ADVANTEST®

ADVANTEST CORPORATION

INSTRUCTION MANUAL

TR8601

High Megohm Meter

MANUAL NUMBER 0662 EB 105

This product has been discontinued.
The Operation Manual is provided by ADC Corporation under the agreement with Advantest Corporation.

TR 8601

HIGH MEGOHM METER

INSTRUCTION MANUAL

CONTENTS

1. GENERAL DESCRIPTION

TR 8601 HIGH MEGOHM METER is an insulation resistance meter that measures insulation resistance at a maximum detection sensitivity of $1 \times 10^{16}\Omega$ (1000V impressed) and small currents at 1×10^{-13} A by means of a regulated high-voltage power supply and MOS-FET picoam meter circuit.

The meter has a single scale. The resistance value can be directly read, without regard to the impressed voltage, especially in resistance measurement. Measurement range displayed on a 7 segment light emitting diode (LED) eliminates the reading errors that frequently occur with other insulation resistance meters, and makes rapid measurement simple. Impressed voltage is 10V ~ 1000V.

2. RATINGS

2-1 Resistance Measurement

(1) Measurement ranges

$0.5 \times 10^{6}\Omega \sim 2 \times 10^{16}\Omega$

$10^{6}\Omega \sim 10^{13}\Omega$ ($2\times10^{14}\Omega$ MAX)	10V impressed
$10^{7}\Omega \sim 10^{14}\Omega$ ($2\times10^{15}\Omega$ MAX)	25, 50, 100V impressed
$10^{8}\Omega \sim 10^{15}\Omega$ ($2\times10^{16}\Omega$ MAX)	250, 500, 1000V impressed

Measurement range is displayed on a 7 segment LED.

(2) Measurement accuracy

Measurement impressed voltage	Range (meter center value)	Measurement range	Measurement accuracy (meter center value)
10V	$1\times10^{6}\sim10^{13}\Omega$	$5\times10^{5}\sim2\times10^{14}\Omega$	±4%+1% ($10^{6}\sim10^{11}$ range) ±8%+1% ($10^{12}\sim10^{13}$ range)
25V	$1\times10^{7}\sim10^{14}\Omega$	$5\times10^{6}\sim2\times10^{15}\Omega$	±4% ($10^{7}\sim10^{12}$ range)
50V	$1\times10^{7}\sim10^{14}\Omega$	$5\times10^{6}\sim2\times10^{15}\Omega$	±8% (10^{13} range)
100V	$1\times10^{7}\sim10^{14}\Omega$	$5\times10^{6}\sim2\times10^{15}\Omega$	±10% (10^{14} range)
250V	$1\times10^{8}\sim10^{15}\Omega$	$5\times10^{7}\sim2\times10^{16}\Omega$	±4% ($10^{8}\sim10^{13}$ range)
500V	$1\times10^{8}\sim10^{15}\Omega$	$5\times10^{7}\sim2\times10^{16}\Omega$	±8% (10^{14} range)
1000V	$1\times10^{8}\sim10^{15}\Omega$	$5\times10^{7}\sim2\times10^{16}\Omega$	±10% (10^{15} range)

(3) Offset current

25V, 250V	impressed	4% of F.S. or less	
50V, 500V	impressed	2%	"
10V, 100V 1000V	impressed	1%	"

(4) Input resistance

Range \ Impressed voltage	10V	25~100V	250~1000V
10^6 Ω	10^4 Ω	-	-
10^7 Ω	10^5 Ω	10^4 Ω	-
10^8 Ω	10^6 Ω	10^5 Ω	10^4 Ω
10^9 Ω	10^7 Ω	10^6 Ω	10^5 Ω
10^{10} Ω	10^8 Ω	10^7 Ω	10^6 Ω
10^{11} Ω	10^9 Ω	10^8 Ω	10^7 Ω
10^{12} Ω	10^{10} Ω	10^9 Ω	10^8 Ω
10^{13} Ω	10^{11} Ω	10^{10} Ω	10^9 Ω
10^{14} Ω	-	10^{11} Ω	10^{10} Ω
10^{15} Ω	-	-	10^{11} Ω

2-2 DC Current Measurement

(1) Measurement range 2×10^{-12}A ~ 2×10^{-5}A full scale

(2) Measurement accuracy

10^{-5}~10^{-10}A ranges ±3% ± meter accuracy

10^{-11}A range ±7% "

10^{-12} A range ±8% "

(3) Response speed

10^{-5} ~ 10^{-12}A range 5s or less

However, the time constant of the specimen electrostatic capacitance and the input resistance of the TR 8601 is added to this.

(4) Offset current

2×10^{-14} A or less

Meter noise

1×10^{-14}A or less (on 10^{-12}A range)

(5) Outputs

AMP OUT (2V at meter F.S.) Internal resistance 100Ω

REC OUT (20mV at meter F.S.) Internal resistance 10Ω

o Both are linear outputs for current value.

o Use by floating.

(6) Meter accuracy

±1.5% of full scale

2-3 General Specifications

Input system	Floating
Dielectric strength	Between [GUARD]-[GND] 500V
Warm-up time	1hr (initial drift stabilization time)
Operating ambient environment	Temperature range 0 ~ 40°C Humidity 80% or less
Storage ambient temperature range	-20°C ~ 70°C
Power requirement	AC100V ±10% or AC230v $^{+8}_{-10}$ % on specification.
Power consumption	Approx 20VA
Dimensions	283(W) X 115 (H) X 290 (D)
Weight	

3. COMPOSITION

1)	TR 8601 HIGH MEGOHM METER	1
2)	Input cable BI-002	1
3)	Power cord MP-19	1
4)	High voltage cord MO-22	1
5)	wrench 3mm	1
6)	Fuse T0.25A (AC 100V) or T0.125A (AC230V)	2
7)	Instruction manual	1

4. OPERATING INSTRUCTIONS

4-1 Inspection

Upon receiving the TR·8601 inspect it for any damage that may have occurred during shipment.

If the instrument is damaged, or does not operate to specifications, contact your nearest Takeda Riken representative.

4-2 Preparations and General Precautions Prior to Use

1) Always set the [POWER] switch to the [OFF] position before connecting the TR·8601 to the AC power line.
2) Use the instrument with an AC90V ~ 110V (50/60Hz) power source.
3) Since the meter will deflect considerably when the [POWER] switch is set to the [ON] position, always set the [METER] switch to the [OFF] position, and the [ZERO CHECK] switch to the [ZERO CHECK] position before turning the power on.
4) The initial drift will cause the zero point to shift for a while after the power is turned on. Therefore, warm-up the instrument for about 1 hour for perform stable measurement. Periodically adjust the zero point with the [ZERO ADJ] control during measurement.
5) A maximum voltage of 1000V appears at the [HIGH VOLTAGE] terminals. Protection is provided by a short-circuit protection circuit, but since a fairly large shock can be received, always set the [HIGH VOLTAGE] switch to the [OFF] position beforehand, especially when connecting the specimen.
6) The TR 8601 measures extremely small currents, and even a little induced noise will make measurement impossible.
   Therefore, use the accessory cable as the input cable, and always shield the specimen at the [GUARD] side.

4-3 Panel Description

The panel of the TR-8601 HIGH MEGOHM METER is shown in Fig. 4-1 on P21.

① [POWER] switch

When this switch is set to the upper position it is turned [ON], power is supplied to the circuits, and the instrument is placed into the operative state.

② Meter zero adjustment screw

This screws adjusts the zero point of the meter.

③ [METER] switch

This switch switches the polarity of the meter. Set it to the [+] position for "+" input, and to the [-] position for "-" input.
When this switch is set to the [OFF] position, the meter is disconnected from the circuit.
Resistance measurement by internal power source is performed on the "+" range.

④ [ZERO CHECK] switch

When this switch is set to the [ZERO CHECK] position, the input circuit is connected to [GUARD] thru a 1MΩ resistance. Zero point check of the circuit is performed in this state. The input resistance at this time is this 1MΩ plus the input resistance of each range, connected in parallel.

⑤ [Ω-A] switch

This switch switches between current measurement and resistance measurement. Current measurement is performed at the [A] position, and resistance measurement is performed at the [Ω] position.

⑥ [SUPPLY VOLTAGE] switch

This switch switches the supply voltage impressed on the specimen. Voltages are 10, 25, 50, 100, 250, 500 and 1000V, and are output at the terminal of item (8) below.

Output current is a maximum 2mA. An overcurrent protection circuit is built in.

(7) [HIGH VOLTAGE] lamp

This lamp indicates that a voltage is being generated at the terminal of item (8) below.

(8) [HIGH VOLTAGE] terminal

When the switch of item (9) below is set to the ON position, the voltage set at the switch of item (6) above appears between this terminal and the GUARD terminal. Since a maximum 1000V is output, handle this terminal with care. Output polarity is (+).

(9) [HIGH VOLTAGE] switch

This switch controls the power impressed on the specimen.
The TR 8601 is set to the DISCHARGE, CHARGE and MEASURE state by means of this switch and the switch of item (4) above.

TR 8601 state	HIGH VOLTAGE switch	ZERO CHECK switch
DISCHARGE	OFF	ZERO CHECK
CHARGE	ON	ZERO CHECK
MEASURE	ON	MEASURE

(10) [INPUT] terminal

This is the ammeter input terminal. The outside of the connector is GUARD.

(11) [GUARD] terminal

This terminal is internally connected to the LOW side of the ammeter circuit. It is normally connected to GND by a shorting bar.
When performing floating measurement disconnect the shorting bar, and apply the input between the INPUT and GUARD terminals.

⑫ [GND] terminal

This is the instrument frame ground terminal. Always ground this terminal when performing floating measurement.

⑬ [ZERO ADJ] control

This is the zero point adjuster. When this control is turned clockwise, circuit zero adjustment is performed at the "+" side, and when it is turned counterclockwise, circuit zero adjustment is performed at the "−" side.

⑭ [RANGE] switch

This switch switches the measurement range. At current measurement, the range is determined by this switch, and at resistance measurement, the range is determined by this switch and the SUPPLY VOLTAGE switch of item ⑦.

⑮ RANGE, FUNCTION indicator lamp

The range set at the switch of item ⑭ above is displayed here on a 7 segment LED. Moreover, "A" is displayed at the right of this lamp at current measurement, and "Ω" is displayed at the right of this lamp at resistance measurement.

This lamp also serves as the power pilot lamp.

⑯ Meter

This is a single scale meter having equally spaced graduations for current and inverse number graduations for resistance. Accuracy is 1.5%.

⑰ [REC OUT] terminal

This is a recorder use output terminal. A 20mV voltage is output from this terminal at measurement range full scale (10mV at meter center value 1×10^n). Its output resistance is 10Ω. Use a recorder having a floating input.

The polarity is switched with the [METER] switch.

A voltage is not output from this terminal when the [METER] switch is set to the [OFF] position.

⑱ [AMP OUT] terminal

The output voltage of the amplifier is output directly from this terminal. A 2V voltage is output at meter full scale. Since the amplifier may be damaged if this terminal is shorted, be careful not to short it.

Connect this terminal by floating connection.

⑲ [GND] terminal

This is the instrument frame ground terminal.

⑳ [AC 230V]

This is the AC power input terminal. Use with an ~~AC100V ±10%~~ (AC line voltage $^{+8}_{-10}$%) power source.

㉑ [T0.25A] AC100V [T0.125A] AC230V

This is the AC power line fuse. Time lag fuse is entered in this holder.

㉒ [REMOTE] terminal

This terminal is used to set the ZERO CHECK and HIGH VOLTAGE switches from the outside.

The pin numbers of the REMOTE terminal are shown below.

OV	1	8	OV
	2	9	
	3	10	
	4	11	
ZERO CHECK (SHORT)	5	12	ZERO CHECK (SHORT)
HIGH VOLTAGE	6	13	HIGH VOLTAGE
	7	14	

The ZERO CHECK and HIGH VOLTAGE switches can be set by shorting the SHORT, or HIGH VOLTAGE, terminal and OV terminal of the above figure. At this time, set the ZERO CHECK switch on the front panel to the

MEASURE position and the HIGH VOLTAGE switch to the OFF position.
When a transistor or other electronic switch is used as the switch to short the terminals, use a device having a rating of 15V, 50mA or greater.
Use a Daiichi Electronics microribbon connector 57 Series 57-30140 as the connector.

4-4 Measurement Method

(1) Zero adjustment

1) Set the [METER] switch to the [OFF] position and [ZERO CHECK] switch to the [ZERO CHECK] position, Then set the [POWER] switch to the [ON] position.

2) Set the [METER] switch to the [+] position, and adjust the [ZERO ADJ] control so that the meter pointer deflects to [0].

(2) Measurement operation

1) Set the [ZERO CHECK] switch to the [ZERO CHECK] position and the [HIGH VOLTAGE] switch to the [OFF] position. Then connect the accessory cable to the [INPUT] terminal and [HIGH VOLTAGE] terminal.

2) Connect the end of the cable to the specimen as shown in Fig. 4-2 Measurement method on P10.

3) Set the [Ω-A] switch to the [Ω] position at insulation resistance test, and to the [A] position at leakage current test.

4) Set the voltage impressed on the specimen at the [SUPPLY VOLTAGE] switch.

5) Turn the [RANGE] switch fully counterclockwise.

6) When the [HIGH VOLTAGE] switch is set to the [ON] position, the instrument is placed into the CHARGE state. If the [ZERO CHECK] switch is then set to the [MEASURE] position, the instrument is placed into the MEASURE state.

Set the [RANGE] switch to the range at which the meter indication is suitable, and read the indication at that time. When the meter pointer has deflected in the opposite direction at this time, reverse the polarity of the [METER] switch.

7) Set the [ZERO CHECK] switch to the [ZERO CHECK] position and the [HIGH VOLTAGE] switch to the [OFF] position to set the instrument to the DISCHARGE state. After the charge on the specimen has been discharged, remove the specimen.

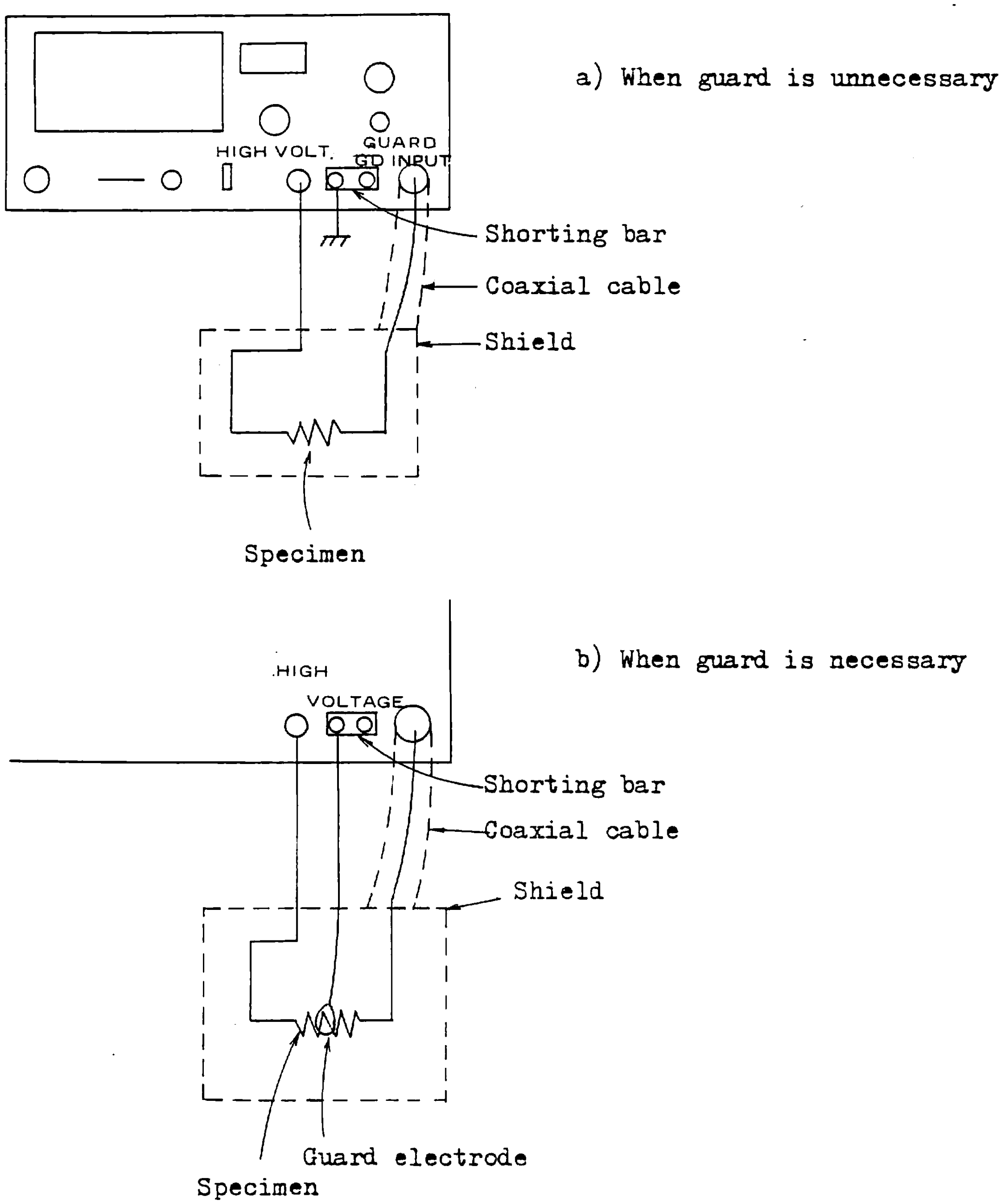


Fig. 4-2 Measurement method

5. CALIBRATION

5-1 Instruments Used

Digital voltmeter TR 6355, etc.

Standard resistance box TR 45, etc.

5-2 Impressed Voltage Calibration

1) Connect the [HIGH VOLTAGE] terminal and [GUARD] terminal of the digital voltmeter to the [Hi] and [Lo] terminals, respectively.
2) Set the [SUPPLY VOLTAGE] switch to the [10V] position, and adjust VR ① of Fig. 5-1 for a reading of 10.00V at the digital voltmeter.
3) Adjust the VR ② to ⑦ from [25V] to [1000V] in the same manner.

5-3 Offset Adjustment

1) Set the [Ω-A] switch of the TR-8601 to the [Ω] position, and the [SUPPLY VOLTAGE] switch to the [25V] position.
2) Set the [ZERO ADJ] control to the center position.
3) Adjust VR ⑧ for a meter reading of "zero".

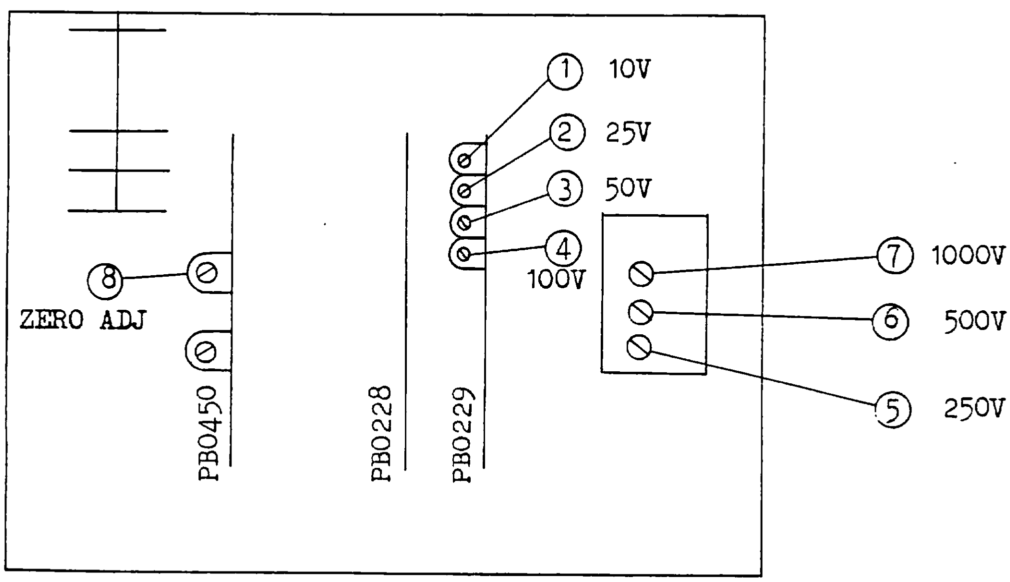


Fig. 5-1 Positions of calibration VR

6. APPLICATION

6-1 Measurement Precautions

Insulation resistance can be found by impressing a voltage on the specimen and dividing the current at this time by the impressed voltage. However, at insulation resistance, the current flowing through the specimen is μA order, even if a high voltage is impressed on the specimen.

A pA order current flows in an especially high insulation resistance specimen. To measure such a minute current, measurement must be performed by shielding the specimen and signal line and using a special cable and observing various other precautions.

(1) Shield

When performing insulation resistance measurement, the point requiring utmost attention is the affect of induced noise. "Induced noise" is mainly caused by the entry of the commercial power frequency at the signal line by capacitance coupling of the AC power line and the specimen or signal line.

Generally, this noise has almost no affect on measurement at resistance values up to about 100MΩ, but at values above this, the specimen must be shielded as shown in Fig. 6-1 so that the entire induced current flows in the shield (GUARD) and not flow to the INPUT.

If measurement is affected by induction, the meter deflection will not change, even when the range is switched, the meter pointer will vibrate slightly, or other phenomena will occur.

When this happens, check if the shield is perfect.

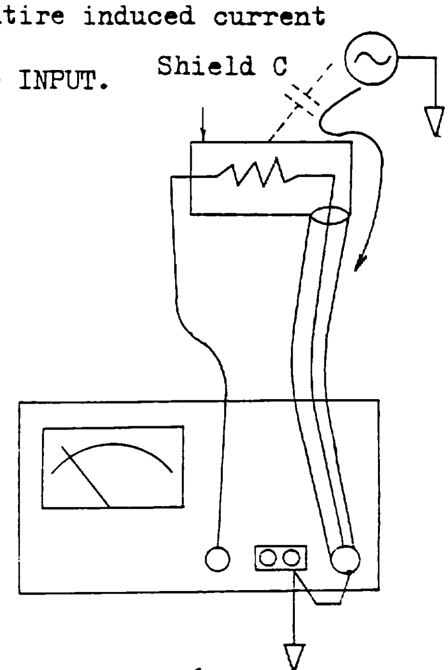


Fig. 6-1

(2) Input cable

Since the current flow is extremely small, as previously mentioned, and the impedance is extremely high, the connection from the shield case to the INPUT terminal of the TR 8601 is affected by induced noise. Therefore, a shielded input cable must be used.

The insulation resistance of this cable must be a minimum $10^{14}\Omega$, because the input impedance of the TR 8601 is a maximum $10^{11}\Omega$.

Furthermore, the small current produced when the cable has been vibrated when measuring such a small current has an affect on measurement.

The high insulation resistance, low noise coaxial cable supplied with the TR 8601 should be used as the input cable. The cable should be as short as possible from the standpoints of cable noise, insulation, etc. A long cable will cause the measurement response to increase noticeably because the electrostatic capacitance C of the cable is in parallel with the input resistance of the TR 8601 and it charged through the impedance of the specimen (Fig. 6-2). The cable must also be made as short as possible for this reason.

When the cable must be especially long, please contact Takeda Riken.

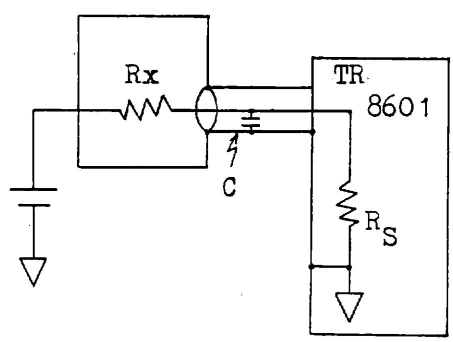


Fig. 6-2

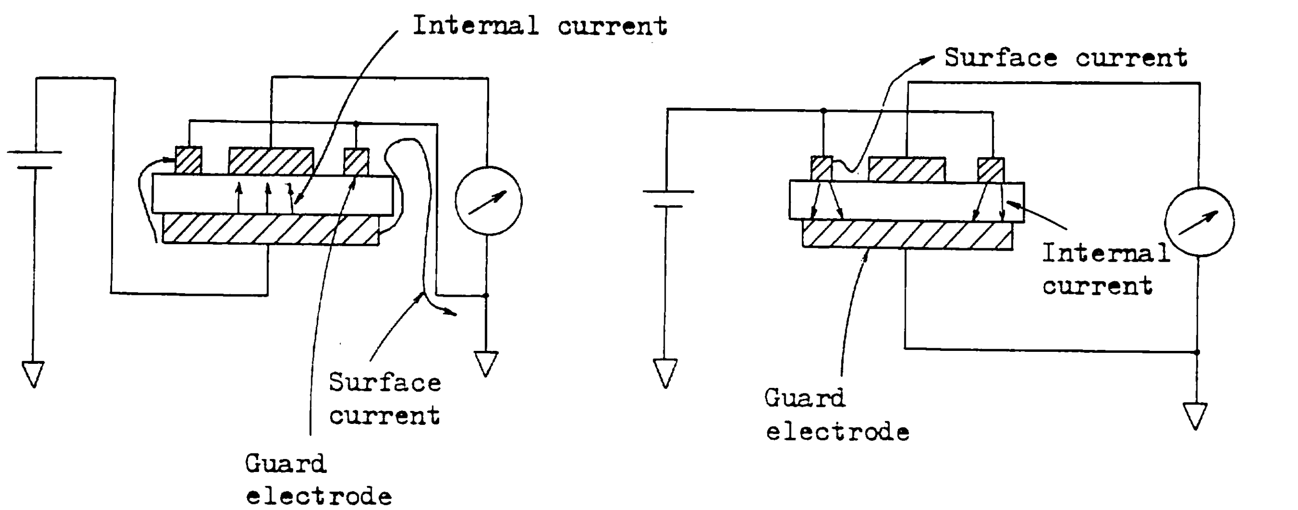
(3) Connecting the specimen

Connection of the specimen inside the shield case is performed with a clip cord, etc.

However, if the [INPUT] side clip and cord touch the shield case or impressed voltage side cord, etc. measurement error will occur.
The cord from the specimen to the [INPUT] side cable must be made of teflon or other high insulation material, as required, and the number of insulators must also be as small as possible.
Note that the measured value will vary and stable measurement will be impossible if the specimen moves inside the shield case when measuring switches, capacitors or other single specimens.

(4) Guard electrode

When insulation resistance is measured without an electrode attached to the specimen, the total value of the resistance (surface resistance) of the surface of the specimen and the resistance (volume resistance) of the interior of the specimen is measured. To measure each of these resistances separately, perform measurement by provide a guard electrode to drain off the current of the element that is not to be measured.(Fig. 6-3) In this case, care is required because measurement errors will be produced if the difference between the surface resistance and volume resistance is too large.



(1) Volume resistance measurement (2) Surface resistance measurement

Fig. 6-3 Providing a guard electrode

(5) Sink current

When a voltage is impressed on the specimen, a large current will initially flow, as shown in Fig. 6-4. This current will then gradually approach a constant value. This initial current is called the sink current or charging current. The current will continue to change for a correspondingly longer time depending on the specimen.
Therefore, the insulation resistance is found from the current value a fixed time (1 min, etc.) after the voltage is impressed.
Moreover, measurement reproducibility is also a problem because of the charge that remains on the specimen once a voltage has been impressed on the specimen.

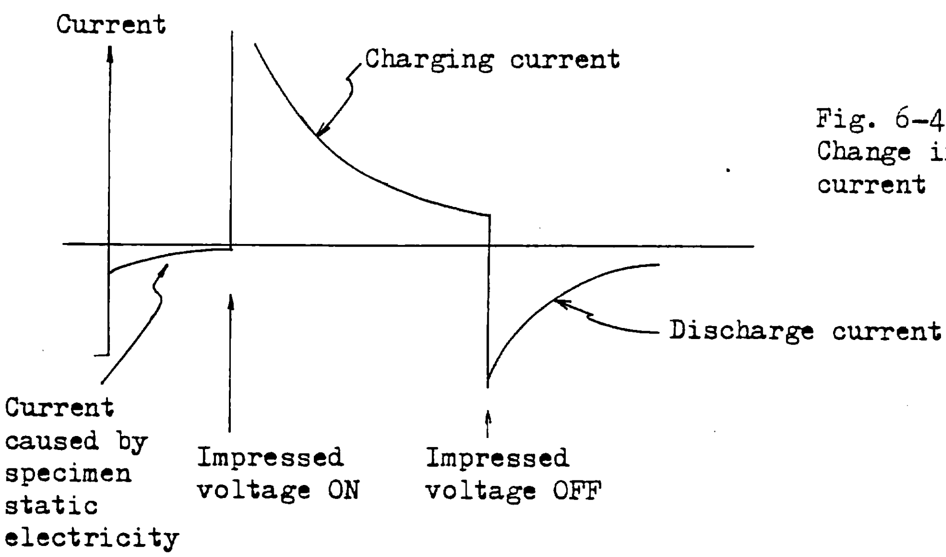


Fig. 6-4
Change in measurement current

When the insulation resistance is about $10^{15}\Omega$, the meter pointer will deflect in the minus direction even when a voltage is impressed on the specimen. This is caused by the static electric charge built-up on the specimen. This charge is easily produced by applying force to the specimen or by rubbing the specimen. Therefore, care must be exercised especially when measuring high polymer specimens (teflon, etc.).

6-2 Insulation Resistance Measurement of High Electrostatic Capacitance Specimens

Capacitors and other high electrostatic capacitance specimens have an extremely long response because of their time constant with the input resistance of the TR-8601. Since the indication does not change immediately, even when the range switch is switched, in this case, it will appear at first glance that the instrument is not linear between ranges.

The time constant is found as the product of the electrostatic capacitance of the specimen and the input resistance of the TR 8601.

Generally, since the leakage current of a capacitor tends to increase when the electrostatic capacitance is large, the input resistance of the TR8601 becomes small when the electrostatic capacitance is large, and there are no special problems. However, care must be exercised with polyester film capacitors and other high capacitance insulation.

6-3 Measuring Sheet Specimens Using the TR 42, 43C

The TR 42 and TR 43 are specimen boxes used in conjunction with the TR 8601 to measure the volume resistance and surface resistance of flat plates and sheet specimens.

The TR 43C is equipped with a specimen heating use constant temperature oven.

The electrodes are shown in Fig. 6-5. The dimensions enclosed in ( ) are the dimensions of the 70ϕ electrode available as an option.

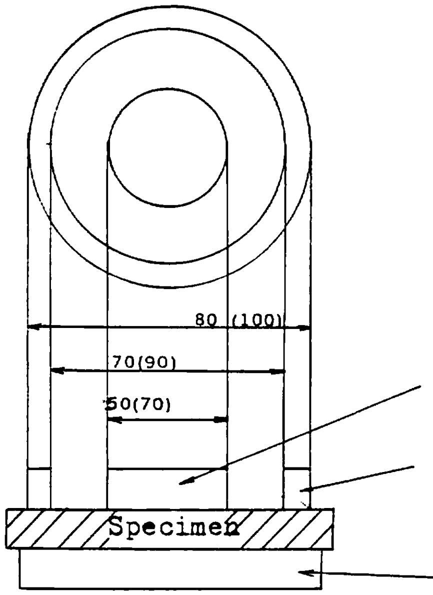


Fig. 6-5
TR 42 (43C) electrodes

(1) Measurement method

1) Connect the TR 42 (43C) to the TR 8601 as shown in Fig. 6-6.

2) Place a specimen whose thickness has been measured with a micrometer onto the opposite electrode of the TR 42 so that it is at the main electrode and protection electrode center circle.
When the surface of the specimen is rough, attach it to the electrode by coating the surface of the electrode with vasoline or paste so that the specimen and electrode fit tightly together.
At this time, the resistance of the vasoline or paste must be lower than the resistance of the specimen.

3) Install the cover of the TR 42 (43C), and perform measurement as described in para. 4-4.

4) Calculate the volume resistivity and surface resistivity of the specimen from the reading of the meter of the TR-8601 by means of the below equation. Note that coefficients Kv and Ks of this equation are different for the 50ø electrode and 70ø electrode.

Volume resistivity $\rho v = Kv \cdot Rv/t$ (Ωcm)

$Kv = 19.62$ (cm^2) 50ϕ electrode

38.46 (cm^2) 70ϕ electrode

Surface resistivity $\rho s = Ks \cdot Rs$ (Ω)

K = 18.8 50ϕ electrode

25.1 70ϕ electrode

Where, Rs, Rv: Measured value for each case

t: Thickness of specimen

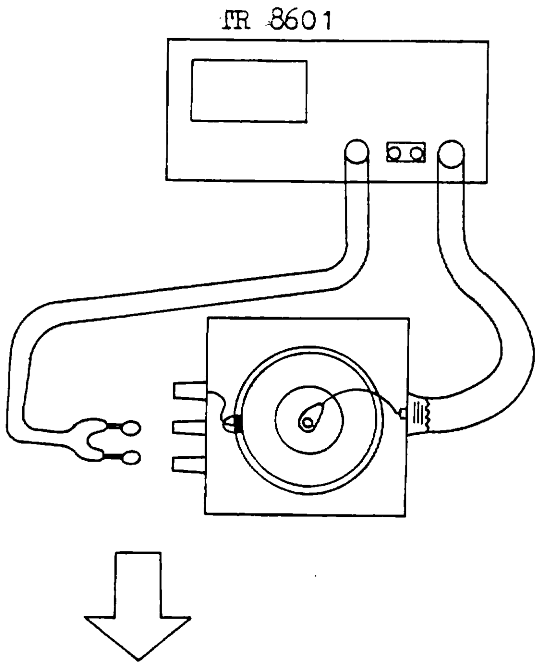
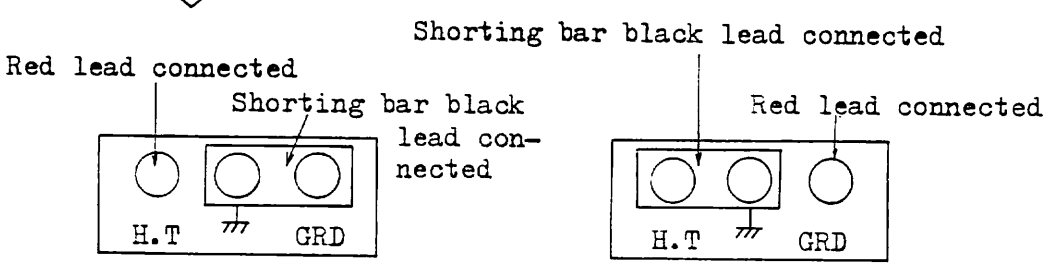


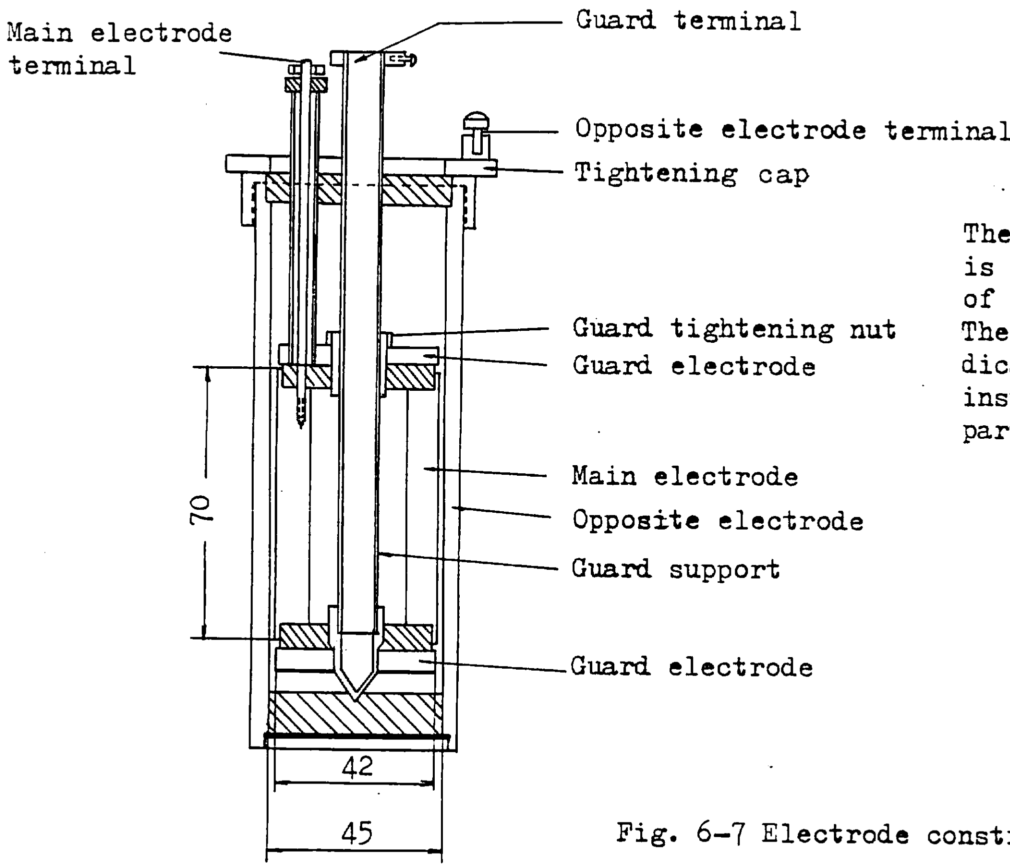
Fig. 6-6
TR 42 (43C) and TR-8601
connection method



For volume resistance measurement   Surface resistance measurement

6-4 Insulation Resistance Measurement of Liquid Specimen with TR 44

The TR 44 is a specimen box used in conjunction with the TR 8601 to measure the volume resistivity of insulating oil, and other liquid specimens. The construction of the electrodes is shown in Fig. 6-7.



The figure at the left is a cross section view of the electrodes. The hatched lines indicates the teflon insulators. The other parts are brass plated.

Fig. 6-7 Electrode construction

(1) Measurement method

1) Remove the tightening cap at the top, and pull the main electrode and guard electrode out from the top.

2) Wash the main electrode and guard electrode, and the inside of the opposite electrode with ethyl, benzene or gasoline.

3) After the washing liquid has dried thoroughly, fill the opposite electrode about 1/2 full of specimen, slowly insert the main electrode and guard electrode so that the specimen does not spill out, and then tighten with the tightening cap

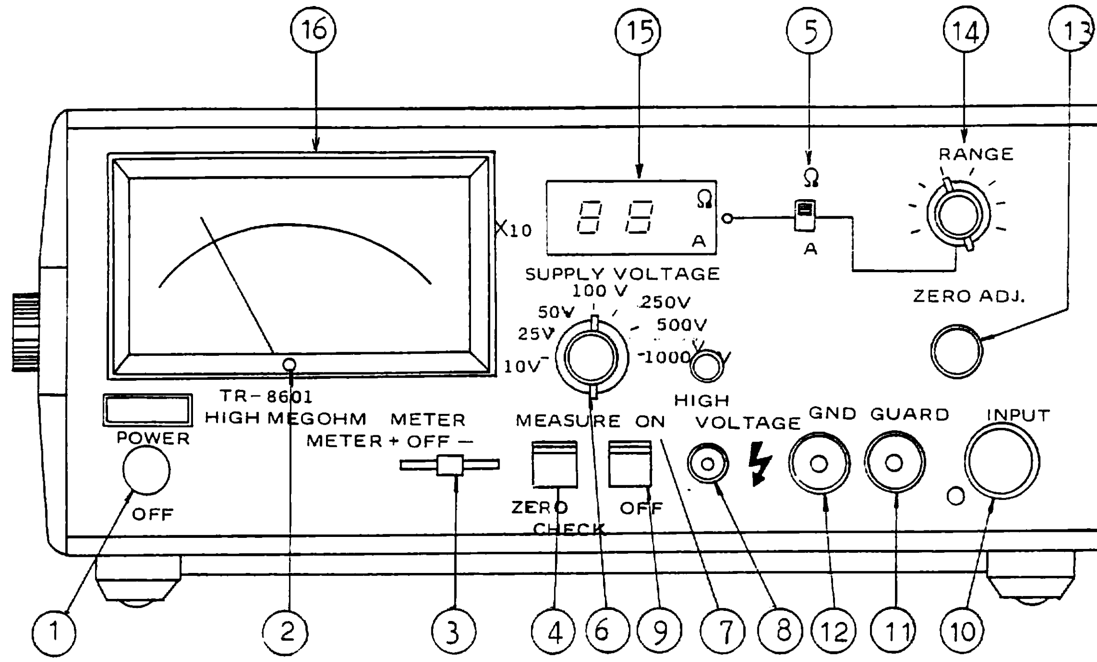
4) Connect the accessory cable of the TR 44 to the main electrode terminal and the INPUT terminal of the TR 8601. Moreover, connect the HIGH VOLTAGE terminal of the TR 8601 to the opposite electrode of the TR-44.

5) Perform measurement as described in para. 4-4.
Since the voltage set at the TR-8601 is present at the opposite electrode and tightening cap at this time, handle them with care.

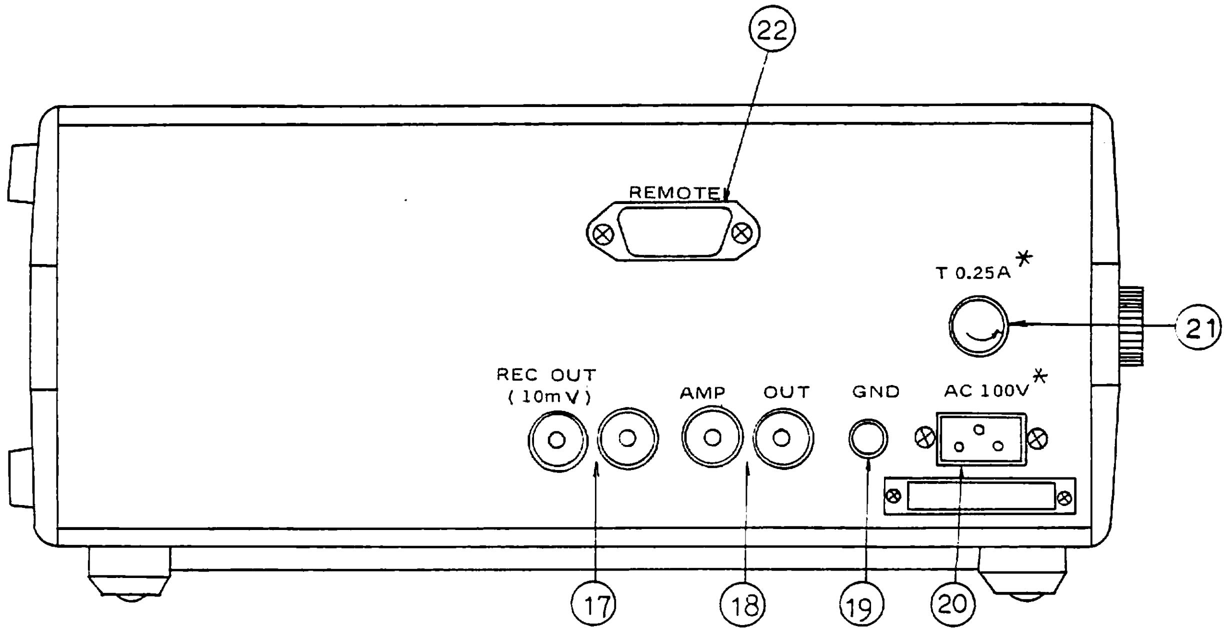
6) Find the volume resistivity ρ of the specimen by multiplying the measured value by the electrode coefficient (637).

$$\rho = 637R \ (\Omega cm)$$

R: Measured value



FRONT VIEW



* AC230V USE AC230V T0.125A

REAR VIEW

Fig. 4-1 Panels