MODEL 114

HIGH SENSITIVE
DC VACUUM-TUBE VOLTMETER

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.

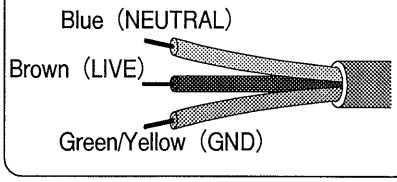
☐ AC power cable

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.

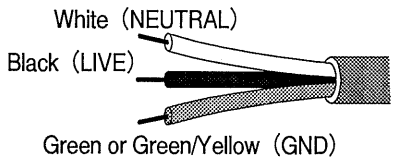
WARNING

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

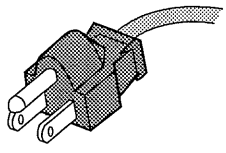
☐ Without a power plug



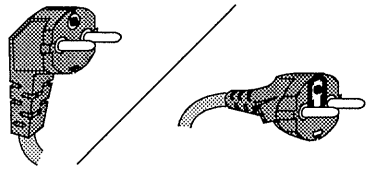
☐ Without a power plug



☐ 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 _____

 Kikusui Part No. Z9-000-027 IB001681

KIKUSUI

- C O N T E N T S -

1. Summary

Kikusui Electronics' MODEL 114 is a high sensitive DC vacuum-tube voltmeter, which can be used for measuring small DC voltage and current and as a DC amplifier.

This model consists of stable DC amplifier of extremely less drift, in which so-called DC-AC converter is employed, so that zero adjustment is not required at all prior to measurement, thus enabling handy and quick measurement.

As for the measuring voltage ranges, input resistance is 11 MΩ fixed at each range and the full scale is 15mV ~ 500V. As for the current ranges, voltage drop is 15mV fixed at each range and the full scale is 1.5μA ~ 50mA. And the both are respectively divided into ten ranges by 1.5-5-15 step. As a DC amplifier, output voltage of 1.5V can be taken out from the output terminal provided on the panel for full scale input value at each of the above voltage and current ranges.

2. Specification

Title	High sensitive DC vacuum-tube voltmeter	
Model	MODEL 114	
Power	AC-----V 50/60 Hz approx. 15 VA	
Dimensions	200D x 140W x 190H	
(Maximum)	(245)D x (140)W x (205)H	
Weight	Approx. 4 kg	
Meter	Scale length 105mm	
	15/50 scale, F.S 100μA	
Vacuum tube	12Ax7	2
	12BH7A	1
Accessories	Type 971 Test prod	1
	Instruction manual	1

DC Voltmeter Part

Polarity		Positive or negative
Measuring range	10 ranges of 0~±15/50/150/500 mV	
		1.5/5/15/50/150/500 V
Input resistance	All ranges	11 MΩ
Input capacitance		Less than 1.6 pF
Accuracy	± 3% of full scale	
Max. input voltage	500V when not including AC component	
	500V when including AC component (at peak value)	
Stability	± 1% to ± 10% variation of power voltage	
	± 1% stability after fifteen minutes upon turning power on	

DC Ammeter Part

Polarity		Positive or negative
Measuring range	10 ranges of 0~±1.5/5/15/50/150/500 μA	
		1.5/ 5/15/50 mA
Voltage drop	All ranges	15 mV
Accuracy	± 3% of full scale	
Stability	Same as the DC voltmeter	

DC Amplifier

Amplification degree (at 15mV range)		100
Accuracy		± 5%
Output voltage	for full scale	1.5V
Output resistance		Approx. 1 KΩ

3. Operating Method

MODEL 114 Vacuum-tube Voltmeter operates with AC ___V of 50 or 60 Hz. Even if power voltage is varied largely, error almost does not occur. But, in view of service life, use of this model in the approximate range of ____ ± 5V is preferred.

3.1 Explanation of panel (see Fig 3-1 for reference)

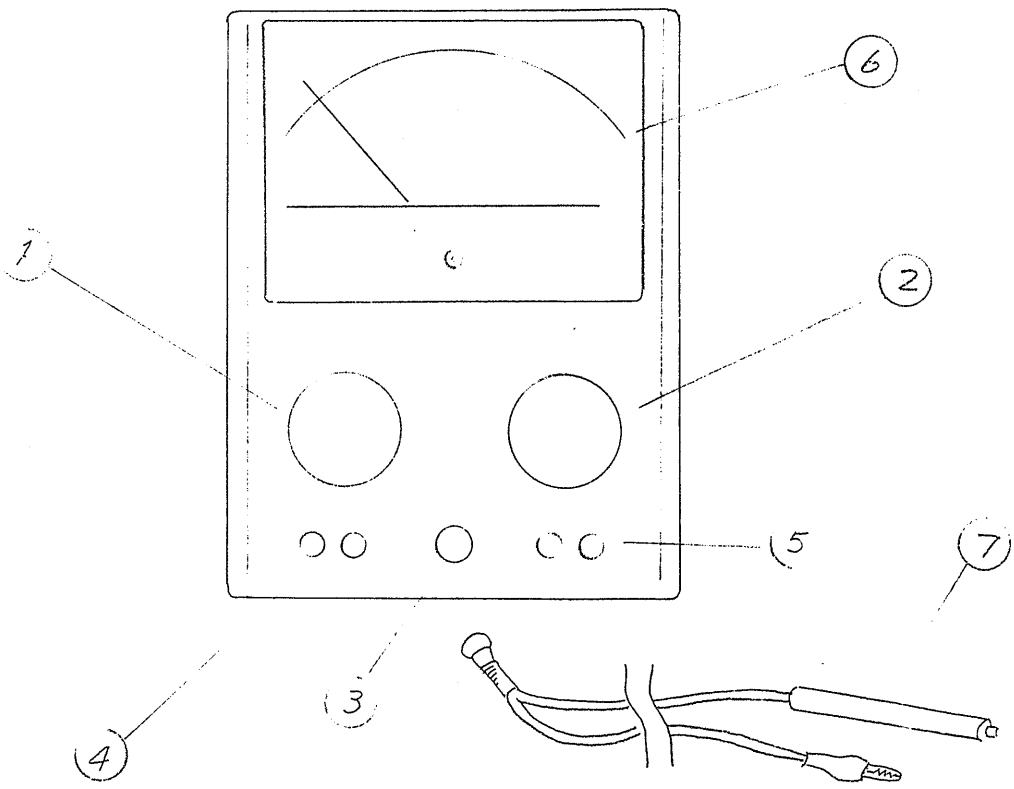


Fig 3-1

① POWER (OFF) VOLTS+ - AMPERES+ - When the selector switch provided on the left side of the panel is rotated counterclockwise to the extreme, power is turned 「OFF」, and when it is set to a position of VOLTS「+」,「-」 or AMPERES「+」,「-」, power becomes 「ON」 and the pilot lamp lights. VOLTS and AMPERES shall be selected depending upon the purpose of use when this instrument is used as a voltmeter or ammeter. The mark 「+」 and 「-」 are of selecting polarity in the respective cases.

② Range Switch This is the rotary switch provided on the right side of the panel, and the characters surrounding the knob indicate the full scale voltage (black color) or current value at the respective range. The range switch is shifted to higher ranges in order as it is rotated clockwise.

③ VOLTS Terminal This is a voltage measuring terminal, and measurement is conducted with the accessory Type 971 test prod connected therewith.

④ AMPERES Terminal These are current measuring terminals provided on the lower left side of the panel, and the black terminal is 「GND」.

⑤ OUT PUT Terminal These are output terminals to be used when this instrument is operated as a DC amplifier. 1.5V output of positive or negative polarity can be obtained for full scale input value at the respective voltage and current ranges.

⑥ Meter — The meter scales are 15 and 50 full scale, and either scale shall be read depending upon the relevant range.

⑦ Test Prod / Alligator Clip — This is a pair of Type 971 test prod and alligator clip to be connected to the [GND] side, and shall be used at the time of voltage measurement.

3.2 Preparation for measurement

1) Keep the selector switch rotated counterclockwise to the extreme, the position of [OFF].
2) Confirm that the pointer of the meter is at the center of the zero point, and, if not, perform correct zero adjustment.
3) Connect the line cord to an AC outlet (□□□V, 50 or 60 c/s)
4) Rotate the selector switch clockwise from [OFF] position to VOLTS [+], [−], or AMPERES [+], [−] for turning power on.
5) After some five minutes upon turning the power on, stably operable state is attained and preparation for measurement is completed.

3.3 Measurement of DC voltage

1) Connect the test prod to VOLTS terminal.

2) Set the selector switch to ⌜+⌟ or ⌜-⌟ position depending upon the polarity of the voltage to be measured. ⌜+⌟ and ⌜-⌟ stand for as follows.

⌜+⌟ : the prod is (+) voltage against the alligator clip (GND)

⌜-⌟ : the prod is (-) voltage against GND

3) Both 15 and 50 scale of the meter are used and shall be read as in Table 3-1.

Range	Scale	Multiple	Unit
± 15 mV	15	x 1	mV
" 50 "	50	"	"
" 150 "	15	x 10	"
" 500 "	50	"	"
" 1.5 V	15	x 0.1	V
" 5 "	50	"	"
" 15 "	15	x 1	"
" 50 "	50	"	"
" 150 "	15	x 10	"
" 500 "	50	"	"

Table 3-1

4) In order to conduct measurement, the alligator clip shall be connected to one end of the voltage to be measured, and the other end shall be touched by the test prod so that an adequate range is selected.
At this time, even if by any chance 500V is impressed on 15mV range mistakenly, the overload protective circuit operates to prevent this instrument from being damaged.

3.4 Measurement of DC current

1) The measurable current range of this instrument is 1.5μA to 50mA in full scale. From the viewpoint of maintaining accuracy, excessive current shall not be flowed with caution through the current measuring circuit, since the circuit is not provided with a protective circuit.
2) Set the selector switch to either ⌜+⌟ or ⌜-⌟ depending upon the polarity.
3) Conduct measurement with the current measuring terminal connected with the circuit, and read the value depending upon the range in the same method as the voltage range.

3.5 Use as DC amplifier

Since this model includes stable amplifier using mechanical chopper in DC-AC converter, the construction permits to use this instrument also as a DC amplifier. This instrument is designed so that output voltage is +1.5V or -1.5V in full scale at each range of voltage and current, and the amplification degree of each voltage range is as shown in

Table 3-2.

Voltage range	Amplification degree
15 mV	x 100
50 "	x 30
150 "	x 10
500 "	x 3
1.5 V	x 1
5 "	x 0.3
15 "	x 0.1
50 "	x 0.03
150 "	x 0.01
500 "	x 0.003

Table 3-2

1) Effect from load

The following effects are exerted upon the indicating accuracy and output voltage by a load resistance to be connected with the output terminals.

Indicating accuracy

In case that the load resistance to be connected with the output terminals is more than 10 KΩ, the accuracy is satisfactorily up to the specification, but if it is less than the said resistance, the accuracy is lowered. Accordingly, when this instrument is used as an amplifier conducting voltage measurement at the same time, it is preferable

to reduce the load.

Output voltage

Voltage of +1.5V or -1.5V full scale, proportional to the input voltage or current, can be taken out as the output voltage.

If the load resistance is more than 100 KΩ , the amplification degree in the specification is satisfied, but if less than that, the output voltage is lowered by the following equation depending upon the load.

$$\text{Output Voltage} \simeq Eo \frac{R_L}{1 + R_L}$$

Eo: Open output voltage

RL: Load resistance(KΩ)

2) Frequency characteristic

Fig 3-1 shows one example of frequency characteristic of the time when this instrument is used as an amplifier with the output open-circuited.

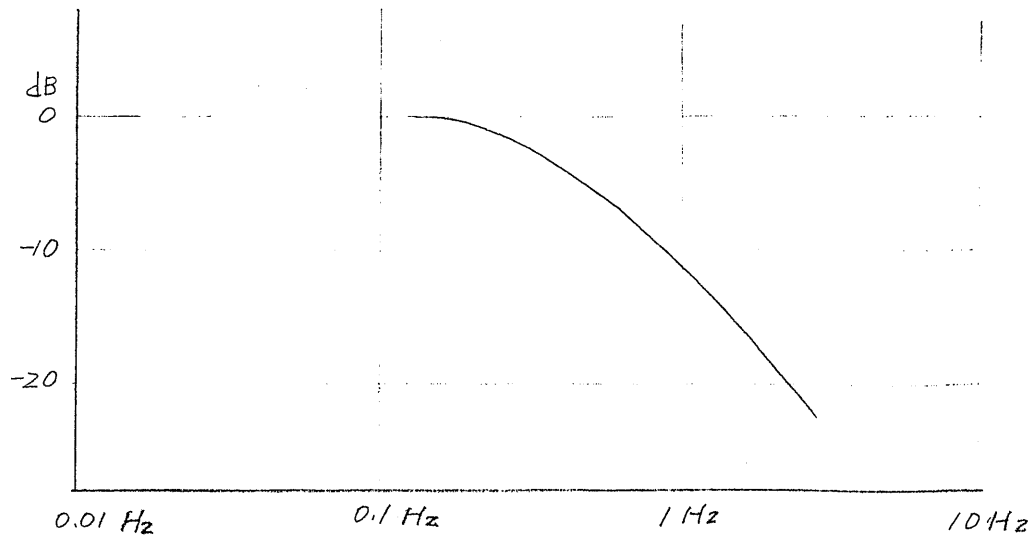


Fig 3-1

4. Operation Principle

As shown in Fig 4-1, MODEL 114 Vacuum-tube Voltmeter consists of input circuit, DC-AC converter circuit, amplifier circuit, synchronous rectifier circuit and power circuit.

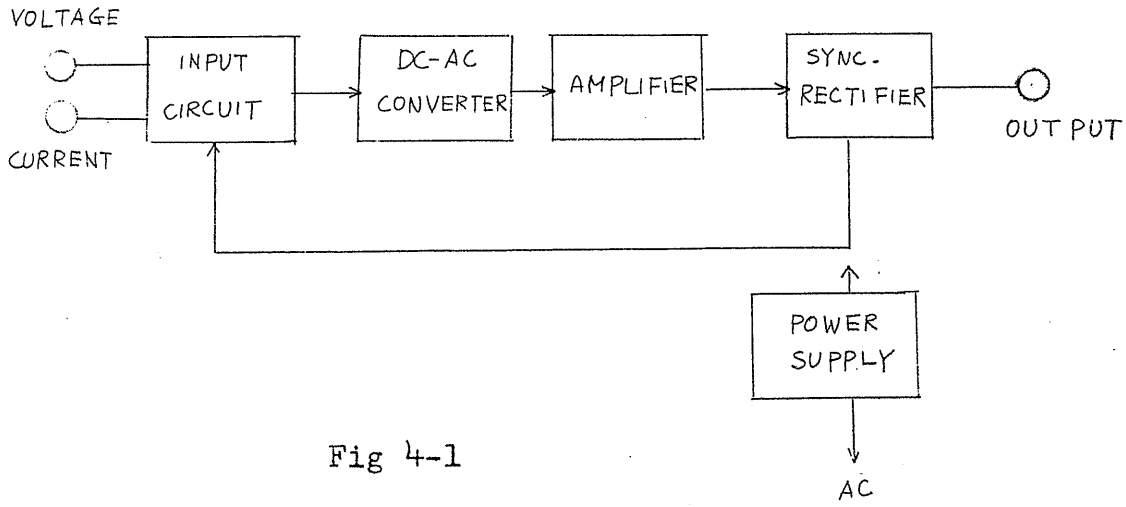


Fig 4-1

4.1 Input circuit

The input circuit consists of range switch, selector switch and low-pass filter provided with overvoltage protective circuit. Here, input terminal is selected by the selector switch corresponding with the voltage or current to be measured, range is changed by input level, and AC component contained in measuring signal is attenuated by low-pass filter having an adequate cut-off frequency. If an excessive voltage is given to this filter, discharge current flows to neon tube provided in the circuit, thus preventing the DC-AC converter and other parts from being damaged.

4.2 DC-AC converter

Signal from the low-pass filter in the input circuit comes into this DC-AC converter circuit, and is converted by mechanical chopper from DC to AC of commercial power frequency.

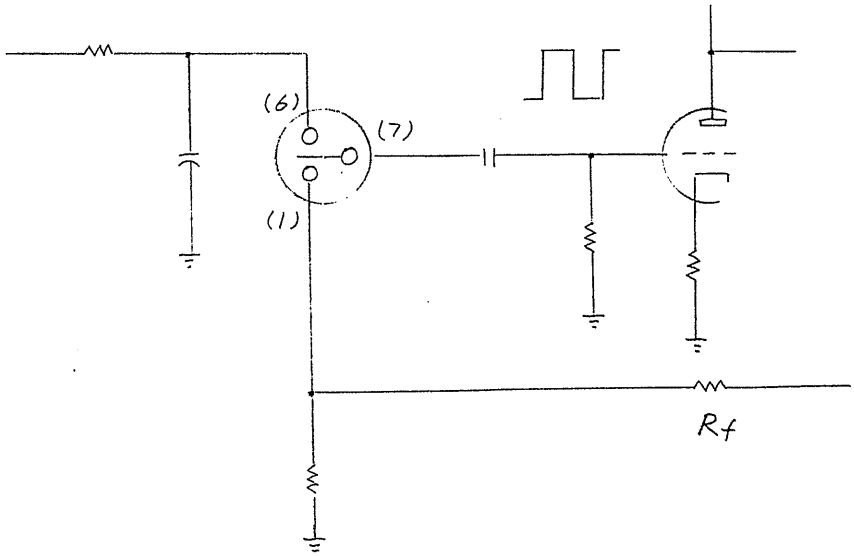


Fig 4-2

As shown in Fig 4-2, the signal from the filter circuit is given to terminal (6), and the signal converted to AC comes into the input of AC amplifier from terminal (7).

There, the signal is sufficiently amplified, synchronously rectified and becomes the DC voltage of output. This output voltage performs negative feedback via Rf to the chopper terminal (1) again, thus serving to improve the stability, linearity, etc., of the DC amplifier.

4.3 Amplifier circuit

This is to amplify the signal converted to AC and RC coupling amplifier circuit of three stages is used therein. On the first stage, current feedback is performed for particularly obtaining high input impedance and the heater is DC-ignited in order to reduce hum and noise.

4.4 Synchronous rectifier circuit

The synchronous rectifier circuit has the function of discriminating the polarity of the signal converted to AC and performing rectification, and the circuit of this instrument includes such a circuit using twin triode as shown in Fig 4-3.

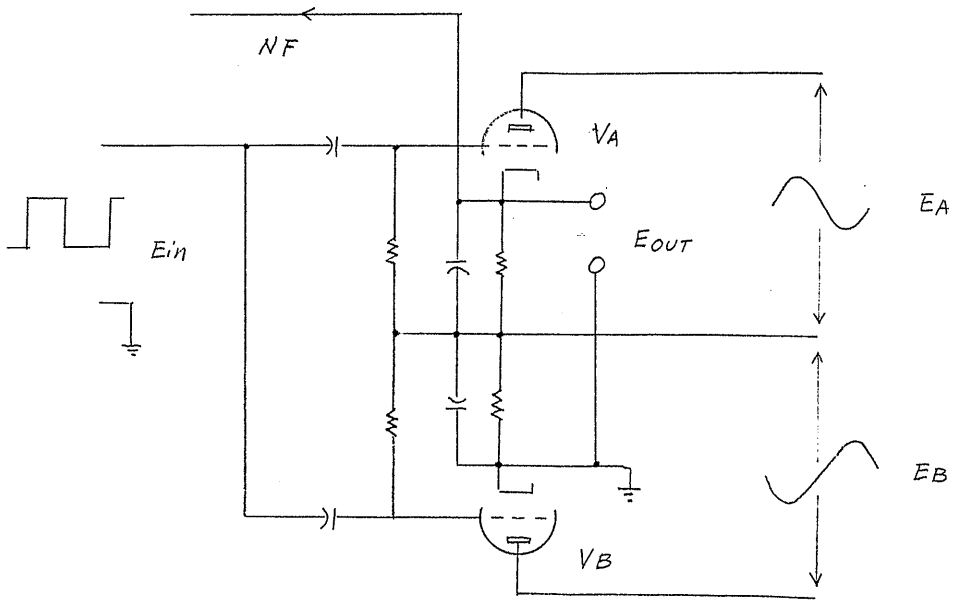


Fig 4-3

In Fig 4-3, the plate of VA and VB are supplied respectively with power (commercial power: 50 or 60 Hz) of phases differed by 180° and of equal amplitude. DC output voltage Eo does not come out when no input is given to this circuit, since equivalent plate current flows to VA and VB, thus bringing forth balanced state.

Here, if the input voltage of same phase as EA is given thereto as shown in the drawing, the plate current of VA is increased more than that of VB, thus bringing forth unbalanced state, and output voltage Eo of positive voltage for the ground side is produced. When Ein becomes antiphase, the plate current of VB is increased on the contrary and negative voltage comes out to the output. The relation between the input voltage and output voltage of this rectifier circuit has linearity, but a great deal of negative feedback is performed from the output to the DC-AC converter circuit, thus improving the characteristics.

4.5 Power circuit

Necessary voltages are taken out by power transformer from commercial line power as mentioned below.

AC	250V 0 250V	Synchronous rectifier circuit
AC	6.3V 0 (Center tap)	Each heater circuit, chopper and pilot lamp

DC	230V 0	B power supply
DC	12V 0	First stage tube heater circuit

5. Maintenance

5.1 Adjustment

1) Internal zero adjustment

This instrument is a vacuum-tube voltmeter of extremely less drift, so that no zero adjustor is provided on the panel. But, internal zero adjustor is provided for attaining the balance of the synchronous rectifier tube, and zero adjustment is made after sufficient ageing.

In such a case that the vacuum tubes thereof are changed to new ones or the meter pointer comes not to point at the zero position after use for a long period, the rubber stopper shall be taken off and zero adjustment be done. (Fig 5-1)

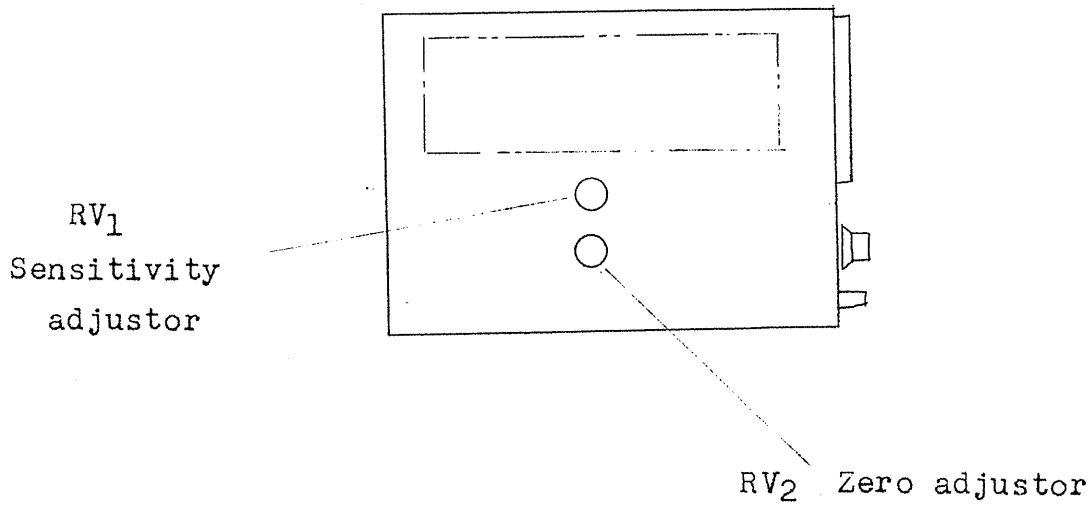


Fig 5-1

2) Sensitivity adjustment

In such a case that the vacuum tubes are changed to new ones or have been used for a long time, it is advised to perform this sensitivity adjustment for calibration. The sensitivity adjustment shall be performed in the following procedures.

① Turn the selector switch to VOLTS [+] .

② Set the range switch to 5V.

③ Provide the input with 5V standard voltage after more than 30 minutes upon turning on power, and adjust RV_1 so that the pointer comes right to the center of 5V scale.

5.2 Internal inspection

The internal inspection can be made, since, as shown in Fig 5-2, the side boards can be taken off towards the both sides when the four screws provided at the four corners of the back of the cabinet are unscrewed and the side boards are pulled towards the back.

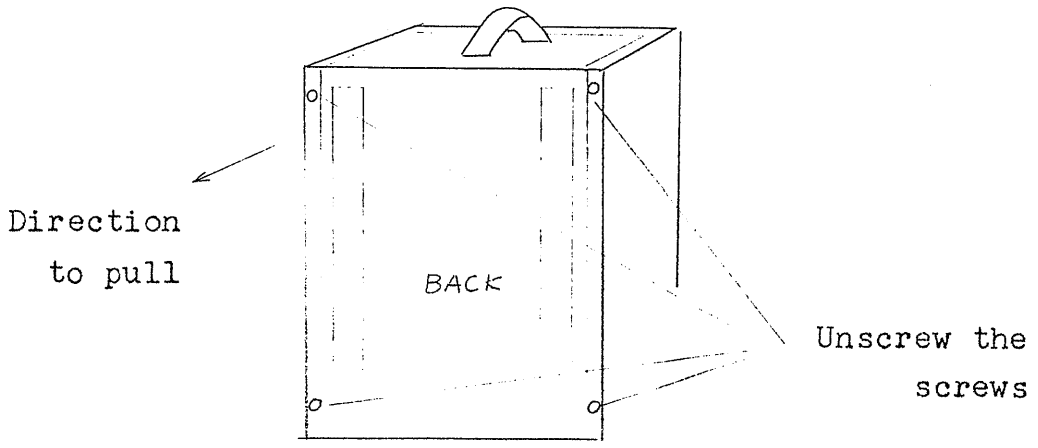


Fig 5-2

5.3 Repair

This instrument was delivered out after being carefully assembled, adjusted and subjected to inspection under severe control. But, if a trouble ever happened due to an accident in transit or service life expiration of the component parts, this paragraph shall be referred to.

1) The meter does not operate at all.

State	Cause
The pilot lamp does not light.	Defect at line cord, plug. Disconnection of fuse. Disconnection of power transformer.
The pilot lamp keeps lighting.	Disconnection of the meter. Disconnection of V_3

2) The zero point is not coincident.

State	Cause
The zero point is not coincident in the state of power turned off.	Defect at the zero adjustor of the meter.
The zero point is out of the correct position in operating state.	Defect at the chopper. Reduction in amplification degree of the amplifier tube. Unbalance of the synchronous rectifier tube.
The meter overscales	One side disconnection of the secondary AC 250V of the power transformer, or layer shortcircuit. Defect at the chopper. Defect at the synchronous rectifier tube.

3) Indication is unstable.

State	Cause
The pointer moves finely	Defect at the chopper. Large noise by the first stage amplifier tube.
The pointer moves slowly as power voltage is varied	Large grid current of the first stage amplifier tube.

4) Indicating error is large

State	Cause
Indicated value differs at each time of measurement	The meter being about to be disconnected.
Large error at both the voltage and current range	Defect at the amplifier tube. Defect at the meter. Large error at R_1 ~ R_4
Large error at the voltage range	Large error at the resistor of the prod. Large error of the voltage dividing resistor.
Large error at the current range	Large error of the shunt resistor.

5) Voltage check of each part

Fig 5-1 shows an example of the voltage distribution to each part and can be put to use when voltage check is conducted. Particularly, the voltage of no designation is the value measured by the vacuum-tube voltmeter of input resistance 11 MΩ taking GND as the reference. The figure [1] shown near to the socket of the printed board stands for PIN NO.

PIN NO.	V_1 12Ax7	V_2 ½12AX7	* V_3 12BH7A
1	+ 93V	+88V	AC 243V
2	0	0	+ 53V
3	0.9V	+0.6V	+ 75V
4	- 5.5V	} AC	
5	+ 5.5V	} 6V	AC 6V
6	+ 106V	——	AC 243V
7	0	——	+ 72V
8	+ 1.5V	——	+ 75V
9	0	——	

* Measurement by connecting GND of the voltmeter to the middle point of the secondary AC 250V of the power transformer.