

SERVICE MANUAL

DM 235 DIGITAL MULTIMETER

sinclair

GENERAL

The instrument has been designed to require the minimum amount of service attention. Service work or recalibration should only be carried out by skilled engineers.

Please note the following points before commencing work.

The tracks on the printed circuit board are very fine and may lift if subjected to excess heat. Use only miniature temperature-controlled soldering irons and remove all solder (on both sides of a joint) with solder wick or suction before attempting to remove a component.

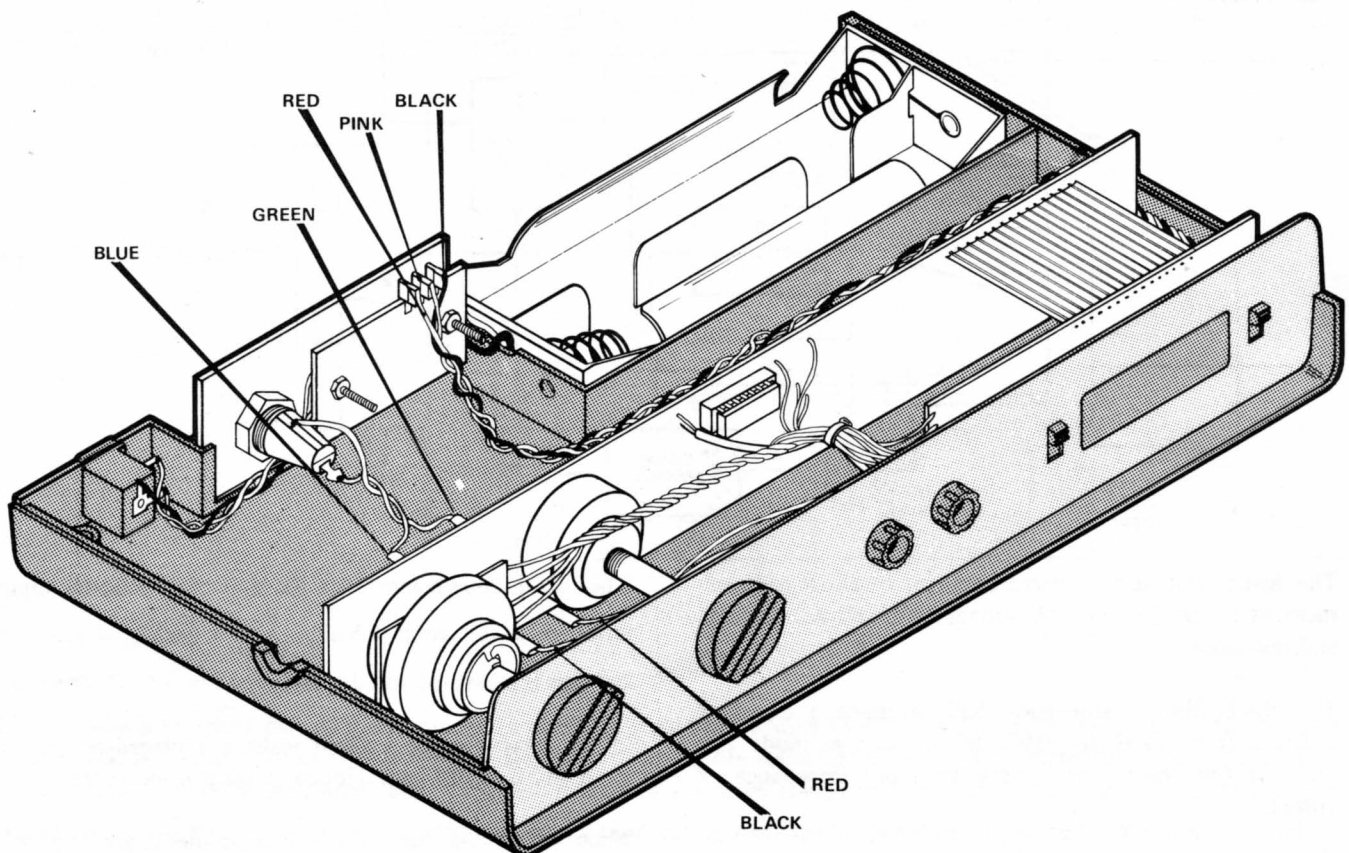
The integrated circuits IC2, IC3 and IC4 are M.O.S. devices and care should be taken when handling them to avoid damage by static discharge.

The very high input impedance of the instrument can give rise to offset voltages caused by minute leakage currents. The P.C.B. must be kept clean and dry to avoid this. A basic input leakage of up to 1nA (causing a $\pm 10\text{mV}$ offset on 2V DC when open circuit) is allowed for, in the specification.

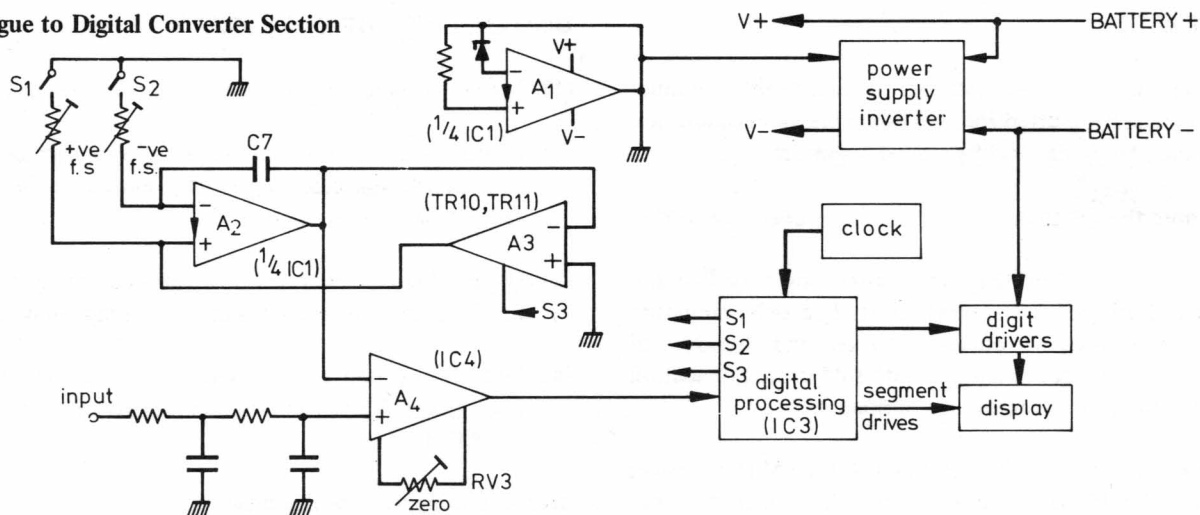
DISMANTLING THE INSTRUMENT

- (1) Invert the meter and remove the four rubber feet.
- (2) Remove the six recessed screws and one surface screw and lift off the case lower. This allows access to the calibration potentiometers.
- (3) Unplug the colour-coded connection leads to the main P.C.B., and lift board assembly out of case upper.
- (4) Pull off the two rotary switch knobs and remove the front panel. This gives complete access to both sides of the P.C.B.

To re-assemble, reverse this procedure.



Analogue to Digital Converter Section



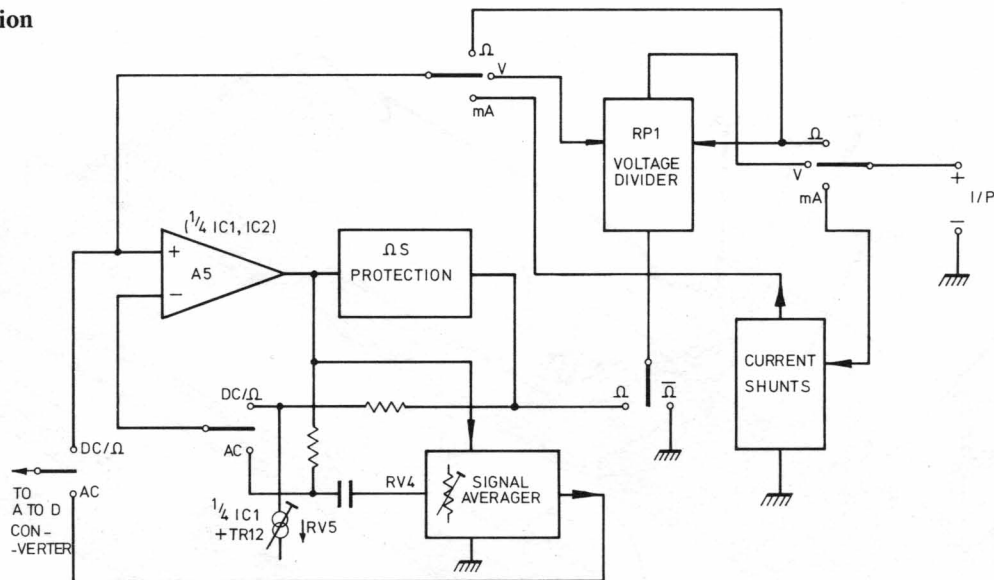
The basis of the instrument is a single ramp auto-polarity A to D converter of basic sensitivity 2 Volts. Operation is as follows:

The voltage to be measured is filtered by RC networks to remove any AC components and applied to the input of the high impedance comparator A4. During period T1 the output of the integrator A2 is held at earth by A3 and the state of A4 output is interrogated by the digital processor IC3. At the start of period T2, A3 is gated off by S3 going low,

and either S1 or S2 is closed, depending upon the polarity of the input. The output of the integrator A2 rises or falls until it reaches the input voltage upon which A4 output changes state causing S1 and S2 to open. During the following period T3, A2 output remains constant.

During period T2 a count is accumulated in IC3 from the clock input, which is decoded and transferred to the display. This count is directly proportional to the input voltage.

Multimeter Section



The instrument also contains circuitry to allow measurement of higher DC and AC voltages, DC and AC currents and resistance.

The thick film resistor pack RP1 contains a chain of resistors from 1KΩ to 9MΩ. In the voltage mode this provides four ranges each with an input impedance of 10MΩ.

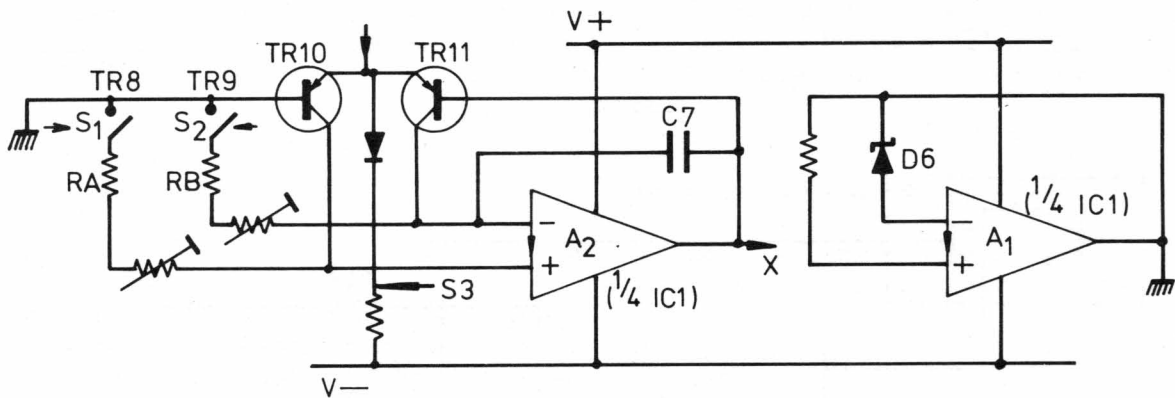
When in the resistance mode, op-amp A5 feeds a current into the input terminal equal to $\frac{1 \text{ Volt}}{R_{\text{ref}}}$ where R ref is the total resistance of the pack as selected by the range switch.

When an unknown resistance R_x is placed across the input terminals a voltage of $1 \text{ Volt} \times \frac{R_x}{R_{\text{ref}}}$ is generated across it, and this is measured and displayed by the A to D converter.

In the current mode a shunt resistor is placed across the input and the voltage developed across it is measured.

When AC voltage or current measurements are required, op-amp A5 is switched to form a mean averaging AC to DC converter, the output of which is fed into the A to D converter.

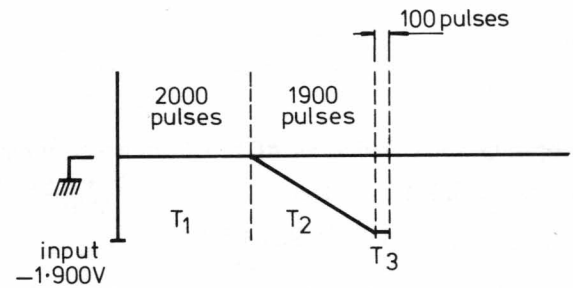
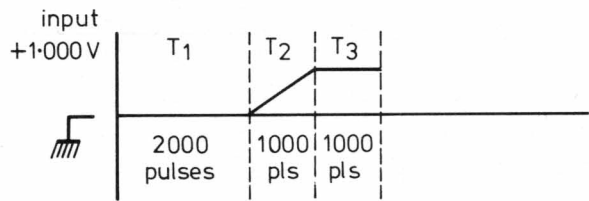
CIRCUIT DESCRIPTIONS



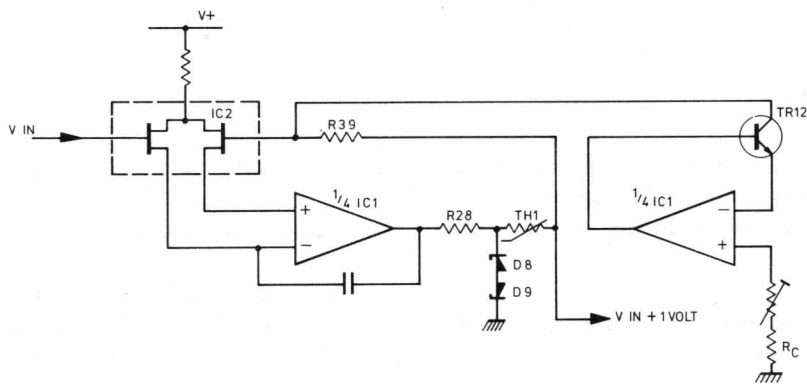
The norton type op-amps in the LM3900 (IC1) have inputs held at one V_{BE} above $V-$. Op-amp A1 provides a precise stable reference voltage between earth and the LM3900 inputs, the resistor chains RA and RB therefore provide precision currents into A2 to produce a positive or negative ramp on the output.

Transistors TR10 and TR11 form a comparator (A3) which forces A2 output to earth when S3 is high.

Full scale calibration of the instrument is adjusted by altering the values of RA and RB. Zeroing is accomplished by varying the voltage offset control (RV3) on the comparator A4.



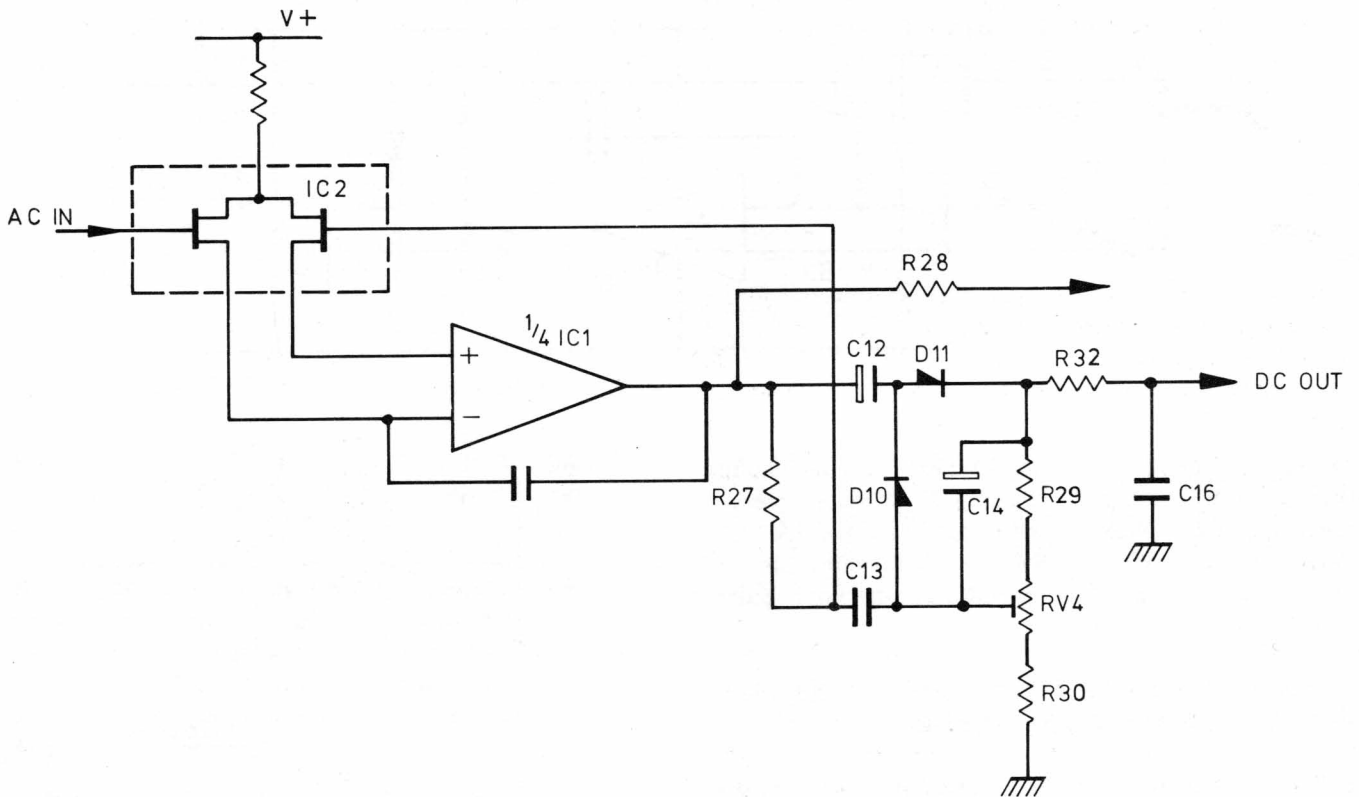
Ω S Current Source Circuit



IC2 provides a matched pair of p channel FETs which, in combination with a section of IC1, form the high input impedance op-amp A5. A precise current is generated by R_c and fed out of the collector of TR12. This current is drawn through R39 across which one volt is generated. This forces the output of A5 to be always one volt higher than the input, and causes a current of $\frac{1 \text{ Volt}}{R_{ref}}$ to flow through the unknown resistor generating a voltage V_{in} which is measured by the A to D converter.

Ω s calibration is accomplished by adjustment of R_c . Thermistor TH1 in conjunction with zeners D8 and D9 provide protection of the resistance functions against voltage overload.

AC to DC Converter



When op-amp A5 is used as an AC to DC converter, the signal is split into positive and negative components and the negative portion is amplified by a factor given by $\frac{R29 + R30}{R30}$ (ignoring RV4). The DC level at the junction of D11 and R29 is therefore given by $\frac{V_{in\ pk}}{\pi} \times \frac{R29 + R30}{R30} - 1$ and this is equal to $\frac{V_{in\ pk}}{\pi} \frac{R30}{R29}$ for a sine wave. C14 bootstraps the divider so that the output is a replica of the input but with DC level as given above. The circuit responds to the mean value of an AC signal but is calibrated to give the r.m.s. value of a sine wave. The AC component of the output is filtered by R32 and C16 in addition to C9, C10, R21 and R25, at the input of the A to D converter.

PROTECTION CIRCUITRY

Voltage ranges have inherent protection whereby up to 250V r.m.s. can be applied to the 2V range and up to 1000V DC or 750V r.m.s. can be applied on the higher voltage ranges.

Current ranges are protected by the two zeners D12 and D13 and the fuse FS1. The zener diodes limit the maximum voltage that can be developed across a shunt resistor to about 4 volts and if the current exceeds 1 amp, the fuse will blow. It is essential that only fast blow fuses are used for replacement. If high voltages (such as AC line) are applied

to the current ranges, the zeners D12 and D13 may be destroyed and must be replaced before the current ranges will operate correctly again.

On Resistance ranges inherent protection exists up to 250V r.m.s. on the 200K Ω , 2000K Ω and 20M Ω ranges. On the 20K Ω range thermistor TH1 limits the maximum dissipation in RP1 to a tolerable level, whilst on the 2K Ω range TH1 in conjunction with zeners D14 and D15 provide protection.

Clock Circuit

This is a conventional astable multivibrator running at approx. 10KHz. This provides a reading rate of $2\frac{1}{2}$ per second.

Display

The display is a common cathode 7 segment light emitting diode array with equivalent segments of each of the 4 digits connected together. Each digit is addressed in turn, synchronised with the provision of the appropriate segment drives.

The display is driven by current taken directly from the battery. Segment drivers are contained within IC3, whilst digit drivers are external. The decimal point is selected by S2D.

Power Supply Inverter

TR3 is used to provide a stabilised rail of about -13.0 volts with respect to $V+$ and is defined by D5 whilst $V-$ is defined at approximately $-6.5V$ by D6 with respect to earth.

Typical Circuit Voltages (Supply Voltage 4V-7V)

No input DC mA function selected
(Relative to earth point unless otherwise stated)

$$V+ \approx +6.5V$$

$$V- \approx -6.5V$$

$$\text{Pins 1, 2, 3, 6, 8, 11, 12 IC1} \approx +0.55V \text{ above } V-$$

$$\text{pin 9 IC1} \quad 0.0V$$

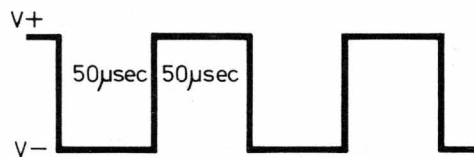
$$\text{pin 10 IC1} \quad +1.0V$$

$$\text{pin 4 IC1} \approx +1.0V \text{ above } V-$$

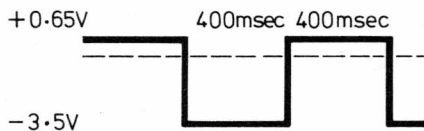
$$\text{pins 3, 6 IC2} \quad 0.0V$$

$$\text{pins 2, 14 IC2} \approx +2.0V$$

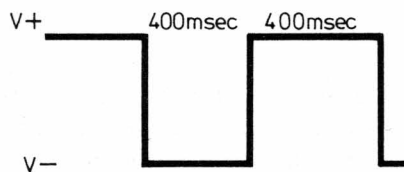
$$\text{pin 3 IC4} \quad 0.0V$$



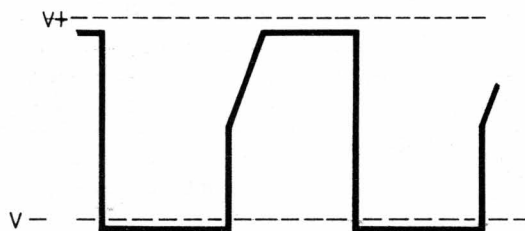
10kHz CLOCK WAVEFORM
PIN 14 IC3



EMITTERS TR10 AND TR11



PIN 6 IC4
SET FOR VERY SMALL +Ve
READING e.g. 002



EMITTER TR3
FREQUENCY 100 kHz - 150 kHz

Factors Affecting Basic Calibration

The A to D Conversion process can be described by the following equation:

$$\text{for -ve inputs } n = \frac{f_c C_7 R_B}{V_{ref}} \times V_{in} = K_1 V_{in}$$

$$\text{for +ve inputs } n = \frac{f_c C_7 R_A k}{V_{ref}} \times V_{in} = K_2 V_{in}$$

where n = total count on display
 f_c = clock frequency (defined by R2, R3, C1, C2)
 R_A = R11 + R16 + RV2
 R_B = R14 + R15 + RV1
 V_{ref} = Voltage of D6
 k = Mirror gain of norton op-amp section

These components are chosen such that by adjusting RV1 and RV2, $K_1 = K_2 = 1,000$ and $\frac{dK}{dT} = 0$.

A change of any of the components whose value is contained in K_1 and K_2 will require the instrument to be

recalibrated. Although it may be possible to do this by readjusting RV1 and RV2, it is likely that the select on test resistors R15 and R16 will have to be changed.

With 1.000 volts applied to the input and RV1 and RV2 central, resistors should be substituted until a reading between 985 and 1015 is obtained. The instrument may then be accurately calibrated.

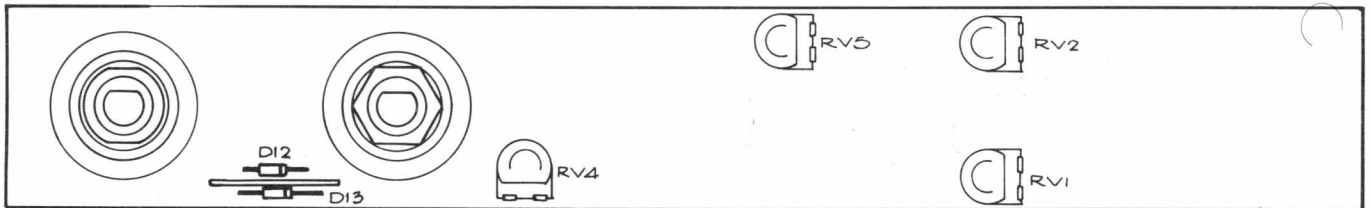
R15 and R16 should normally be within the range 0 to 390K.

Ω s calibration is defined by the equation

$$\frac{R_{39} \times V_{ref} \times k}{R_c} = 1$$

Where $R_c = R_{31} + R_{33} + RV_5$

Changing of any of these components will, therefore, require recalibration of Ω s via R31 and RV5. This should be done as described above, but on the 2K Ω range with a 1K Ω precision resistor across the input.



CALIBRATION PROCEDURE

Only four calibration points are provided, these are adjust positive full scale (RV2); adjust negative full scale (RV1); adjust AC full scale (RV4); and adjust resistance full scale (RV5).

To recalibrate the instrument, a precision voltage source of some known value between 1V and 1.999V and a precision resistor of between 1K Ω and 1.999K Ω are desirable. (Values known to $\pm 0.1\%$).

- (1) Set instrument to mA DC and adjust RV3 for 000 or -000.
- (2) Set instrument to 2V DC, connect voltage source and adjust RV2 for correct reading on display.
- (3) Reverse connections to voltage source and adjust RV1 for correct reading with negative sign displayed.
- (4) Set instrument to 2V AC, connect AC sinewave signal and adjust RV4 for correct reading.

Failures Caused by Severe Range Overload

Where the instrument has been damaged by mis-use, the probable mode of failure can be predicted.

Note:

Where very high voltages in excess of 2KV have been applied to the instrument, internal arcing may occur causing damage to any part of the circuit.

(a) Damage on DC volts or AC volts

(i) 2 volt range

Voltage in excess of 300V r.m.s. could cause failure of IC2 or IC4. In addition, resistors R20, R21, R25 and capacitors C9, C10 could be damaged. This failure mode will be referred to as Mode 'A'.

(ii) Other voltage ranges

Voltages in excess of 1KV DC or 750V r.m.s. continuous could cause damage to the resistor pack RP1 resulting in mis-calibration.

- (5) Set instrument to 2K Ω and connect the precision resistor. Adjust RV5 for correct reading on display.

If precision sources are not available, then non-precise sources may be used (such as a 1½V battery and a 1.5K Ω 5% carbon film resistor), in conjunction with a 0.1% accuracy digital multimeter to monitor their actual values. (Measure resistor separately).

No other calibration should be necessary; should calibration of any other ranges remain at fault, it will be necessary to replace RP1 or R34 to R37 as appropriate.

Note:

When attempting to set zero, a slight jitter to 001 may occur – this is normal.

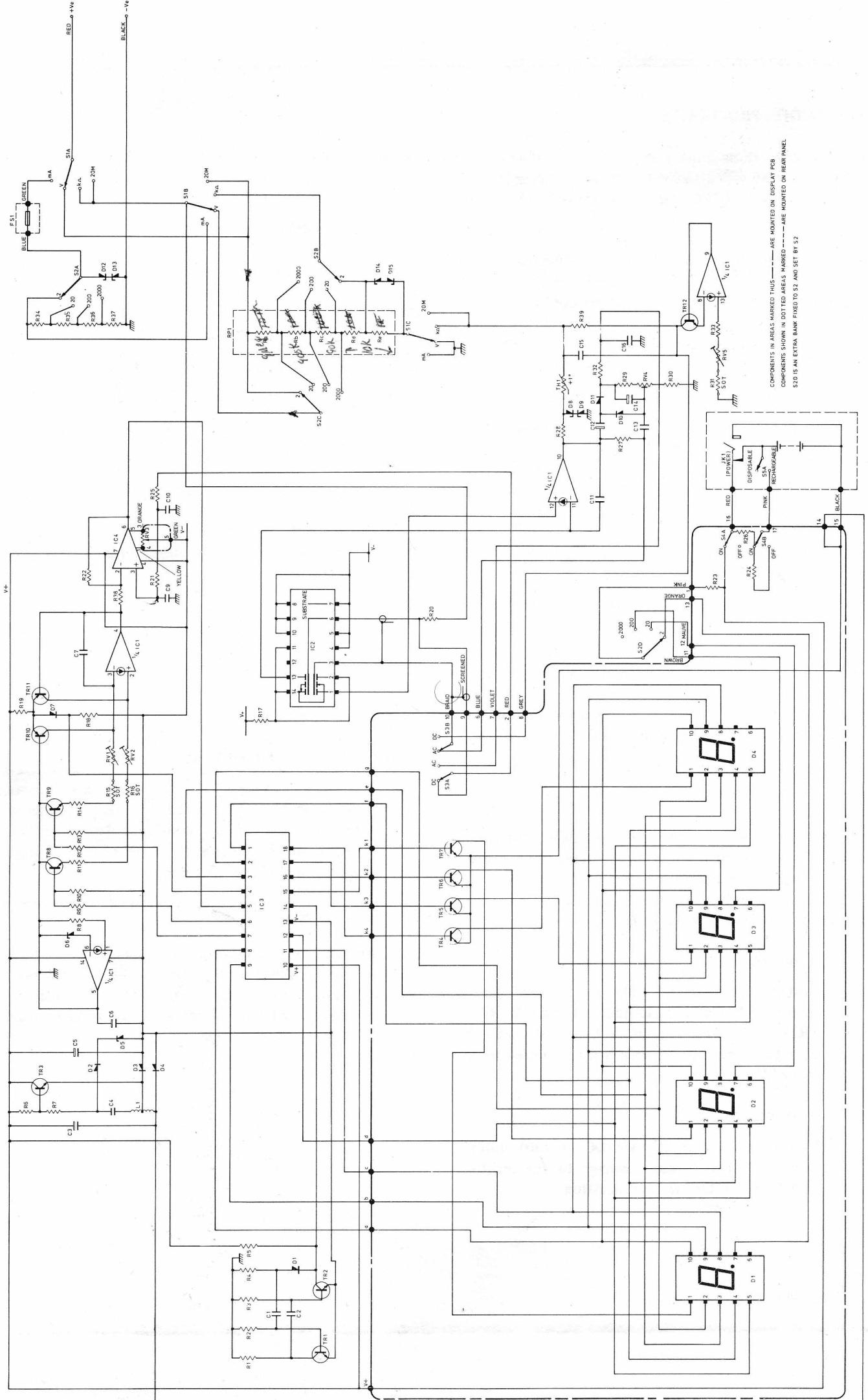
(b) Damage on resistance ranges.

(i) 10M Ω , 1M Ω , 100K Ω ranges

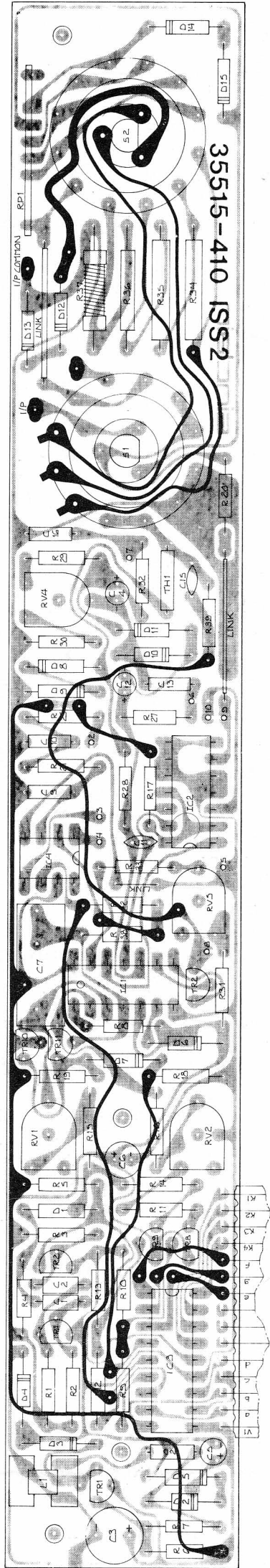
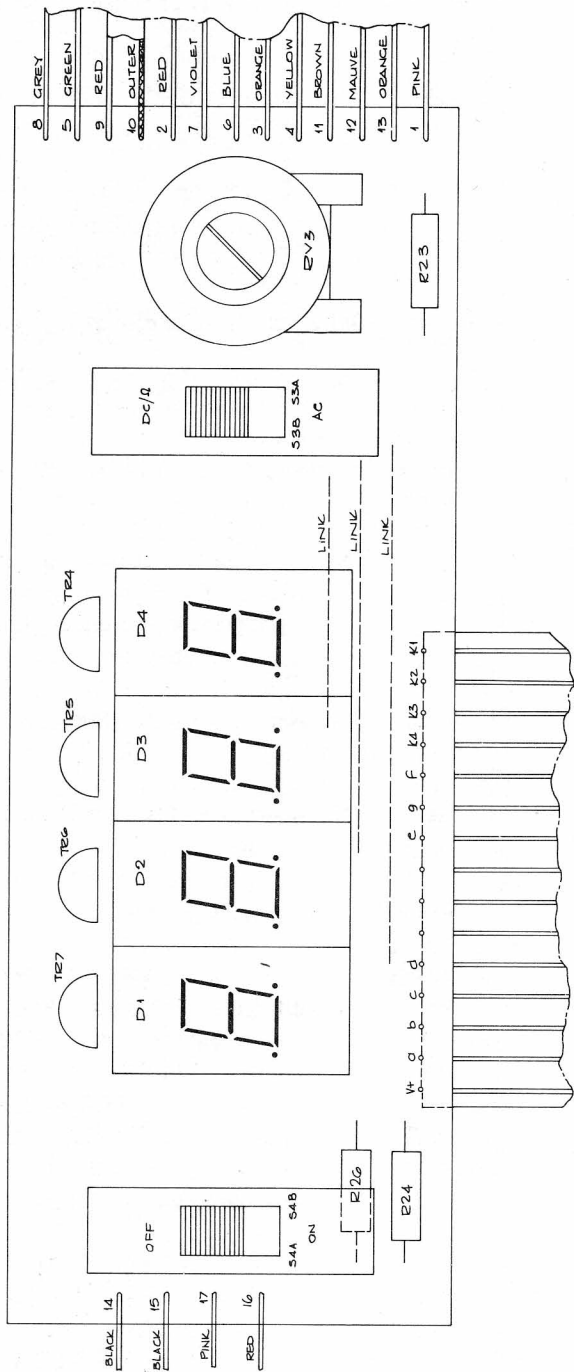
Voltage in excess of 300V r.m.s. could cause failure in Mode 'A', or damage to RP1. Voltage in excess of 250V r.m.s. could cause damage to RP1. Where the voltage was in excess of 300V r.m.s., failure in Mode 'A' could result.

(c) Damage on current ranges

Current ranges are protected by a fast blow 1A fuse. Where a very high voltage such as AC line has been applied, the protection zeners D12 and D13 may go short circuit and must be replaced. No damage to the shunt resistors should occur.



COMPONENTS IN AREAS MARKED THIS --- ARE MOUNTED ON DISPLAY PCB
COMPONENTS SHOWN IN DOTTED AREAS MARKED - - - - ARE MOUNTED ON REAR PANEL
S20 IS AN EXTRA BANK FIXED TO S2 AND SET BY S2



FAULT FINDING CHART

1. Is there anything visible on display?

Yes →
 No → Check power voltage (4V–7V) and power lead connections. Check for broken or short circuit P.C.B. tracks.

2. Are V+ and V– voltages correct?

Yes →
 No → Check power supply inverter circuitry and condition of IC1.

3. Are all three digits illuminated and at normal brightness?

Yes →
 No → Check clock oscillator circuit. Check digit and segment drives.

4. Can display be set to zero?

Yes →
 No → Display shows continuous positive overload = 000. Check TR8 and associated circuitry. Check pin 6 IC3 is near V+. Check condition of IC1 and IC4.

→ Display shows continuous negative overload ≡ 000. Check TR9 and associated circuitry. Check pin 7, IC3 is near V+. Check condition of IC1 and IC4.

5. Apply 1 volt to input. Does pin 3 IC4 read 0.8V? (Using 10MΩ meter).

Yes →
 No → Check continuity, R25, R21, P.C.B. S/c or o/c tracks.

6. With 1 volt applied, does display read correctly?

Yes →
 No → Reads near zero: Check D7, R18.
 → Reads randomly: Check IC1, IC4.
 → Reading stable but incorrect: Check all components affecting full scale accuracy (see page 5).

↓
 7. Apply 10V, 100V, 1000V does display read correctly?

Yes →
 No → Check RP1, IC4, IC2 or P.C.B. S/cs or O/cs, S2C

8. Switch to Ωs, connect 1KΩ resistor, does display read correctly?

Yes →
 No → Pin 10 IC1 reads 1V above display reading → Check S1C, S3B.
 → Pin 10 IC1 does not read 1 volt above display reading → Check IC2, IC1 TR12 and associated circuitry.

9. Connect 10MΩ resistor, does display read correctly?

Yes →
 No → Check IC2, IC4, C9, C10 and C12.

10. Apply 1V AC r.m.s. 50/60Hz does display read correctly?

Yes →
 No → Does input signal appear on pins 3 and 6 IC2? If yes, check R32. If no, check condition of D10, D11 and associated circuitry.

11. Apply 1mA, 10mA, 100mA, 1000mA. Does display read correctly?

Yes →
 No → Check FS1, D12 and D13, R34 to R37.

↓
 No Fault

PARTS LIST

Main PCB Assembly

<i>Location</i>	<i>Description</i>	<i>Part No.</i>
R1	22K 1/3W 5% Carbon Film	23180-002
R2	150K 1/3W 2% Carbon Film	23165-001
R3	150K 1/3W 2% Carbon Film	23165-001
R4	22K 1/3W 5% Carbon Film	23180-002
R5	22K 1/3W 5% Carbon Film	23180-002
R6	3K9 1/3W 5% Carbon Film	23180-155
R7	220R 1/3W 5% Carbon Film	23180-115
R8	33K 1/3W 5% Carbon Film	23180-126
R9	100K 1/3W 5% Carbon Film	23180-121
R10	270K 1/3W 5% Carbon Film	23180-123
R11	1M 1/3W 2% Carbon Film	23165-003
R12	100K 1/3W 5% Carbon Film	23180-121
R13	270K 1/3W 5% Carbon Film	23180-123
R14	1M 1/3W 2% Carbon Film	23165-003
R15	Select-on-test (see separate list)	
R16	Select-on-test (see separate list)	
R17	27K 1/3W 5% Carbon Film	23180-150
R18	68K 1/3W 5% Carbon Film	23180-105
R19	270K 1/3W 5% Carbon Film	23180-123
R20	270K 1/3W 5% Carbon Film	23180-123
R21	820K 1/3W 5% Carbon Film	23180-124
R22	10M 1/3W 10% Carbon Film	23192-202
R23	390R 1/3W 5% Carbon Film	23180-110
R24	27R 1/3W 5% Carbon Film	23180-160
R25	820K 1/3W 5% Carbon Film	23180-124
R26	68R 1/3W 5% Carbon Film	23180-129
R27	10M 1/3W 10% Carbon Film	23192-202
R28	220R 1/3W 5% Carbon Film	23180-115
R29	22K 1/2W 1% Metal Film	23205-202
R30	10K 1/2W 1% Metal Film	23205-201
R31	Select-on-test (see separate list)	
R32	1M 1/3 2% Carbon Film	23165-003
R33	1M 1/3W 2% Carbon Film	23165-003
R34	900R 1/2W 0.25% Metal Film	23215-604
R35	90R 1/2W 0.25% Metal Film	23215-603
R36	9R 1/2W 0.5% Metal Film	23205-102
R37	1R 4W 0.5% Wirewound	23295-004
R38	2K2 1/3W 5% Carbon Film	23180-101
R39	200K 1/3W 2% Carbon Film	23165-002
RP1	Thick Film Resistor Network	23301-807
C1	470pF 2½% Polystyrene	23646-001
C2	470pF 2½% Polystyrene	23646-001
C3	220µF 10V Electrolytic	23557-209
C4	0.022µF Polyester	23663-105
C5	10µF 16V Electrolytic	23557-208
C6	47µF 10V Electrolytic	23557-200
C7	0.47µF Polycarbonate	23662-104
C8	Not Used	
C9	0.047µF Polyester	23662-102
C10	0.047µF Polyester	23662-102

<i>Location</i>	<i>Description</i>	<i>Part No.</i>
C11	33pF Disc Ceramic	23427-246
C12	10μF 16V Electrolytic	23557-208
C13	0.047μF Polyester	23662-102
C14	1μF 63V Electrolytic	23557-203
C15	33pF 500V Disc Ceramic	23424-228
TH1	Thermistor (High Voltage Current Limiter)	23386-001
RV1	50K Horizontal Preset	23376-027
RV2	50K Horizontal Preset	23376-027
RV3	100K Horizontal Preset	23376-056
RV4	1K Horizontal Preset	23376-004
RV5	50K Horizontal Preset	23376-027
IC1	LM3900N	27106-501 - ECG-992
IC2	CD4007AE (Special Selection)	27164-501 - ECG-4007
IC3	AY-5-3507	27250-401
IC4	CA3130E (Special Selection)	27106-601 - ECG-930
TR1	ZTX 239	25380-217
TR2	ZTX 239	25380-217
TR3	BFR 41	25383-501
TR4	ZTX 239	25380-217
TR5	ZTX 239	25380-217
TR6	ZTX 239	25380-217
TR7	ZTX 239	25380-217
TR8	ZTX 239	25380-217
TR9	ZTX 239	25380-217
TR10	ZTX 214B	} matched pair 25341-208
TR11	ZTX 214B	
TR12	ZTX 239	25380-217
D1	1S44 or equivalent	25023-201
D2	1S44 or equivalent	25023-201
D3	1S44 or equivalent	25023-201
D4	1S44 or equivalent	25023-201
D5	13V Zener	25131-216
D6	6V2 Zener (Special selection)	25130-805
D7	1S44 or equivalent	25023-201
D8	5V6 Zener	25130-217
D9	5V6 Zener	25130-217
D10	1S44 or equivalent	25023-201
D11	1S44 or equivalent	25023-201
D12	3V9 Zener	25131-217
D13	3V9 Zener	25131-217
D14	3V9 Zener	25131-217
D15	3V9 Zener	25131-217
Displays	(4 off) H.P. 5082-7740	25061-104
L1	Coil	43751-730
S3,S4,S5.	2 pole 2 way slide switches	22218-204
S1,S2.	2 pole, 4 way rotary switches	22220-001

Part No.

Select-on-test resistors (see service notes)

22K	23180-122
47K	23180-138
68K	23180-105
91K	23180-206
110K	23180-207
130K	23180-170
150K	23180-127
180K	23180-140
200K	23180-205
220K	23180-107
240K	23180-208
270K	23180-123
300K	23180-209
330K	23180-139
360K	23180-210

Mechanical Components

Display Connector (15 way)	35171-210
Main Harness (Main PCB - display)	43183-030
Power Harness (to rear panel)	43183-040
Decimal Point Harness	43183-050
Case Assembly	41537-120
Battery Cover	33335-020
Sleeved Handle	31336-200
Knobs	37151-170
Front Panel	33331-190
Window	37634-040
Knob Clip	20620-009
Red Socket	22571-653
Black Socket	22571-654
Bush	31122-150
Red Input Connector (socket to PCB)	43136-030
Black Input Connector (socket to PCB)	43136-040
Fibre Spacing Washer	20612-009
Sinclair Logo Label	37521-030
Black PVC Feet	31748-190
Instruction Label	37558-007
Screws 6BA x 5/32" Cheese Head	20124-326
Screws 6BA x 7/8" Cheese Head	20124-485
Battery Compartment	20656-004
Fuseholder (excluding U.S.A. versions)	22300-204
Back Panel (excluding U.S.A. versions)	33231-170
PVC Grommet	22443-001
Jack Socket	22581-508
Main PCB	35515-410
Display PCB	35515-420
Switch PCB (decimal point)	35511-260
Rear Panel PCB	35511-270
Decimal Point Switch Moulding	31122-140

This manual has been prepared to aid the experienced engineer in the maintenance and repair of the Sinclair DM235 Digital Multimeter. Any queries concerning servicing should be addressed to:

sinclair

**The Multimeter Service Department,
Sinclair Radionics Limited,
London Road,
St. Ives,
Huntingdon,
Cambridgeshire.
PE17 4HJ.
Tel: St. Ives (0480) 64646
Telex: 32250**

The policy of the company is one of continuous improvement and we reserve the right to alter specification without prior notice.

**Sinclair Radionics Inc.
Galleria, 115 East 57th Street
New York, N.Y. 10022 USA.
Tel: (212) 355 5005**

In countries outside the U.K. and U.S.A. engineers should contact the main agent for that country.