Q Meter T2

Instruction Manual

ADVANCE

Q Meter T2

Instruction Manual

ADVANCE ELECTRONICS LIMITED
INSTRUMENT DIVISION
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TELEPHONE 01-500 1000 TELEGRAMS ATTENUATE, ILFORD

Manual Part No. 11305 LP 9/66/100 Printed in England

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Introduction — *Section 1*

The Advance Q Meter T2 is operated from ac supplies and provides a convenient method of measuring and comparing circuit magnification (Q), inductance, capacitance and power factor at frequencies between 100 kHz and 100 MHz. The comparison measurement facility enables the instrument to be used for small batch testing by unskilled personnel. The T2E is similar to the T2 but operates from a different range of supply voltages as indicated in Section 2.

The test terminals for connecting external inductance and capacitance protrude from four polythene insulating washers at the top of the case. Each terminal is rhodium plated to ensure a good electrical connection and to minimise wear.

The signal from the internal oscillator is injected into an inductive loop and the voltage across the loop is metered, and can be adjusted to a set level. A part of the loop consists of a bar from earth to one of the test terminals, and thus provides a signal path of very low impedance to the test circuit. The coil under test is in series resonance with an internal low-loss variable capacitor, and the voltage across the capacitor is detected by a valve voltmeter calibrated directly in terms of circuit magnification. The oscillator is modulated 50% at the supply frequency, so that dc amplifiers need not be used in the valve-voltmeter and this eliminates the need for zero setting. An unknown capacitor may be connected in parallel with the standard capacitor, and its capacitance and power factor obtained by substitution.

The meter amplifier has a calibrated gain control and this forms the basis of the method used to compare values of Q. When this control is set at zero the amplifier gain is 100% of normal and may be varied ±10% about the normal value. The instrument is set up using a standard coil with the incremental capacitor and %Q dials at zero, and a convenient reading established by means of the SET level control. The unknown coil is substituted for the standard, and with all other controls unaltered, the incremental capacitor and %Q dials are adjusted so that the same reading is obtained at resonance.

The reading of the incremental capacitor is a measure of the difference in inductance, and the reading of the %Q dial indicates directly the difference in Q between the test coil and standard. In order to simplify calculations of inductance and reactance the variable capacitor is calibrated in three scales. The first scale is calibrated in pF; the second scale is calibrated to read Zf so that the reactance in ohms may be obtained, by dividing the reading by the frequency in MHz. The third scale is calibrated to read Lf^2 so that inductance (μH) may be calculated by dividing the reading by the square of the frequency in MHz.

Specification

Oscillator Frequency Ranges

100 kHz to 300 kHz
300 kHz to 1,000 kHz
1 MHz to 3 MHz
3 MHz to 10 MHz
10 MHz to 30 MHz
30 MHz to 100 MHz
Frequency accuracy ±1%

Tuning Capacitor

Capacitance calibration 40—550pF±2%
Zf calibration 4,000—300 (Ω, MHz) ±2%
Lf^2 calibration 600—50 (μH, MHz^2) ±2%

Trimming Capacitor

Calibration ±2·5pF

Accuracy of Inductance Measurement

±5% plus residual inductance of 0·05μH when using Stand-Off Platform, part no. 11405.

Residual Inductance

0·03μH approximately

Q Reading Ranges

10—100
40—400
Accuracy ±(5%+5% f.s.d.) up to 50 MHz.

Detector Load

30M Ω

%Q Dial

Range ±10% (with respect to nominal Q reading)
Accuracy ±1% (i.e., ±1 division) up to 50 MHz.

External Meter

Up to 100μA f.s.d. } Padded up to
Resistance up to 1k Ω } 100μA 1k Ω

Power Supply

T2: 110-120V, 200-210V, 220-230V, 240-250V, 40-60 Hz.
T2E: 110-125V, 130-140V, 160V, 220V, 40-60 Hz.

Consumption

20W

Specification

Section 2

Accessories Supplied

One plug for external meter jack
One Q Meter Stand-off Platform, part no. 11405

Dimensions

Height $10\frac{1}{4}$ in (26 cm), Width $15\frac{1}{2}$ in (39·4 cm), Depth $6\frac{1}{2}$ in (16·5 cm)

Weight

14 lb (6·4 kg)

Finish

Dark blue metal case with leather carrying handle and light grey front panel.

3.1 SUPPLY VOLTAGE

The instrument should first be set for the correct supply voltage. The small plate above SUPPLY SELECTOR should be removed and the voltage tap set to the nominal voltage of the local supply. The power supply lead is a three-core cable and, for the instrument to work correctly, it is essential that the earth lead is properly connected. If the instrument is to be connected to a 2-pin socket alternative means of earthing must be provided.

3.2 MEASUREMENT FREQUENCY

Measurements may be made at any frequency between 100 kHz and 100 MHz using the internal oscillator. The frequency of measurement may be selected to an accuracy of ±1% by use of the 6-position band selector switch, and the calibrated frequency dial. Continuous adjustment of the dial is by the outer knob set vertically beneath the dial window. Movement of the inner knob clockwise locks the dial in any desired position.

The 6 bands are:

100— 300kHz	3— 10MHz
100—1,000kHz	10— 30MHz
1— 3MHz	30—100MHz

3.3 INTERNAL CAPACITORS

There are two internal calibrated capacitors, the main capacitor and the trimmer. The main capacitor is calibrated from 40-550pF and the same scale is also calibrated in a reactance factor Zf and in an inductance Lf^2 (where Z is reactance in ohms, L is inductance in µH and f is frequency in MHz). The use of these scales is explained in the paragraph on measurements of inductance (para. 3.7).

The capacitor dial is driven by a slow-motion control which is the outer knob situated vertically beneath the dial window, and symmetrically with the frequency slow-motion control. Movement of the inner knob clockwise locks the capacitor dial at any desired point on the scale.

The trimmer capacitor is driven by a control that is immediately below the main capacitor scale. This control is calibrated over a range of ±2·5pF at intervals of 0·5 pF.

3.4 MEASUREMENT OF Q

Values of Q may be read directly off the meter after the correct setting-up procedure has been carried out:

(1) Connect the test coil across the INDUCTANCE test terminals.

(2) Set the internal oscillator to the desired frequency and the △Q% and △C dials to zero.

(3) Move the Q RANGE switch to SET. Adjust the internal oscillator across the test circuit to a predetermined level by means of the SET level control and the red line on the meter.

(4) Select the 40-400 range using the Q RANGE switch.

(5) With the main CAPACITANCE control (range 40-550pF) obtain a maximum reading on the meter. The test coil is now at resonance and values of Q may be read directly from the meter. For indicated values of Q less than 100, move the Q RANGE switch to the 10-100 position.

If a true maximum reading cannot be obtained in this way tune for resonance using the FREQUENCY control. When the frequency of measurement is altered the procedure of sub-para (3) must be repeated, in order to check that the oscillator signal level across the test circuit has not changed.

It is permissible to adjust the signal level during tuning to obtain the maximum indication at a convenient meter reading. Recheck the signal level across the test circuit (para 3.4 (3)) before reading off values of Q.

Note The self-capacitance of a coil can affect the accuracy of the indicated Q, especially if the self-capacitance is a large fraction of the capacitance required for tuning to resonance. This will be most apparent with coils of large inductance measured at high frequency. The true Q value of a coil (Q_t) is given by

$$Q_t = Q_i \left(1 + \frac{C_s}{C} \right)$$

where Q_t = true value of Q
Q_i = indicated value of Q
C = capacity required to tune the coil for resonance
C_s = self-capacity of the coil (see para 3.9)

An additional source of error in the Q reading is obtained at low frequencies where the dynamic impedance of the tuned circuit $\left(\frac{L}{Cr} \Omega \right)$ is significant compared to the input impedance of the valve voltmeter contained in the instrument.

If Q_t is the true Q
Q_r is the Q reading
and Z is the input impedance

$$\text{Then } Q_t = \frac{Q_r Z}{Z - Q_r wL}$$

For the T2, $Z = 6M\,\Omega$

3.5 Q METER STAND-OFF PLATFORM (Part No. 11405)

Use this platform when measuring the Q of coils above 1mH. It may be left in position when measuring low inductances and capacitances but will add 0·05μH and 3pF to the respective readings.

The platform is supplied dismantled in a flat box. The pillars must be aligned with the instrument terminals when assembling.

3.6 Q MEASUREMENTS OF SMALL CAPACITORS

The Q values of small capacitors are generally too large to be read with any degree of accuracy. Approximations may be made by resonating a coil on the Q meter, and then noting the reduction in Q obtained when the capacitor is added.

When the added capacitance is large in proportion to the Q meter minimum capacitance (40pF), the following formula will give the Q of the capacitor.

$$Q_c = \frac{Q_1 Q_2}{Q_1 - Q_2}$$

Q_1 is the Q of the coil.
Q_2 is the Q of the coil plus added capacitance.

When the added capacitance is small in proportion to the Q meter minimum capacitance of 40pF, the above expression must be modified to allow for the sharing of the oscillatory current between the test capacitance and the Q meter capacitance. The general formula is:

$$\frac{1}{Q_1} + \frac{1}{KQ_c} = \frac{1}{Q_2}$$

where K is the ratio of total capacity to the capacity of the test capacitor. If the Q meter capacitor is adjusted to the value of the test capacitor, i.e. $K=2$ then the formula simplifies to,

$$Q_c = \frac{Q_1 \; Q_2}{2(Q_1 - Q_2)}$$

3.7 MEASUREMENT OF INDUCTANCE AND REACTANCE

(1) Connect the component to be measured across the INDUCTANCE terminals.

(2) With the Q RANGE switch in the SET position, adjust the signal level across the inductor under test by means of the SET level control and the red line on the meter.

Note Reset Q Range switch to 10-100 or 40-400 position.

(3) Adjust the main CAPACITANCE and FREQUENCY controls for a maximum reading on the meter.

Note The signal level may be adjusted to obtain a convenient meter reading while tuning for resonance. If Q readings are also required, the signal level must also be readjusted as outlined in para 3.7 (2).

(4) The value of inductance (in µH) is found by reading off the Lf^2 scale and by dividing this reading by the square of the test frequency in

MHz. Thus, with a frequency of 2·8 MHz and with a Lf^2 scale reading of 245, the inductance is given by

$$\frac{245}{(2\cdot8)^2}\ \mu H \quad \textit{i.e.}\ 31.3\mu H$$

(5) The reactance of the component (in ohms) is obtained by reading off the Zf scale and by dividing this reading by the test frequency in MHz. Thus, with a frequency of 1·8 MHz and a Zf scale reading of 570, the reactance equals

$$\frac{570}{1\cdot8} \quad \textit{i.e.}\ 317\,\Omega$$

Certain "errors" can be introduced into the calculations of inductance and reactance by the self-capacitance of an inductor. The true or "pure" inductance (L_t) of a coil having a self-capacity C_s is given by the equation

$$L_t = \frac{1}{4\pi^2 f^2 (C+C_s)}$$

Hence, for the true value of inductance of a coil, the value of self-capacitance must be added to the capacitance scale reading as indicated in the expression for L_t above. For determination of a coil's self-capacitance see para 3.9.

3.8 MEASUREMENT OF CAPACITANCE AND POWER FACTOR

Though the Q meter operates most simply as an inductance measuring device, any capacitor of 460pF or less capacitance can be measured by substitution methods as follows:

(1) Connect a suitable inductance across the INDUCTANCE terminals. It is not necessary to know the value of this inductance, though it is desirable to use a high Q component.

(2) First resonate the test circuit with a low value of internal capacitance (40 or 50pF) which is in parallel with the unknown capacitor across the CAPACITANCE terminals. Note the value of the internal capacitance (C_1).

(3) Remove the unknown capacitor and resonate the test circuit again using only the internal variable capacitor with the frequency unchanged. Note the reading of this capacitor (C_2).

(4) The value of the unknown capacitance is equal to (C_2 —C_1)pF.

(5) If Q_1, C_1 and Q_2, C_2 are respectively the readings obtained with and without the unknown capacitor, then the power factor of the latter is

$$\frac{Q_2 - Q_1}{Q_2\,Q_1} \times \frac{C_1}{C_1 - C_2}$$

Note Other methods of measuring capacitance involve change of frequency, but in these cases the self-capacitance of the inductance must be taken into account.

3.9 SELF-CAPACITANCE OF A COIL

Using the readings taken on the T2, the self-capacitance of a coil can be calculated from the equation.

$$C_s = \frac{C_2 - C_1 K^2}{K^2 - 1}$$

where C_1 is the capacity required to resonate the coil at a frequency f_1, C_2 is the capacity required to resonate the coil at a frequency f_2 and $K = \frac{f_1}{f_2}$

If the frequency f_2 is selected so that $f_2 = \frac{f_1}{2}$, the above equation is simplified as follows,

$$C_s = \frac{C_2 - 4C_1}{3}$$

The value for C_s may be used to obtain more accurate values of Q, inductance and reactance of a coil as described in para 3.4 and 3.7.

3.10 COMPARISON OF INDUCTANCE AND Q

(1) Connect a standard coil of the required value across the INDUCTANCE terminals.

(2) Set the △Q% and △C dials to zero.

(3) Obtain a condition of resonance by adjustment of the main CAPACITANCE and FREQUENCY controls.

(4) With the Q RANGE switch in the appropriate position (10-100 or 40-400) and using only the SET control, adjust the meter reading to a convenient value. Note this reading.

(5) Check that resonance still occurs with the trimmer capacitor at zero.

(6) Replace the standard coil by the test coil and adjust the trimmer capacitor (△C) for resonance. The reading of the trimmer capacitor is a measure of the change in inductance.

(7) Reset the meter with the △%Q control to the meter reading previously noted in sub-para (4). The reading of this control indicates directly the percentage variation between the values of Q for the test coil and standard coil.

It is visualised that in practice the above facility will be used for batch testing by unskilled personnel, and that rejection figures for C and Q will be calculated by the designer and given to the operator.

4.1 GENERAL

The circuit diagram for the T2 is given at the rear of the Manual. This instrument consists basically of a variable frequency oscillator, test circuit, detectors and a valve voltmeter circuit.

The oscillator supplies a modulated r.f. signal to the test circuit which consists of an internal variable capacitor and the component under test. The test circuit is tuned for resonance. The signal across the variable capacitor is detected and presented by the voltmeter as a direct reading of Q. By modulating the oscillator at the supply frequency, dc amplification of the detected signal is replaced by ac amplification, and the need for repeated zero adjustments is avoided.

4.2 POWER SUPPLY

The supply voltage is connected to T1 via the voltage selector switch and the ON/OFF switch S1. A neon pilot lamp N1 is connected across the 110V primary winding of T1 to indicate when the instrument is switched on.

Transformer T1 supplies 115V ac to the half-wave rectifying circuit consisting of W1 and reservoir capacitor C20. Resistor R1 serves as a simple current limiting device. Valve heater supplies are provided by the two low voltage secondary windings, with a simple low-pass filter L8, C19 in series with the heater of V1 to exclude superimposed r.f. signals. The heater winding for V3 has a balanced earth connection via VR24 which is set at the factory to give the minimum hum level in the voltmeter circuit.

The capacitive input smoothing circuit consists of C21, R12, C22 and provides dc at a level of 105V to the valve voltmeter.

A second dc supply is derived from the 70V tap on the main secondary winding of T1 and, after smoothing by C1, L7, C2, provides the anode voltage for the oscillator valve V1. R4 is an anode stopper to eliminate spurious oscillations. VR2 (SET level) provides means of adjusting the voltage to V1 anode and hence the signal level to the test circuit.

4.3 R.F. OSCILLATOR

The oscillator is a modified Hartley with six ranges having a common tuning capacitor C4 and trimmer C5. R5, C3 provide automatic bias for the oscillator grid circuit. Individual alignment on each range is obtained by adjusting the variable cores of each coil and the appropriate wire trimmer (C6 to C11). A small section of each coil is used for coupling the oscillator output to the test circuit. Resistor R6 limits the signal level that is coupled to the test circuit on the high frequency range; R7 and R27 are amplitude limiters on the two lowest ranges.

4.4 MEASURING CIRCUIT

The r.f. oscillator output is connected to the loop L9 and, via the bar forming part of the loop, is injected into the test circuit C16 (CAPACITANCE), C17(△C), CX, LX. Thus the signal is injected into the test circuit from a very low impedance source which will have no significant effect on the Q of this circuit and hence on the accuracy of the measured Q of the component.

The r.f. signal level into the test circuit is monitored when switch S2 is in the mid-position (SET) and can be adjusted by the SET level control (VR2). In this way the meter is calibrated to read values of Q direct. The monitoring circuit consists of the detector V2A, fed by C13. The 50Hz detected signal passes via the r.f. filter R8, C12 to the preset potentiometer VR13 and then via S2 to the voltmeter circuit. VR13 provides a means of recalibrating the instrument if a coil of known Q is available (see para 5.4) by causing the meter needle and red line to coincide, with the T2 previously set to the known indicated value of Q.

4.5 VALVE VOLTMETER

The valve voltmeter is a two-stage conventional R/C coupled amplifier, followed by a semiconductor detector circuit and 100μA meter, with provision for connecting an additional external meter of 100μA f.s.d. Potentiometer VR21 is preset and modifies the Q scale associated with VR22. Adjustment of VR23 modifies the negative feedback between cathode and grid of V3B in order to allow for differences in characteristics between individual valves of the ECC81 type. VR22 (△Q) adjusts the level of amplified signal to the detector circuit.

The higher Q range is selected by switching the ÷ 4 attenuator R14, R15, R16 into circuit using S2A.

5.1 TERMINAL INSULATION

In order to obtain accurate Q readings care must be taken to prevent the insulation of the terminals deteriorating, due to dust, etc. It is therefore necessary to clean the polythene terminal insulators occasionally. These insulators can easily be reached by removal of the chromium-plated terminal plate. The insulators may then be wiped clean with a soft cloth.

5.2 REMOVING THE INSTRUMENT CASE

First remove the terminal screws. Next remove the terminal plate and insulators which are held by two mushroom-headed screws. Finally remove the twelve screws round the edge of the front panel, allowing the instrument to be lifted from its case.

5.3 VALVE REPLACEMENT

The 6AL5 double diode detector is mounted on the oscillator box. The 12AT7 belonging to the meter amplifier is mounted on the printed circuit board. The ECC91 oscillator valve is mounted inside the screened oscillator box which may be removed after unscrewing the P.K. screws. This valve may be renewed with little effect on frequency, and the inductor cores and capacitor trimmers should not normally be disturbed if the frequency calibration is to be maintained.

In all cases of difficulty the instrument should be returned to the factory for service as directed in Section 7.

5.4 INSTRUMENT CALIBRATION CHECK

A calibration check on the T2 may be carried out if a coil of known Q is available (Q_i of para 3.4).

(1) Connect the coil across the INDUCTANCE terminals.

(2) Set the frequency scale to correspond to the previous test frequency of the coil.

(3) Set the Q RANGE switch to either the 10-100 or 40-400 position.

(4) By means of the SET level control adjust the meter reading to the known Q of the coil.

(5) With the Q RANGE switch in the SET position, check that the meter needle and red regerence line coincide.

(6) If the conditions of sub-para. (5) are not satisfied, remove the instrument from its case (para 5.2), and alter the meter needle to the desired position by adjustment of the present potentiometer VR13. To gain access to VR13, remove the small plate at the rear of the instrument case.

Components List and Circuit Diagram — Section 6

RESISTORS (10% ¼W unless specified)

Ref.	Value	Description	Part No.
R1	1K		1175
VR2	50K	3W Wirewound Pot.	10024
R3	15K	10% ½W	6381
R4	22		4419
R5	3·3K	10% Dubilier B.T.T.	7116
R6	22		4419
R7	820	10% Dubilier B.T.T.	10620
R8	47K		2933
R9	22		4419
R10	10M		1179
R11	15M	10% RRC type S	3994
R12	6·8K	10% ½W	10355
VR13	250K	Preset. Plessey	11078
R14	1·5M		7016
R15	4·5M	2% High Stability	10029
R16	1·5M	2% High Stability	10030
R17	2·7K		10990
R18	68K		7296
R19	3·9K	Dubilier B.T.T.	10737
R20	1·5M	Dubilier B.T.T.	10629
VR21	1K	Preset Egen. 195	915
VR22	1K	Colvern Pot.	1464
VR23	2K	Preset Egen. 195	915
VR24	100	Preset Egen. 196	1465
R25	1K		1175
R26	3·9K	10% Dubilier B.T.T.	10737
R27	1·5K	10% Dubilier B.T.T.	10622
R28	15M	10% RRC type S	3994

CAPACITORS

Ref.	Value	Description	Part No.
C1	0·005μ	400V Min. Paper Tubular	8780
C2	0·005μ	400V Min. Paper Tubular	8780
C3	560p	20% Erie Ceramicon	329
C4	13-528p	Variable Air Cap	7368
C5		Wire Trimmer	7810
C6		Not used	
C7		Wire Trimmer	7810
C8		Wire Trimmer	7810
C9		Wire Trimmer	7810
C10		Wire Trimmer	7810
C11		Wire Trimmer	7810
C12	0·005μ	400V Min. Paper Tubular	8780
C13	4700p	+80%-20% Erie K350081/811	3995
C14	2200p	20% 150V Ceramicon	331
C15	0·04μ	150V Min. Paper Tubular	7485
C16	13-528p	Variable Air Cap	7368
C17	3·5-25p	Variable Air Cap	5998
C18	100p	Silvered Mica	2758
C19	0·005μ	400V Min. Paper Tubular	8780
C20	16μ	150V Hunts JF154	10598
C21	32+32μ	150V Hunts JF275T	10108
C22	32+32μ	150V Hunts JE275T	10108
C23	0·005μ	400V Min. Paper Tubular	8780
C24	0·04μ	150V Min. Paper Tubular	7485
C25	1·0μ	150V Hunts	326
C26	100μ	6V Electrolytic Hunts	10028
C27	200μ	6V Plessey	12972
C28	200μ	6V Plessey	12972

MISCELLANEOUS

Ref.	Description	Part No.
L1	Oscillator Coil and C.P.L.G.	7421
	30-100 MHz core	7423
L2	Oscillator Coil and C.P.L.G. 10-30 MHz	RF589
L3	Oscillator Coil and C.P.L.G. 3-10 MHz	RF536
L4	Oscillator Coil and C.P.L.G. 1-3 MHz	RF537
L5	Oscillator Coil and C.P.L.G. 300-1,000 kHz	RF593
L6	Oscillator Coil and C.P.L.G. 100-300 Hz	RF592A
L7	Oscillator H.T. Choke	C16
L8	Oscillator L.T. Choke	C95
L9	Inductive Loop to Test Circuit	
V1	ECC 91 (6J6)	7034
V2	EB 91 (6AL5)	5970
V3	ECC 81 (12AT7)	7106
W1	Selenium Rectifier 125V ac 30mA	7084
W2	Germanium Crystal Bath Type CG.46/H	5871
W3	Germanium Crystal Bath Type CG.46/H	5871
S1	Power Supply Switch	332
S2	Q-Range Switch	10376
S3	Oscillator Frequency Range Switch	7381
P1	Plug for External Meter	10806
M1	0-100μA Meter	10761
N1	Neon Indicator Lamp	1165
T1	Supply Transformer	MT341/A
J1	External Meter Jack	10805

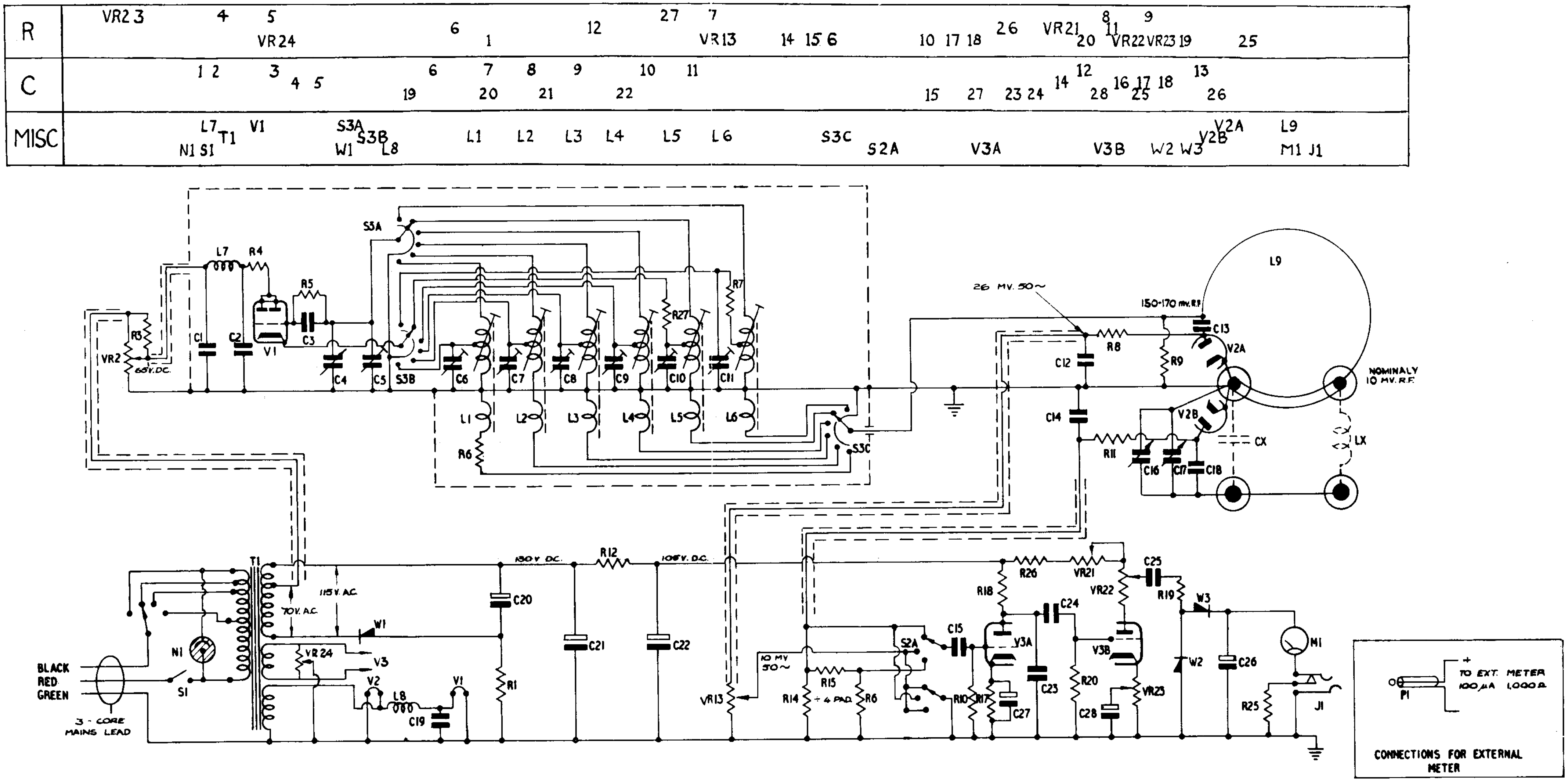

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Fig. 1 Circuit Diagram

Note: N1 should be shown connected across the 110V winding of T1.
C6 is no longer fitted.

The right is reserved to amend values or alter the circuit without notice

Guarantee and Service Facilities *Section 7*

This instrument is guaranteed for a period of one year from its delivery to the purchaser, covering the replacement of defective parts other than valves, semiconductors and fuses. Valves and semiconductors are subject to the manufacturers' guarantee.

We maintain comprehensive after sales facilities and the instrument can, if necessary, be returned to our factory for servicing. The Type and Serial Number of the instrument should always be quoted, together with full details of any fault and the service required. The Service Department can also provide maintenance and repair information by telephone or letter.

Equipment returned to us for servicing must be adequately packed, preferably in the special box supplied, and shipped with transportation charges prepaid. We can accept no responsibility for instruments arriving damaged. Should the cause of failure during the guarantee period be due to misuse or abuse of the instrument, or if the guarantee has expired, the repair will be put in hand without delay and charged unless other instructions are received.

OUR SALES, SERVICE AND ENGINEERING DEPARTMENTS ARE READY TO ASSIST YOU AT ALL TIMES.

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