BPL (British Physical Labs) RM-175-LZ Mk2 Megohmmeter S.N. 12583.
Condition: pretty good – unmodified. eBay June 2012,
Article in 1957 December Wireless World.
0 to 1kVdc test voltage. Delay on meter connection for capacitor charging when measuring.
Measurement range from 900kΩ to 5TΩ (5,000 Gigohm, or 5 million Megohm). Compared to the base CX version, the LZ model provides up to 1kV test level. The Mark 2 upgrade is not yet clarified.

Sw1 – mains on switch	
Sw2 – delay seconds switch	controls energisation of relay RL1 with 3 contacts: RL1A for delay indicator; RL1B for meter; RL1C for load
Sw3 – Test Voltage or Off or Measure	use to set test voltage, and then to make measurement
Sw4 – Range 'Multiply By'	use with meter reading and test voltage to determine result

T1	KB883; resonant auto-transformer; 0, 44.7%, 67%, 100% turns.
T2	KB881; 4.66:1 turns ratio
T3	KB1017: 0-245V, 0-1050V.
T4	KB1016: 0-250V, 230-0-230V, 6.3V at least 2A.
Caps	Dubilier Nitrogel B255 VG , 0.5uF 1250VDC ; 1964, July
	Static 4uF 800V SD 4 C
	Static 2uF 400V SB 2 C
	DALY 8uF 500V J7 4/15 WE (1965, May)
	ERO
Pots	Colvern WW XG
	Bercostat L75
Resistors	Welwyn AW3111 WH (1965, Aug)
Relay	AK8207 198 H44/4
	?
Diode	Senter K3/45 A66
	BYY34 zener K28
Valves V2	EZ80 Mullard kC5 ±6E3 (kC=EZ80, 5=change symbol; Chartres, 1966, May)
V3	12AU7 USA 23C 56-43 ; relay RL1 driver
V4,5	EF37A (x2) Mullard EP2 B6C2 red coated (EP=EF37A, 2=change code; B=Blackburn, 1966, March)
Meter M1	100uA FSD Res: 86.6ΩS.N. 8219/A/6

Other functional uses:

1. High voltage DC supply between '+' black terminal and Guard terminal, with metering (keyswitch set to "Test Voltage"). Current limited droop from series 25k (ie. about 52mA short circuit). Instant current limit from series 10k (ie. about 100mA short circuit).
2. uA/pA FS meter between '–' red terminal and Guard terminal, with metering (keyswitch set to "Measure").
   Multiply x0.1: 555uA FS; 250mV drop; 444ohm sense;
   Multiply x1: 55.5uA FS; 250mV drop; 4.44kohm sense;
   Multiply x10: 5.55uA FS; 250mV drop; 44.4kohm sense;
   Multiply x100: 0.555uA FS; 250mV drop; 444kohm sense;
   Multiply x1000: 55.5pA FS; 250mV drop; 4.44Mohm sense;
   Multiply x10,000: 5.55pA FS; 250mV drop; 44.4Mohm sense;

Notes:
Schematic identifies front panel Rx black terminal as '+', and red terminal as '-'. Black '+' terminal is energised when front panel pushbutton is pressed up or down.
Rx RED terminal in grounded/range feed – shown on schematic as HIGH.
Guard terminal is taken direct to chassis.

Top panel provides access to valves, and sensitivity trimpot. Rear and base wrap-around panel provides access to underneath chassis – the rear mains socket connects to top of chassis via an octal plug.
C1 4uF cap disconnected and missing – needs to be at least 400VAC rated due to T1 2:1 step-up.
Trim resistor goes to T4 primary, not to R1 front panel pot.
T3 secondary 0V taken direct to chassis mounting bolt.
V1 uses BYY34 zener.
Meter M1 missing side mount.

Front panel lever switch S3 has some differences to schematic and contact scheme:

- The sketch on the schematic shows the (original) lever switch contact connections.
- Schematic switch S3H not connected.
    - Original schematic has the bottom of R20 grounded when off and measure are active, rather than floating at rail, but this doesn't appear to have any consequence or benefit.
- R22 (10k) connected to 0V for Test Voltage and Off, and initially for Measure until RL1 is energised. R22 provides a somewhat low resistance path for any shunt capacitance across the DUT to charge up to the test voltage whilst the time delay is active.

Dating:
Schematic dated 1959 for Issue 2.
Parts appear to be 1965-6 (not 1956).
Initials and date written on chassis: C.A. 16-11-66
Instruction book/manual from AEF library: https://www.aef.se/Biblioteket/Tabeller/Dokumentarkiv_A-F.htm and

Issues:

- Mains socket and connection to chassis via octal plug.
- mains side control parts: panel pot (set volts); trim pot; 4uF oilcan cap.
- No mains fuse, or power supply secondary fuse, or HV secondary fuse
- Electrolytic filter cap C5 - old.
- R31 self-discharge is a 1/2W resistor and has to withstand 1kV.
- Stability of R15. R4 = 4k (not 15k). R5 >+10%
- Front panel Rx red terminal has a cracked insulator – this is high insulation type.
- Something is sliding inside the meter housing when enclosure is tilted on side.

Modifications

- Installed bracket with IEC socket with 0.8A IEC T fuse on chassis rear panel, and cutout folding panel. Active to chassis octal disconnected.
- Separated AC primary wiring from secondary side wiring.
- Series UF4007 with each EZ80 anode.
- Added IEC T 5x20mm 80mA fuse in T4 secondary CT, and star the first filter cap points.
- Replaced C5 8uF electrolytic with 10uF 250VAC poly.
- Made a side mounting bracket for meter.
- Replaced R31, R4, R5, R6.
- Added 1N4004 across RL1 coil.
- Megger tested all primary side parts and secondary side B+ parts.
- Fail-safe wiper on Adjust to infinity.
- Replaced R20=10MΩ for voltage measurement (made from 5 series high stability resistors, but prone to soldering cracks due to very short terminals) – 10M02 made from 6 series 1% resistors (1M999+2M02+2M002+2M003+1M996).
- Replaced C1 with 4uF 350Vac poly, measured as 4.11uF.
- Added a screwdriver locating tube to top panel for long-shaft screwdriver to adjust sensitivity trimpot without panel removal.

To do:

- Delay indicator not always functioning as anticipated. Sometimes off or on, and appears to not be related to relay operation.

Options:

- Could insert another RC filter between V3 and V4,5 with cap going direct to R19.
- Add switch to turn HV supply off – perhaps in link from R1 wiper to T3, to maintain loading on mains reg.
    - No 'test voltage' function.
    - uA/pA measurement function.
    - But this is same as Test Pressure Control set to zero, so no benefit except for fail-safe removal of HT to black terminal.

Design

Heater current: 0.6+0.6+0.2+0.2+0.2+0.2 = 2A

HT supply
T4 primary ESR=83Ω; secondary ESR 240+260Ω
EZ80 can cope with lots of first filter capacitance, as load is up to only 14mA (7mA/anode) with relay RL1 energised (15k+1k5) and Vak~70V. Fuse added in HT CT. An IEC T 80mA 5x20mm fuse is ok for the CT, based on PSUD2 (lower rated fuse better but only 80mA in stock).

Simulate period in PSUD2	10ms	40ms	200ms	continuous
Simulated RMS current	0.28A	0.15A	0.075A	0.033A
Multiplier (based on 0.08A fuse rating)	3.5	1.9	0.94	0.42
IEC60127-2 Time-lag T min limit multiplier	10	4	2.75	1

Resonant reactor voltage regulator
Reference is Lee 1955.
Primary inductance of T1, and C1, are parallel-resonant at mains AC frequency. So reactive voltage across inductance of T2 primary is lowish as LC tank doesn't draw much current, and T1 is partially saturated. If AC mains voltage falls, then tank becomes untuned and current drawn through T2 becomes more capacitive, and increases T2 primary voltage. Conversely, a more inductive current in the tank occurs with higher AC mains voltage, which reduces voltage across T2 primary.

T2 primary voltage is about 156V, and secondary about 34V. T1 tap voltages are about 173V, 260V and 390V. Regulated voltage to T3 and T4 is about 267V to 264V, over mains AC range of 180V to 240V. Heater voltage was kept to 1% for mains AC variation from 180-240V. Heater voltage was 6.4V for C1=4.4uF, and 6.0V for C1=3.3uF. T1 gets warm.

Test voltage measurement FS is 100uA through 10MΩ 1% (ie. 1kVdc). Sw3 routes the voltage presented to Rx + red terminal through R20 (10MΩ) and 100uA meter to 0V. The Rx black terminal is switched to 0V.

Divider resistances using K179 and RL1C energised:
R29=445.2 (+0.27%); R28=4k030 (+0.75%); R27=40k31 (+0.78%), R26=402k6 (+0.65%), R25=4M11 (+2.8%), R20=10M3, R12=10M0,
HP34401A: R26=402k6 (+0.65%), R25=4M11 (+2.8%)
ESI 230B: R26=402k6 (+0.65%), R25=4M106 (+2.8%), R24=20M1+20M0 (+0.25%), R15=47M0, R23=2M12, R20=10M3
Note:

- Meters compare well.
- R15=40M on schematic, but part colours are 47M, and 47M is a better balance for ∑ of divider = 44M4 plus 2M12).
- R24 comprises 2x series 20M.
- R25 is sufficiently out of spec to modify with //155M (ie. 2x68M+22M).
  - x1000 Range could be 2.5% high.
- Tempco of concern, so really need to retest with warm room before any tweaking.

External resistance measurement with Range 1 (x1/10) and test voltage measured at 500V, supplies 500V across the external resistance and the lower arm of the Range divider. For a meter FS reading with 0.9MΩ external resistance, the voltage generated across the 444Ω divider is 500x(444/900444) = 246.5mV. Loading on 500V supply is 900kΩ and 0.56mA.
Range 2 (x1) is 500x4444/9004444 = 246.8mV. Loading on 500V is 9 MΩ.
Etc.

On Range 6 (x10,000) and 500V, the FS is 90GΩ through 44.444MΩ, or 5.55pA. Leakage to chassis to upset reading would be creepage on Red terminal, and leakage through 2M to V5 EF37 TC grid, and via C10 polystyrene, and two switch assemblies (Measure and internal relay), and range switch.

Performance

Heater voltage is 6.3V +/-0.05V across mains 200-240V span. Any connected external meter will load the HT rail (eg. 10M), as well as DUT. Voltage meter measurement is within parallax error across range, however negative reading error increases at lower voltage (eg. 125V at 100V reading).

- Reading at 1kV can be adjusted to exact (using external meter), along with 0V reading adjusted to exact (using Adj. to infinity), along with mechanical meter adjustment to minimise reading error.

Full-scale and mid-scale setting test resistors are located in a small plastic storage container, as detailed below. Measured using ESI 230B guarded bridge with 803A 200V generator – confident that <0.1% tolerance. Initially the 68M 5% VR68 resistors were value batched to 0.1% bins using a 24V battery (Keithley 197 voltage measurement), and resistor in series with Picotest M3510A voltage inputs (10.0MΩ input resistance), and the final test resistor made by series connection of batched parts.

Measurement at 500V test level

Fit test resistor, adjust for 500V, then adjust infinity, then select multiply by switch, then adjust (internal sensitivity trimpot) for FS, then repeat adjustments. This procedure does typically need internal trimpot adjustment for multiply by settings of 1/10 and above 10, due to loading on internal supply rail for 1/10, and leakage at high multiplier settings. After test voltage measured, then FS resistance measurement may take 2-3 lever switch activations to settle on final value to then adjust using internal sensitivity trim.

Prepared FS test resistors for 500V are 900k, 9M, 90M, 900M, 9G, 90G, with 500V rating.

1/10	900k = 390k+390k+120k using 1% resistors (800V limit)	[ESI 900.05 kΩ]
1	9M = 3M9+3M9+1M2 using 1% resistors (800V limit)	[ESI 8.9677 MΩ]
10	90M = 30M+30M+30M using parted out analog meter	[ESI 90.52 MΩ]
100	900M = 68.6Mx13 + 6M8+1M5	[ESI 900.0 MΩ]
1000	9G = (10x12 +10)x68.5M	[ESI 8.9 GΩ].
10,000	90G (no test part yet)	

Prepared mid-scale test resistors for 500V are circa 3-4M, and 10x multiples, with 500V rating.

1/10	3M6 = 1M8+1M8 using 1% MRS25 resistors (700V limit)	[ESI 3.58 MΩ]
1	34M = 68M//68M using 5% VR68 resistors selected using Aneng 8009	[ESI 33.87 MΩ]
10	343M = 5x 68M6 (part of 900M FS test resistor)	[ESI 343.3 MΩ]
100	3.4G = 4x12x68M5 (part of 9G FS test resistor).	[ESI 3.42 GΩ]
1000	34G (no test part yet)	
10,000	340G (no test part yet)	

The 900MΩ reference (13x68+3.9+3.9) was measured as:

- 896Megohm using a 99.62Vdc supply and with 900M in series with 34401A on 10V range (10.015Meg input resistance) to show 1.1016V (interconnect test leads splayed to suppress stray leakage).
- 899.4MΩ using ESI 230B and 200Vdc bipolar
- Modified to 13x68M+6M8+1M5 to measure as 900.0

The 9GΩ reference (130x68M5) was measured as:

- Initially measured using nominal 100Vdc supply and checking each 10 sections of 12 series 68M resistors (822M) and extra 505M section, and summing to 8751.4M. Also measured total directly using 34401A to 8749M – and no change when Nomex sheets added as separators between each section. Amb of 23C and nominal humidity. Then tweaked.
- 8.9GΩ using ESI 230B and 200Vdc bipolar

Measurement at 1kV test level

This doubles the displayed value, so '9' FS becomes 18.

FS		
1/10	1.8M (use half the 3M6 mid-scale resistor)	
1	18M (68//68//68//68M + 1M5//1M5)	[ESI 18.007 MΩ]
10	180M (part of 900M string = 2x 68M + 68//68M + 4M7 + 3M3)	[ESI 179.8 MΩ]
100	1.8G (part of 9G string = 26x 68M5 + 17M)	[ESI 1.798 GΩ]
1000	18G	
10,000	180G	

Applications:

- Sullivan T2100 1000V Volt Box. 28/6/2025 measured com to chassis at 500V at 36Gohm using 8.9G reference.

BPL RM 175 - LZ II Megohmeter
1956

1—DESCRIPTION

1.1 This instrument is capable of measuring, to a high degree of accuracy, the value of insulation resistances from under one megohm up to five million megohms. In operation it is exceptionally stable and its simplicity of control, together with the very thorough character of the incorporated protective devices, renders it entirely suitable for use by unskilled operators.

1.2 The circuit used combines the advantages, such as stability and accuracy, of the bridge with the direct indication of the ohmmeter; this is a feature of exceptional value, in that the effect of physical treatment of test samples (e.g., changes in ambient temperature, pressure, humidity, configuration, etc.) can be observed immediately without the readjustment delay inevitable in a simple null bridge system. In effect, the operation of this instrument is equivalent to that of a self-balancing bridge.

1.3 Two other valuable features are the complete protection of the indicator circuit—the meter will not be damaged even shou'd the test terminals be short-circuited—and the fact that the polarizing voltage is substantially independent of the resistance of the circuit or component under test.

1.4 The RM-175 Megohmmeter is made in three standard types; all have the same resistance ranges but see paragraphs 3.1 and 3.2.

1.41 The RM-175-CX is the basic model, with a test pressure of 500 volts D.C. and includes an adjustable automatic delay circuit which does not insert the indicating circuit until a pre-determined charging period has elapsed; it is, therefore, particularly suitable for measuring the insulation resistance of large capacitors.

1.42 The RM-175-LZ includes this feature, and in addition the test voltage can be continuously varied from zero up to 1000 volts D.C.; the actual voltage is directly indicated by an additional meter. The measuring range is increased to 10 x 10^{12} ohms.

1.43 Instruments with the suffix S have the low terminal connected to chassis and earth.

2—INSTALLATION

2.1 This instrument is suitable for 200 to 250 volts A.C. at 50 cycles per second; within this range no other mains adjustment is necessary. No mains fuses are provided; power consumption is of the order of 70 watts.

2.2 It is most desirable that the instrument should be earthed and a third core (not red or black) is provided in the mains lead for this purpose.

2.21 For notes on guarding see paragraph 6.

2.3 The exact valve arrangement varies with each model; the appropriate holders are clearly indicated by labels on the chassis. It is essential that the correct replacement types be used.

		RM-175-CZ	RM-175-LZ	RM175-LZ MkII
V.1	...	6X5-G	6X5-G	EZ80
V.2	...	U50	HVR2	K3-45 2.5
V.3	...	6SN7	6SN7	ECC82
V.4	...	ME 1400	ME 1400	EF37A
V.5	...	ME 1400	ME 1400	EF37A
V6			CA50	8yy3T

2.33 In all cases the ME 1400 can be used as a replacement for the EF 37, used previously.

3—RANGES

3.1 On all instruments the same six ranges are provided; selection is made by use of the " MULTIPLY BY " Switch.

Range 1 x 1/10	0.9 to 50	megohms
Range 2 x 1	9 to 500	megohms
Range 3 x 10	90 to 5000	megohms
Range 4 x 100	900 to 50000	megohms
Range 5 x 1000	9000 to 5000000	megohms
Range 6 x 10000	90000 to 5000000	megohms

3.2 Since the range is a function of the test voltage, on the RM-175-LZ model, for any voltage other than 500 a very simple correction must be applied, i.e. Reading x $\frac{\text{Test Pressure}}{500}$. For example, if the test voltage is adjusted to 1000 each of the above ranges is doubled.

3.3 On models which incorporate a charging delay circuit, four time ranges are provided, 0, 1, 3 and 10 seconds. The most suitable range varies both with the capacitance of the condenser and with its expected leakage resistance.

4—ACCURACY

4.2 On the RM-175-LZ model the voltage under test is correctly indicated within 2%, unaffected by the resistance of the circuit under test.

4.3 The time delay circuit is adjusted to within − 0, + 1 sec. of the indicated time.

5—OPERATION

5.1 If possible the instrument should be allowed to warm up for about 20 minutes before use.

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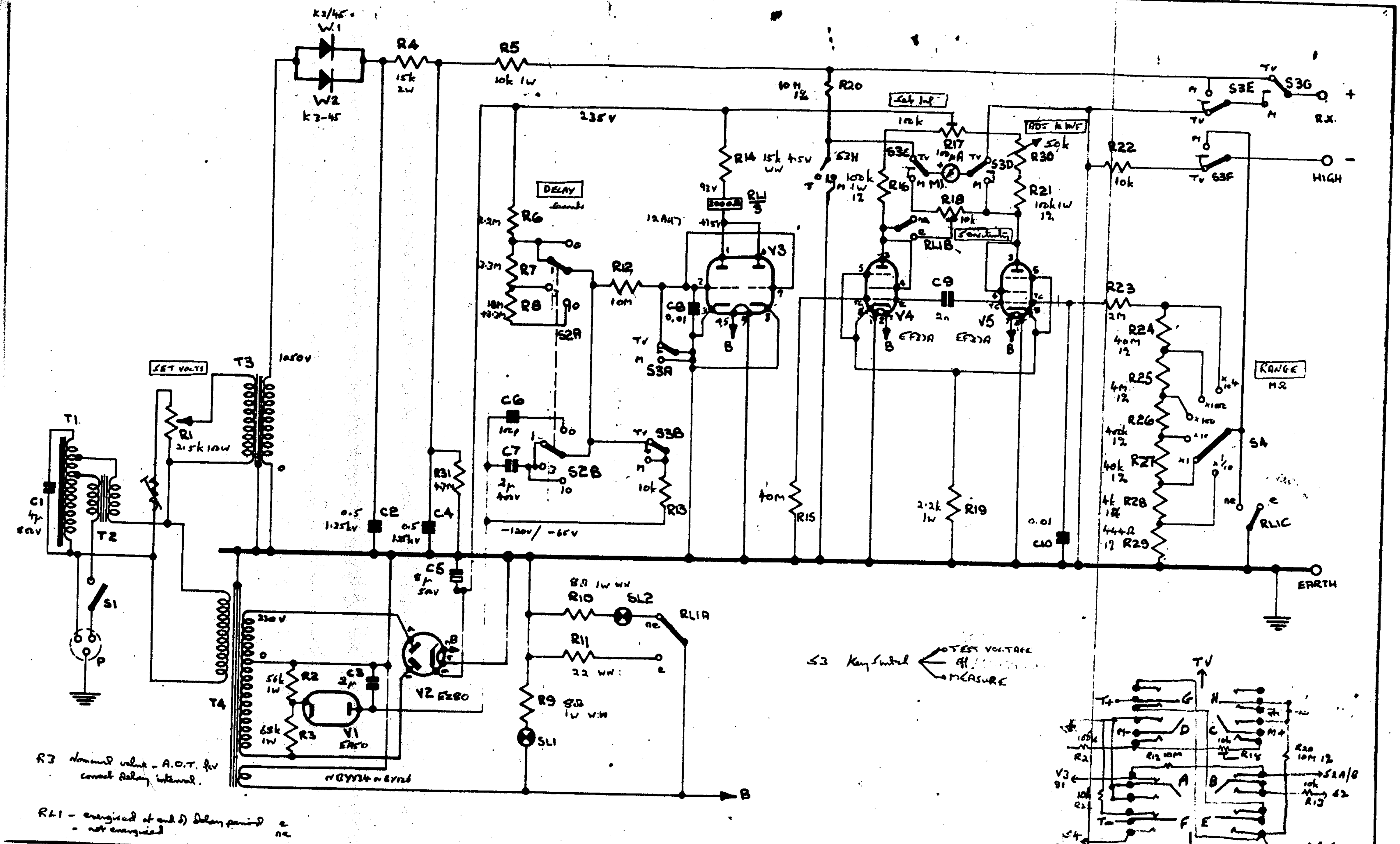
5.3 Using the ADJ. TO INFINITY control, set the MEGOHMS meter to read infinity.



ISSUE 2 TRANSFORMER WIRING CHANGED A.H. 15-5-59	DRN: TCD: CKD: DATE 16:10:56	PARTS LIST No. D 950G8.
		TITLE RM 175 - L7 MK II MEGOHMMETER
BRITISH PHYSICAL LABORATORIES, RADLETT, HERTS.	DIAGRAM No D. 143	SHEET 2

INSTRUCTION BOOK

for

MEGOHMMETER

Model RM-175-LZ

BRITISH PHYSICAL LABORATORIES

HOUSEBOAT WORKS . RADLETT . HERTS . ENGLAND

BRITISH PHYSICAL LABORATORIES
Designers and Manufacturers of Electrical Laboratory and Production Testing Equipment

INSTRUCTION BOOK
for
MEGOHMMETER
Model RM-175-LZ

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5.3 Using the ADJ. TO INFINITY control, set the MEGOHMS meter to read infinity.

5.4 With the RM-175-LZ model, adjust the TEST VOLTAGE to the desired value, using the TEST VOLTAGE CONTROL.

5.5 Set the range switch (MULTIPLY BY) to the appropriate range.

5.6 With models with a delay circuit (RM-175-CZ and RM-175-LZ), set the delay time to an appropriate value. In practice, use of this delay circuit is confined to the testing of large condensers of high leakage resistance; the selected time should be a direct function of both capacitance and expected leakage resistance.

5.7 Operate the PRESS TO READ key and the insulation resistance is indicated directly by the MEGOHMS meter; in the case of the RM-175-LZ this reading is subject to correction according to the test pressure. In such a case the reading should be multiplied by test pressure divided by 500.

5.8 The DELAY INDICATOR lamp will indicate the expiration of the delay period, and must light up after the pre-set period. During this period any capacitance across the test sample is charged directly from a low impedance source and the indicating circuit is not in operation.

6—GUARDING

6.1 When testing an insulation resistance which forms part of a multi-terminal network it is frequently desirable to make use of the principle of guarding. For example, a paper condenser in a metal case may be considered as a three terminal network in that both electrodes will have some leakage resistance to the case. If this case be connected to the GUARD terminal, even should these two leakages be comparable in value with the direct electrode to electrode leakage, their presence will in no way affect the accuracy of measurement.

6.2 Guarding has been loosely described as " insulation by conduction "; more accurately, it confines stray leakages to paths where their effect is unimportant. It is not possible to deal more fully with the subject here and reference should be made to any standard text-book dealing with high resistance measurement.

7—SERVICE

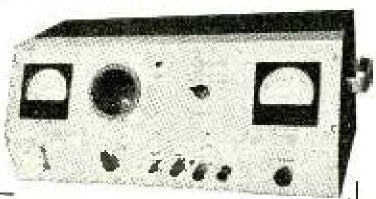
7.1 In case of any difficulty, before returning the instrument the customer should communicate with the manufacturers, who will be pleased to render every possible assistance.

7.2 Should it be necessary to change either V4 or V5, it may also be necessary to re-adjust the sensitivity of the indicator circuit. This may be conveniently done by connecting a known resistance to the test terminals, a value of the order of one or two megohms is suitable. After having carefully adjusted the MEGOHMS meter to infinity, press the key and adjust the internal SENSITIVITY control (on the chassis) until the meter reads correctly. This correction holds good for all ranges.

High Value

INSULATION RESISTANCE METER

MODEL
RM175-LZ



0.9 TO 10,000,000 MEGOHMS

Self-contained, mains operated with stabilised voltage compensation and incorporating meter overload protection in the case of sample breakdown, this resistance meter is designed for intensive use in testing high values of insulation. Test pressure variable from 0-1,000 V.D.C.

Write for full specification.

0-1,000 V.D.C.

SELF-CONTAINED STABILISED OVERLOAD PROTECTION

See our exhibits. Stand No. 1A British Instrument Industries Exhibition, Olympia, London

BRITISH PHYSICAL LABORATORIES LTD

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