics. We hope to be able to give this summary, together with the main points of the discussion that followed, in our next issue. Copies of the paper are still available and may be obtained on application to our local agents or from Mr. J. W. Gladwell, Lobby, Engineer-in-Chief's Office.

The Council of the I.P.O.E.E. has decided again to offer five prizes of two guineas each for the five most meritorious essays submitted to it by workmen of the Engineering Department. Particulars of the competition are published at the end of this issue, from which it will be seen a very wide range of subjects is open for essays. The last competition was very successful and a large entry is expected. Papers must be in the hands of the Secretary, I.P.O.E.E., by the 31st December.

The rapid advance in the development of machine switching in telephone exchanges and the consequent impossibility of literature on the subject to keep in phase with the progress being made renders it difficult for telephone engineers and workmen not

actually in close touch with those changes to keep abreast of the movement. At most of the polytechnics and technical schools—in London at any rate—classes supported by the Department have been opened for the purpose of teaching the men the principles of the new art. It is not always possible for all members of the staff to take advantage of those classes, but yet every one who has his business at heart must feel the necessity for acquiring a knowledge of the direction in which all telephone switching is moving. We have been asked to announce the formation of a correspondence course on the subject, which has been started by members of the headquarters staff who are actively engaged in the work of changing-over. We can recommend the officers of the "Telephone Tutorial" Staff to our readers as men well-equipped for their undertaking, and trust their labours will be followed by advantage to themselves as we are sure the Department will benefit considerably thereby.

Unit of Transmission.—The discussion of the unit of telephonic transmission to be adopted in Europe was continued at the meeting of the International Consulting Committee in Paris in June, 1925. The choice lay between the use of the attenuation length βl, the "Décie" and the "Transmission Unit" (TU) adopted in 1924 by the Bell Companies of America. The relative characteristics of these units were explained in the Journal for July. The majority of European Administrations expressed themselves in favour of the adoption of "βl." In view, however, of the importance of obtaining uniformity of practice throughout the telephone world the final decision was postponed until arrangements could be made for American representatives to be present to discuss the matter. Pending this discussion it was decided to use "βl" when dealing with international European telephone questions.

Mr. Guy Burney, founder and managing director of the Sterling Company, who retired the other day, is better known perhaps to members of the old N.T. Company's staff than to P.O. men, although his alert upright figure was sometimes seen in the precincts of the G.P.O. He built up a large and successful business and the Company's works at Dagenham cover an area of twelve acres and are laid-out on modern lines with shops equipped with the latest machine tools for mass production. Mr. Burney realised quickly the immense future for radio work and took full advantage of the broad-casting boom. He was a believer in early retirement and has acted up to his belief. In an interview he said "It is better to enjoy the fruit of happiness while there is still some

life left in the old dog; besides it leaves the door open to the younger men."

We note with interest the fact that an experimental rural automatic exchange on the Relay system was installed some time ago in Switzerland. As a result of the experience gained on this type of equipment we understand that a further 20 rural exchanges are being similarly equipped. The problem of giving service to rural communities is an interesting and important one and all Administrations feel the desirability of giving that service automatically on a 24-hour basis. As to whether automatic equipment designed on a *ratchet and pawl* or *relay* basis is the correct development, various authorities hold different opinions and it will be interesting to see the results of this somewhat extensive trial in Switzerland. It is satisfactory to note that English produced telephone plant is securing a footing on the Continent.

The Relay Automatic Telephone Co. has just cut-over a large P.A.B.X. of 550 lines for the Admiralty at one of H.M. Naval Establishments. Standard dialling, ringing and B.B. tones are provided and arrangements are made for holding conferences of officials through the medium of the exchange. Two sets of 32 v. 340 A*h* chloride cells and duplicate ringing machines have been installed.

The L.M.S. Railway has been provided with an automatic telephone equipment at Victoria Station, Manchester, with an ultimate capacity of 800 lines by the A.T.M. Co., Liverpool. Inter-communication with the public service will be afforded by an associated manual switchboard. The manufacturing company has sent us a beautiful print of a photo taken from the air of their extensive works at Milton Road, Edge Lane, Liverpool. The ground area occupied by the works is $9\frac{1}{2}$ acres, while extensions are still in progress.

Messrs. Creed and Co., the well-known manufacturers of telegraph apparatus, have intimated that "they have purchased Mr. Donald Murray's Telegraph business, including the Murray Telegraph Patents, and shall in future manufacture and supply the Murray Multiplex and other Murray apparatus. Mr. Murray will for a time give the Company the benefit of his valuable experience." Old telegraph men will remember that Messrs. Creed and Murray were in partnership before and we trust their re-union or absorp-

tion, whichever it may be, will be free from estrangements which divorced those able pioneers of printing telegraphs so long. We can scarcely conceive Mr. Donald Murray being content with merely contributing valuable advice; nor can we accept his paper on "Speeding up the Telegraphs" as his Swan-song.

The Managing Editor, I.P.O.E.E. Journal.

Dear Sir,—I was much interested in Mr. Hill's letter, published in the July issue of the Journal, in which he has very kindly added useful supplementary information to my article on the theory of the shunted condenser.

The question raised by Mr. Hill as to what precisely happens in the circuit under discussion when the mathematical equation $L=CR^2$ holds good is important and I should like to add some further notes on this point.

Before doing so, it may be interesting to point out that the equation (2) given in my article is not necessarily of an oscillatory form when the condition $L=CR^2$ is true. In order to prove this, let us examine the equation referred to. If it is oscillatory in form then β must be an imaginary quantity,

$$i.e., \left(\frac{R_1}{2L}-\frac{G}{2C}\right)^2-\frac{1}{LC} \text{ must be negative.}$$

If $L=CR^2$ this condition becomes—

$(R_1-3R)(R_1+R)$ must be negative,

i.e., R must be greater than $\frac{1}{3}R_1$.

So that it follows that the resistance used to shunt the condenser must be greater than one-third of the relay resistance if, when $L=CR^2$, my equation (2) is to be of the same form as equation (2) given in Mr. Hill's letter. In practice this condition is generally fulfilled.

But what does precisely happen in this circuit with the usual values of R if CR^2 is made equal to L? To answer this question let us consider the circuit shown in Fig. 1.

On depressing the key a voltage V is suddenly applied to the shunted condenser arrangement and on releasing the key the circuit is suddenly discharged. The current i_C passing through the relay on depressing the key is given by equation (2) in my article; the current i_D in the relay on releasing the key is given by:—

$$i_D=-\frac{V}{R+R_1}e^{-\alpha t}\left[\frac{(R+R_1)-L(\alpha+\beta)}{2L\beta}e^{+\beta t}-\frac{(R+R_1)-L(\alpha-\beta)}{2L\beta}e^{-\beta t}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(a)$$

Equation (*a*) assumes that the condenser is fully charged up to the voltage $V \times \frac{R}{R+R_1}$ before the key is released.

Now, if $L=CR^2$, and also equation (*a*) is of the oscillatory form then it follows that the *quantity* of electricity passing through the relay on suddenly discharging the circuit is zero. If a truly ballistic galvanometer were placed in the circuit in the position shown dotted in Fig. 1, it would not be affected. This then is the significance of the relation $L=CR^2$, and the truth of this statement will now be proved.

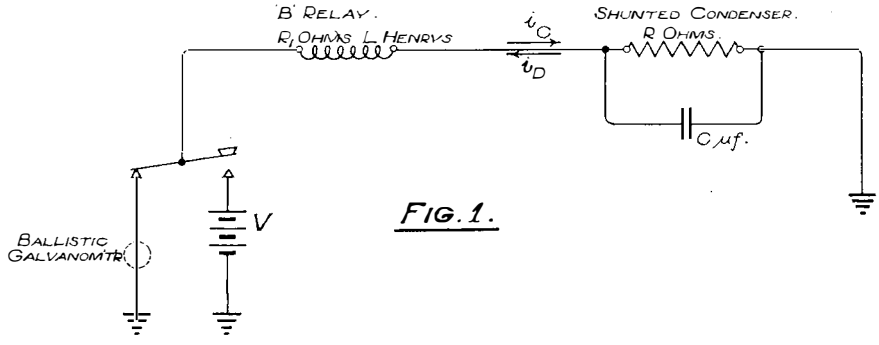


FIG. 1.

The quantity of electricity passing through the relay on releasing the key is given by—

$$q_D = \int_{t=0}^{t=\infty} i_D \, dt \qquad \ldots\ldots(b)$$

When the discharge is oscillatory the value of i_D in equation (*a*) may be written—

$$i_D = -\frac{V}{R+R_1} e^{-at}\left[\cos \beta_1 t - \frac{R+R_1-La}{L\beta_1} \sin \beta_1 t\right] \qquad \ldots\ldots(c)$$

where $\beta = j\beta_1 = \sqrt{-1}\,\beta_1$

$$\therefore \; q_D = \frac{V}{R+R_1} \int_{t=0}^{t=\infty} e^{-at}\left[\cos \beta_1 t - \frac{R+R_1-La}{L\beta_1} \sin \beta_1 t\right] dt$$

If $L=CR^2$ this reduces to

$$q_D = \frac{V}{R+R_1}\left[\frac{e^{-at} \sin \beta_1 t}{\beta_1}\right]_{t=0}^{t=\infty}$$

$$= 0$$

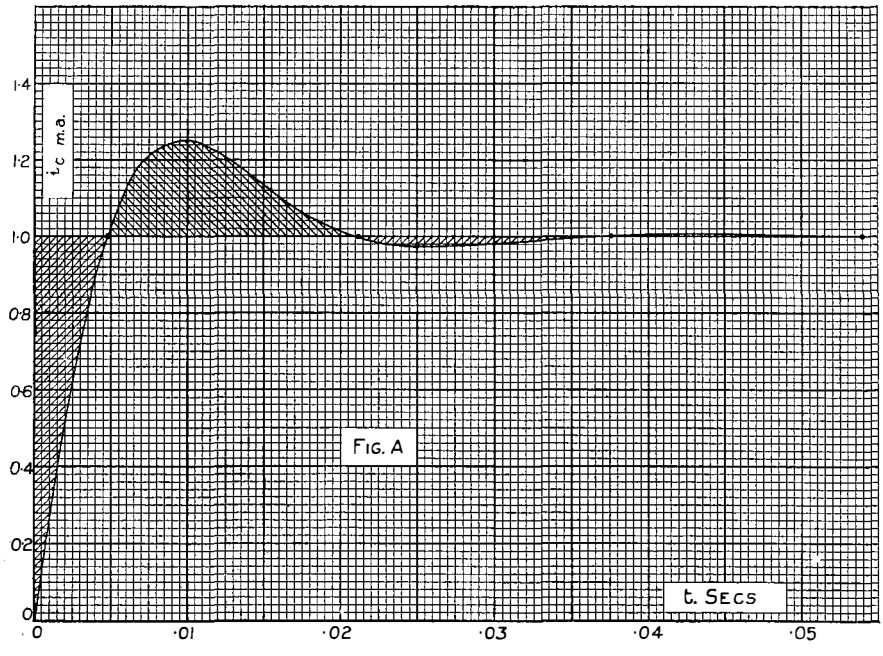
Therefore, q_D is zero when $L=CR^2$ *and* the discharge current is oscillatory.

This point will perhaps be made quite clear by means of an illustrative numerical example.

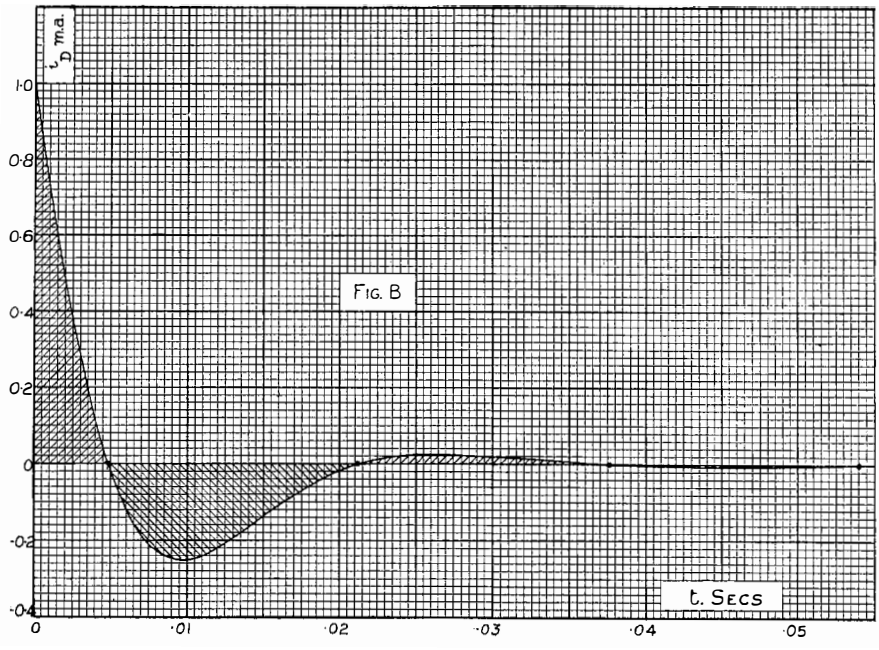
Suppose L $=3.5$ henrys
,, $R_1 = 300$ ohms
,, $R = 700$ ohms
,, $C = \frac{L}{R^2} = 7.14\ \mu f.$
and $V = 1$ volt

Then using these figures, the charge current i_C has been calculated by means of equation (2) of my article and the discharge current i_D has been calculated by using equation (a) given in this letter. The results are given in the table which follows :—

t secs.	i_C m.a.	i_D m.a.
0.000	0.000	1.000
0.001	0.272	0.728
0.002	0.513	0.487
0.003	0.717	0.283
0.004	0.885	0.115
0.005	1.017	−0.017
0.008	1.226	−0.226
0.010	1.249	−0.249
0.015	1.136	−0.136
0.020	1.017	−0.017
0.025	0.977	0.023
0.030	0.984	0.016
0.040	1.002	−0.002
0.050	1.0007	−0.0007



These tabulated values of i_C and i_D are plotted on Figs. A and B respectively. In Fig. B, if the curve were continued to $t=\infty$, the sum of the areas shaded from right to left would be equal to the sum of the areas shaded from left to right. The former areas are above the zero line and the latter are below the zero line. Hence the net quantity of electricity flowing through the relay coils on releasing the key is zero, when $L=CR^2$. Considering Fig. A the sum of the shaded areas above the horizontal line drawn at a current of 1 m.a. is equal to the sum of the shaded areas below this line. I think that this shows the theoretical condition of affairs when $L=CR^2$ and the charge and discharge



curves are oscillatory. Other conditions being the same, the greater the value of CR^2 the more rapidly does the current rise and fall in the relay coils on depressing and releasing the key respectively.

In using the rule $L=CR^2$ in practice it seems to me that the main difficulty is to decide what is the value of L; in the case of a "B" relay or Wheatstone receiver L is by no means a constant as was shown by the experimental results given in my article.

I am, dear Sir,

Yours faithfully,

A. B. MORICE.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed :—

Exchange.	Type.	No. of Lines.
Dudley Extension ...	Auto	300
Portsmouth Extension ...	,,	—
Albert Docks New ...	Manual	1600
Enfield Extension ...	,,	450
Buxton New	,,	300
Canterbury Extension ...	,,	340
Ealing ,, ...	,,	1680
Leeds Trunk ,, ...	,,	—
Palmers Green New ...	,,	2200
Cloans M.F.	,,	—
Whitley Bay New ...	,,	800
Benton & Stone	P.A.B.X.	40
Bury Co-op. Society ...	,,	50
W. & G. Du Cros ...	,,	50
Dunlop Rubber Co. ...	,,	80
Gardner & Co.	,,	60
J. & J. Hayes	,,	40
Langs Bread	,,	25
Nairn & Co.	,,	80
P.L.A. Head Office ...	,,	200
P.L.A. St. Katherine's Dock	,,	70
Prudential Assurance Co...	,,	400
Shell-Mex, Glasgow ...	,,	30
Shell-Mex, Manchester ...	,,	30
Shell-Mex, Tunbridge Wells	,,	25
Wallpaper Manufacturers, Ltd.	,,	25
Wilderness Country Club	,,	40

Orders have been placed for the following new Exchanges :—

Exchange.	Type.	No. of Lines.
Ainsdale	Auto	618
Birkdale	,,	1100
Chesterfield	,,	925
Churchtown	,,	921
Cosham	,,	160
Exeter	,,	1990
Hayling Island	,,	107
Sheffield Central	,,	6300
Southport	,,	3000
Staveley	,,	50
Topsham	,,	90
Beaconsfield	Manual	660
Bexley Heath	,,	780
Burgh Heath	,,	1650
Coatbridge	,,	600
Huddersfield Desk ...	,,	—
Leigh (Lancs.)	,,	680
London Toll (New) ...	,,	2350
Walton-on-Thames ...	,,	1040

Exchange.	Type.	No. of Lines.
Amalgamated Dental ...	P.A.B.X.	50
Appleyard Ltd.	,,	30
Barrow Hepburn & Gale	,,	70
Battersea Council ...	,,	70
Benson Ltd.	,,	70
Chad Valley Co.	,,	30
Clark Hunt & Co. ...	,,	40
Coults & Co.	,,	50
Delaney & Co.	,,	30
Featherstones Ltd. ...	,,	30
Johnson	,,	30
Kenrick & Jefferson ...	,,	40
Ledingham & Sons ...	,,	30
Lines Bros.	,,	50
McNamara & Co.	,,	80
Navy, Army & Air Force Institute	,,	190
Prices Candle Co. ...	,,	70
Robinson, E. S. & A. ...	,,	80
Robinson, J. & H. ...	,,	40
Scottish Oils	,,	63
Shanks & Co.	,,	40
Shell-Mex, Tunbridge Wells	,,	30
Union Cold Storage ...	,,	230
Waddington Ltd.	,,	30
Wagon Repairs	,,	40

Orders have been placed for extensions to existing equipments as follows:—

Exchange.	Type.	No. of Lines.
Aberdeen	Manual	1520
Birmingham Central ...	,,	1250
Chiswick	,,	1500
Guildford	,,	540
Huddersfield	,,	720
Hull Toll	,,	—
Leeds Trunk	,,	—
Ramsgate	,,	380
St. Annes-on-Sea	,,	540
Trafford Park	,,	520
Truro	,,	100
Woking	,,	300

LONDON ENGINEERING DISTRICT.

Mileage Statistics.

During the three months ended 30th June, 1925, the following changes have occurred:—

Telegraphs.—Nett decrease in open wire of 154 miles and a nett increase in underground of 318 miles.

Telephones (Exchange).—Nett decrease in open wire (including aerial cable) of 1,196 miles and a nett increase in underground of 38,584 miles.

Telephones (Trunks).—Nett increases in open wire and underground of 1 mile and 2,227 miles respectively.

Pole Line.—Nett increase of 60 miles, bringing the total to date to 5,138 miles.

Pipe Line.—Nett increase of 187 miles, the total to date being 6,091 miles.

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

Telegraphs	24,031
Telephones (Exchange)	1,610,388
Telephones (Trunks)	55,553
Spares	47,343

External Construction.

During the quarter ended 26th June, 1925, 9,968 exchange lines, 6,364 internal extensions and 1,302 external extensions were provided. In the same period 2,974 exchange lines, 2,851 internal extensions and 610 external extensions were recovered, making nett increases of 6,994 exchange lines, 3,513 internal extensions and 692 external extensions.

Internal Construction.

New Exchanges.—During the past quarter new Manual Exchanges have been opened at Enfield (C.B.1, 1,840 lines), Albert Docks (C.B.1, 1,500 lines) and Sloane temporary—(C.B.10, 2,760 lines). A new Manual Exchange at East Ham (C.B.1, 1,700 lines) is in course of construction.

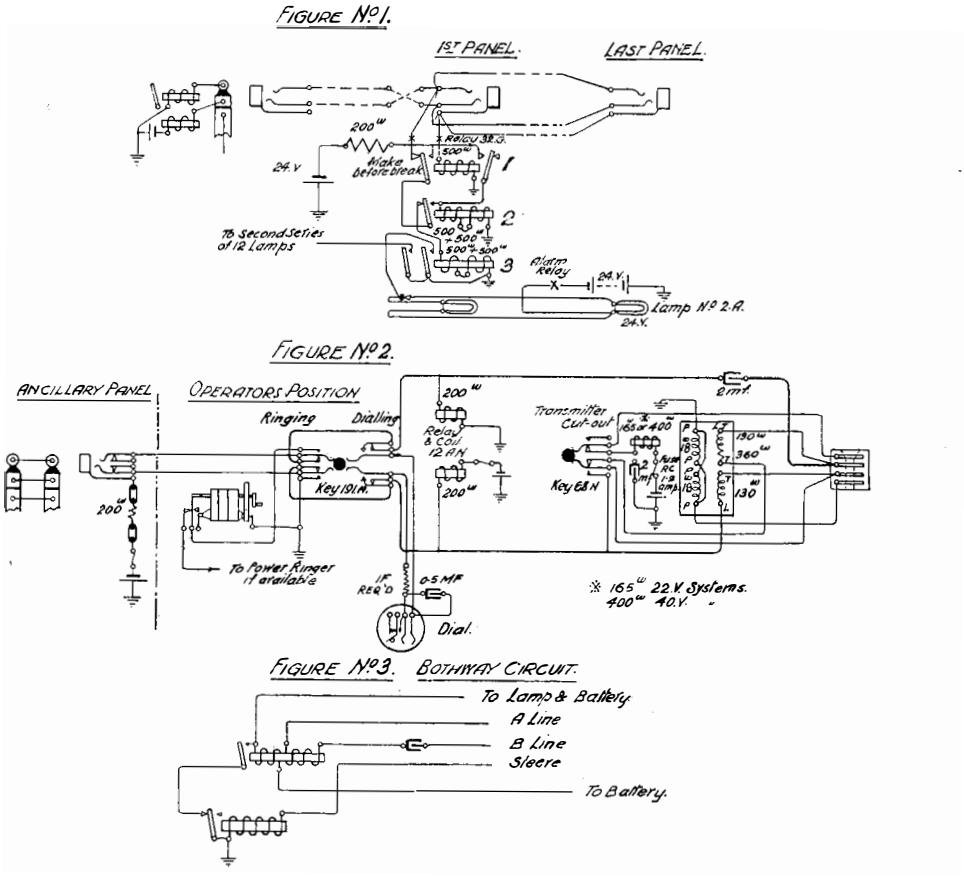
The construction of the Automatic Exchanges at Holborn and Bishopsgate, and of the Tandem Exchange is proceeding. The provision of the Coder Call Indicator equipment, which is to be provided at all Manual Exchanges affected by the introduction of automatic working, has commenced.

Exchange Extensions.—Extensions and modifications of the exchange equipment at seventy of the Exchanges in the London District are in hand.

P.A.B.X.'s.—The Private Automatic Branch Exchange installation supplied under contract by Messrs. Siemens Brothers for the Port of London Authority was formally opened by Lord Ritchie, the Chairman of the Authority, on July 27th, in the presence of representatives of the Authority, the Department, the Contractors and public bodies. The installation consists of Automatic Exchanges at the Head Office in Trinity Square, London, and St. Katherine's Dock, East & West India and Millwall Docks,

Victoria & Albert Docks and Tilbury. Manual Boards are located at the Head Office and at Tilbury only. Incoming calls for all the Docks, with the exception of Tilbury, pass through the manual board at the Head Office. The extensions on the Docks Installations dial the nearest public Exchange direct for outgoing service, and intercommunication between extensions on the installations of the various Docks is effected automatically over tie lines concentrated on the Head Office. A fuller description appears elsewhere in this issue.

TELEGRAPHS.



Concentration of Phonograms at Central Telegraph Office.

Between the hours of 10 p.m. and 7 a.m., a percentage of Phonogram junctions, consisting of outgoing junctions to Central and Trunk Exchanges, and incoming from Central, and one Bothway Junction from Waterloo Railway Station, are switched by means of break-jacks from the Main Phonogram Switchboard on the first floor of the C.T.O. to a concentrator which has been

fitted in the Central Hall on the ground floor. The stalls occupy two tables on the east side of the room. The circuits are multipled to five small switchboards, and provision has been made for 15 operators. The whole installation is self-contained, the fuse-board, relays, etc., being enclosed in a cabinet on the north side of the room.

The line circuit is shown in Fig. No. **1**. A current from the distant Exchange on the "B" line operates No. 3 relay, lighting the calling lamp.

When the operator plugs into the jack the battery on the sleeve operates No. 1 relay and this in turn operates No. 2 which, being slow-acting, will retain if the distant Exchange has not cleared when the Phonogram operator withdraws his plug on the completion of conversation. The operator's jack and speaking circuit is shown in Fig. No. **2**, the Keys being for the purpose of cutting out the operator's transmitter and for ringing on the both-way circuits. A diagram of the latter is shown in Fig. No. **3**, connection from the operator's jack to the multiple being made by a looping cord.

The room in which the concentrator is installed is particularly suitable for this purpose, as on the west side are situated the Pneumatic Tube services which convey telegrams to and from all the principal Post Offices and Cable Companies in London. The room, being decidedly smaller than the main Phonogram room, results in economy in lighting, heating and staffing, and is generally more convenient for all concerned during the slack hours.

THE POST OFFICE TELEPHONE AND TELEGRAPH SOCIETY OF LONDON.

Session 1925-26.

Meetings will be held at the Institution of Electrical Engineers, Victoria Embankment, W.C.2, at 5.30 p.m.

Programme.

1925.

October 19th. "London Telephone Service." M. C. Pink, Esq. (Assistant Controller London Telephone Service).

November 16th. "Wireless Telegraphy and its Application to Ship and Shore Work." Comdr. F. G. Loring, R.N. (Inspector of Wireless Telegraph G.P.O.).

December 21st. "Fifty Years of Telephone Progress." W. Day, Esq., M.I.E.E. (Engineer-in-Chief's Office, G.P.O.).

1926.

January 18th. "Recent Developments in the Inland Telegraph Service." L. Simon, Esq. (Assistant Secretary G.P.O.).

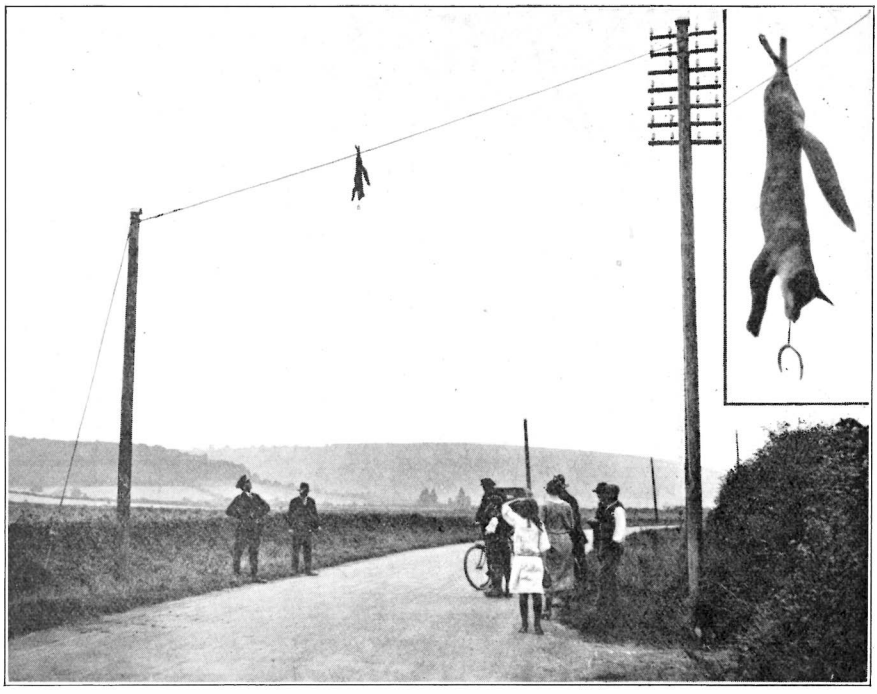
February 15th. "Some Sidelights on the International Tele-

graph Conference." J. Lee, Esq., C.B.E. (Controller, Central Telegraph Office).

March 15th. (*a*) "Internal Circulation in the Central Telegraph Office." (*b*) "Phonograms." Miss M. Tynan (Assistant Supervisor Central Telegraph Office).

April 19th. "Wireless." E. H. Shaughnessy, Esq., O.B.E., M.I.E.E., M.I.R.E. (Assistant Engineer-in-Chief G.P.O.).

A NEW USE FOR AERIAL STAY WIRES.



A dead fox was found hanging, as shown, above the Hereford-Leominster Road the other week. The photo appeared in the *Hereford Times,* from whom we are indebted for the loan. On the right is a close-up snap of the fox.

BOOK REVIEWS.

"An Outline of Automatic Telephony." By William Aitken. E. Benn, London.

This little volume is an attempt—and a very praiseworthy attempt—to cover, within the limits of a hand-book, descriptions of the automatic telephone systems in use in the world to-day. It

thus really takes the form of an abridged edition of the author's well-known treatise, to which it may serve as an introduction.

On the whole the attempt is very successful, though the inclusion of so many systems restricts the amount of space that can be given to each.

But it is not surprising that, in a book dealing with a subject so rapidly changing as automatic telephony, a few errors are apparent.

Thus, the lettering on the dial shown in Fig. 5 is not that which has been adopted for London. Again, on page 85 it is stated that slip wiring has been generally used and will continue to be used to a considerable extent on selector banks. Though this may be true by itself, it follows immediately after a description of grading, and the advantages obtained by means of grading are almost entirely lost if slip wiring is employed. Slip wiring has been practically abandoned by the Post Office.

As is usual in Mr. Aitken's books, the diagrams are clear, and the reproduction, too, is excellent. In tracing circuits the author's bus-routing scheme, familiar from its employment in the larger work, is extensively used.

G. F. O'DELL.

BOOKS RECEIVED.

"Dictionary of Technological Terms used in Electrical Communication. Part I, English—German." By O. Sattelberg, Telegraphentechnische Reichsamt, Berlin. Julius Springer, Berlin. 9 gebunden goldmark.

"Electricity and the Structure of Matter." L. Southerns, M.A., B.Sc. Oxford University Press, London. 2*s*. 6*d*. net.

PAPERS RECEIVED.

The Selected Papers from the Journal of the Institute of Electrical Engineers of Japan.

No. 1. The Electromagnetic Induction and the Effective Self-Inductance of a Rectilinear Transmission Line with Earth Return, and the Potential Difference on the Earth Surface. Hidetaro Ho. Member.

No. 2. On the Continuity of Vector Power in an Alternating Electric and Magnetic Current Field. Heiichi Nukigama, Member.

No. 3. On the Induction Synchronous Motor characterised by Automatic Transmission. Tadaoki Yamamoto, Member.

No. 4. Transient Phenomena in a Short-Circuited Alternator. Taro Otake, Member.

No. 5. Jump in the Self-Excitation of D.C. Generators. Masataro Kawarada, Member.

No. 6. New Method for Electrical Machine Design. Jutaro Takenchi, Member.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Grade.	Promoted to.	Date.
Blick, F.	Assistant Engineer, London District.	Executive Engineer, E.-in-C. Office.	30-6-25
Stone, H. C.	Assistant Engineer, London District.	Executive Engineer, London District.	28-7-25
Prescott, J.	Chief Inspector, London District.	Assistant Engineer, London District.	16-8-25
Martin, P. C.	Chief Inspector, N. Wales District.	Assistant Engineer, N. Wales District.	8-9-25
Gresswell, F. P. ...	Chief Inspector, N. Wales District.	Assistant Engineer, S. West District.	20-8-25
White, H.	Chief Inspector, London District.	Assistant Engineer, London District.	To be fixed later.
Roberts, F. H. ...	Inspector, N. Mid. District.	Chief Inspector, N. Mid. District.	7-4-25
Croughton, G. F. ...	Inspector, Testing Branch.	Chief Inspector, Testing Branch.	12-4-25
Kennard, E. G. ...	Inspector, Testing Branch.	Chief Inspector, Testing Branch.	19-4-25
Bagley, T.	Inspector, N. Mid. District.	Chief Inspector, N. Mid. District.	7-5-25
Beighton, T. A. ...	Inspector, N. Mid. District.	Chief Inspector, S. Mid. Ditrict.	17-5-25
Cornish, G.	Inspector, S. East District.	Chief Inspector, S. East District.	24-5-25
Whenmouth, H. ...	Inspector, London District.	Chief Inspector, London District.	16-8-25
Clifford, F.	Inspector, London District.	Chief Inspector, London District.	22-7-25
Cuthbert, C. T. ...	Inspector, London District.	Chief Inspector, London District.	26-7-25
Scarborough, H. ...	Inspector, N. East District.	Chief Inspector, S. Wales District.	13-7-25
Hargreaves, T. ...	Inspector, N. West District.	Chief Inspector, E.-in-C. Office.	4-8-25
Meek, L.	Inspector, N. Mid. District.	Chief Inspector, E.-in-C. Office.	14-8-25
Rafferty, A.	Inspector, Scot. W. District.	Chief Inspector, Met. Power District.	To be fixed later.
Christie, G. C. ...	Inspector, N. Mid. District.	Chief Inspector, N. Wales District.	To be fixed later.
Hodge, H. R.	Inspector, N. Mid. District.	Chief Inspector, N. Wales District.	To be fixed later.
Martin, J. A. S. ...	Repeater Officer, Cl. II., Lowestoft.	Chief Inspector, E.-in-C. Office.	To be fixed later.
Towle, E. H. N. ...	Inspector, London District.	Chief Inspector, London District.	To be fixed later.
Buckley, T.	Skilled Workman, Class I., London District.	Inspector, London District.	11-1-25
Faulkner, W.	,,	,,	1-4-24
Wenman, G. A. ...	,,	,,	29-6-24
Bull, C.	,,	,,	5-4-25
Pearson, M.	,,	,,	1-7-24
Deboise, A. S.... ...	,,	,,	25-8-24
Ives, G. T.	,,	,,	5-1-25
Nye, C. P.	,,	,,	25-8-24
Allen, A. G. R. ...	,,	,,	8-4-25
Rhodes, E. R.... ...	,,	,,	25-8-24
House, R.	,,	,,	8-4-25
Endacott, J.	,,	,,	25-8-24

PROMOTIONS.—continued.

Name.	Grade.	Promoted to.	Date.
Greenwood, G. F. ...	Skilled Workman, Class I., London District.	Inspector, London District.	1-9-24
Goater, H. W. ...	,,	,,	25-8-24
Searle, C. T.	,,	,,	25-8-24
Streatfield, F. G. ...	,,	,,	5-1-25
Simpson, W. F. ..	,,	,,	5-4-25
Stace, C. F.	,,	,,	5-10-24
Chapman, E. J. ...	,,	,,	7-10-24
Lee, J. A.	,,	,,	1-12-24
Elsey, W.	,,	,,	1-12-24
Young, H. T.	,,	,,	5-1-25
Evans, J. W.	,,	,,	14-12-24
Brient, A.	,,	,,	8-4-25
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Diplock, H.	Skilled Workman, Class I., S. East District.	Inspector, S. East District.	8-10-24
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Stainer, W. H. ..	,,	,,	5-1-25

PROMOTIONS—continued.

Name.	Grade.	Promoted to.	Date.
Janks, F. A. E. ...	Skilled Workman, Class I., S. East District.	Inspector, S. East District.	5-1-25
Grainger, C. H. ...	,,	,,	5-1-25
Johnson, E. W. ...	,,	,,	1-5-25
Twort, H. S.	,,	,,	25-6-25
Boyce, C. T.	Skilled Workman, Class I., N. Ireland District.	Inspector, N Ireland District.	1-4-25
Cattle, F.	Skilled Workman, Class I., Testing Branch.	Inspector, Testing Branch.	19-4-25
Rowe, A. W.	,,	,,	12-4-25
Nicoll, D. A. D. ...	,,	,,	24-6-25
Smith, J. R.	Shift Officer, Wireless Station, Oxford.	Inspector, Rugby.	1-4-25
Sheppard, A. C. ...	,,	Inspector, Oxford.	18-7-25
Wain, S. W.	,,	Inspector, Northolt.	2-7-25
Stroulger, A. J. ...	Skilled Workman, Class I., E. District.	Inspector, East District.	1-4-25
Darkin, J.	,,	Inspector, East District.	1-7-25
Grieve, P. R.	Skilled Workman, Class I., S. Lancs. District.	Inspector, S. Lancs. District.	15-3-25
Scott, J.	Skilled Workman, Class I., Scot. W. District.	Inspector, Scot. West District.	26-7-25
Thompson, W. ...	,,	Inspector, Scot. West District.	9-3-25
Measey, W. F. ...	,,	Inspector, Scot. West District.	9-3-25
Hulton, H. H. ...	Skilled Workman, Class I., S. West District.	Inspector, S. West District.	10-3-25
Fegan, G. R. F. ...	,,	Inspector, S. West District.	31-3-25
Simpson, D. A. ...	Skilled Workman, Class I., Scot. East. District.	Inspector, Scot. East District.	30-7-25
Butterworth, H. ...	Wayleave Officer, N.W. District.	Inspector, N. West District.	27-8-25
Wilton, D. V. ...	Wayleave Officer, London District.	Inspector, London District.	28-5-25
Seller, W. G.	Wayleave Officer, London District.	Inspector, London District.	28-5-25
Shields, A. V.	Telegraphist, C.T.O.	Repeater Officer, Class II.	29-4-25

REVERSION.

Name.	Grade.	Reverted to.	Date.
Bull, C. E.	Chief Inspector, London District.	Inspector, London District. (At own request.)	18-8-25

STAFF CHANGES.

APPOINTMENT.

Name.	Grade.	Appointed.	Date.
McDonald, A. G. ...	Probationary Assistant Engineer. E.-in-C. Office.	Assistant Engineer. E.-in-C. Office.	1-9-25

TRANSFERS.

Name.	Grade.	Transferred.		Date.
		From.	To.	
McMurray, C. H...	Asst. Engineer.	S. West Dist.	S. Wales Dist.	23-8-25
Horn, T. ...	Chief Inspector.	S. Wales Dist.	E.-in-C. Office.	18-6-25

DEATHS.

Name.	Grade.	District.	Date.
Patterson, T.	Executive Engineer	London	8-6-25
Yule, J.	Assistant Engineer	South West	28-8-25
Sutton, G.	2nd Cl. Engineer	Testing Branch	9-9-25
Watt, J.	Inspector	Scotland East	6-7-25
Humber, J.	,,	East	18-7-25

RETIREMENTS.

Name	Grade.	District.	Date.
Williams, E.	Inspector	S. Wales	28-8-25
Pendreigh, W.	,,	London	9-5-25

CLERICAL ESTABLISHMENT.

PROMOTION.

Name.	Grade.	Promoted to	Date.
Freeman, S. M. ...	Executive Officer, E.-in-C. Office.	Higher Exec. Officer, E.-in-C. Office.	13-7-25
Henderson, G. F. H....	Clerical Officer, E.-in-C. Office.	Executive Officer, E.-in-C. Office.	1-3-25
Scrafton, C. D. ...	Clerical Officer, N. District.	Higher Clerical Officer, N. Mid. District.	1-7-25
Thompson, J. T. ...	Clerical Officer, S. Mid. District.	Higher Clerical Officer, S. East District.	21-6-25
Edwards, A.	Clerical Officer, East District.	Higher Clerical Officer, East District.	14-2-25
Pratt, C. W.	Clerical Officer, N. District.	Higher Clerical Officer, S. Wales District.	21-7-25
Corney, P. A.	Clerical Officer, S. Mid. District.	Higher Clerical Officer, S. West District.	12-8-25
Coleman, A. T. ...	Clerical Officer, S. West District.	Higher Clerical Officer. S. Wales District.	16-8-25

STAFF CHANGES.

Appointments as Clerical Officer.

Name.	District.	Date.
Leatherbarrow, J. ...	S. Lancs.	1-5-25
Morrison, C. T.	N. Mid.	17-5-25
Ruddy, T .H.	S. Lancs.	17-5-25
Russell, J. C.	E.-in-C. Office	24-5-25
Saxon, T. H.	S. Lancs.	24-5-25
Earlam, T.	do.	24-5-25
Chambers, J. W.	do.	31-5-25
Kemmery, H. W.	S. West	31-5-25
Randall, P.	Met. Power	21-6-25
Kelly, P.	S. Lancs.	21-6-25
Hanwell, J.	N.	1-7-25
Frew, A.	N. East	2-8-25
Bywater, F. L.	N. Mid.	23-8-25
Thomas, W. E.	S. Mid.	23-8-25
Johns, R. L.	E.-in-C. Office	20-9-25

Transfers.

Name.	Rank.	Transferred.		Date.
		From.	To.	
Brown, C. ...	Hr. Clerical Officer.	S.E. Dist.	S. West. Dist.	1-7-25
Timms, R. H. ...	Clerical Officer.	I. of W.T.'s Staff.	,, Leafield W.T. Station.	1-4-25
Laughton, E. ...	,,	Savings Bank Dept.	Sc. E. Dist.	14-5-25
Milne, J.T. ...	,,	Sc. E. Dist.	Savings Bank Dept.	14-5-25
Lyford, G. S. ...	,,	N. Dist.	S. Mid. Dist.	1-6-25
Neale, H. B. ...	,,	London.	S. East. Dist.	13-6-25
Betts, G. ...	,,	N. West. Dist.	S. Mid. Dist.	14-6-25
Booth, H. T. ...	,,	S. Lancs. Dist.	N. West. Dist.	14-6-25
Farrand, S. ...	,,	S. Lancs. Dist.	N. West. Dist.	14-6-25
Dawson, A. A. ...	,,	N. West. Dist.	Sc. E. Dist.	14-6-25
MacKenzie, W. M.	,,	S. East. Dist.	London Postal Service.	14-6-25
Allen, L. R. S. ...	,,	Met. Power Dist.	Board of Control.	22-6-25
Lightfoot J. ...	,,	Ministry of Pensions.	S. Lancs. Dist.	15-6-25
Evans, L. E. J. ...	,,	Ministry of Pensions.	S. West Dist.	15-6-25
Horrocks, W. J. ...	,,	Ministry of Pensions.	S. Lancs. Dist.	16-6-25
Wills, N. T. ...	,,	Ministry of Pensions.	S. Lancs. Dist.	16-6-25
Greensmith, F. G..	,,	Ministry of Pensions.	N. Mid. Dist.	1-7-25
Cox, F. ...	,,	Savings Bank Dept.	S. Mid. Dist.	21-6-25
Eagland, S. V. ...	,,	Savings Bank Dept.	E.-in-C. Office.	1-7-25
Carpenter, W. G...	,,	Savings Bank Dept.	S. East. Dist.	1-7-25
Farrell, W. ...	,,	N. Mid. Dist.	E.-in-C. Office.	12-7-25
Laird, J. H. ...	,,	N. Wales Dist.	Sc. East. Dist.	1-7-25
Ashwell, G. H. ...	,,	N. Mid. Dist.	N. Dist.	23-8-25
Randall, F. W. ...	,,	S. West. Dist.	S. Wales Dist.	23-8-25
McHugh, C. J. ...	,,	S. Lancs. Dist.	Land Registry, Ireland.	1-9-25
Hale, R. E. ...	,,	London.	London Postal Service.	1-9-25

OTHER CHANGES.

Name.	Rank.	District	Cause.	Date.
Few, H. P. ...	Higher Exec. Officer.	E.-in-C. Office.	Superannuation.	12-6-25
Parkinson, E. ...	Clerical Officer.	N. East. Dist.	Superannuation.	30-6-25
Henderson, . J. ...	Higher Clerical Officer.	S. Lancs. Dist.	Reverted to Clerical Officer (at own request)	16-6-25
Gibbs, A. ...	Clerical Officer.	S. Wales Dist.	Deceased.	25-6-25
Woad H. E. ...	Clerical Officer.	S. Lancs. Dist.	Deceased.	29-6-25
Dundas, A. G. ...	Clerical Officer.	Ireland.	Resignation.	31-8-25

COMMUNICATIONS.

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

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Telephone Fitting.
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Extension of Large Multiples.
Subscribers' Switchboards.
Telephone Buildings.
Automatic Telephony.
Semi-Automatic Telephony.
Rural Automatic Exchanges.
Automatic Private Branch Exchanges.
Multi Office Automatic Telephony.
Underground Cables.
Precision Testing in Underground Cables.
Cable Drawing.
Cable Balancing.
Overhead Line Construction.
Overhead Line Maintenance.
Aerial Cables.
The Training of Youths.
Primary Batteries.
Secondary Batteries.
Matters for Reform.
Development Studies.
New Ways of Doing Old Jobs.
The 'Phone Doctor.
Advice Note Procedure.
Unit Costs.
Store Keeping.
Oscillographs.
Fire Alarm Systems.
Electrical Clocks.
Insulation.
Numbering Machines.
Stamping Machines.
The Loading of Telephone Circuits.
Modern Telephone Practice.
Telephone Line Construction.
A Short History of Telephony.
Telephone Transmission over A.S.P.C. Cables.
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Change Over from an Old to a New Exchange Equipment.
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Fault Procedure at Automatic and Manual Exchanges.

The London Trunk Exchange.
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The Theory of the Accumulator.
The Economy of the Leclanché Cell.
Practical Electrical Units, Sub-Units, etc.
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Telegraph Printing Apparatus.
Emergency Maintenance.
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Capacity Effects in Telephony—Wired and Wireless.
Carrier Wave Telegraphy and Telephony.

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(4) The Essays must reach the Secretary,
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Room 50a, G.P.O. (W), E.C.1.
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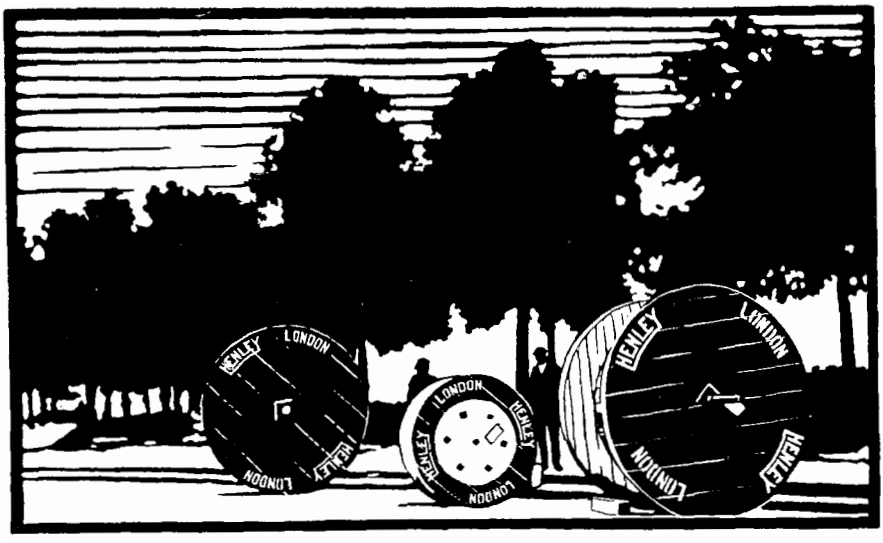
R. V. HANSFORD,
Secretary.



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Errors in Part 3, Vol. XVIII., October, 1925, issue.

We regret that a number of errors crept into our last issue. Readers interested will perhaps amend their copies as follows :—

Corrections to article on

"Junctions working between Automatic and Manual Exchanges."

Page 231 GB should read GG.

Fig. 13 Relays (from left to right) should be labelled C, D and S.

,, 14 Relays (from left to right) should be labelled S, H, CO and A.

Page 238 Sixth line from bottom—LA should read LB.

,, 239 Number and title of Fig. 17 should be placed under second diagram on page 240.

,, 240 Number and title of Fig. 19 should be placed under diagram on page 239.

,, 241 First diagram should be labelled Fig. 22—"Magneto and C.B.S. No. 1 Exs. Dial Key per Junction."

,, 241 Second diagram should be labelled Fig. 23—"C.B.S. No. 1 Exs. Outgoing; Loop or battery dialling or outgoing portion of bothway, battery dialling."

,, 242 First diagram should be labelled Fig. 20—"Non Mult. Magneto Exs., Outgoing loop or battery dialling or outgoing portion of bothway, battery dialling."

,, 242 Second diagram should be labelled Fig. 21—"Non Mult. Magneto Exs., outgoing portion of Bothway—Loop dialling."

,, 242-3 Delete references to C.B.S. No. 3 Exchanges.

,, 243 Fig. 25. Relay marked E should be D; Relay A should be L; Relay C should be CO.

,, 244 Fig. 26. Relay D should be S,
Top Jack and lamp should be No. 2.
Bottom ,, ,, ,, ,, ,, No. 1.

,, 245 Fig. 27. Relay C.L. should be F.
,, D.D. ,, ,, M.
,, D ,, ,, S.

,, 246 Fig. 29. Relay D ,, ,, S.
,, D.D. ,, ,, M.

,, 246 Last line, springs 11 and 9 should read 10 and 9.

,, ,, Third last line, comma after D.M.