DIGITAL MULTIMETER

MODEL 152

OPERATION MANUAL

KIKUSUI ELECTRONICS CORP.

Power Requirements of this Product

Power requirements of this product have been changed and the relevant sections of the Operation Manual should be revised accordingly.
(Revision should be applied to items indicated by a check mark ☑.)

☐ Input voltage

The input voltage of this product is ________ VAC,
and the voltage range is ________ to ________ VAC. Use the product within this range only.

☐ Input fuse

The rating of this product's input fuse is ________A, ________VAC, and ________.

WARNING

- To avoid electrical shock, always disconnect the AC power cable or turn off the switch on the switchboard before attempting to check or replace the fuse.
- Use a fuse element having a shape, rating, and characteristics suitable for this product. The use of a fuse with a different rating or one that short circuits the fuse holder may result in fire, electric shock, or irreparable damage.

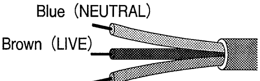
☐ AC power cable

The product is porvided with AC power cables described below. If the cable has no power plug, attach a power plug or crimp-style terminals to the cable in accordance with the wire colors specified in the drawing.

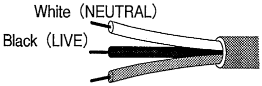
WARNING

- The attachment of a power plug or crimp-style terminals must be carried out by qualified personnel.

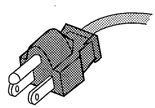
☐ Without a power plug



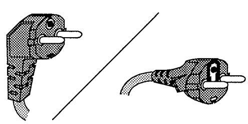
☐ Without a power plug



☐ Plugs for USA



☐ Plugs for Europe



☐ Provided by Kikusui agents

Kikusui agents can provide you with suitable AC power cable.
For further information, contact your Kikusui agent.

☐ Another Cable ______________________________

CONTENTS

SECTION 1	Introduction	4
SECTION 2	Specification	5
SECTION 3	**Operation**	7
3.1	Preliminary	7
3.2	Display	7
3.3	Check	7
3.4	Zero	8
3.5	Cal	8
3.6	Voltage Measurements	8
3.7	Current Measurements	8
3.8	Resistance Measurements	8
3.9	Other Facilities	9
SECTION 4	**Circuit Description**	10
4.1	Power Supply	10
4.2	Display	10
4.3	Analogue to Digital Conversion	10
4.4	DC Ranges	11
4.5	AC to DC Converter	11
4.6	AC Ranges	12
4.7	Current Measurement	12
4.8	Resistance Measurements	12
SECTION 5	**Maintenance**	13
5.1	Dismantling the instrument	13
5.2	Fuse Replacement	13
5.3	Recalibration	13
5.4	Fault Location	14
SECTION 6	**Components List and Illustrations**	16

ILLUSTRATIONS

Fig. 1	Circuit Diagram	23
Fig. 2	Battery Connections	25
Fig. 3	Printed Circuit Interconnection	25
Fig. 4	Block Diagram	27
Fig. 5	Display Assembly Component Location	28
Fig. 6	Power Supply and Attenuator Assembly Component Location	29
SECTION 7	**Guarantee and Service Facilities**	30

Optional Accessories
BP2 and SP2 (inside back cover)

INTRODUCTION

The Digital Multimeter 152 is a compact instrument providing a clear digital reading of AC and DC volts, AC and DC current and Ohms. All functions and ranges are selected by push buttons and the display has a maximum reading of 1999 with automatically positional decimal point. Overrange and reverse polarity indications are provided. The instrument is housed in an attractive plastic case and is constructed on two printed circuit boards which open out for ease of servicing.

Dual slope integration is used in the measuring system. Combined with automatic zero circuitry, this provides a very high degree of stability and freedom from zero drift. Display storage is incorporated giving a flicker-free readout at all times.

A single M.O.S. L.S.I. integrated circuit is employed to perform all of the counting and storage functions. This contributes greatly to the high reliability of the instrument.

The 152 is designed for operation from the AC supply, an external 12V (nominal) supply or from the rechargeable battery pack which is available as an option. A further option is a current shunt with switched ranges for extending the current measuring facilities of the instrument.

SPECIFICATION

Display 3½ digit in line numerical display with decimal point, overload and reverse polarity indication.

Maximum Reading 1999

RANGES

DC Ranges

Range	Accuracy (at 25 ±1°C) ± % rdg.	± % F.S.	Input Impedance	Resolution	Max. Continuous Overload
200.0mV	0.1	0.15	10MΩ	100μV	150V
2.000V	0.1	0.1	10MΩ	1mV	150V
20.00V	0.2	0.1	10MΩ	10mV	500V
200.0V	0.2	0.1	10MΩ	100mV	500V
1000V	0.2	0.1	10MΩ	1V	1000V*
200μA	0.3	0.2	1kΩ	100nA	10mA

*Using 1kV terminal. Normal input terminal may be used up to 500V.

AC Ranges

Range	Accuracy (at 25±1°C) ± % rdg.	± % F.S.	Frequency Range	Input Impedance (Typical)	Resolution	Max. Cont. Overload
200.0mV	0.3	0.15	40Hz-20kHz	1MΩ/150pF	100μV	200V
2.000V	0.4	0.2	40Hz-20kHz	1MΩ/110pF	1mV	350V
20.00V	0.4	0.2	40Hz-20kHz	1MΩ/110pF	10mV	350V
200.0V	0.4	0.2	40Hz-10kHz	1MΩ/110pF	100mV	350V
1000V	0.4	0.2	40Hz-2kHz	10MΩ/40pF	1V	1000V*
200.0μA	0.5	0.5	40Hz-10kHz	1kΩ	100nA	10mA

*Using 1kV terminal

Resistance Ranges

Range	Accuracy (at 25±1°C) ± % rdg.	± % F.S.	Resolution	Measuring Current	Max. Overload
200.0Ω	0.4	0.15	100mΩ	1mA	50V
2.000kΩ	0.3	0.15	1Ω	1mA	50V
20.00kΩ	0.3	0.15	10Ω	100μA	50V
200.0kΩ	0.3	0.15	100Ω	10μA	50V
2000kΩ	0.3	0.15	1kΩ	1μA	50V

Open circuit voltage on resistance ranges, 11 volts.

SPECIFICATION

SPECIFICATION (cont.)

Operating Temperature	0 – 50°C
Temperature Coefficient (Typical)	10° – 40°C 200mV, 2V DC ranges. 0.005% of rdg. per °C. Other ranges (except 2MΩ range) 0.01% of rdg. per °C. 2MΩ range 0.05% of rdg. per °C.
Sample Rate	approximately 5 readings/second
Common Mode Rejection	>90dB at 50 Hz with 1kΩ unbalance.
Response Time	DC ranges – Less than 1 second. AC ranges – Approx. 3 seconds.
Supply	200 – 260V AC 50-60Hz 8VA 100 – 130V AC 50-60Hz 8VA 11 – 17V DC 0.35A
Dimensions	20 cms (8") wide, 8 cms (3¼") high, 18.3 cms (7⅜") deep.
Weights	1.64 Kg (3.5 lbs)
Accessories Supplied	Supply lead PL71. Handbook.
Optional Accessories	Rechargeable Battery Pack. BP2 Current shunts. SP2

3.1 PRELIMINARY

The instrument is despatched from the factory connected for use on 100V-125V AC supply voltages. To operate from 200V-250V AC supply voltages, links on the printed circuit board must be changed as shown in Fig. 6. The links are located adjacent to the supply transformer. The supply fuse FS1, also adjacent to the supply transformer, must be changed from 500mA to 250mA size 00 for 200-250V operation.

The AC supply voltage is connected via the Power Cable to the three pin socket at the rear of the instrument marked "AC supply". Check that the AC/DC selector switch recessed at the rear of the instrument is in the "AC" position. The instrument may now be switched on with the slider ON/Off switch, also at the rear.

For battery operation an 11V-17V DC supply is applied via a 3 way DIN plug to the socket marked "DC Supply". Connections are shown in Fig. 2. The DC Supply may be isolated or have either terminal grounded. Check that the AC/DC selector switch at the rear of the instrument is in the "DC" position. The instrument may now be switched on with the slider ON/OFF switch at the rear.

3.2 DISPLAY

The display has a maximum reading of 1999 with decimal points automatically selected. If the reading exceeds 1999 an indicator neon marked 'O/L' on the lower left of the display is illuminated. If wrong polarity input is applied on DC ranges a flashing neon marked 'POL' on the upper left of the display will be observed.

3.3 CHECK

To check the instrument operation connect the positive terminal to the white socket (CHECK 1V). Select the +2V range. The instrument should read 1.000 ±2 digits at 25°C. This voltage is derived from the constant current generator which is used to measure resistance on the OHMS ranges. The current is not necessarily that which gives 1V on ranges other than 2V DC. The readings which are displayed on other ranges are:—

Range	Reading (±2 digits) at 25°C
200mV DC	O/L
2V DC	1.000
20V DC	0.10
200V DC	00.0
200Ω	O/L
2kΩ	1.000k
20kΩ	1.00k
200kΩ	01.0k

NOTE: This facility is NOT a calibration check but is intended as a check on the correct operation of the multimeter.

3.4 ZERO

To set the zero, short circuit the positive terminal to the negative terminal. Select the 200mV DC range. Adjust R43 through the hole on the right hand side of the instrument (labelled ZERO) in a clockwise direction to obtain a reading. Now turn R43 anti-clockwise until 1 in the least significant digit is just extinguished.

The zero adjustment may be used to offset input lead resistance on the 200Ω range if necessary, but must be reset on the 200mV range for correct use on all other ranges.

3.5 CAL

A calibration potentiometer R54 is provided; adjustable through a hole (labelled CAL) on the right hand side of the instrument. Select the 2V DC range and apply 1.999V accurate to ±0.1% or better to the input and set R54 to read full scale (1.999).

3.6 VOLTAGE MEASUREMENTS

Select the volts push button labelled V. Now select the appropriate push button from the three labelled +, – (DC) or ∿(AC) from the three left hand buttons. Finally select the required range from the upper row of five buttons. Care must be taken not to exceed maximum ratings of ranges (see specification).

The multimeter is a single polarity instrument with a polarity reversing switch. The normal operating mode is with the DC input applied to the + and – terminals, observing correct polarity. In this mode the + push button will give the correct reading. If a wrong polarity voltage is applied to the input then selecting the – push button will give correct operation.

Connect the input to terminals labelled +, –, for DC voltages up to 500V. For positive voltages above 500V DC use +1kV and – terminals with the + push button selected. For negative voltages above 500V DC the input connections on +1kV and – terminals must be reversed. Use the + and – terminals for AC voltages up to 200V RMS. Voltages above 200V AC must be connected via +1kV and – terminals.

3.7 CURRENT MEASUREMENT

One internal 200μA current range is provided. Select the push button labelled 200μA and +, – (DC) or ∿(AC) as appropriate. The range switches become inoperative when the 200μA push button is selected.

3.8 RESISTANCE MEASUREMENT

When measuring resistance select the Ω (OHMS) push button. This overrides AC and DC operation but the + and – push buttons reverse the measuring current from the terminals. The current flows from the + terminal when the + push button is selected.

Select the appropriate range from the five upper push buttons and connect the resistance between the + and – terminals. If the resistance to be measured is connected to ground it is preferable to connect the grounded end to the – terminals with the + push button selected.

3.9 OTHER FACILITIES

If it is required to hold a reading this may be achieved by connecting the reset pulse to 0V. Connections may be made to "reset (RS)" and "0V" on pins used for board interconnections at the right-hand side of the upper board.

When using the instrument on the 200mV or 2V DC ranges high input impedances can be achieved by releasing the voltage button V. The input resistance is then approximately 100MΩ on the 200mV range and 100MΩ on the 2V range.

4.1 POWER SUPPLY (see Figs. 1 and 4)

The DC supply from the DC input or AC rectifier is regulated to 9.5 volts and fed to the inverter, TR38, TR39 and T2. The outputs are rectified to provide four DC supplies to the instrument.

4.2 DISPLAY (see Figs. 1 and 4)

The display uses a sequential switching technique whereby each digit is switched on in turn. The cathodes of the indicators have corresponding numbers connected in parallel and the decimal information is fed to these parallel combinations. The correct digit is switched on by anode switches which are controlled by a decoding network.

The sequential switching is controlled by multivibrator TR26, TR27 which operates at approximately 1.5kHz. This waveform is fed to the strobe input of IC3. IC3 is an L.S.I. (Large scale integrated circuit) which contains 4 counting decades and 4 storage decades.

The 4-wire binary-coded decimal outputs from the 4 storage decades appear one decade at a time at the outputs from IC3, switched internally by the strobe signal. These outputs are then decoded in IC4, the decimal outputs of which are connected to the cathodes of the neon numerical indicators.

The outputs P and Q from IC3 identify the decade connected to the BCD output at any given time. The P and Q outputs are buffered and inverted by TR28 to TR31 and decoded by D19 – D26 in order to operate the anode switches TR32 to TR35 which conduct in sequence to switch on the indicator tubes at the correct time, so that each indicator conducts for 1/4 of the total time.

The reverse polarity indicator ILP6 is operated by TR25.

4.3 ANALOGUE TO DIGITAL CONVERSION (see Figs. 1 and 4)

The voltmeter is of the dual slope integrating type, in which C23 is discharged at a rate proportional to the voltage to be measured for a fixed period of time, and then re-charged at a constant rate until the original voltage is regained. The time to recharge C23 is measured and displayed to indicate the voltage which is being measured. A measurement is initiated by the uni-junction transistor TR41 which triggers approximately 5 times per second and is synchronised to the supply frequency when the instrument is being operated from the AC supply. The pulse generated is used to reset the counting decades in IC3. The carry output from IC3 goes high at reset and causes the measuring circuit to switch to the discharge state which unclamps the clock multivibrator TR23, TR24.

The voltage to be measured is applied to IC2, a high gain amplifier, via C18. The output of IC2 generates a current in TR5, TR6 and R46-R50. The voltage developed across these resistors is fed back to the input via field-effect transistor TR4 which is made to conduct during a measurement, thus controlling the gain of the amplifier. The current in TR5, TR6 is drawn from C23 via D14, R45, discharging C23 during this first fixed time interval.

At the end of the first time interval, determined by the first carry output from the counter IC3, diode D14 is reverse biased and a constant reference current generated by TR9, TR10 recharges C23. TR10 operates as a zener diode.

When C23 has recharged to its original voltage the comparator amplifier TR11, TR12, TR14, TR15 switches on TR13 and clamps the clock multivibrator via D40, stopping the count. TR13 also applies a pulse via C30 to the LOAD input of IC3 causing the contents of the counting decades to be transferred to the storage decades also in IC3. The voltage measurement is then displayed as described above.

In order to stabilise the zero of the instrument against changes of temperature two forms of zero drift correction are used.

The input amplifier IC2 is connected as a unity gain amplifier between measurements by diode gate D12, D11 so that its output is held at 0 volts. During a measurement the diode gate is opened but C22 continues to supply the necessary bias current to the amplifier.

The comparator circuit is drift corrected by means of D18. Between measurements the constant current from TR9 continues to flow but the comparator diverts this current from C23 via D18, holding the voltage on C23 at the trigger point of the comparator. Thus when a measurement is made C23 starts to discharge from the comparator trigger voltage and recharges to the same voltage, so that drift of this trigger voltage does not affect the instrument reading.

If a reverse polarity input is applied to the instrument input then the output of IC2 goes negative during a measurement period and operates the reverse polarity indicator via TR7, TR8, TR25. TR8 is gated off between measurements.

4.4 DC VOLTAGE RANGES (see Figs. 1 and 4)

The 2V and 200mV ranges are achieved by changing the gain of the input amplifier, the feedback being taken from the emitter of TR6 for 2V and the slider of R49 for 200mV.

For other ranges the amplifier gain is set for the 2V range and the input is attenuated via R3 to R9, which have 10MΩ total resistance. The 1kV range attenuator is formed by R2, R8, R9.

R2 and R3 are each made up of two resistors selected to give ±0.1% accuracy.

R20, D3, D4 provide protection against excessive voltage inputs. Appropriate decimal points are selected by S7a, S8b, S9a, S10b.

4.5 AC TO DC CONVERTER (see Figs. 1 and 4)

AC input voltages are converted to DC by the operational amplifier IC1 and

//

associated components.

R19, D42, D43 provide protection against overload. IC1 is preceded by emitter followers TR2, TR3 and the output is rectified by diodes D1, D2. The output from the diodes is combined in R131, R136 to re-form the AC waveform which is applied as negative feedback to the amplifier input. Variable resistor R136 is used to adjust the voltage gain of the circuit. The DC output is taken from D2 via a filter to the DC input of the voltmeter. The gain of the analogue to digital converter is switched to a suitable value by S3f.

The DC working point of the amplifier IC1, TR2, TR3 is controlled by negative feedback via R27, R28 decoupled by C11, C12.

4.6 AC VOLTAGE RANGES (see Figs. 1 and 4)

The basic range of the AC to DC converter is 0-200mV and other ranges are obtained by means of the potential divider resistors R4 to R9, with switched shunt capacitors to maintain a flat frequency response at the higher frequencies. The 2 volt range has a separate adjustment R5. The total resistance of the attenuator is 1MΩ except on the 1kV range which is connected via R2 giving 10MΩ input resistance. Decimal points are selected as for the DC ranges.

4.7 CURRENT MEASUREMENT (see Figs. 1 and 4)

Currents are measured by using the 200mV range, on AC or DC, to measure the voltage developed across the 1kΩ input shunt resistor R1.

4.8 RESISTANCE MEASUREMENT (see Figs. 1 and 4)

The reference voltage from TR10 is applied to TR1 to generate a constant current which is applied to the resistance to be measured. The voltage developed is displayed as the resistance value. R18, FS2, D6, D7 provide protection against voltages applied to the instrument terminals.

The 200Ω and 2kΩ ranges are obtained by using 1mA constant current with the Analogue to Digital converter set to the 200mV and 2V ranges respectively. On other ranges the constant current is changed and the 2V range used. Decimal points are selected as for the voltage ranges.

5.1 DISMANTLING THE INSTRUMENT (see Figs. 5 and 6)

Disconnect input and supply leads. Remove the four screws from the feet, and lift off the top half of the case. Lift the handle assembly from the slots. Remove the printed circuit board assembly including the front panel from the lower half of the case. Remove three screws from the top front and a further three screws from the bottom rear; now the two large printed circuit boards can be unfolded. Take care not to damage the screen grounding springs on the track side of the printed circuit boards.

To remove the AC amplifier screens, lever off the spring clip shown in Fig. 5. The AC to DC converter board can now be removed by unsoldering the five connections made to the display board.

5.2 FUSE REPLACEMENT

The supply fuse FS1 is located on the Power Supply and Attenuator board adjacent to the transformer T1. Replace with a 250mA size 00 fuse for 240V AC supply or 500mA size 00 fuse for 120V AC supply.

When an excessive voltage is applied to an OHMS range the protection fuse FS2 will blow. FS2 is located on the Power Supply and Attenuator board behind the range switch, replace with a 10mA size 00 fuse.

5.3 RECALIBRATION (see Figs. 5 and 6)

Adjustments MUST be made in the following sequence.

1) Adjust R128 for 9.5V ±2% across C39.
2) Short circuit the + and – input terminals, select the 200mV DC range and set R43 for zero reading (see 3.4)
3) Select the 2V DC range and apply 1.999V ±0.05% (or better) to the + and – terminals and adjust R54 for a reading of 1.999.
4) Select the 200mV DC range and apply 199.9mV ±0.05% (or better) to the + and – terminals and adjust R49 for a reading of 199.9.
5) Select the 2MΩ range. Connect 1.999MΩ ±0.1% (or better) to the + and – terminals and adjust R14 for a reading of 1999.
6) Select the 200kΩ range. Connect 199.9kΩ ±0.1% (or better) to the + and – terminals and adjust R15 for a reading of 199.9
7) Select the 20kΩ range. Connect 19.99kΩ ±0.1% (or better) to the + and – terminals and adjust R16 for a reading of 19.99.
8) Select the 2kΩ range. Connect 1.999kΩ ±0.05% (or better) to the + and – terminals and adjust R17 for a reading of 1.999.
9) Short circuit the + and – input terminals, select the 200mV AC range and adjust R133 for zero reading. (Note reading takes time to settle due to AC coupling).
10) Select the 200mV AC range and apply 199.9mV ±0.1% RMS 800Hz sine wave to the + and – terminals and adjust R136 for a reading of 199.9

12

11) Select the 2V AC range and apply 1.999V ±0.1% RMS 800Hz sine wave to the + and – terminals and adjust R5 for a reading of 1.999.
12) Re-assemble the instrument except for the case for the remaining calibration.
13) Select the 2V AC range and apply 1.999V ±0.1% RMS 20kHz sine wave via a screened lead to the + and – terminals. Adjust C2 for a reading of 1.999.
14) Select the 20V AC range and apply 19.99V ±0.1% RMS 20kHz sine wave via a screened lead to the + and – terminals. Adjust C4 for a reading of 19.99.
15) Select the 200V AC range and apply 199.9V ±0.1% RMS 20kHz sine wave via a screened lead to the + and – terminals. Adjust C5 for a reading of 199.9.
16) Select the 1kV AC range and apply 1000V ±0.1% RMS 5kHz sine wave via a screened lead to the +1kV and – terminals. Adjust C1 (formed in the wiring adjacent to R2) for a reading of 1000.

5.4 FAULT FINDING

Follow the suggested sequence for fault finding in association with the Circuit Description (section 4).

a) NO DISPLAY ON ONE OR MORE DIGITS

1) Measure the supply to the instrument.
2) Check AC supply fuse FS1.
3) Check for regulated 9.5V supply across C39.
4) Measure the instrument supplies relative to the 0V line. +190V, +5V, –12V, +17V (TP5-8 respectively).
5) Check anode drive from the multivibrator TR26, TR27 (TP18) which generates a 1 to 1.5kHz square wave. IC3 contains a divider circuit giving half this frequency at P and one quarter at Q. Check that buffers TR28, TR29 (TP19) TR30, TR31 (TP20) give approximately 10V amplitude pulses. Check that TR32, TR33, TR34, TR35 collectors (TP21-TP24) switch.

b) FAULTY DISPLAY e.g. double numbers

1) If fault appears on only one of the digits check the indicator tube and appropriate pair of diodes from D19–D26
2) If fault appears on all indicators check IC4 then IC3 outputs.
3) No decimal point. Check wiring to switches.

c) NO MEASUREMENT ON 200mV or 2V DC RANGE

Apply full scale input and carry out the following:

1) Check input wiring.
2) Check reset pulse at TR22 collector (TP9), positive pulse approximately 3V amplitude and 10μS wide.

3) Check IC3 resets (pin 4 goes +ve)
4) Check that TR16, TR17, TR20 switch on after reset and that TR18, TR19 switch off after reset (TP10).
5) Check that the output of amplifier IC1 (TP12) steps +ve 1 to 2 volts for 2 to 3mS after reset.
6) Check for dual ramp on C23 (TP14). DC level is approximately +9V; first ramp goes negative, second ramp returns to +9V.
7) Check comparator output. TR14 collector (TP15) goes –ve during measurement.
8) Check that multivibrator output TR23, TR24 (TP16) produces a burst of pulses for 2 to 7mS at 300 to 400kHz.
9) Check IC3 pin 6 (TP17) for 2 or 3 pulses approximately 2mS wide (carry from third decade).
10) Check IC3 pin 14 load pulse. A pulse from + to 0V at the end of each measurement should be present.
11) Check BCD outputs of IC3 pins 7-10. +ve = 0 0V = 1.
12) Check IC4 inputs and outputs.

d) NO MEASUREMENT ON OHMS RANGES

1) Check FS2.
2) Check voltage at the base of TR1 (approximately +11V).
3) Check voltage at the emitter of TR1 (approximately +11.5V).

e) NO MEASUREMENT ON AC RANGES

Select 200mV range and apply full scale input at approximately 1kHz.

1) Check input voltage at C7 (TP25).
2) Check amplifier output is 10 x input waveform amplitude with steps at the mid point (TP26).
3) Check +ve half of waveform appears at D2 cathode (TP27).

f) NO MEASUREMENT ON 20V – 1kV DC and 2V – 1kV AC RANGES

1) Check input wiring.
2) Check attenuator division.
3) Check wiring from attenuator to the input amplifiers, AC or DC.

Ref	*Value*	*Description*			*Part No*
RESISTORS					
R1	1K	Welwyn 40-30 Series	±.1%		29347
R2a	9.99M	Welwyn 40-30 Series	±.1%		29344
R2b		Matched pair			
R3a	9M	Welwyn 40-30 Series	±.1%		29345
R3b		Matched Pair			
R4	400K	Welwyn 40-30 Series	±.1%		29348
R5	3.3K	Carbon Variable			26868
R6	90K	Welwyn 40-30 Series	±.1%		29350
R7	15Ω	Cr. Carbon	±5%	⅛W	2085
R8	9K	Welwyn 40-30 Series	±.1%		29351
R9	1K	Welwyn 40-30 Series	±.1%		29347
R10	6.49M	Welwyn 40-30 Series	±1%		29346
R11	649K	Welwyn 40-30 Series	±1%		29352
R12	64.9K	Welwyn 40-30 Series	±1%		29353
R13	6.49K	Welwyn 40-30 Series	±1%		29354
R14	1M	Carbon Variable			26867
R15	100K	Carbon Variable			26582
R16	10K	Carbon Variable			28525
R17	1K	Carbon Variable			26870
R18	4.7K	Cr. Carbon	±5%	½W	18558
R19	150K	Met. Oxide	±2%		28826
R20	220K	Cr. Carbon	±5%	⅛W	4023
R21	560K	Cr. Carbon	±5%	⅛W	17966
R22	1.8K	Welwyn 40-30 Series	±1%		29360
R23	16K	Welwyn 40-30 Series	±1%		29361
R24/25	1M	Cr. Carbon	±5%	⅛W	766
R26/27	100K	Welwyn 40-30 Series	±1%		29355
R28	470K	Cr. Carbon	±5%		1518
R29	2.2K	Cr. Carbon	±5%		425
R30	4.7K	Welwyn 40-30 Series	±1%		29356
R31	1.2K	Welwyn 40-30 Series	±1%		28932
R32	4.7K	Welwyn 40-30 Series	±1%		29356
R33	220K	Cr. Carbon	±5%	⅛W	4023
R34	1M	Cr. Carbon	±5%	⅛W	766
R35	100K	Cr. Carbon	±5%	⅛W	319
R36	470K	Cr. Carbon	±5%	⅛W	1518
R37	100K	Cr. Carbon	±5%	⅛W	319
R38	220K	Cr. Carbon	±5%	⅛W	4023
R39	1K	Cr. Carbon	±5%	⅛W	384
R40	1.5K	Cr. Carbon	±5%	⅛W	385

Ref	*Value*	*Description*			*Part No*
RESISTORS (Cont.)					
R41	100K	Cr. Carbon	±5%	⅛W	319
R42	22K	Cr. Carbon	±5%	⅛W	1544
R43	220K	Carbon Variable			29364
R44	1M	Cr. Carbon	±5%	⅛W	766
R45	10Ω	Cr. Carbon	±5%	⅛W	2259
R46	649Ω	Welwyn 40-30 Series	±1%		29357
R47	243Ω	Welwyn 40-30 Series	±1%		29358
R48	10Ω	Met. Oxide TR5	±5%		28771
R49	100Ω	Carbon Variable			28520
R50	95Ω	Welwyn 40-30 Series	±1%		29359
R51	10K	Cr. Carbon	±5%	⅛W	11503
R52	22K	Cr. Carbon	±5%	⅛W	1544
R53	6.8K	Cr. Carbon	±5%	⅛W	313
R54	220Ω	Carbon Variable			4708
R55	6.19K	Welwyn 4033C	±1%		30042
R56	10K	Cr. Carbon	±5%	⅛W	11503
R57	4.7M	Cr. Carbon	±10%	½W	30264
R58	8.2	Cr. Carbon	±5%	⅛W	29435
R59	470K	Cr. Carbon	±5%	⅛W	1518
R60	33K	Cr. Carbon	±5%	⅛W	317
R61	470K	Cr. Carbon	±5%	⅛W	1518
R62	560K	Cr. Carbon	±5%	⅛W	17966
R63	2.2K	Cr. Carbon	±5%	⅛W	425
R64	1K	Cr. Carbon	±5%	⅛W	384
R65	100K	Cr. Carbon	±5%	⅛W	319
R66	18K	Cr. Carbon	±5%	⅛W	634
R67	1K	Cr. Carbon	±5%	⅛W	384
R68	18K	Cr. Carbon	±5%	⅛W	638
R69	1K	Cr. Carbon	±5%	⅛W	384
R70	510Ω	Cr. Carbon	±5%	⅛W	29434
R71	1K	Cr. Carbon	±5%	⅛W	384
R72	22K	Cr. Carbon	±5%	⅛W	1544
R73	4.7K	Cr. Carbon	±5%	⅛W	386
R74	22K	Cr. Carbon	±5%	⅛W	1544
R75	1.8K	Cr. Carbon	±5%	⅛W	310
R76	8.2K	Cr. Carbon	±5%	⅛W	314
R77	10K	Cr. Carbon	±5%	⅛W	11503
R78		Not Used			
R79	22K	Cr. Carbon	±5%	⅛W	1544
R80	470K	Cr. Carbon	±5%	⅛W	1518

Ref	Value	Description			Part No
RESISTORS (Cont.)					
R81	56K	Cr. Carbon	±5%	⅛W	756
R82	3.3K	Cr. Carbon	±5%	⅛W	1638
R83	1K	Cr. Carbon	±5%	⅛W	384
R84	12K	Cr. Carbon	±5%	⅛W	1685
R85	10K	Cr. Carbon	±5%	⅛W	11503
R86	1K	Cr. Carbon	±5%	⅛W	384
R87	150Ω	Cr. Carbon	±5%	⅛W	301
R88	150K	Cr. Carbon	±5%	⅛W	4018
R89	120K	Cr. Carbon	±5%	⅛W	5332
R90/92	10K	Cr. Carbon	±5%	⅛W	11503
R93/94	100K	Cr. Carbon	±5%	⅛W	319
R95	10K	Cr. Carbon	±5%	⅛W	11503
R96	22K	Cr. Carbon	±5%	⅛W	1544
R97	10K	Cr. Carbon	±5%	⅛W	11503
R98	1K	Cr. Carbon	±5%	⅛W	384
R99	6.8K	Cr. Carbon	±5%	⅛W	313
R100	27K	Cr. Carbon	±5%	⅛W	316
R101	6.8K	Cr. Carbon	±5%	⅛W	313
R102	1K	Cr. Carbon	±5%	⅛W	384
R103	6.8K	Cr. Carbon	±5%	⅛W	313
R104	27K	Cr. Carbon	±5%	⅛W	316
R105	6.8K	Cr. Carbon	±5%	⅛W	313
R106		Not used			
R107	22K	Cr. Carbon	±5%	⅛W	1544
R108	15K	Cr. Carbon	±5%	⅛W	315
R109	22K	Cr. Carbon	±5%	⅛W	1544
R110	47K	Cr. Carbon	±5%	⅛W	318
R111	22K	Cr. Carbon	±5%	⅛W	1544
R112	15K	Cr. Carbon	±5%	⅛W	315
R113	6.8K	Cr. Carbon	±5%	⅛W	313
R114	22K	Cr. Carbon	±5%	⅛W	1544
R115	15K	Cr. Carbon	±5%	⅛W	315
R116	6.8K	Cr. Carbon	±5%	⅛W	313
R117	22K	Cr. Carbon	±5%	⅛W	1544
R118	15K	Cr. Carbon	±5%	⅛W	315
R119	6.8K	Cr. Carbon	±5%	⅛W	313
R120/123	1M	Cr. Carbon	±5%	⅛W	766
R124/125	470K	Cr. Carbon	±5%	⅛W	1518
R126	330Ω	Cr. Carbon	±5%	⅛W	1894
R127	180Ω	Cr. Carbon	±5%	⅛W	1517
R128	470Ω	Carbon Variable			28524

Ref	*Value*	*Description*			*Part No*
R129	820Ω	Cr. Carbon	±5%	⅛W	1637
R130/131	10Ω	Cr. Carbon	±5%	⅛W	2259
R132	8.2Ω	Cr. Carbon	±5%	⅛W	29435
R133	220K	Carbon Variable			29363
R134	100K	Cr. Carbon	±5%	⅛W	319
R135	1.2K	Cr. Carbon	±5%	⅛W	2087
R136	100Ω	Wire Wound Variable			24343
R137	4.7K	Cr. Carbon	±5%	⅛W	386
R138	180Ω	Cr. Carbon	±5%	⅛W	1517
R139	497K	Welwyn 40-30 Series	±.1%		29349
R140		Cr. Carbon	±5%	⅛W	A.O.T.
R141	47K	Cr. Carbon	±5%	⅛W	318
R142	39K	Cr. Carbon	±5%	⅛W	1639
R143	33K	Cr. Carbon	±5%	⅛W	317
R144/145		Not Used			
R146	1K	Cr. Carbon	±5%	⅛W	384
R147	4.7K	Cr. Carbon	±5%	⅛W	386
R148	82K	Cr. Carbon	±5%	⅛W	2088
R149	16K	Welwyn 40-30 Series	±1%		29361
R150	22K	Cr. Carbon	±5%	⅛W	1544
R151		Not used			
R152	4.7K	Cr. Carbon	±5%	⅛W	386
R153/154	560Ω	Cr. Carbon	±5%	⅛W	308
R155	12K	Cr. Carbon	±5%	⅛W	1685
R156	1K	Welwyn 40-30 Series	±.1%		29347
R157	10K	Cr. Carbon	±5%	⅛W	11503
CAPACITORS					
C1		Formed in Wiring			
C2	0-6pF	Ceramic Trimmer			29421
C3	150pF	Silver/Mica	±1%		4514
C4/5	0-6pF	Ceramic Trimmer			29421
C6	1000pF	Silver/Mica		350V	29436
C7	.47μF	Polyester		125V	2429
C8	.047μF	Ceramic	+80% -20%	30V	2793
C9	33pF	Ceramic	10%		22370
C10	5pF	Silver/Mica	±½pF		29437
C11/12	20μF	Electrolytic	-10% +50%	16V	21514
C13	2.2μF	Filmcap TF1	5%		25738
C14	.47μF	Polyester		125V	2429

Ref	*Value*	*Description*			*Part No*
CAPACITORS (Cont.)					
C15/16	.1µF	Polyester	10%	160V	2740
C17	.01µF	Ceramic	25%		22395
C18	.1µF	Polyester	10%	160V	2740
C19	10pF	Ceramic	10%		22364
C20	4700pF	Ceramic	25%		22393
C21	220pF	Ceramic	10%		22379
C22	.1µF	Ceramic	25%		19647
C23	1.4µF	Polycarbonate M.T.F.I.	±5%	63V	30041
C24	1.6µF	Electrolytic		25V	4453
C25/26	220pF	Silver/Mica	1%		11587
C27	1.6µF	Electrolytic		25V	4453
C28	5600pF	Ceramic	25%		22394
C29	.01µF	Ceramic	25%	250V	22395
C30	1000pF	Ceramic	10%		22387
C31	.1µF	Ceramic	25%		19647
C32/35	.033µF	Polyester		400V	4529
C36/37	1800pF	Ceramic		1250V	28157
C38	1250µF	Electrolytic		25V	19215
C39	125µF	Electrolytic		16V	20781
C40/41	.01µF	Ceramic	25%	250V	22395
C42	50µF	Electrolytic		25V	21518
C43	25µF	Electrolytic		25V	20776
C44/45	40µF	Electrolytic		16V	21519
C46/47	20µF	Electrolytic		16V	21514
C48	8µF	Electrolytic		350V	19895
C49	12.5µF	Electrolytic		25V	20775
C50	1.6µF	Electrolytic	25%	25V	4453
C51	0.47µF	Polyester	10%	160V	2429
C52	.01µF	Ceramic	25%	250V	22395
C53	4700pF	Polystyrene	2½%	63V	29432
C54	.01µF	Polystyrene	2½%	63V	29431
C55		Not Used			
C56/57	56pF	Silver/Mica	5%		29438
C58	.047µF	Ceramic		30V	2793
C59	12.5µF	Electrolytic		25V	20775
C60	56pF	Ceramic	10%		22373
C61	43pF	Silver/Mica	±5%		29653
C62	6.8pF	Silver/Mica	±½pF		4617
C63	18pF	Silver/Mica	±1pF		4506
C64	1000pF	Polystyrene	2½%	125V	29800

Ref	Value	Description	Part No
DIODES			
D1/2		IN 4148	23802
D3/4		IN 3595	29330
D5		Zener 4.3V	1723
D6		IN 4148	23802
D7		IN 3595	29330
D8/9		IN 4148	23802
D10/11		IN 3595	29330
D12/27		IN 4148	23802
D28		Zener 3.9V	3817
D29		Zener 5.6V	4109
D30/32		IN 4148	23802
D33/36		Not Used	
D37/38		IN 4148	23802
D39		IN 4148	23802
D40		IN 4148	23802
D41		IN 4003	23462
D42/43		IN 3595	29330
D44/45		IN 4148	23802
D46		IN 4003	23462
BRIDGE RECTIFIERS			
MR1		W02	19725
MR2		W04	29367
TRANSISTORS			
TR1		BC 212K	29327
TR2/3		BC 107	26790
TR4		MPF 102 FET	25870
TR5/6		BC 108	26110
TR7/9		BC 212K	29327
TR10		BSX 26	28735
TR11		BC 107	26790
TR12		BC 108	26110
TR13		BSX 20	23307
TR14/15		BC 212K	29327
TR16		BSX 20	23307
TR17		BC 212K	29327
TR18		BC 108	26110
TR19		BC 212K	29327
TR20		BC 107	26790
TR21/24		BSX 20	23307
TR25		C407	20388

Ref	*Value*	*Description*	*Part No*
TRANSISTORS (Cont.)			
TR26/31		BSX 20	23307
TR32/35		2N 5400	29328
TR36		BC 212K	29327
TR37		2N 5296	28630
TR38/39		BFY51	29329
TR40		BC 108	26110
TR41		2N 4871	29509
INTEGRATED CIRCUITS			
IC1		SL 701C	29142
IC2		709 (µA 709C)	26664
IC3		LSI 4-Decade Type 1	29011
IC4		U19284 (CµL960)	27347
SOCKETS			
SKA		3 Pin B/Lee	3302
SKB		3 Pin DIN	3574
SKC		1 Pin B/Lee L1413 WHT.	29207
SKD		Terminal B/Lee L1850 RED	24872
SKE		Terminal B/Lee L1850 BLK.	24873
SKF		Terminal B/Lee L1850 RED	24872
MISCELLANEOUS			
ILP1/3		Indicator Neon 0-9	28127
ILP4		Indicator Neon 23L	28126
ILP5/6		Indicator Neon 16L	29201
ILP7		Not used	
ILP8/9		Indicator Neon 16L	29201
FS1	250mA	Fuse	19815
FS2	10mA	Fuse	4046
T1		Transformer-Supply	MT.649
T2		Transformer-Inverter	MT.650
L1		Choke Toroid	A.28145
S1/5		Switch - Range	B.29197
S6/11		Switch - Function	B.29198
S12/13		Switch Slider 2P 2w	4069

Fig. 1 CIRCUIT DIAGRAM

22

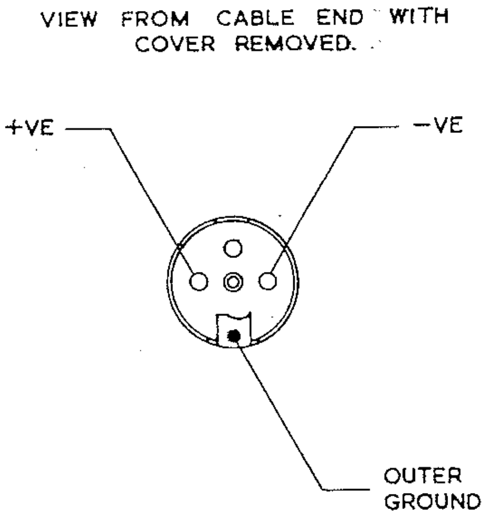


Fig. 2 BATTERY CONNECTIONS

(A) FRONT PANEL to DISPLAY BOARD

	Check +1V socket	S5b1
Screened lead	+ Terminal	S2a3
	N/C	Screen S1a2
Screened lead	− Terminal	S2b3
	N/C	Screen S2a2
Screened lead	+1kV Terminal	R2A
	N/C	Screen 0V

Fig. 3 PRINTED CIRCUIT INTERCONNECTION (A)

(B)

DISPLAY BOARD to POWER SUPPLY BOARD

Listed from front to back

	Display board	Power supply board
	0V	0V
	Decimal point common	DPC
Screened lead	Dec. pt. 2	S9a2
	Dec. pt. 1	S10b2
	Screen 0V	N/C
Screened lead	Dec. pt. 1	S7a2
	Dec. pt. 3	S8b2
	Screen 0V	N/C
	S3a1	S8f3
Screened lead	S3a3	S7f3
	Screen S2a2	N/C
	S3b2	S9d3
	S3d1	S11c2
Screened lead	S3d3	S8c2
	Screen 0V (adj. to S4c3)	N/C
	Attenuator ATT	ATT
	Const. Current C.C.	C.C.
	Feed back F.B.	F.B.
	0.2V Gain 0.2 G	0.2 G
	Filter FILT	FILT
	0.2Z not connected	0.2Z
	2V GAIN 2G	2G
	Reference REF	REF
	−12V	−12V
	+17V	+17V
	+5V	+5V
	Reset R.S.	R.S.
	+190V	+190V

Fig. 3 PRINTED CIRCUIT INTERCONNECTION (B)

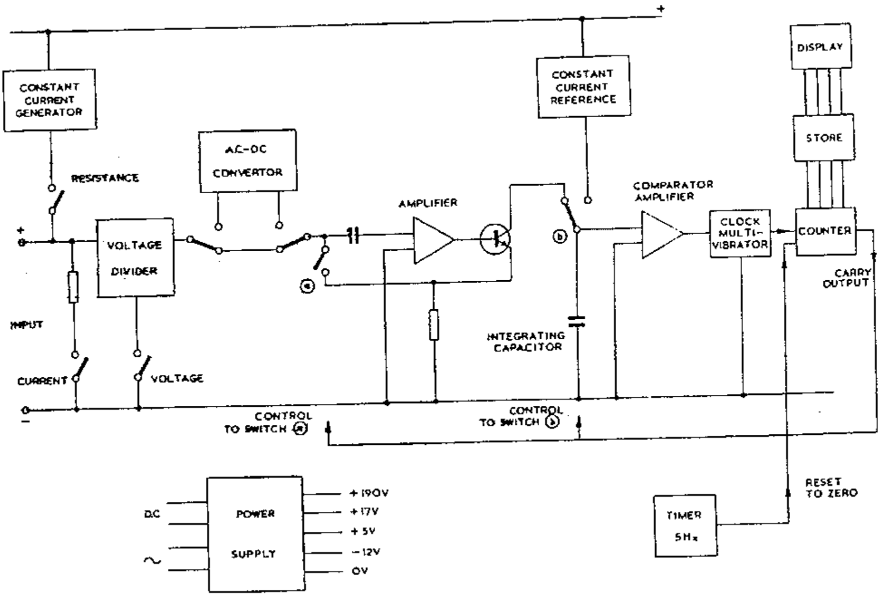


Fig. 4 BLOCK DIAGRAM

25

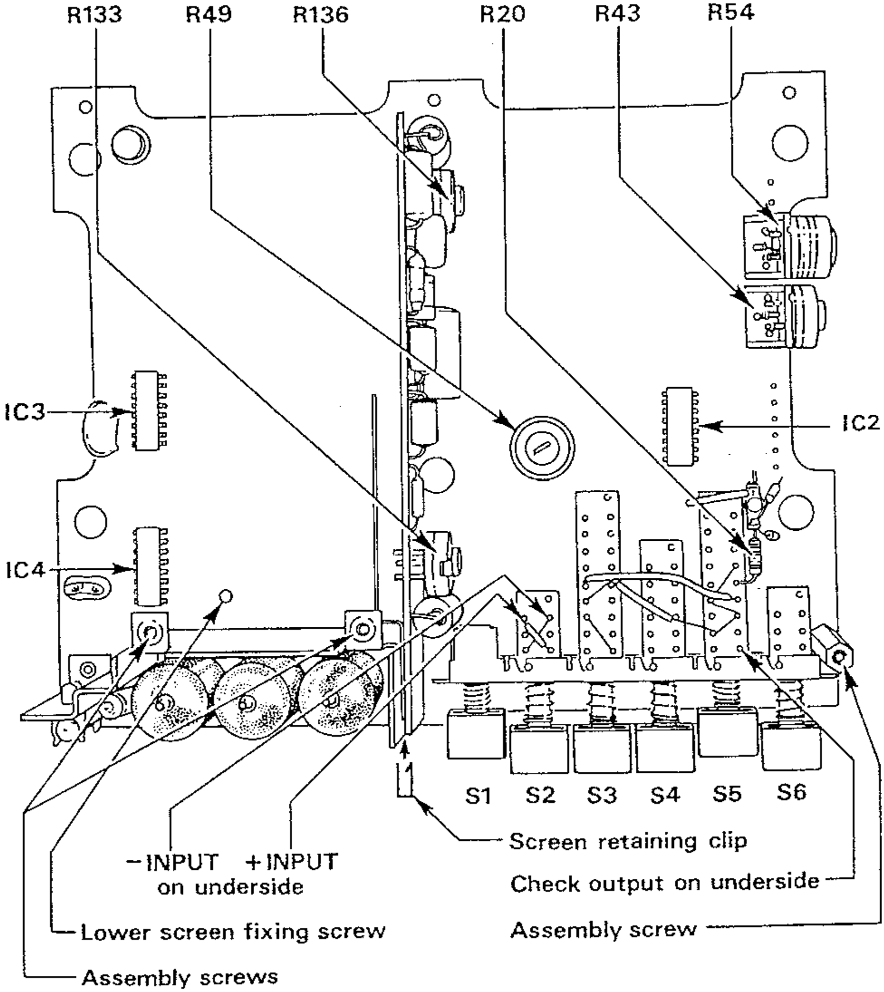


Fig. 5 DISPLAY ASSEMBLY COMPONENT LOCATION

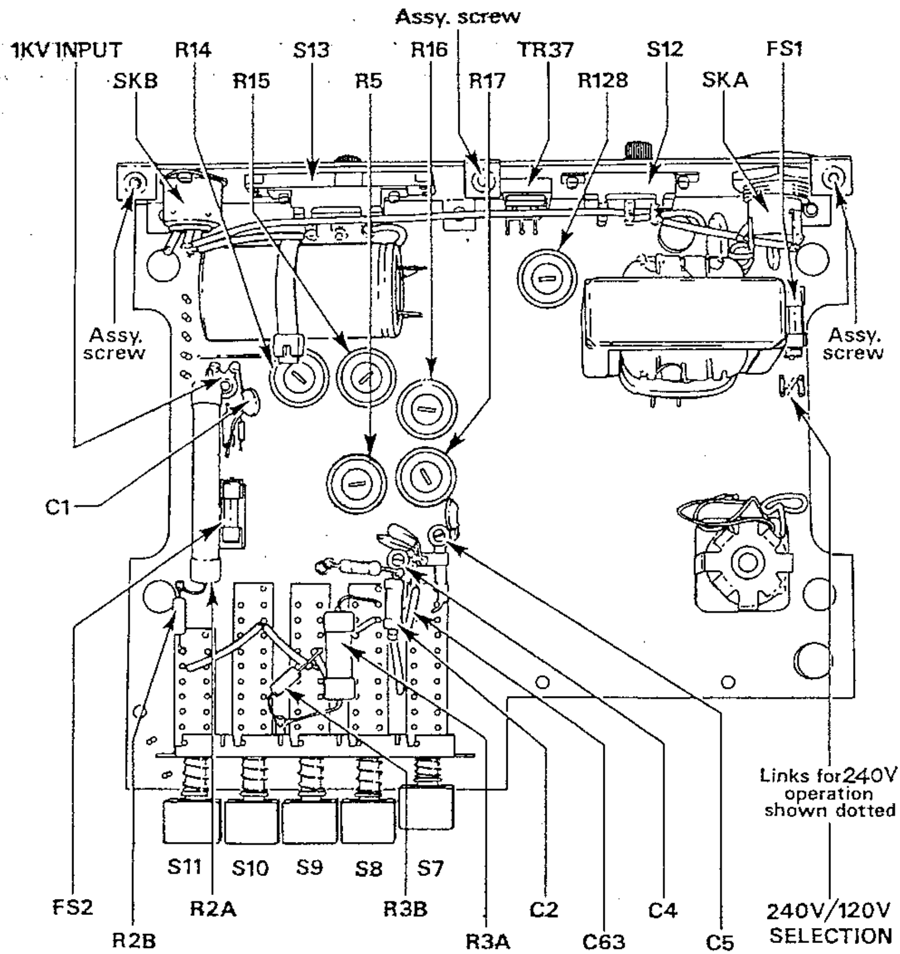


Fig. 6 POWER SUPPLY & ATTENUATOR ASSEMBLY COMPONENT LOCATION

27

This instrument is guaranteed for a period of one year from its delivery to the purchaser, covering the replacement of defective parts other than tubes, semiconductors and fuses. Tubes 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.