D.C. TEST CIRCUITS AND TELEPHONE PANEL, TP/2.

D.C. Test Circuits

The D.C. test circuits equipped on the Line Termination bay provide facilities for the routine testing of O.B. lines.

In the earlier models of this equipment the necessary switching for setting up the various test connections is performed by the operation of keys which also provide for the switching in connection with an associated telephone circuit. In the more recent equipments the telephone and D.C. test circuits have been separated and the keys in the case of the D.C. test panel are replaced by jacks. In these equipments the various test conditions are obtained by plugging up the meter circuit to the appropriate jack.

The circuits of the three types of equipment in use are given in Figures 1, 2 and 3 and the operations involved in making the various tests possible with the equipment, with simplified schematics of the test connections in each case, are given in Tables 1, 2 and 3, respectively. (Figure 2 and Table 2 apply only to the equipment at Edinburgh.)

The voltmeter is a moving-coil instrument with **0–60V** and **0–6V** ranges, passing 0.4mA at full-scale deflection and having an internal resistance of approximately 2,500 ohms per volt. In the insulation and conductor resistance tests the instrument is used as a milliammeter and provision is made for obtaining a third scale by connecting a **shunt** across the meter with the instrument adjusted for the **0–6V** range. Full-scale deflection in this case corresponds to a current of 4.0mA in the circuit under test. A resistance scale is provided and is direct reading for the **6V** range of the meter. The readings must be multiplied by 10 for the **60V** range and divided by 10 for the **6V Shunt** range. Before making resistance measurements, however, the instrument must first be calibrated for the particular range to be used, and for this purpose a 10,000 ohm rheostat with an **Off** position is connected across the moving coil of the voltmeter.

Calibration is carried out by inserting the test plug in the **Loop** jack and, in the case of the equipment using keys by setting the keys as for Test 3 in the table, or in the case of the equipment using jacks by inserting the meter plug in the **Ins.A to B** jack, then by operating the meter range keys appropriately for the range to be used, and by adjusting the rheostat on the meter panel to give full-scale deflection.

The test plug can then be connected to the line to be tested and the various tests carried out by the operation of the test keys, or by the insertion of the meter plug in the Test jacks, as the case may be, in the manner detailed in the appropriate table. The meter must be recalibrated whenever a different range is to be used.

For the foreign battery tests the instrument is used as a voltmeter on either the 6V or 60V range and the movement must be unshunted. For these tests therefore, the rheostat should be turned to the **Off** position. In the case of the equipment using jacks the calibration rheostat is automatically disconnected when the meter plug is inserted in any of the foreign battery test jacks.

D.C. Test Circuits (*Contd*)

The theory underlying the use of the voltmeter for the direct reading of resistances is as follows :—

If V is the Battery voltage,

R_V the resistance of the voltmeter,

and D_1 the deflection in the loop condition,

then
$$D_1 = k\frac{V}{R_V}$$
where k is a constant.

If now the loop is replaced by an unknown resistance X, to be measured, and if D_2 is the corresponding voltmeter deflection,

$$D_2 = k\frac{V}{R_V + X}$$

therefore
$$\frac{D_1}{D_2} = \frac{R_V + X}{R_V} = 1 + \frac{X}{R_V}$$

whence
$$\frac{X}{R_V} = \frac{D_1}{D_2} - 1$$

and
$$X = R_V\left(\frac{D_1}{D_2} - 1\right)$$

The value of R_V is independent of the deflection, so that if D_1 can be fixed at a constant value, X will become a simple function of D_2 and it will then be possible to calibrate the meter directly in ohms. Now D_1 can be made constant, either by adjusting the value of the battery voltage, or by suitably adjusting the meter sensitivity. Since the former course is not practicable, the desired result is obtained by shunting the moving coil of the instrument with a 10,000 ohm variable resistance, and by using this to adjust the sensitivity of the meter so as to give full-scale deflection at the battery voltage available, with only the meter resistance in circuit.

From the values of insulation resistance to earth for the two legs of the line, obtained in Test 1, the leakance unbalance in micromhos should be calculated and is given by $10^6 (R_1 - R_2) / R_1 R_2$, where R_1 is the larger and R_2 the smaller of the two values. The line should be judged faulty if the leakance unbalance exceeds 3 micromhos.

The **loop resistance** obtained in Test 3 should be checked up against the average of the readings previously obtained for the circuit, and the line should be judged faulty if the value measured differs from this average by more than ± 4 per cent. An abnormally low reading may indicate a partial or complete short-circuit between the two conductors at some point, while an abnormally high reading may indicate a high resistance joint or a bad connection. The BBC apparatus connected to the line should be examined for the fault before rejecting the line.

D.C. Test Circuits *(Contd)*

If **resistance unbalance** is measured as in Test 4a with an earthed loop at the distant end, it is important that two practically simultaneous readings for the two legs of the circuit should be used in order to avoid an error due to variations in potential between the near-end and far-end earths. On this account the actual conductor resistance values obtained will be neither consistent nor reliable, but if instantaneous readings for the two positions of the line-reverse key are obtained their difference should give a consistent value. This difficulty of course does not arise if the procedure of Test 4b is followed, but in this case the resistance unbalance determined is that for the two lines together. The circuit should be judged faulty if this difference is found to be greater than 3 ohms for one line or 6 ohms for two lines, but when reporting the matter the conditions of test should be stated. When two lines have been tested together (Test 4b) and found faulty efforts should be made to have the lines isolated for individual test (Test 4a) in order to determine on which of the lines the fault is located.

The **foreign battery** tests, Nos. 5 and 6, are designed to reveal a fault condition in which, due to contact between either of the conductors and a power circuit, one of them is maintained at a potential above earth or above that of the other conductor. Any reading obtained indicates a fault on the circuit, and the voltmeter reverse key enables the polarity of the voltmeter to be readily changed if necessary, according to the polarity of the foreign battery, in order to enable the actual voltage present to be measured.

Telephone Circuit, TP/2

In the case of the key-operated equipments the key positions designated **Ring, Speak, Hold, XMR Cut-off, Battery**, and in the case of Edinburgh, **Ring Rev.**, are required for the operation of the associated telephone circuit, TP/2. The different grouping in the two cases of the switching on to the various key positions results from the necessity in the case of equipments covered by Figure 1 to render it possible for a test and a telephone conversation to be carried on simultaneously on separate circuits.

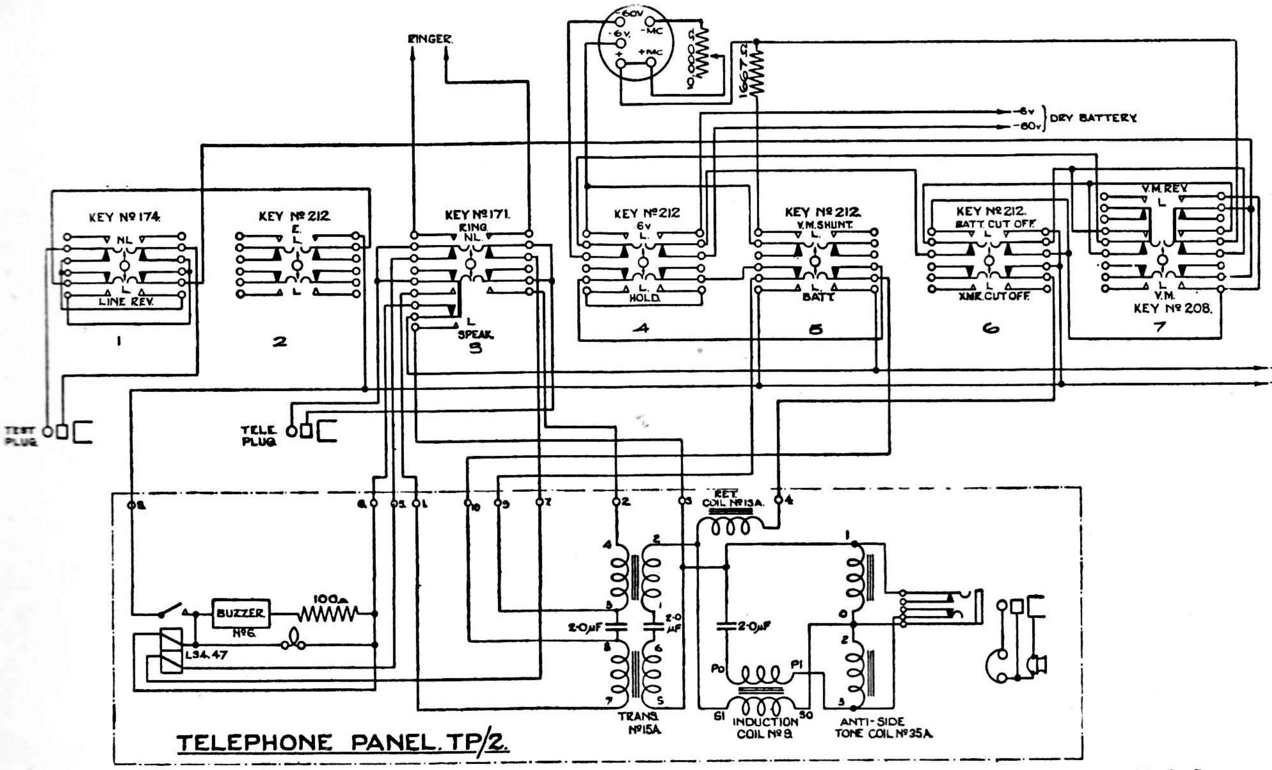
Operation of the **Ring** key connects the output of the 16 c/s ringer to line, and the **Ring Rev** key in the case of Edinburgh, provides for reversing the connection. Ringing current incoming from a line to which the **Tele** cord has been plugged up, causes the line relay to operate over the break contacts of the **Speak** and **Ring** keys. The relay upon operation provides a holding circuit for itself from the 24V battery via the break contacts of the **Speak** key, and at the same time completes the buzzer and calling lamp circuits. Operation of the **Speak** key releases the line relay, silences the buzzer and extinguishes the calling lamp. It also connects the secondary of the speech transformer across the line via the tip and ring contacts of the **Tele** plug, and completes the +24V connection to the telephone transmitter, via the ring circuit of the headset jack and plug. The −24V connection to the telephone transmitter is completed via the sleeve circuit of the headset plug and jack and the break contacts of the **XMR cut-off** key. The latter key enables the transmitter to be disconnected in order to facilitate listening on a circuit with a low level of incoming speech.

The **Hold** key is provided for working into a C.B. exchange and when operated short-circuits the 2μF condenser separating the two halves of the secondary of the speech transformer,

Telephone Circuit, TP/2 (*Contd*)

thus placing a loop across the line. It is used for calling the exchange and for holding the circuit during the conversation. This key must be operated before the **Speak** key when answering an incoming call, since otherwise the disconnection from the line of the Line relay winding by the operation of the **Speak** key would break down the connection. On the completion of the conversation the connection is broken down and the clearing signal given to the exchange by restoring the **Hold** key.

The **Batt** key is used when working into an exchange using the local battery system, for calling the exchange and for providing the D.C. ‘ talking ’ current. It connects the 24 volt battery in series with the secondary winding of the speech transformer. When answering an incoming call from such an exchange this key must be thrown before the **Speak** key, and must remain operated throughout the conversation. The line is cleared by restoring the **Batt.** key.



(N.B.—For Edinburgh, see Figure 2.) *Drawing A 2332, Issue 5.*

Figure 1. D.C. Test and Telephone Circuits.

D.C. Test Panel Fitted with Key Switching
(*not applicable to Edinburgh*)

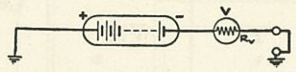
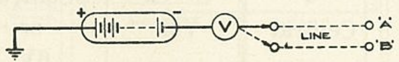
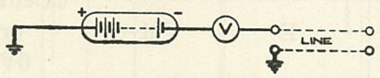
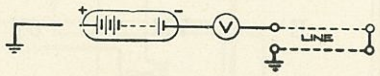
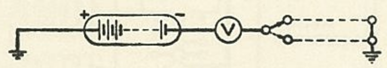
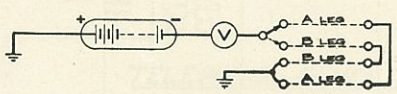
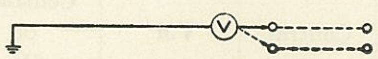
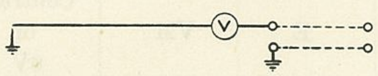
Test No.	Description.	Test Schematic.	External Connections.	Key Positions. 1	2	3	4	5	6	7
0	Calibration of Voltmeter.		**Test** plug to **Loop** jack. Voltmeter Range keys as required. Adjust Rheostat for full-scale deflection.	Central	E	Central	Central or 6V (To give desired range)	Central or VM Shunt	Central	VM
1	Insulation to Earth (i) A to E and (ii) B to E		**Test** plug to **Line** jack. Line open-circuited at distant end.	(i) Central (ii) Line Rev.	Central	Central	ϕCentral or 6V	Central	Central	VM
2	Insulation between Legs A to B		**Test** plug to **Line** jack. Line open-circuited at distant end.	Central	E	Central	ϕCentral or 6V	Central	Central	VM
3	Loop Resistance A + B		**Test** plug to **Line** jack. Line short-circuited A to B at distant end.	Central	E	Central	6V	VM Shunt	Central	VM
4	Resistance Unbalance (a) By earth at distant end, or (b) Between $A_1 + A_2$ and $B_1 + B_2$	 	for (a) **Test** plug to **Line** jack. Line short-circuited A to B and earthed at distant end. for (b) **Test** plug to **Line 1** jack. **Line 2** jack to **Loop** and **Earth.**	(i) Central (ii) Line Rev.	Central	Central	6V	VM Shunt	Central	VM
5	Foreign Battery (i) A to E and (ii) B to E		**Test** plug to **Line** jack. Line open-circuited at distant end.	(i) Central (ii) Line Rev.	Central	Central	Central or 6V	Central	Batt. cut-off	VM or VM Rev.
6	Foreign Battery A to B		**Test** plug to **Line** jack. Line open-circuited at distant end.	Central	E	Central	Central or 6V	Central	Batt. cut-off	VM or VM Rev.

Table 1. Operation of D.C. Test Circuits.

ϕ Normally the 60V range should be used but if the reading is very low the 6V range should be used. The meter must be recalibrated if the range is altered.

(Figure 1 attached)

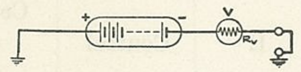
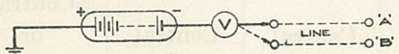
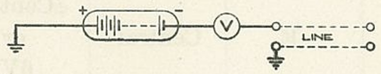
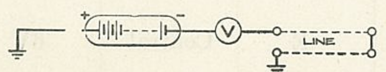
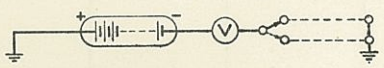
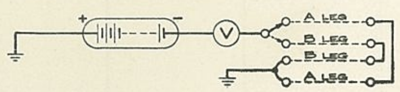
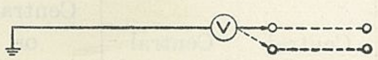
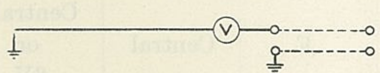
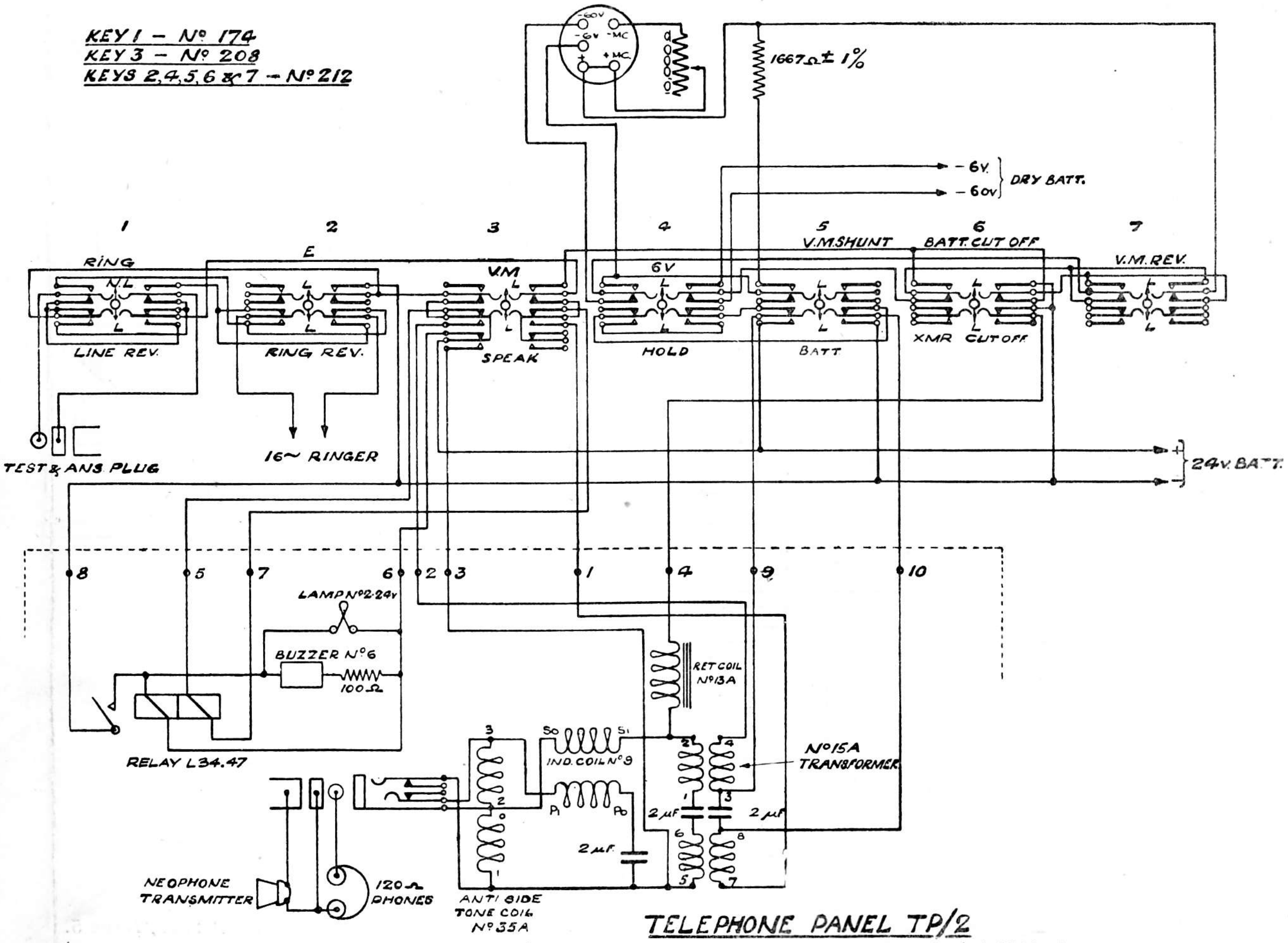
Test No.	Description.	Test Schematic.	External Connections.	Key Positions.						
				1	2	3	4	5	6	7
0	Calibration of Voltmeter.		**Test** plug to **Loop** jack. Voltmeter Range keys as required. Adjust Rheostat for full-scale deflection.	Central	E	VM	Central or 6V (To give desired range)	Central or VM Shunt	Central	Central
1	Insulation to Earth (i) A to E and (ii) B to E		**Test** plug to **Line** jack. Line open-circuited at distant end.	(i) Central (ii) Line Rev.	Central	VM	ϕCentral or 6V	Central	Central	Central
2	Insulation between Legs A to B		**Test** plug to **Line** jack. Line open-circuited at distant end.	Central	E	VM	ϕCentral or 6V	Central	Central	Central
3	Loop Resistance A + B		**Test** plug to **Line** jack. Line short-circuited A to B at distant end.	Central	E	VM	6V	VM Shunt	Central	Central
4	Resistance Unbalance (a) By earth at distant end, or (b) Between $A_1 + A_2$ and $B_1 + B_2$	 	for (a) **Test** plug to **Line** jack. Line short-circuited A to B and earthed at distant end. for (b) **Test** plug to **Line 1** jack. **Line 2** jack to **Loop** and **Earth.**	(i) Central (ii) Line Rev.	Central	VM	6V	VM Shunt	Central	Central
5	Foreign Battery (i) A to E and (ii) B to E		**Test** plug to **Line** jack. Line open-circuited at distant end.	(i) Central (ii) Line Rev.	Central	VM	Central or 6V	Central	Batt. cut-off	Central or VM Rev.
6	Foreign Battery A to B		**Test** plug to **Line** jack. Line open-circuited at distant end.	Central	E	VM	Central or 6V	Central	Batt. cut-off	Central or VM Rev.

Table 2. Operation of D.C. Test Panel at Edinburgh

ϕ Normally the 60V range should be used but if the reading is very low the 6V range should be used. The meter must be recalibrated if the range is altered.

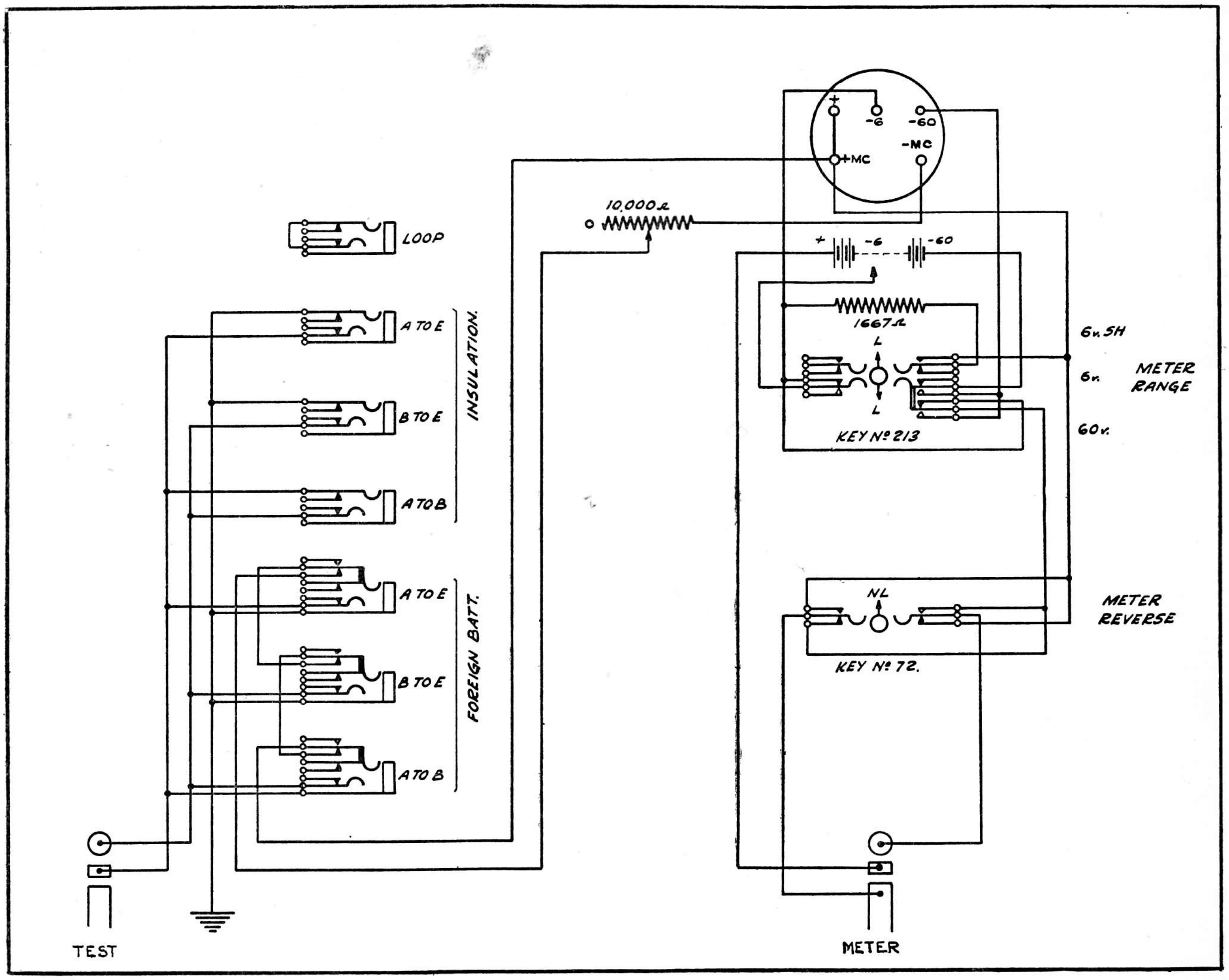


(*N.B.—This Circuit applies only at Edinburgh.*)

Drawing A 1962, *Issue* 5.

Figure 2. D.C. Test and Telephone Circuits.

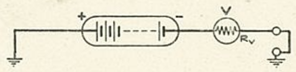
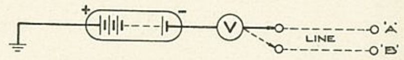
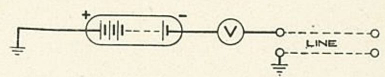
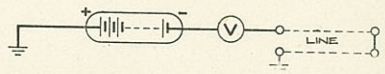
(*Table 2 attached*)

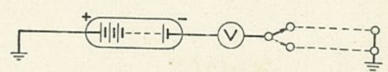
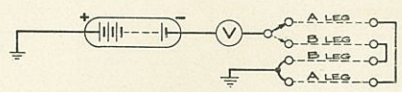


Drawing A 3534 *Issue* 3

Figure 3. D.C. Test Circuits.

D.C. Test Panel Fitted with Jacks.

Test No.	Description.	Test Schematic.	Connections.	Meter Keys.
0	Calibration of Voltmeter.		**Test** plug to **Loop** jack. **Meter** plug to **Ins. A to B.** Adjust rheostat for full-scale deflection.	Range key to 60V, 6V or 6 V SH according to value of quantity to be measured.
1	Insulation to Earth (i) A to E (ii) B to E		**Test** plug to **Line** jack. **Meter** plug to (i) **Ins. A to E.** (ii) **Ins. B to E.** Line open-circuited at distant end.	Range key to 60V or 6V according to value of the insulation resistance. Recalibrate if range is altered.
2	Insulation between legs A to B		**Test** plug to **Line** jack. **Meter** plug to **Ins. A to B.** Line open-circuited at distant end.	Range key to 60V or 6V according to value of the insulation resistance. Recalibrate if range is altered.
3	Loop Resistance A + B		**Test** plug to **Line** jack. **Meter** plug to **Ins. A to B.** Line short-circuited A to B at distant end.	Range key to 6V SH.

4	Resistance Unbalance
	(a) By Earth at distant end
	or
	(b) Between $A_1 + A_2$ and $B_1 + B_2$
		
		
			For (a) **Test** plug to **Line** jack.
			For (b) **Test** plug to **Line 1** jack.
			For (a) & (b) **Meter** plug to (i) **Ins. A to E.**
			(ii) **Ins. B to E.**
			For (a) Line short-circuited A to B and earthed at distant end.
			For (b) Lines connected A_1 to A_2 and B_1 to B_2 at distant end Line 2 plugged to **Loop** and **Earth** at near end.
				Range key to 6V SH.

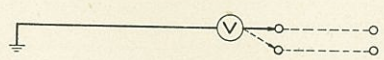
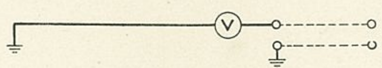
5	Foreign Battery (i) A to E and (ii) B to E		**Test** plug to **Line** jack. **Meter** plug to (i) **For. Batt. A to E.** (ii) **For. Batt. B to E.**	Range key to 60V or 6V according to voltage of Foreign Battery. Operate Meter Reverse key if necessary.
6	Foreign Battery A to B		**Test** plug to **Line** jack. **Meter** plug to **For. Batt. A to B.**	Range key to 60V or 6V according to voltage of Foreign Battery. Operate Meter Reverse key if necessary.

Table 3. Operation of D.C. Test Panel.

(*Figure 3 attached*)