

MODEL 115
ELECTRONIC VOLTMETER
OPERATION MANUAL

日本電子工業株式会社

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 provided 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.



- C O N T E N T S -

1. Summary	1 - 1
2. Specifications	2 - 1
3. How to Use	3 - 1
3.1 Descriptions of panel furnishings	3 - 1
3.2 Preparations for measurement	3 - 3
3.3 Measurement of DC voltage	3 - 4
3.4 Measurement of DC current	3 - 5
3.5 Utilization as DC amplifier	3 - 5
4. Operation Principle	4 - 1
4.1 Input circuit	4 - 1
4.2 DC-AC converter	4 - 2
4.3 AC amplifier	4 - 3
4.4 Synchronous rectifier	4 - 3
4.5 DC amplifier	4 - 4
4.6 Zero adjuster	4 - 4
4.7 Power supply	4 - 4
5. Maintenance	5 - 1
5.1 Internal inspection	5 - 1
5.2 Adjustment and calibration	5 - 2
5.3 Repair	5 - 3

1. Summary

KIKUSUI ELECTRONICS' MODEL 115 ELECTRONIC VOLTMETER is a high sensitive DC voltammeter designed for measuring small DC voltage and current and for using as a DC amplifier.

This instrument consists of the stable amplifier of extremely less drift employing a DC-AC converter, and the measuring terminal is floated.

Also, zero center type is adopted, so that simple and quick measurement is ensured without requiring attention to the polarity. The input resistance of each measuring voltage range is $11M\Omega$ constant and the full scale is $1.5mV \sim 500V$. The current range is $0.15\mu A \sim 50mA$. They are divided into 12 ranges respectively in 1.5 - 5 - 15 step.

As DC amplifier, this instrument enables to take out from the output terminal provided at the back side of the panel 1.5V output voltage to the input value of the full scale at each of the above voltage and current ranges.

2. Specifications

Title	High Sensitive DC Voltammeter
Model	MODEL 115
Power Supply	AC 100V 50/60 Hz approx. 7 VA
Dimensions (maximum)	250D x 140W x 190H (320)D x (140)W x (205)H
Weight	Approx. 3.7 kg
Meter	Zero center with mirror Scale F.S 1mA 15/5 scale
Accessories	Type 971 test prod 1 Instruction manual 1

DC Voltmeter

Polarity	Positive or negative	
Measuring range	0 ~ $\pm 1.5/5/15/50/150/500\text{mV}$	
	$1.5/5/15/50/150/500\text{V}$	12 ranges
Input resistance	All ranges	11 M Ω
Input capacitance		2 PF
Accuracy	of full scale	$\pm 3\%$
Max. input voltage		
	At the time of not containing AC component	500V
	At the time of containing AC component (at peak value)	500V
Stability	to $\pm 10\%$ fluctuation of power voltage	$\pm 1\%$
	stability at 15 min. after turning power on	$\pm 1\%$

DC Ammeter

Polarity	Positive or negative	
Measuring range	0 ~ $\pm 0.15/0.5/1.5/5/15/50/150/500\mu\text{A}$	
	$1.5/5/15/50\text{mA}$	12 ranges
Voltage drop	0.15 μA ~ 5mA range	1.5mV
	15mA range	4.5mV
	50mA range	15mV
Accuracy	of full scale	$\pm 3\%$
Stability	Same as the DC voltmeter	

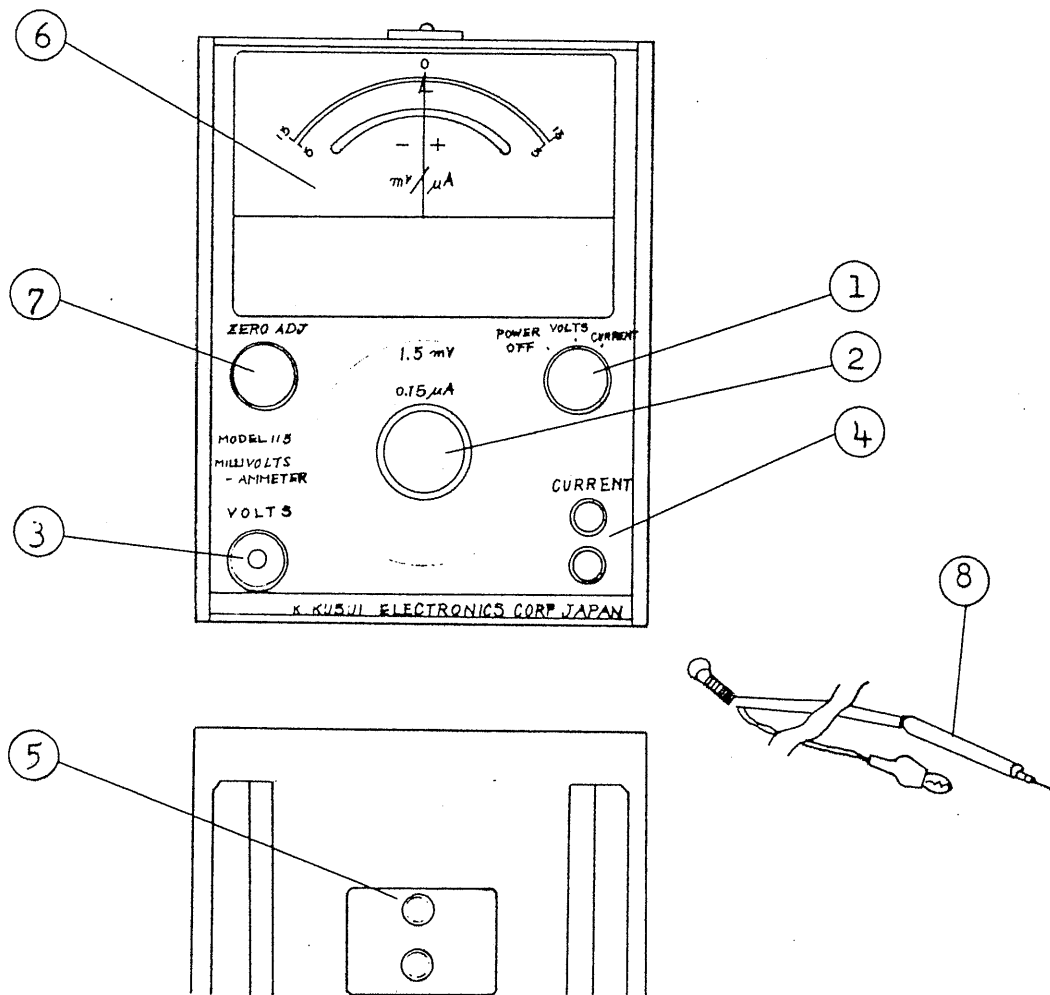
DC Amplifier

Amplification degree (at 1.5mV range)	1000
Accuracy	$\pm 3\%$
Output voltage	at full scale 1.5V
Output resistance	Approx. 1 K Ω

3. How to Use

MODEL 115 ELECTRONIC VOLTMETER operates on 50 or 60 Hz AC power 100V. If the power voltage is largely fluctuated, almost no error is produced, but in view of the service life, it is advised to apply the power of approx. 100V±5V for using this instrument.

3.1 Descriptions of panel furnishings



- 1) POWER OFF
VOLTS
CURRENT
- is the use selector switch provided on the right side of the panel, and when rotated counterclockwise to the extreme, power is turned [OFF], and when set to each position of VOLTS and CURRENT, power is turned on and the pilot lamp is lighted. VOLTS and CURRENT shall be used by setting to either position corresponding with the use when this instrument is used as a voltmeter or ammeter.
- 2) Range Switch
- is the rotary switch provided at the center of the panel, and the dial figures show the full scale voltage (the outer) or current values at the ranges. When this range switch is rotated clockwise, higher ranges are obtained in order.
- 3) VOLTS Terminal
- is the terminal for measuring voltage, and the measurement shall be conducted by connecting this terminal with Type 971 test prod that is accessory to this instrument.
- 4) CURRENT Terminal
- is the terminal for measuring current, provided in the left lower part of the panel, and the white terminal serves as [GND].
- 5) OUTPUT Terminal
- is the output terminal to be used when this instrument is utilized as a DC amplifier, and enables to obtain 1.5V output voltage in positive phase to the full scale input value at each of the voltage, current ranges.

- 6 Meter is of 15 and 5 full scale in scale graduation, and either graduation shall be read depending upon the range.
- 7 Zero Adjusting Knob shall be used for performing the zero adjustment of the meter or for erasing the offset of the measuring voltage, and has the variable range of the full scale $\pm 30\%$ approximately.
- 8 Test Prod Alligator Clip is a couple of Type 971 test prod and alligator clip to be connected to GND side, and shall be used at the time of measuring voltage.

3.2 Preparations for measurement

- 1) Set the use selector switch to OFF position rotated counter-clockwise to the extreme.
- 2) Make sure that the pointer of the meter is at the center of the zero point, and if not, perform the zero adjustment correctly.
- 3) Connect the line cord with an AC outlet (110V 50 or 60 Hz).
- 4) Rotate the use selector switch from OFF to VOLTS or CURRENT, to turn on the power.
- 5) At some 5 minutes after turning the power on, perform the zero adjustment by means of the adjusting knob, and the stable state for operation will be attained. The above are all for completing the measuring preparations.

3.3 Measurement of DC voltage

- 1) Connect the test prod to VOLTS terminal.
- 2) Change the use selector switch to $\overline{\text{VOLTS}}$.
- 3) Use the 5, 15 scale of the meter graduation, and read the values as shown in Table 3-1.

Range	Scale	Multiple	Unit
\pm 1.5 mV	15	X 0.1	mV
" 5 "	5	X 1	"
" 15 "	15	X 1	"
" 50 "	5	X 10	"
" 150 "	15	X 10	"
" 500 "	5	X 100	"
" 1.5 V	15	X 0.1	V
" 5 "	5	X 1	"
" 15 "	15	X 1	"
" 50 "	5	X 10	"
" 150 "	15	X 10	"
" 500 "	5	X 100	"

Table 3-1

- 4) In case of performing the test, connect the alligator clip to one end of the voltage to be measured and touch the other end with the test prod, and select an adequate range. Even if the 1.5mV range is provided with 500V by mistake on this occasion, the overload protective circuit operates and prevents this instrument from damage.

3.4 Measurement of DC current

- 1) The current measuring range of this instrument is 0.15 μ A up to 50mA full scale. From the view of maintaining the accuracy, be careful so that no overcurrent flows, since the current measuring circuit is not provided with a protective circuit.
- 2) Connect the current measuring terminal to the circuit, perform the test and read the value depending upon the range in the same manner as the voltage range.

3.5 Utilization as DC amplifier

Since this instrument employs a stable amplifier in which a mechanical chopper is adopted to the DC-AC converter, the structure enables to use this instrument as a DC amplifier. This is designed so that the output voltage at the full scale in each of the voltage and current ranges is +1.5V or -1.5V, and the amplification degree of each voltage range is as shown in Table 3-2.

Voltage Range	Amplification Degree
1.5 mV	X 1000
5 "	X 300
15 "	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) Influence from load

The resistance of the load connected to the output terminal exerts on the indication accuracy and output voltage the influence as mentioned below.

Indication accuracy

when the resistance of the load connected to the output terminal is more than $10k\Omega$, the accuracy fulfills the specification requirements, but when it is lower than the value as mentioned above, the accuracy is lowered. Accordingly, it is advised that the load is to be reduced when this instrument is used as an amplifier while measuring voltage.

Output voltage

The output voltage of +1.5V or -1.5V full scale in proportion to the input voltage or current can be taken out. When the resistance of the load is more than 100K Ω , the voltage fulfills the specified amplification degree, but when less than that, the output voltage is reduced as per the following equation depending upon the load.

$$\text{Output Voltage} \approx E = \frac{R}{1 + R} \quad \begin{array}{l} \text{E: Output voltage opened} \\ \text{()} \\ \text{R: Load resistance} \\ \text{(K}\Omega\text{)} \end{array}$$

2) Frequency characteristic

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

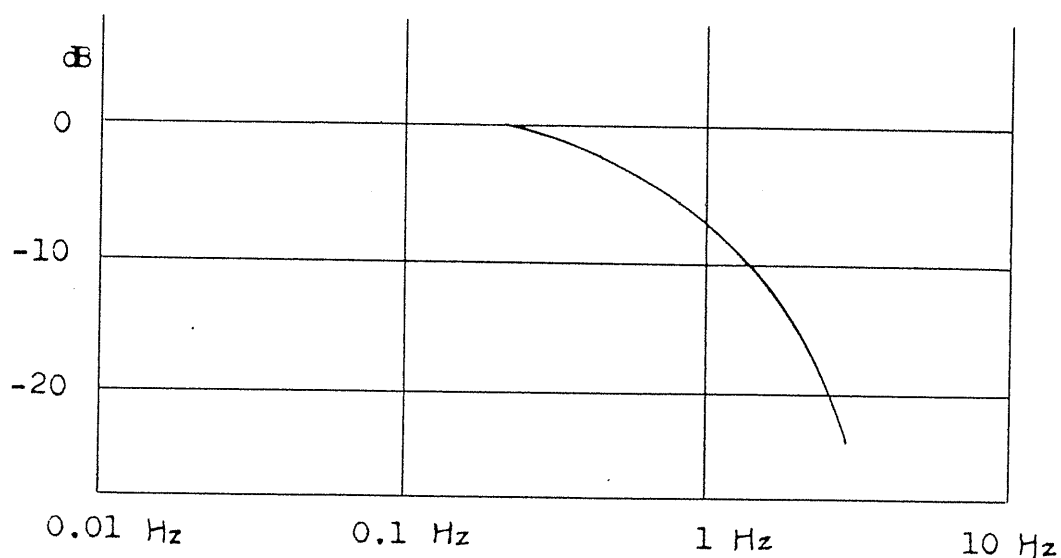


Fig 3-1

4. Operation Principle

As shown in Fig 4-1, MODEL 115 High Sensitive DC Voltmeter consists of the input circuit, DC-AC converter, AC amplifier, synchronous rectifier, DC amplifier and power supply.

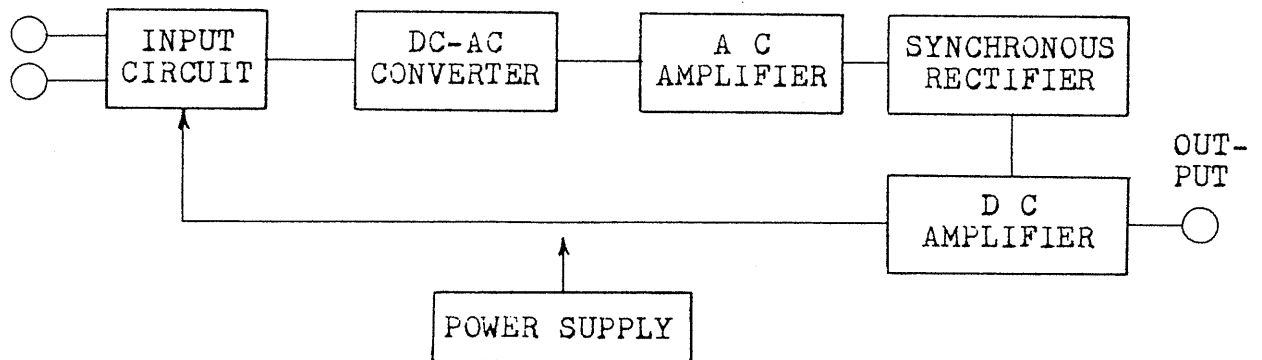


Fig 4-1

4.1 Input circuit

The input circuit consists of a range switch, use selector switch and low-pass filter provided with a overvoltage protective circuit. In this circuit, an input terminal is selected by the use selector switch depending upon the voltage or current to be tested, the range is changed by the input level, and then the low-pass filter having an adequate cut-off frequency attenuates the AC component that is doubled over the measuring signal. When an overvoltage is impressed upon this filter, the diode in the circuit is put to continuity thus preventing the DC-AC converter and other parts from damage.

4.2 DC-AC converter

The signal from the low-pass filter of the input circuit enters into this DC-AC converter and is converted from direct current to the alternating current of the commercial power frequency by means of the mechanical chopper.

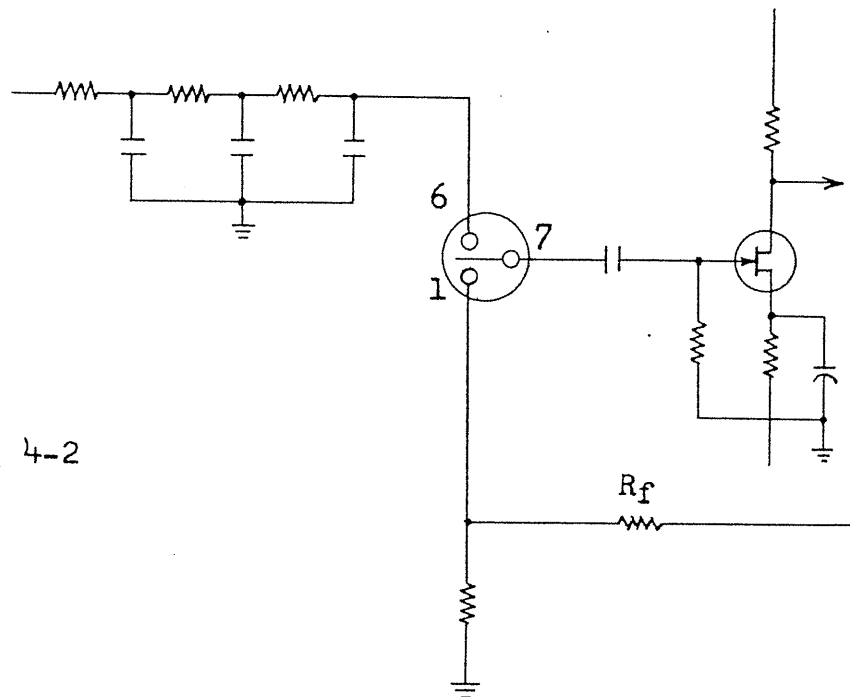


Fig 4-2

In Fig 4-2, the signal from the filter circuit is given to the terminal (6), and the signal converted to the alternating current comes from the terminal (7) into the input of the AC amplifier. There, the signal is sufficiently amplified, is synchronously rectified and becomes the output DC voltage. This output voltage is subjected to negative feedback again to the chopper terminal (1) via R_f , and improves the stability and linearity of the DC amplifier.

4.3 AC amplifier

This is for amplifying the signal that was converted to AC, and employs 3 step RO coupled amplifier circuit. The first step of amplification particularly uses FET for obtaining high input impedance.

4.4 Synchronous rectifier

The synchronous rectifier is functioned to discriminate the polarity of the signal that was converted to the alternating current and to perform rectification, and the circuit employs such a circuit as shown in Fig 4-3 in which diodes are used.

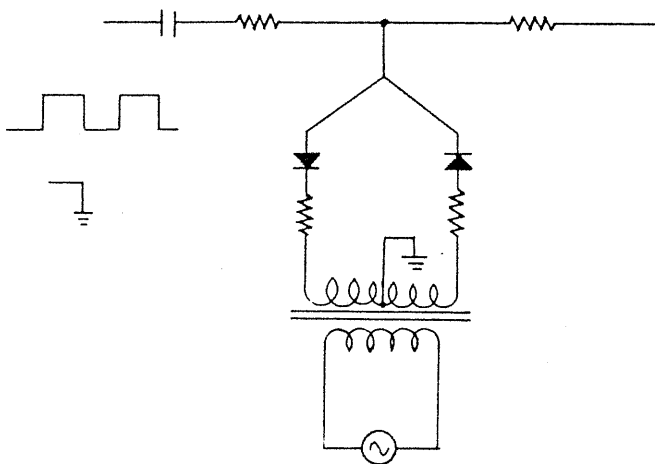


Fig 4-3

4.5 DC amplifier

This is for amplifying the signal that was converted again from alternating current to direct current, amplifies by the differential amplifier through the emitter follower and obtains the output voltage by the emitter follower.

4.6 Zero adjuster

This produces the stable small voltage of positive and negative polarity by utilizing the forward characteristic of the diode, and gives it to the input circuit via the variable resistor for zero adjustment, thus attaining the zero adjustment. The variable range of the adjustment is approx. 30% of the full scale.

4.7 Power supply

This consists of the regulated +15V and -15V power supply, AC 6.3V for driving the chopper and for illuminating the range dial, and AC 6.3V, 0, 6.3V for synchronous rectification.

5. Maintenance

5.1 Internal inspection

The internal inspection can be performed by pulling out backwards the top, bottom and both side boards after unfastening and removing the two screws provided at the back of the case.

Fig 5-1 shows the arrangement plan of the respective parts at the time when the both side boards are taken off.

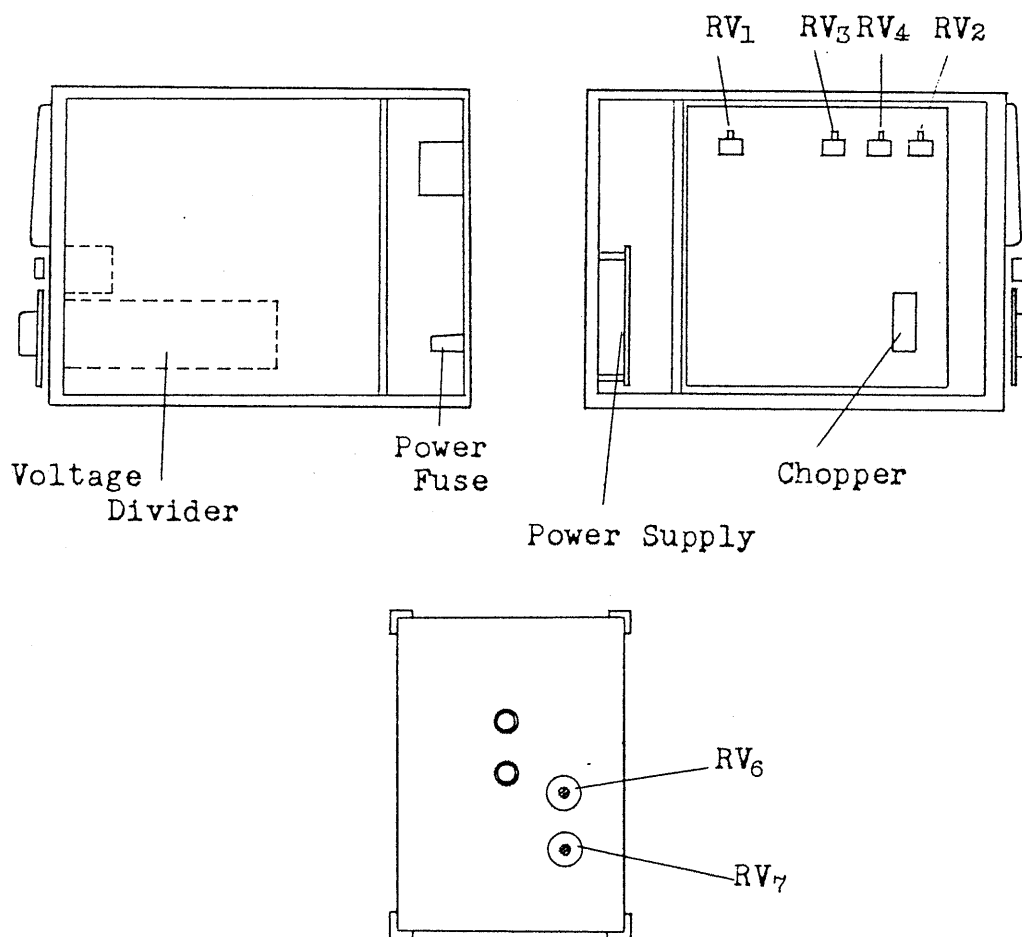


Fig 5-1

5-2 Adjustment and calibration

If this instrument does not fulfill the specification requirements after having not been used for a long time or having been repaired, the adjustment and calibration shall be conducted in the following methods.

1) Adjustment of the constant-voltage circuit

First adjust the negative power circuit to -15V by means of the variable resistor RV, and then adjust the $+15\text{V}$ by RV.

2) Calibration of meter

Voltmeter range

Bring the variable resistor RV₅ for zero adjustment to the center position of the rotary angle, and adjust the variable resistor RV₅ so that the meter pointer comes to point at the zero position.

Then, apply the calibrating voltage (1.5V) to the 1.5V range, adjust the variable resistor RV₄ so that the output voltage becomes 1.5V , and adjust the full scale of the meter by the variable resistor RV₂.

Ammeter range

Flow the calibrating current ($150\mu\text{A}$) to the $150\mu\text{A}$ range, and adjust the full scale of the meter by the variable resistor RV₃.

5.3 Repair

Prior to delivery out of our factory, this instrument has been carefully assembled and adjusted, and been subjected to inspection under severe control. But, if a trouble ever happens due to a casual accident or termination in the life of the component parts, the voltage distribution to the respective parts shown in this section shall be referred.

Table 5-1 shows one example of voltage distribution to the respective parts at the time of no signal. These voltages are the values measured on the basis of grounding.

Table 5-1

Transistor		Emitter source	Base gate	Collector drain
Q ₁	2SK13	1.36 V		9.2 V
Q ₂	2SC372	-0.69	-0.09	7.1
Q ₃	"	-0.71	-0.15	8.5
Q ₄	"	-0.9	-0.46	14.5
Q ₅	"	-1.48	-0.9	9.4
Q ₆	"	-1.48	-0.86	7
Q ₇	"	-0.86	-0.3	14.5
Q ₈	"	-0.83	-7.5	-1.48
Q ₉	2SB56	4.0	7.1	0.6
Q ₁₀	2SC372	0	0.6	8
Q ₁₁	M9064A	-27.6	-27	-15
Q ₁₂	2SB56	-15	-15.2	-27
Q ₁₃	2SC372	-23.6	-23	-15.2
Q ₁₄	2SB56	-7	-7.2	-15.2
Q ₁₅	M9064A	15	15.6	27.6
Q ₁₆	2SB56	23.2	23	15.6
Q ₁₇	2SC372	0	0.6	15.6