SECTION 18

ROUTINE LINE TESTERS RLT/1 AND RLT/1P

Introduction

Routine Line Testers RLT/1 and RLT/1P are designed to carry out all the normal d.c. tests on lines. The RLT/1 is for mounting on a 19-in. bay and is used on A.C. Test Bay AC/55, and contains its own internal mains unit. The RLT/1P is the portable version of RLT/1 and is powered from self-contained batteries; it replaces the Bridge-Megger.

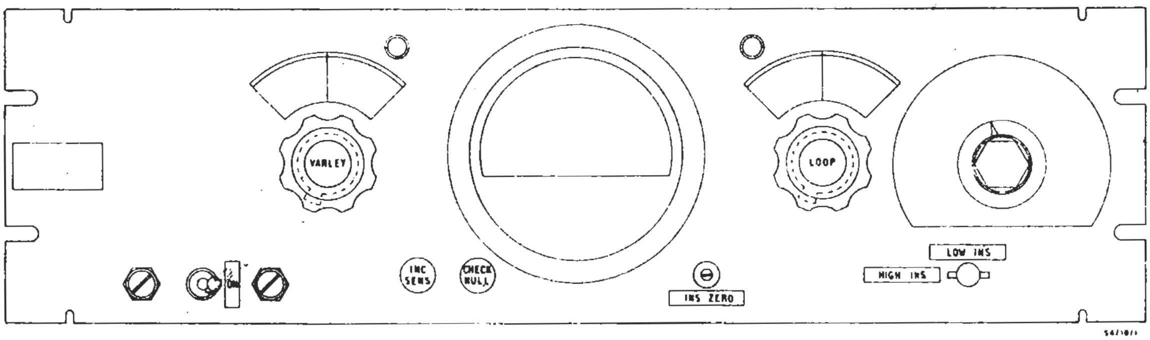

Fig. 18.1. RLT/1: Face Panel

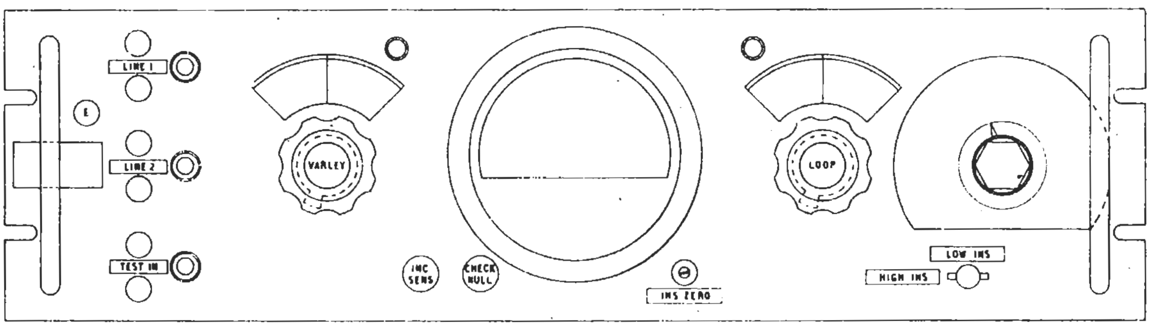

Fig. 18.2. RLT/1P: Face Panel

The performance of the two units is similar and both have facilities for checking the insulation resistance, the loop resistance and the out-of-balance of lines, and for checking that there is no standing d.c. voltage on the line.

Quick operation is provided by using a single multi-position rotary switch to cover all test conditions, and by using a continuously-variable measuring resistor instead of the usual 3 or 4 decade resistor as in the Bridge-Megger. A low-voltage source is provided for bridge measurements to reduce the probability of a line fault, such as a high-resistance joint, being influenced by the testing source.

The galvanometer used is of the shaped-pole centre-zero type giving high-sensitivity at mid-scale with great overload capacity and a convenient scale when it is used as an ohmmeter with a high-voltage source for measuring insulation resistance.

General Description

Each unit is constructed on a 19 in. × 5 ¼ in. panel, the RLT/1 having a standard 6-in. rear dust cover, and the RLT/1P being mounted in an aluminium alloy carrying case. The layout of the two panels is shown in Figs. 18.1 and 18.2.

Calibrated Dials

The calibrated dials of the two continuously-variable resistors marked VARLEY and LOOP respectively are mounted behind the panel to save panel space and to protect them from dust and handling. Their markings are visible through perspex covered cut-outs in the panel. Each dial is mounted on a detail having a thin-walled sleeve with longitudinal saw-cuts surrounding the resistor spindle and fitting inside the knob. When the knob is removed the dial can be rotated on the spindle which is provided with a screwdriver slot to enable it to be adjusted in the absence of the knob. When the knob is replaced and the two-set screws tightened, the whole assembly is locked to the spindle.

Multi-position Switch

The multi-position rotary switch which arranges the circuit of the unit to suit the particular test to be carried out is situated on the right of the panel. The dial is engraved to show the function performed for each position of the switch.

Galvanometer

The centre-zero galvanometer is provided with two scales; the top scale is calibrated in megohms, the left-hand quadrant reading 1·5 to 60 megohms from left to right and the right-hand quadrant reading 0 — 2 megohms from right to left. The lower scale is marked − 50, − 25, + 25, + 50 volts.

When the galvanometer is used as a null indicator in bridge measurements the sensitivity can be increased by pressing the button marked INC. SENS which short-circuits a 12-kΩ resistor which is normally in series with the meter under these conditions.

The coil of the meter has a resistance of 1 kΩ and the current taken for full scale deflection is ± 55 μA.

In the RLT/1P a micro-switch, operated on closing the lid, short-circuits the galvanometer for safety during transport.

Battery Charging Socket

In the RLT/1P a socket, accessible through the side of the case, allows the usual O.B. charging equipment to be connected.

Line Termination

On the RLT/1 two tags are provided for line termination and these are intended to be wired to the tip and ring of a suitable jack.

On the RLT/1P two pairs of spring terminals are provided so that two lines can be terminated; either line can then be connected to the test circuit by a short patching cord plugged from the associated parallel jack to the *Test-In* jack, the insertion of the plug in the latter jack closing a pair of protective contacts in the bridge battery supply circuit.

Direct access to the testing circuit in the RLT/1P is provided by spring terminals in parallel with the *Test-In* jack, but a plug must be inserted in the *Test-In* jack to complete the battery circuit.

Circuit Description (Figs. 26 & 27)

Insulation Resistance

With the main rotary switch SWA in positions 1, 2 or 3 the voltage source in series with a limiting resistance of 82 kΩ is applied between the **A** wire and earth, the **B** wire and earth, or between the **A** and **B** wires through a universal meter shunt consisting of a 3·3-kΩ fixed resistor (R11) in series with a variable 2-kΩ resistor (R21 in RLT/1 and R20 in RLT/1P) which is used to adjust the instrument zero.

With switch SWB in the *High Insulation* position the meter is connected directly across this shunt as shown in Fig. 18.3(a) which is a simplified diagram of the circuit for measuring insulation resistance to earth. The pointer of the meter indicates the insulation resistance directly on the left hand quadrant of the meter scale.

With switch SWB in the *Low Insulation* position an additional shunt consisting of R12 (3·3 kΩ) and R13 (268Ω) in series is connected in parallel with the previous shunt, and the meter in series with R14 (2·2 kΩ) is connected across R13. (See Fig. 18.3(b).) The connections to the meter are reversed in this case thereby causing the pointer to read over the right-hand quadrant of the scale.

In both cases the arrangement is such that the shunt resistance across the meter terminals is high (5,300 or 2,500Ω). This ensures a lively movement of the galvanometer needle so that short breakdowns due to sparking will be noticeable, and a reading can be obtained quickly on a normal line.

The internal resistance of the whole circuit is also kept fairly low (about 84 kΩ) in both cases resulting in a rapid charging time, even for a line of considerable length. This low resistance may result in a meter current of 1 mA in the *High Insulation* condition if there is a direct earth on the line, but the meter can withstand pulses of over 2 mA without ill effects.

The meter scale is calibrated to read resistance when the slider of the variable resistor marked INSTRUMENT ZERO is to the extreme left in the diagrams (i.e. the whole of the resistance is in series with the external resistance to be measured) and the source e.m.f. is 100 volts. The zero mark

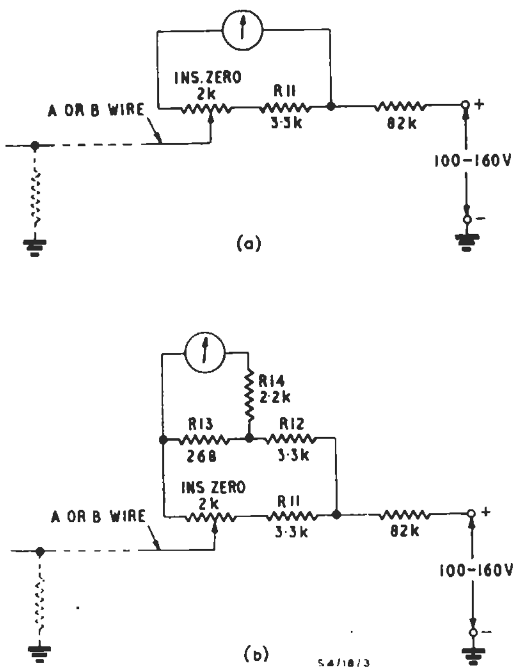

Fig. 18.3. Simplified Measuring Circuits
(a) high-insulation resistance to Earth
(b) low-insulation resistance to Earth

which is at the right-hand end of the right-hand quadrant corresponds to a galvanometer current of 55 μA and a short-circuit line current of 1·19 mA.

Negligible error occurs in the resistance scale if the source e.m.f. lies between 100 and 160 volts provided the deflection for a short-circuit is adjusted to the zero mark by means of the *Instrument Zero* resistor which allows the multiplying power of the universal shunt to be increased up to 1·6 times its minimum value.

The values of the resistors in the padded galvanometer circuit for the *Low Insulation* condition have been chosen to give negligible error for low values of resistance by making the input resistance of the padded galvanometer circuit almost equal to R11. In the *High Insulation* condition variations of internal resistance are in any case negligible compared with the lowest significant line insulation resistance of 1·5 MΩ.

No provision has been made to correct for variation in internal resistance of the source which is negligible in the RLT/1 and is also negligible in the RLT/1P if proper battery maintenance checks are carried out since the normal internal resistances of the 135-V battery is about 300Ω which is only 0·35% of the minimum circuit resistances.

Line Discharge Circuit

Position 4 of the main switch connects the A and B wires of the line to earth via R15 and R16 (3·3 kΩ) of Figs. 26(a) and 27(a). Normally the line will retain a charge from the insulation test, and moving the switch through the discharge position to subsequent positions for further tests gives ample time for complete discharge and thus prevents spurious meter deflections.

Foreign Battery

In positions 5, 6 and 7 of the main switch the galvanometer in series with a 1-MΩ resistor (R9 of Figs. 26(b) and 27(b)) is used as a voltmeter connected to line in accordance with the engraved designations. The meter will be only lightly damped owing to the high series resistance, and the indications will, therefore, be as rapid as practicable. Only two voltages are marked in each quadrant, 50 and 20 volts, which are in the regions of the foreign battery voltages most likely to be encountered.

Loop Resistance

In positions 8, 9 and 10 of the main switch the circuit of the unit is arranged as a Wheatstone Bridge for measuring loop resistance, the simplified circuit for unity ratio being shown in Fig. 18.4. The positive side of the low-voltage source is connected to either P′ or P″ for the other two ratios × 10 or ÷ 10 respectively.

A 1-kΩ resistor (R7 of Figs. 26(d) and 27(d)) is inserted in series with the galvanometer in the inequality ratio positions to protect the galvanometer.

The resistor R6 (12 kΩ) is normally in series with the galvanometer but can be short-circuited by operating the key marked INC. SENS to give full sensitivity; the meter will be slightly sluggish in this condition.

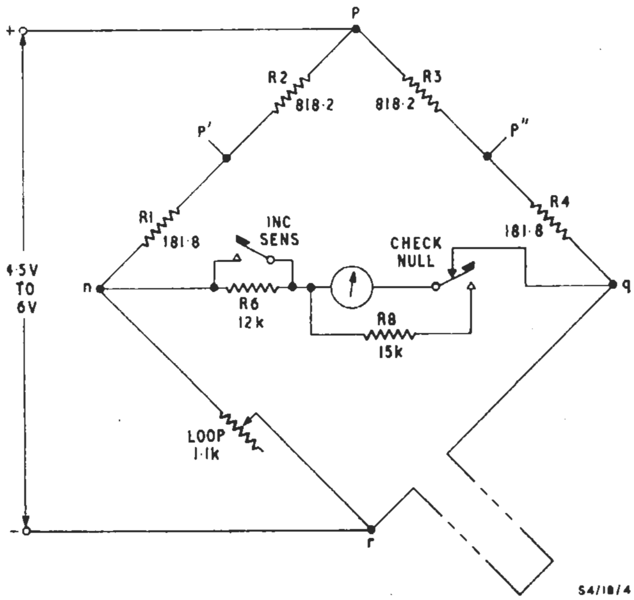

Fig. 18.4. Simplified Circuit of Unity Ratio Bridge for loop resistance measurement

In order to check that a true balance has been obtained (which is only necessary in special cases) the *Check Null* key is depressed; this disconnects the galvanometer from the bridge circuit and connects it across R8 (15 kΩ) which provides enough damping to bring the pointer to rest quickly but still allows a little overswing to show that the movement is free.

A lamp near the calibrated dial of the loop measuring resistor is automatically illuminated from the low-voltage source.

Resistance Unbalance

Positions 11 and 12 of the main switch give the bridge circuit for the normal *Varley Loop* measurement except that a 25-Ω fixed resistor **R5** in Figs. 26(d) and 27(d) is included in one leg so that for a perfectly balanced line the bridge will balance when the resistance of the 50-Ω variable resistor marked VARLEY is 25 Ω. This gives zero unbalance in the middle of the resistor scale with positive and negative unbalances on either side of this zero. Hence it is never necessary to reverse the bridge to obtain a balance. The simplified circuit is shown in Fig. 18.5.

The *Varley Reverse* position (No. 12), which reverses the **A** and **B** wires and is only used in special cases, is provided to enable the bridge to be checked or to give very accurate unbalance readings. A reading is first taken in the normal position and then one in the reverse position and each is given its correct sign (readings in the red portion of the scale are positive). The reverse reading should then be *subtracted algebraically* from the normal reading, and the result, divided by 2, will give the true unbalance apart from second order errors. This takes account of errors in the ratio arms and in the location of the scale of the measuring resistor in relation to the wiper position. These errors may be important if unbalance is to be measured to fine limits on a long line.

The lamp adjacent to the scale of the measuring resistor marked VARLEY is illuminated when the switch is in either Position 11 or 12.

Earth-to-Earth Tests

Positions 13 and 14 of the main switch simply give a unity-ratio Wheatstone Bridge connection similar to that shown in Fig. 18.4 except that the **A** or **B** wire of the line is connected to point **q** and point **r** is earthed. The wire under test is earthed at the distant end and the bridge measures the resistance of the **A** or **B** wire plus that between the two earth connections. Earth potential differences which may be appreciable in comparison with the source voltage are to be expected on

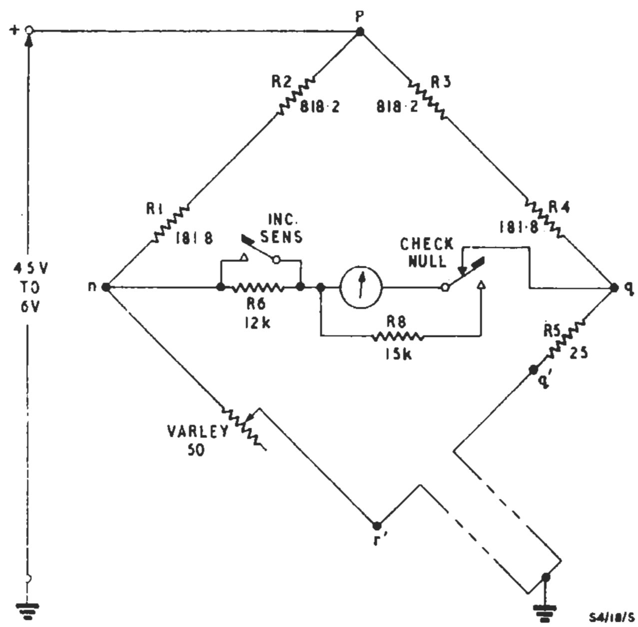

Fig. 18.5. Simplified Varley-Loop Bridge Circuit for measurement of resistance unbalance

long lines and a steady reading will not always be obtainable on this test.

Power Supply

In the RLT/1 a simple self-contained mains unit provides a low-voltage d.c. supply at 4·5 V nominal for bridge measurements and a high voltage d.c. supply at 150 V nominal for insulation resistance measurements. A neon stabiliser valve is connected across the high-voltage supply.

With the main rotary switch in any of the positions for bridge measurements and the appropriate lamp alight, the voltage across the capacitor C2 (Fig. 26(a)) measured on an Avometer should be about 5.9 V.

With the main rotary switch in position 3 (INS.A/B) the voltage across the neon stabiliser valve measured on an Avometer should be 150 V ± 5%.

In the RLT/1P a 4·5-volt battery (3 Siemens " S " cells) is used for the low-voltage source and three 45-volt batteries (Ever-Ready Type B102) in series for the high-voltage source. Measured on an Avometer the voltage across the 4·5-V battery should be 4·5 V ± 10% and that across the high-voltage battery should be 135 V ± 10%. The 135-V battery should be capable of delivering a current of not less than 0·25 A when the 1 A range of an Avometer is connected momentarily across its terminals.

Accuracy

Insulation Resistance

Specified as ± 10% of scale reading and likely to be within ± 3%.

Foreign Battery

Specified as ± 10% at calibrated points and likely to be within ± 1 volt.

Loop Resistance

The maximum errors specified are:—

Ratio	÷ 10	± 1% of reading or	± 0·25Ω
,,	× 1	± 1% ,, ,, ,,	± 2·5Ω
,,	× 10	± 1% ,, ,, ,,	± 2·5Ω

The larger of the two values applies and scale readings below 100 are excluded. The limit of accuracy at low readings is chiefly in the linearity of the variable resistor winding which is stated by the makers to be ± 0·2% of the full winding resistance. The engraving also introduces some error.

Resistance Unbalance

On a loop of 2,000-Ω resistance or less the maximum error on a bridge reading should not exceed 0·25Ω. If the mean of a normal and reversed measurement is taken the error should not exceed 0·1Ω. These values apply to unbalances between 0 and 5Ω.

For higher unbalances, the error should not exceed ± 0·5Ω. The limiting factors here are the resistance per turn of the 50Ω variable resistor, which is approximately 0·1Ω, and the accuracy of the ratio arms, the latter factor becoming the more important on long lines.

Calibration Checks

If the dials of the *Loop* and *Varley* variable resistors are removed at any time, it is necessary to ensure that they are replaced correctly otherwise the calibration will be lost. The recommended method of checking the accuracy of the dial locations is as follows :—

Loop Resistance

Connect a resistor of 1,000 ohms ± 1 ohm to the *Test In* jack or terminals. In the RLT/1P, the resistor R17 is provided for this purpose and is connected to the bridge input by strapping the *Test In* spring terminals to the *Line* 2 terminals. For the rack mounted RLT/1, a high-grade resistance box should be used. The main rotary switch SWA is set to position 9 (*Loop* X1), and the bridge should of course balance when the *Loop* dial is set to read 1,000 ohms. Should it be necessary to adjust the dial, first temporarily mark the approximate position of the knob relative to the dial, then remove the knob. Set the resistor by means of the screw-driver slot in the spindle so as to balance the bridge, and then set the dial (which is now free on the spindle) to read 1,000 ohms accurately. Replace the knob in approximately its original position relative to the dial and tighten the grub screws. The whole assembly is now locked. Check that the end stops are working correctly—there should be full movement covering the calibrated part of the dial, and rotation should be restricted at each end by the end stops, not by the wiper of the variable resistor.

Resistance Unbalance

On the RLT/1P, short-circuit and earth the *Test In* spring terminals. On the RLT/1, plug the *Test In* jack to an earthed loop by a known good cord. Set the rotary switch SWA to *Position* 11 (*Varley Normal*). It will be seen from Fig. 18.5 that the circuit is now that of a unity ratio bridge, comparing the 50-ohm *Varley* resistor with R5, 25 ohms. The *Varley* resistor should, therefore, give a balance when adjusted to the midscale value, calibrated as Zero unbalance. Check in the *Varley Reverse*, or No. 12 position of rotary switch SWA. Since this merely reverses the connections to the earthed loop under test, it should not change the balance unless there is appreciable contact resistance, or unless the earthed loop is faulty. If it is necessary to adjust the dial, see the relevant remarks under Loop Resistance in the preceding section.

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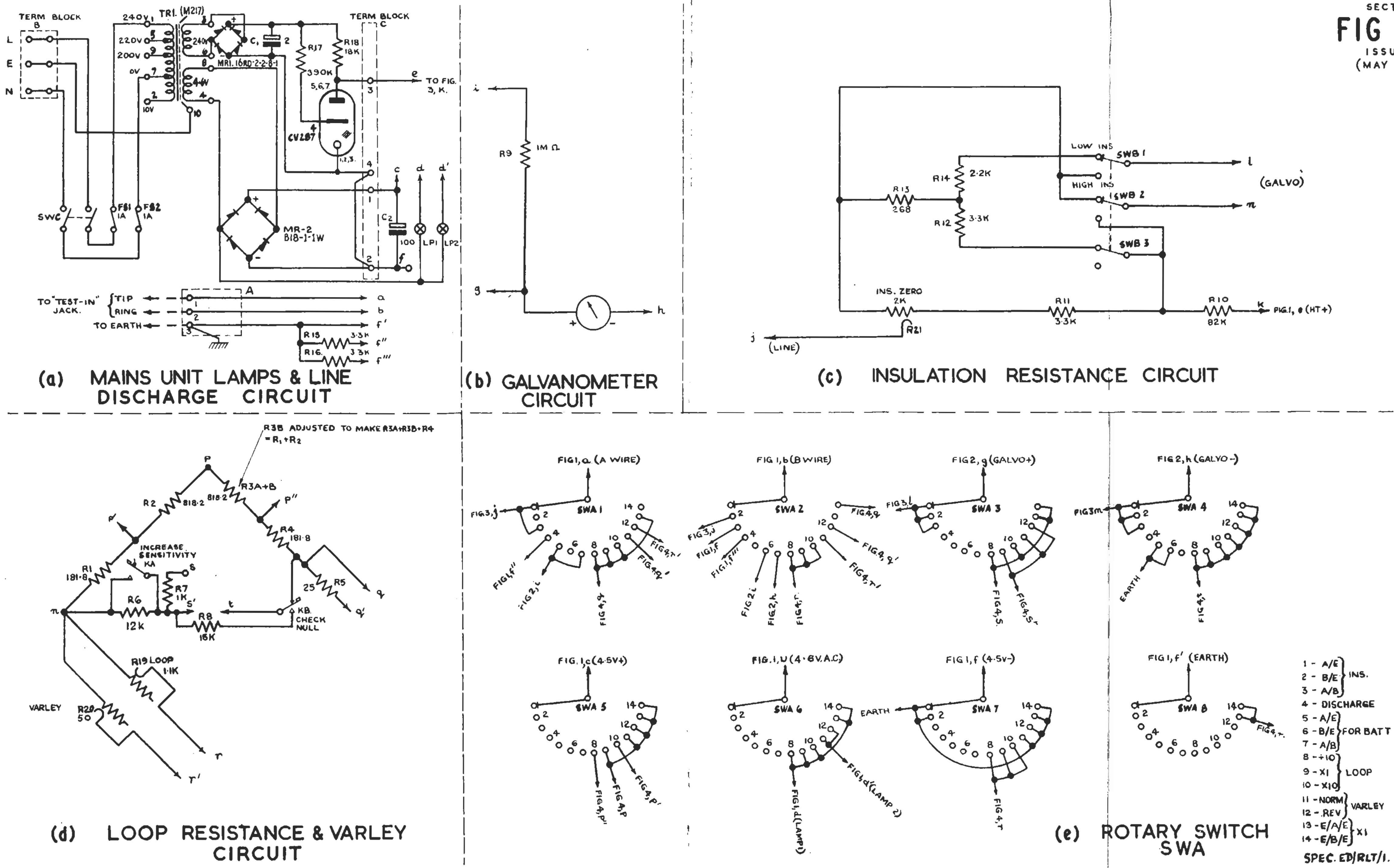
COMPONENT TABLE: FIG, 26

Comp.	Type	Tolerance per cent.
C1	T.C.C. SCE76PE/PVC	−20+50
C2	T.C.C. CE32A/PVC	„
FS1	Belling & Lee L562/1, 1A miniature	
FS2	„ „	
KA	P.O. No. 284	
KB	„	
LP1	P.O. No. 2, 6V	
LP2	„ „ „	
MR1	Westalite 16RD-2-2-8-1	
MR2	S.T.C. B18-1-1W	
R1-R5	Wirewound	± 0·1
R6	Erie 9	±10
R7	„ „	±10
R8	„ „	±10
R9	Erie 108	± 2

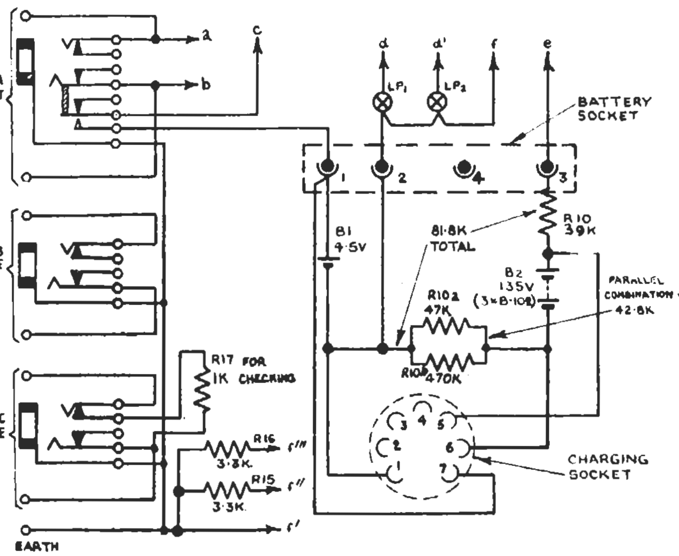
Comp.	Type	Tolerance per cent.
R10	Painton P302	± 5
R11	Erie 108	± 2
R12	„ „	± 2
R13	„ „	± 2
R14	„ „	± 2
R15	Erie 9	±10
R16	„ „	±10
R17	„ „	±10
R18	Painton P301	± 5
R19	Painton CV25S	
R20	Painton CV15S	
R21	Painton CV2P	
SWA	Painton, Winkler, AS/2P/14/4B	
SWB	B.B.C. EPA7606	
SWC	N.S.F. 8373/B145, Toggle, D.P.C.O.	



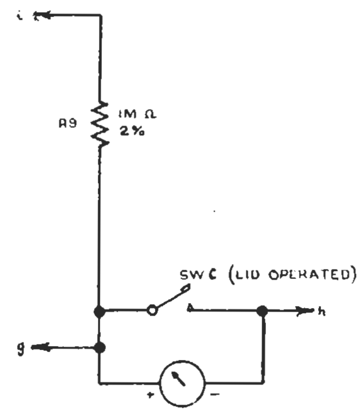
ROUTINE LINE TESTER RLT/1: CIRCUIT

COMPONENT TABLE: FIG. 27

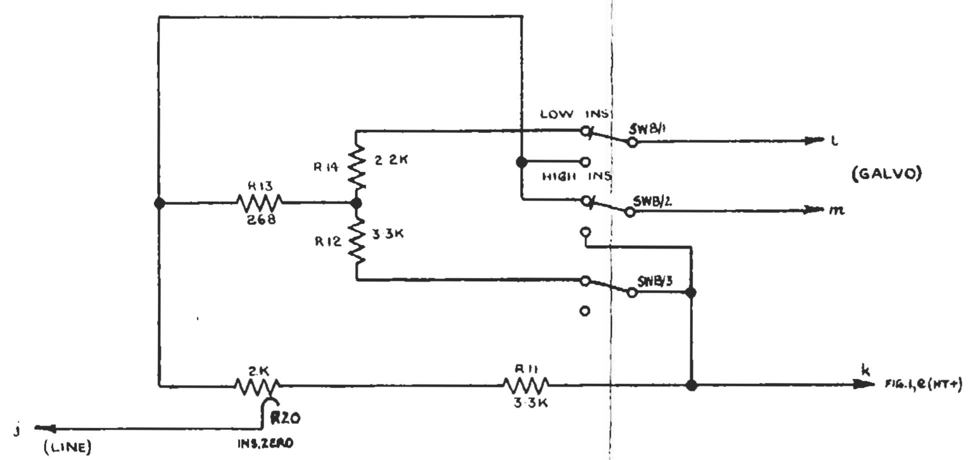
Comp.	Type	Tolerance per cent.
B1	Siemens Size S (3 off)	
B2	Ever Ready B102 (3 off)	
JKA	S.T.C. 4114B	
JKB	S.T.C. 4112B	
JKC	S.T.C. 4112C	
KA	P.O. No. 284	
KB	„ „	
LP1	P.O. No. 2 6V	
LP2	„ „	
R1-R5	Wirewound	± 0·1
R6	Erie 9	±10
R7	„ „	±10
R8	„ „	±10
R9	Erie 108	± 2
R10	Painton P302	± 5
R10a	Painton P302	± 5
R10b	Erie 109	± 2
R11	Erie 108	± 2
R12	„ „	± 2
R13	„ „	± 2
R14	„ „	± 2
R15	Erie 9	±10
R16	„ „	±10
R17	Wirewound	± 0·1
R18	Painton CV25S	
R19	„ CV15S	
R20	„ CV2P	
SWA	Painton, Winkler, AS 2P 14 4B	
SWB	B.B.C. EPA7606	
SWC	Bulgin, microswitch, S500	



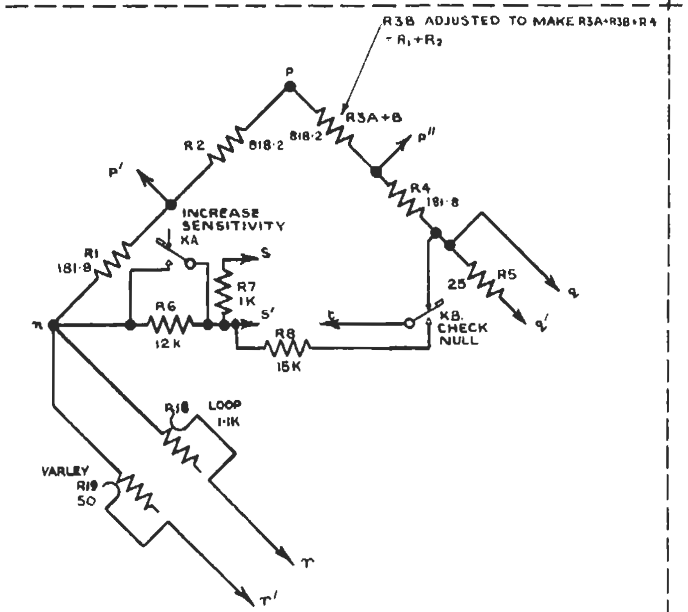
(a) LINE TERMINATIONS BATTERIES LAMPS & LINE DISCHARGE CIRCUIT



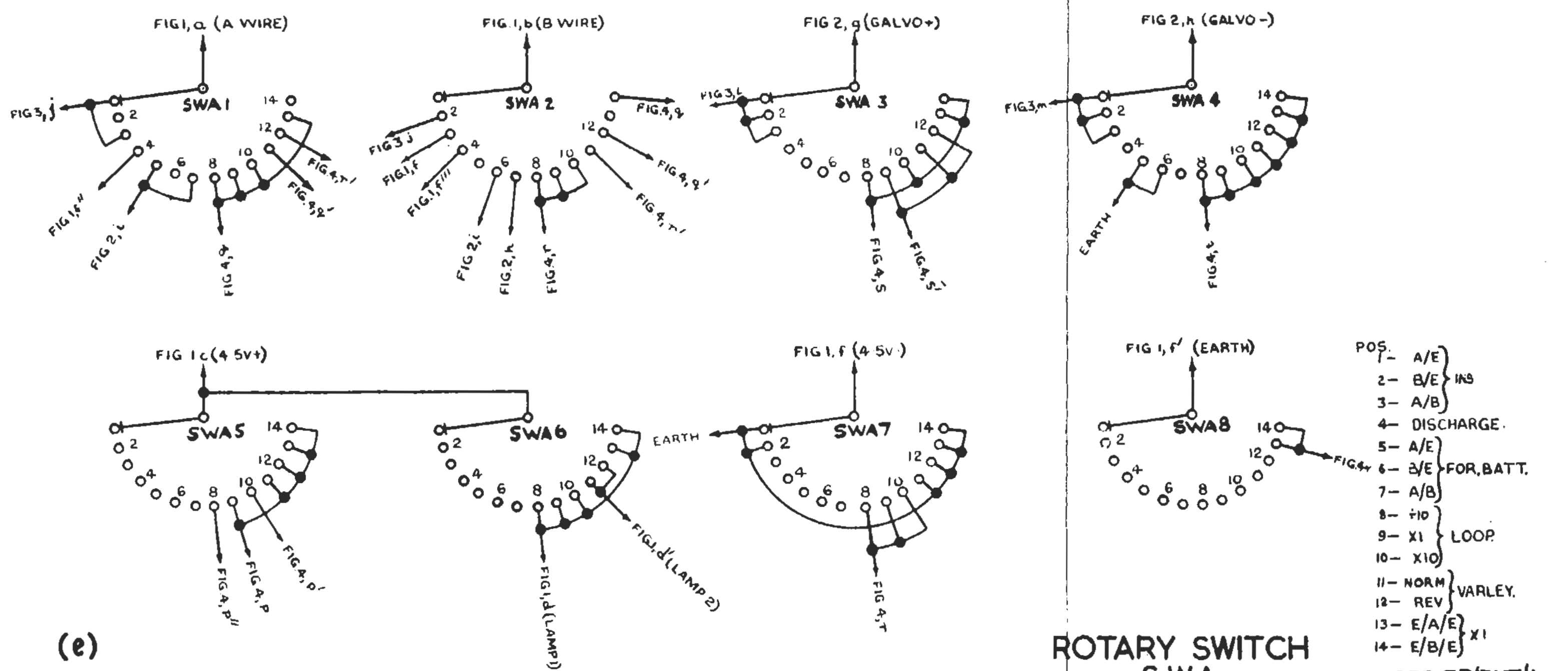
(b) GALVANOMETER CIRCUIT



(c) INSULATION RESISTANCE CIRCUIT



(d) LOOP RESISTANCE & VARLEY CIRCUIT



(e) ROTARY SWITCH SWA

SPEC. ED/RLT/1

ROUTINE LINE TESTER (PORTABLE) RLT/1P: CIRCUIT