MODEL 1501

DIGITAL MULTIMETER

INSTRUCTION MANUAL

KIKUSUI ELECTRONICS CORP.

CONTENTS

1. GENERAL

The KIKUSUI MODEL 1501 Digital Multimeter is a compact, lightweight, multi-purpose digital meter which measures DC and AC voltages and currents, and resistances.
The maximum displayed number is 1999.

The multimeter has an automatic polarity switching function for DC voltage current measurement. The "-" sign is indicated when the measured DC voltage or current is negative.

Measuring ranges are as follows: DC voltage 100 μA ~ 1000 V, AC voltage 100 μV ~ 500 V, DC and AC current 10 μA ~ 199.9 mA, and resistance 0.1 Ω ~ 1.999 MΩ. Thus the Multimeter is featured with high sensitivity and wide measuring range.

The Multimeter employs a dual slope integration system and incorporates an automatic zero erase circuit, eliminating the requirement of manual zero adjustment and ensuring highly stable measurement.

The Multimeter fully employs IC circuits and LED indicators, making itself compact, lightweight, less power consumption, and highly reliable.

The input terminal is isolated from the casing, enabling safe measurement of floated voltage.

2. SPECIFICATIONS

Instrument name:	Digital Multimeter
Model::	MODEL 1501
Measuring function:	DC voltage, DC current, AC voltage, AC current, and resistance
Measuring system:	Dual slope integration system
Display system:	LED readout device
Maximum effective display:	1999
Polarity indication:	Automatic indication (The negative sign alone is indicated.)
Overrange input indication:	Indicated by flickering of readout device
Sampling period:	Approx. 3 times/second
Ambient temperature and humidity:	5°C to 35°C, Less than 85% RH
Dielectric voltage against ground:	250V maximum
Power requirements:	100 V AC, 50/60 Hz, approx. 5VA
Dimensions:	180(W) x 65(H) x 150(D) mm
(Maximum dimensions):	192(W) x 76(H) x 176(D) mm (when portable state: 215(D) mm)
Weight:	Approx. 1.6 kg
Accessories:	Input cable ················ 1 Instruction manual ·········· 1

DC voltage

Range	Accuracy (23°C ± 5°C)	Resolution	Input resistance	Maximum continuous input over-voltage
200 mV	±(0.5% of rdg +2 digit)	100 µV	10 MΩ	150 V
2 V		1 mV		
20 V		10 mV		500 V
200 V		100 mV		
1000 V		1 V		1200 V

Full-scale temperature coefficient: ±0.025 % /°C

DC current

Range	Accuracy (23°C ± 5°C)	Resolution	Internal resistance	Maximum continuous input over-current
20 mA	±(0.5%of rdg + 1 digit)	10 µA	10 Ω	50 mA
200 mA		100 µA	100 Ω	500 mA

Full-scale temperature coefficient: ±0.03 %/°C

AC voltage

Range	Accuracy (23°C ±5°C)	Resolution	Frequency response	Input impedance	Maximum continuous input over-voltage
200 mV	±(1% of rdg + 2 digit)	100 µV	50 Hz ~ 10 kHz	1 MΩ/50pF	150 V
2 V		1 mV			
20 V		10 mV			500 V
200 V	±(2% of rdg +2 digit)	100 mV	50 Hz ~ 1 kHz		
500 V		1 V		10 MΩ/5 pF	600 V

Full-scale temperature coefficient: ±0.05%/°C

AC current

Range	Accuracy (23°C±5°C)	Resolution	Frequency response	Internal resistance	Maximum continuous input over-current
20 mA	±(1% of rdg +1 digit)	10 µA	50 Hz ~ 10 kHz	10 Ω	50 mA
200 mA		100 µA		1 Ω	500 mA

Full-scale temperature coefficient: ±0.05%/°C

Ohmmeter

Range	Accuracy (23°C ± 5°C)	Resolution	Measuring current	Maximum continuous input over-voltage
200 Ω	±(1% of rdg + 2 digit)	0.1 Ω	10 mA	50 V
2 kΩ		1 Ω	1 mA	
20 kΩ		10 Ω	100 µA	
200 kΩ		100 Ω	10 µA	
2 MΩ		1 kΩ	1 µA	

Full-scale temperature coefficient: ±0.03%/°C

3. OPERATION METHOD

3.1 EXPLANATION OF THE FRONT PANEL

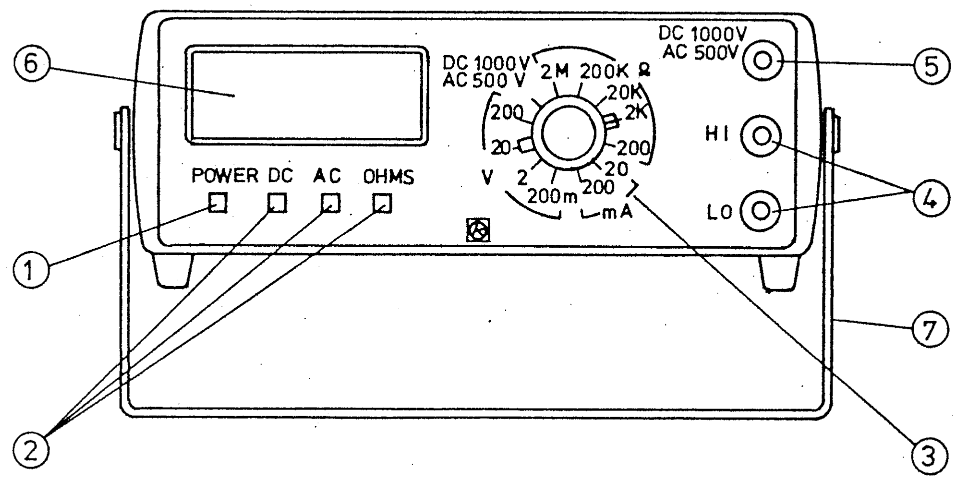

Fig. 3-1

(1) POWER

This switch is for ON-OFF switching of the instrument main power is turned ON as the button is depressed and locked; it is turned OFF as the button is depressed again and unlocked.

(2) FUNCTION SELECTOR SWITCHS

The DC, AC, or OHMS button is depressed to select measuring functions, respectively, of the instrument.

(3) RANGE SELECTOR SWITCH

This rotary switch is for selection of measuring ranges. The figures on the panel indicate the full-scale values for voltage, current, and resistance measurement.

(4) HI, LO

These are input terminals for the measured signal, the HI terminal for high impedance line and the LO terminal for low impedance line. (When the measured voltage is higher than 200 V, used the DC 100 V/ AC 500 V input terminal.)

Both HI and LO terminals are isolated from the caseing, enabling measurement of floated voltage.

The maximum dielectric voltage against the case is 250 V.

(5) DC 1000 V
AC 500 V

When the measured voltage is higher than 200V DC or AC, the measured voltage must be applied between this high voltage terminal and the LO terminal.

(6) DIGITAL DISPLAY DEVICE (READOUT DEVICE)

This device employs LED's for decimal 4-digit display for a range of 0 ~ 1999. When an over-range input is applied, this device flickers. The decimal point shifts in response to the RANGE SELECTOR switch. The negative sign "-" is displayed when the polarity of the applied DC voltage or current is negative.

(7) HANDLE

Other than for carrying the instrument , this handle is used as a stand for the instrument as illustrated in order to obtain a better viewing angle. When using the handle for this purpose, lock the handle in the direction indicated as LOCK at the clamping position of the handle.

3.2 EXPLANATION OF THE REAR PANEL

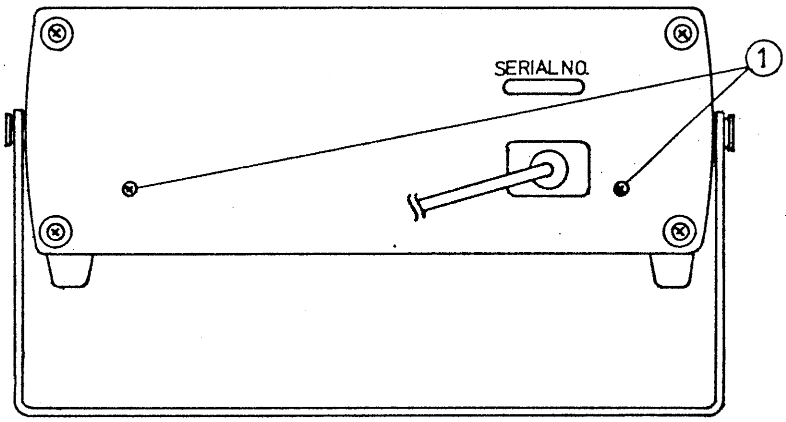

Fig. 3-2

(1) CLAMPING-SCREW OF THE CASING

The casing is fixed to the chassis with these two clamping-screws. To remove the casing, remove these two screws and, then, pull the casing backward.

3.3 PREPARATIONS FOR MEASUREMENT

(1) Turn-off the POWER switch on the front panel of the instrument.

(2) Connect the power cord to an AC line receptacle(100 V, 50/60 Hz AC).

(3) Turn-on the POWER switch. The readout device may remain unstable for several tens seconds after turning on the instrument power, but this is a transient state caused by turning-on of the instrument power and is not as abnormal indication.

(4) After turning-on the instrument power, allow several minutes of stabilization period. If the best accuracy is required, allow more than 30 minutes of stabilization period.

3.4 MEASURING PROCEDURES

3. 4.1 DC voltage measurement

(1) Depress the DC button of the FUNCTION SELECTOR switches. Set the RANGE SELECTOR switch in a position corresponding to the measured voltage.

(2) With the input cable (supplied as an accessory), apply the measured voltage between LO terminal and HI terminal (or DC 1000 V/AC 500 V terminal if the measured voltage is higher than 200 V DC). If the distance between the instrument and the signal source is more than can be covered by the input cable supplied, use a quality shielded cable.

(3) If the measured voltage level is unpredictable, start with the highest range and gradually lower the range value displayed on the readout device becomes less than 1999.

3.4.2 DC Current Measurement

(1) Depress the DC button of the FUNCTION SELECTOR switches. Set the RANGE SELECTOR switch in a position corresponding to the measured current.

(2) Apply the measured current between HI and LO terminals with the input cable. If the measured current level is unpredictable, start with the 200 mA range.

3.4.3 AC Voltage Measurement

(1) Depress the AC button of the FUNCTION SELECTOR switches. Set the RANGE SELECTOR switch in a position corresponding to the measured voltage.

(2) Apply the measured voltage between LO terminal and HI terminal (or DC 1000 V/AC 500 V terminal if the measured voltage is higher than 200 V AC) with the input cable.

(3) If the measured voltage level is unpredictable, start with the highest range and gradually lower the range until the value displayed on the readout device becomes less than 1999.

3.4.4 AC Current Measurement

(1) Depress the AC button of the FUNCTION SELECTOR switches. Set the RANGE SELECTOR switch in a position corresponding to the measured current.

(2) Apply the measured current between HI and LO terminals. If the measured current level is unpredictable, start with the 200mA range.

3.4.5 RESISTANCE MEASUREMENT

(1) Depress the OHMS button of the FUNCTION SELECTOR switches. Set the RANGE SELECTOR switch in a position corresponding to the measured resistance.

(2) Connect the measured resistance element or circuit to LO and HI terminals. If the measured resistance is unpredictable, start with the 2 MΩ range and gradually lower the range.

(3) When an input cable longer than the supplied one is used, pay attention to errors caused by the resistance of the cable itself at lower resistance range or to errors caused by the insulation for the cable at higher resistance range.

4. OPERATING PRINCIPLE

4.1 BASIC MEASURING PRINCIPLE

(Refer to the block diagram in Fig.4-1.)

The MODEL 1501 Digital Multimeter basically is a DC voltmeter. AC voltage or resistance is converted in to DC voltage before measurement.

For DC current measurement, the current is fed to a resistor and the voltage drop produced across the resistor is measured.

For AC voltage measurement, the voltage is divided with a voltage divider; for AC current measurement, the current is fed to a resistor to produced a voltage drop. The divided voltage or the drop voltage is converted into a DC voltage by an AC/DC converted DC voltage is measured.

Resistance measurement is made by converting with an ohm converter which consists of a ratio measuring circuit and by measuring the converted DC voltage.

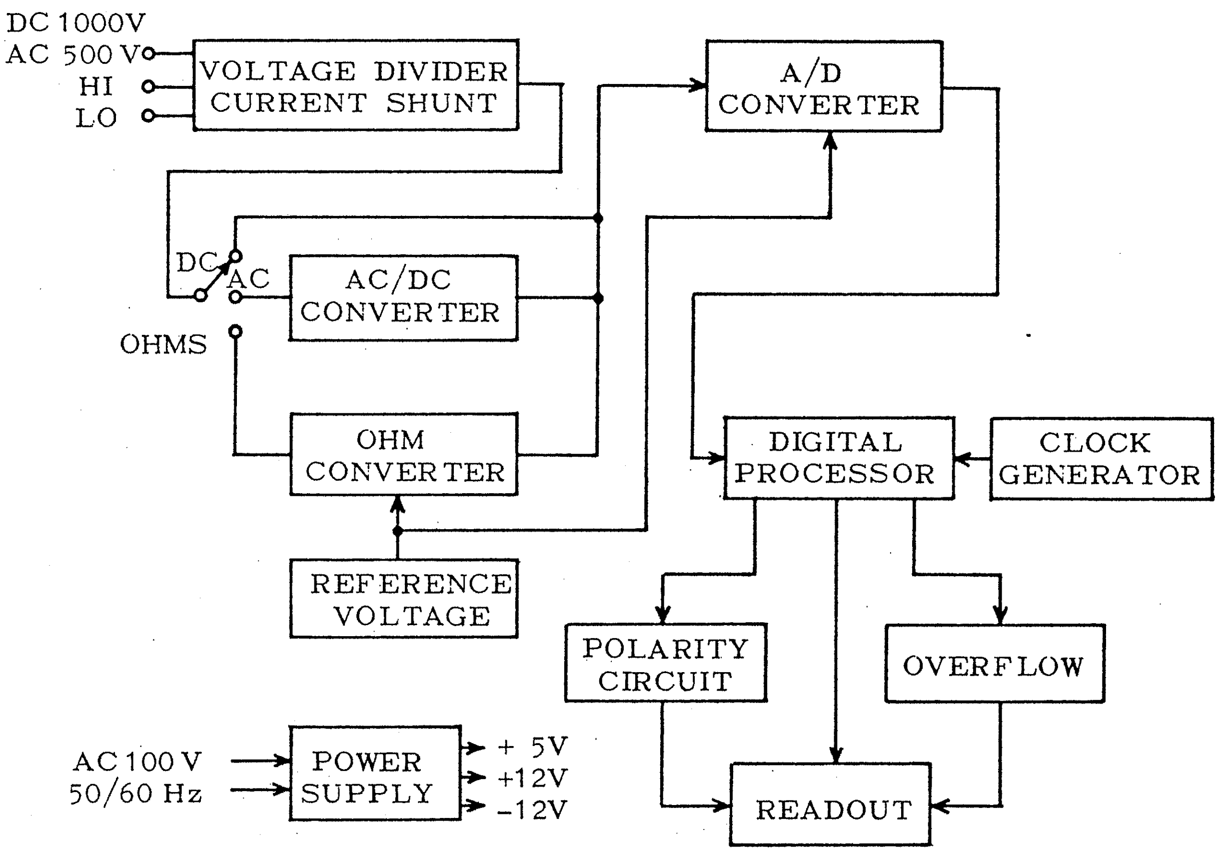

Fig. 4-1 Block diagram of the Digital Multimeter

4.2 VOLTAGE DIVIDER AND CURRENT SHUNT

The voltage divider and current shunt are used in common for DC/AC voltages and DC/AC currents. The voltage divider incorporates also an AC voltage dividing circuit consisting of compensating capacitors. For resistance measurement a reference resistor circuit independent of the above is provided.

4.3 AC/DC CONVERTER

This unit consists of an amplifier (approx. 20 dB) and a linear detector. It converts an AC input voltage into a DC output in good linearity.

4.4 OHM CONVERTER

The A/D converter of this instrument compares the input voltage with the reference voltage and produces an output signal which is proportional to the ratio between the two voltages. Referring to the block diagram of the ohm converter shown in Fig. 4-2, as the measured resistance value Rx varies, the ratio between V_{IN} and V_{REF} varies, the converter output varies in direct proportion to the variation of the ratio and, thus, the resistance value is measured as the converter output represents the measured resistance.
The measuring accuracy is unaffected, theoretically, by variation of reference voltage V_{REF}, thereby providing a high reference voltage rejection ratio.

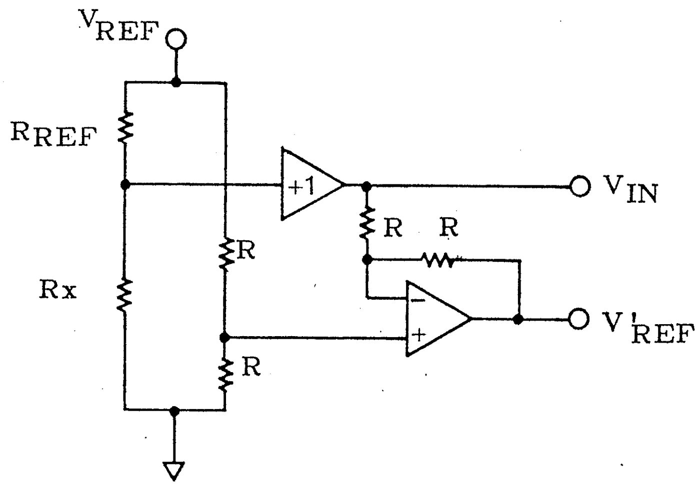

Fig. 4-2

4.5 A/D CONVERTER

The A/D converter comprises an integrator, an analog comparator which transfers the state of the integrator, an up-down logic circuit which controls pulse-width modulation of the reference voltage with respect to the state of the comparator, and an automatic zero erase circuit. The automatic zero erase circuit operates in a time-division manner between measuring period and automatic zero compensation period. The ratio between the two periods for each cycle is 2:1.
In the automatic zero compensation period, internal offset and drift are converted into an automatic zero compensation store voltage and the A/D converter is maintained in an automatically zero compensated balanced state with respect to the store voltage in order that offset and drift are baranced out and do not cause errors in the measuring period of the next cycle.
In the measuring period, the input voltage is applied to the buffer amplifier and its output is applied to the integrator.

Next, the comparator detects the disturbance caused on the balanced state (which existed during the automatic zero compensation period) by application of the input voltage, and conveys the detected disturbance information to the digital processor.

At the digital processor the up-down logic signal is generated in order to return the integrator output to the store voltage, the pulse width of the reference voltage applied to the integrator is so controlled that the integrator output restores the balanced state, and the BCD counter (which is synchronized to the up-down logic signal) operates to convert the analog input voltage into a digital output signal.

4.6 DIGITAL PROCESSOR

The digital processor comprises a control circuit, a time base counter, BCD counter, latch, multiplexer circuit, etc..

The control circuit controls the timing signal and the up-down logic signal with respect to the state of the comparator output. The time base counter provides, with respect to the clock signal, the time base signal for switching between measuring period and automatic zero compensation period.

The digitalized data is loaded in the latch, is converted into a BCD signal by the multiplexer, and is displayed on the readout device.

4.7 REFERENCE VOLTAGE

The reference voltage is for the A/D converter and ohm converter. It is a highly stable DC voltage of approximately 6.5 V.

4.8 CLOCK GENERATOR

This unit generator the clock signal for processing of digital signals. The unit is a multivibrator which oscillates at approximately 20 kHz.

4.9 POWER SUPPLY

This unit provides regulated DC supply voltages of +5 V, +12 V, and -12 V.

5. MAINTENANCE

5.1 REMOVING THE CASING

Disconnect the AC power cord from the AC line receptacle.

Remove the two clamping-screws on the rear panel.

Pull out the front panel slowly and carefully.

5.2 LAYOUT OF ADJUSTMENT POTENTIOMETERS

Locations of adjustment potentiometers are shown in Fig. 5-1.

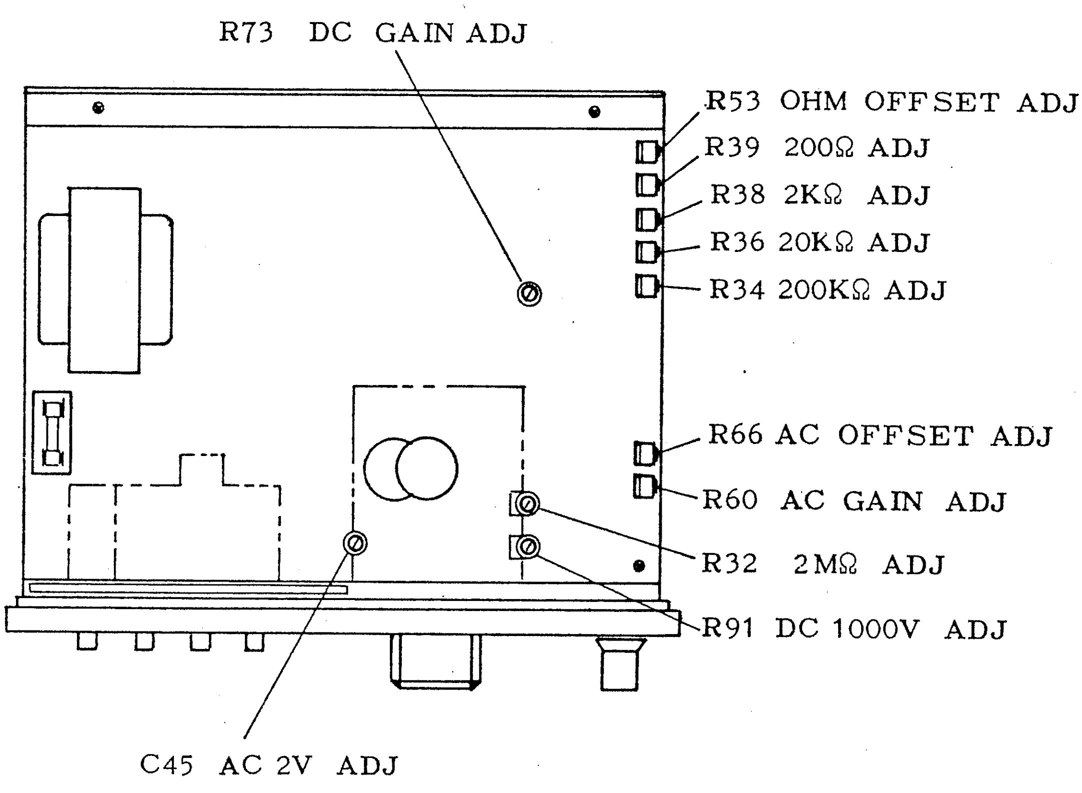

Fig. 5-1

5.3 CALIBRATION

It is highly recomendable th calibrate the instrument periodically. Calibration should be made in an ambient temperature of approximately 23 C, after allowing more than 30 minutes of stabilization period.

5.3.1 Check of DC Voltage

Check the DC voltages at the points shown in Table 5-1.

Check point (with respect to ground)	Normal indication
+5 V supply: Emitter of transistor Q1	+4.5 V to +5.5 V
+12 V supply: Emitter of transistor Q4	+11 V to +13 V
-12 V supply: Anode of zener diode CR5	-11 V to -13 V
+6 V supply : Cathode of zener diode CR4	+6 V to +7 V

Table 5-1

5.3.2 Check of Clock Generator

Measure the oscillating frequency picking up a signal between the collector of transistor Q14 and the ground. The normal indication is 20 kHz ± 4 kHz.

5.3.3 Calibration of DC Voltage Ranges

(1) Depress the DC button of the FUNCTION SELECTOR switches, set the RANGE SELECTOR switch in the 200 mV position, and check that the readout device displays zero as the HI LO terminals are shorted.

(2) Set a standard DC voltage generator (accuracy better than 0.05%) at +199.0 mV. Apply this voltage to the input terminals of the Multimeter and so adjust potentiometer R73 that the readout device indicates +199.0 mV.

(3) Set the RANGE SELECTOR switch in the DC 1000 V position. Apply a standard voltage of +1000 V to input terminals LO and DC 1000 V and so adjust potentiometer R91 that the readout device indicates +1000 V.

5.3.4 Calibration of AC Voltage Ranges

(1) Depress the AC button of the FUNCTION SELECTOR switches and set the RANGE SELECTOR switch in the 200 mV position. Short the HI and LO input terminals and so adjust potentiometer R66 that the readout device indicates zero.

(2) Set a standard AC voltage generator (accuracy better than 0.1%) at 1 kHz, 199.0 mV. Apply this signal to the Multimeter and so adjust potentiometer R60 that the readout device indicates 199.0 mV.

(3) Set the standard AC voltage generator at 10 kHz, 1.990 V and the Multimeter at the 2 V range. Apply the standard voltage to the Multimeter and so adjust semi-fixed capacitor C45 that the readout device indicates 1.990 V.

5.3.5 Calibration of Resistance Ranges

(1) Depress the OHMS button of the FUNCTION SELECTOR switches and set the RANGE SELECTOR switch in the 2 MΩ position. Short the input terminals HI and LO, and so adjust potentiometer R53 that the readout device indicates zero.

(2) Set the RANGE SELECTOR switch in the 200 Ω position. Connect a standard resistance box (accuracy better than 0.1%) set at 199.0 Ω to the Multimeter, and so adjust potentiometer R39 that the readout device indicates 199.0 Ω.

(3) In the same manner as above, set the RANGE SELECTOR switches in the 2 kΩ, 20 kΩ, 200 kΩ and 2 MΩ positions and connect to the Multimeter the standard resistance box set at 1.990 kΩ, 19.90 kΩ, 199.0 kΩ and 1.990 MΩ, and adjustment with potentiometers R38, R36, R34 and R32, respectively.