MODEL 104

DC VOLTAGE STANDARD

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.

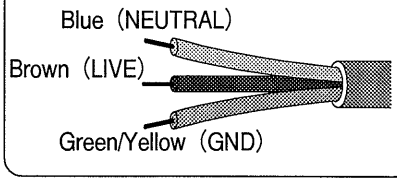
☐ AC power cable

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.

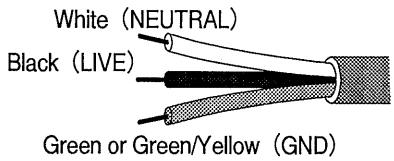
WARNING

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

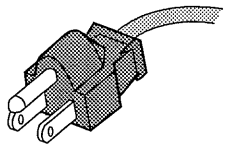
☐ Without a power plug



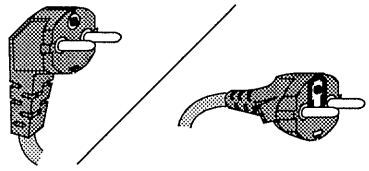
☐ Without a power plug



☐ 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

CONTENTS

1. INTRODUCTION

Kikusui's Model 104 DC Voltage Standard is a regulated power supply for obtaining a DC voltage of 0 to ±1,000V, 0 to 10mA, with an accuracy of 0.05%. The circuits are of hybrid design with vacuum tubes in the control unit and transistors in the other sections.

The output voltage of 0 to 1,000V can optionally be selected with 3-decimal-digit fine tuning dials and a range switch. With the fine tuning dials, the output voltage can be varied within 0.001% of the voltage range.

If the output current exceeds the rated value due to a short-circuit or other overload, an electronic protection circuit works to limit the current, and an overload lamp lights up.

Model 104 is used for calibration of general DC voltmeters and also as the power supply for a DC bridge or as the reference voltage precision regulated power supply for a potentiometer. Thus it has a wide variety of applications such as research, inspection, quality control and electronic equipment maintenance.

2. SPECIFICATIONS

Name	DC Voltage Standard
Model	Model 104
Output voltage	0 ~ ±1,000V
Range	±1V, ±10V, ±100V and ±1,000V 4 ranges
Polarity switching	Positive or negative polarity
Accuracy	0.05% of setting or 0.02% of range, whichever is greater
Output current	0 ~ 10mA
Sampling terminals	Provided on front panel
Protection against over load	Automatic crossover type
Ripple and noise	300μVRMS or 0.0001% of range, whichever is greater (5 Hz ~ 1 MHz)
Load regulation	Less than ±0.002% of range or 100μV, whichever is greater against no load to full load change.
Line regulation	Less than ±0.002% of range or 100μV, whichever is greater against ±10% line voltage change.
Power source	-------- V, 50/60 Hz Approx. _____VA

Dimensions	200mm (W) x 140mm (H) x 390mm (D)	
(largest part)	200mm (W) x 155mm (H) x 430mm (D)	
Weight	Approx. 6.7kg	
Accessories	Short bars	2
	Operation Manual	1

3. OPERATION

3.1 Front and Rear Panelsdescription (See fig.3-1 and 3-2)

① POWER	Pushbutton on-off power switch. Depression of this switch turns on the power for operation with pilot lamp alight.
② RANGE	Used for selecting ranges 1V, 10V, 100V and 1,000V are the maximum voltages in the respective ranges. The position of the decimal point shifts simultaneously with range changeover.
③ Dials for voltages setting	Dials for setting voltage. Clockwise turn advances the reading. Each dial is graduated from 0 to 9.
④ VERNIER	Variation equivalent to the reading "1" in the dial in the least significant position is obtained by turning this control from 0 to 10.

Accordingly, the maximum voltages in the respective voltage ranges are obtained by setting the dials to "999" and turning this control fully clockwise.

⑤ POLARITY — Output voltage polarity and stand-by switch. When this switch is set to "+", the output terminal (red) becomes positive. When the switch is set to "-", the output terminal (red) becomes negative.

⑥ OUTPUT SAMPLING terminals — DC voltage output terminals, from which an output of 0 to 1,000V, 0 to 10mA is obtained. The OUTPUT'S are current terminals. Connect a load to these terminals. SAMPLING terminals are for "remote sensing" and are usually connected to current terminals with a short bar.

⑦ OVERLOAD — When an output current of our approximately 11mA or more, this indicator lamp lights to limit the current.

⑧	Fuse	A 1A fuse provided on the primary side of the power transformer. The bracket can be removed by turning it counterclockwise.
⑨	Power cord	Connect this cord to a 50/60 Hz AC power source.
⑩	Cord winders	Wind cords around these winders when the set is not in use.

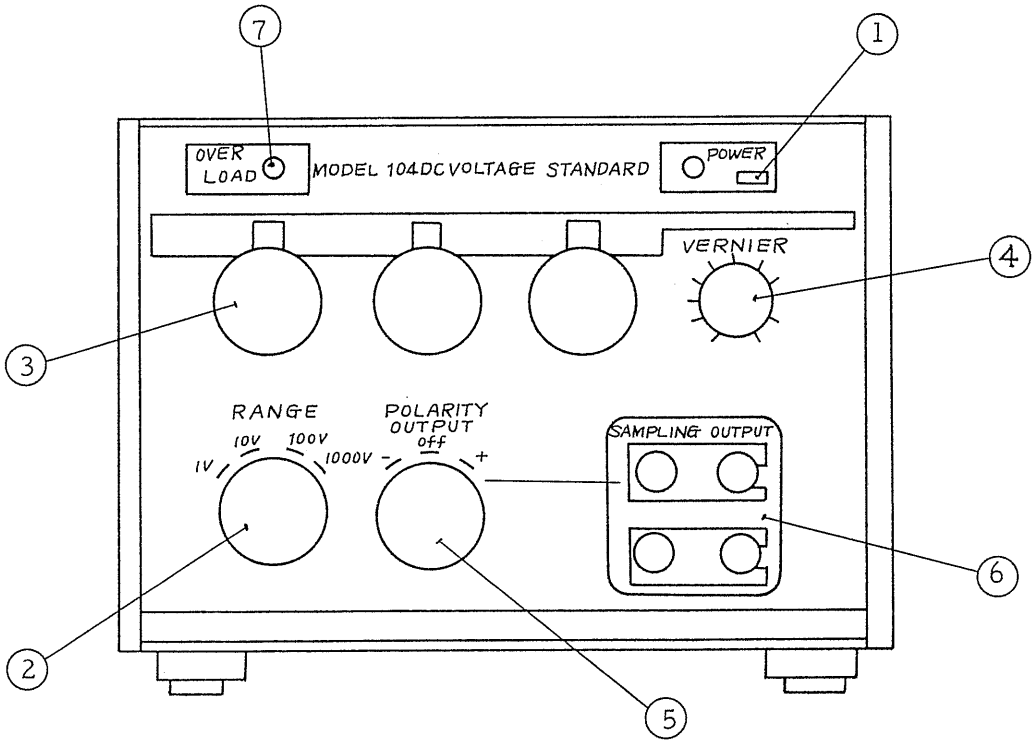

7
1
OVER LOAD
MODEL 104DC VOLTAGE STANDARD
POWER
VERNIER
4
3
RANGE
1V
10V
100V
1000V
POLARITY OUTPUT
off
-
+
SAMPLING OUTPUT
6
2
5

Fig. 3-1

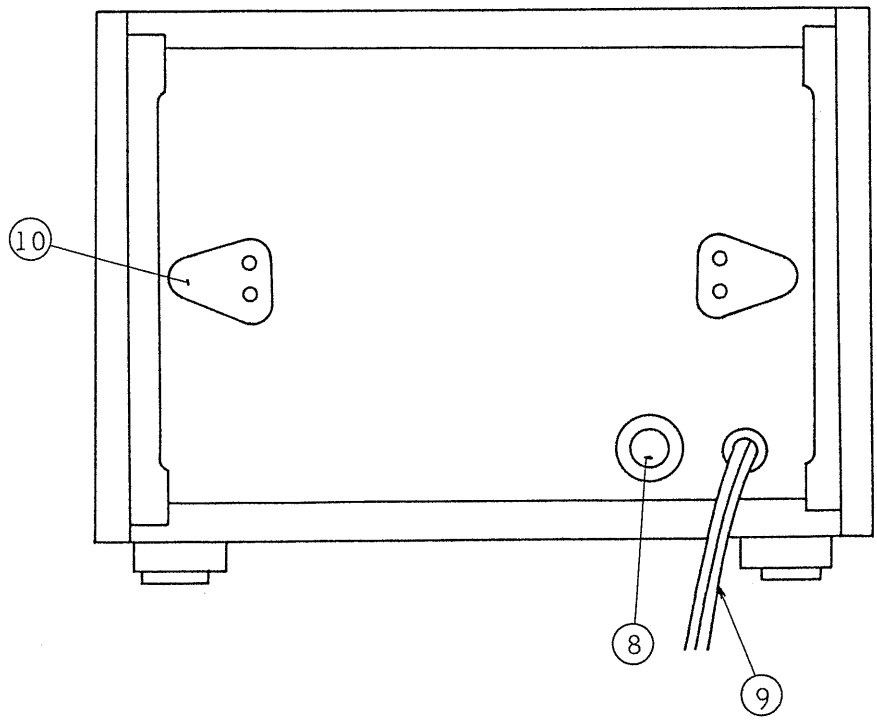

10
8
9

Fig. 3-2

3.2 Preliminary operation

1. Set all the output voltage dials to zero and the polarity switch to OFF.

2. Connect the AC cord to a 50/60 Hz power source and turn on the POWER switch.

3. Model 104, which uses a thermostatic oven, requires pre-heating for approximately 30 minutes. However, it becomes ready for operation in a few minutes after the power is turned on if voltage accuracy is not required.

3.3 Use of SAMPLING terminals

Use the SAMPLING terminals when this power supply unit and the load are kept apart some distance, and it is desired to adjust the load terminals to the specified voltage.

The error in the case where the SAMPLING terminals, as in Fig. 3-3, are not in use can be calculated as follows.

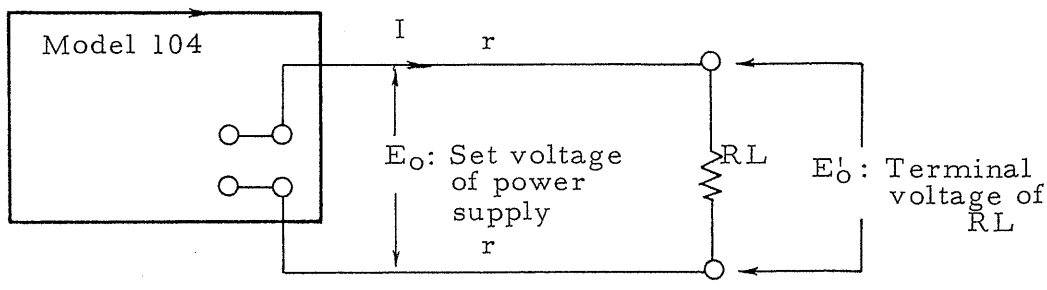


Fig. 3-3

r : Electric resistance on one side from power supply to load

RL : Load resistance

ΔE : Error voltage caused by r

ΔE : $E_o - E'_o = I(RL + 2r) - I \cdot RL$

$\therefore \Delta E = 2rI$

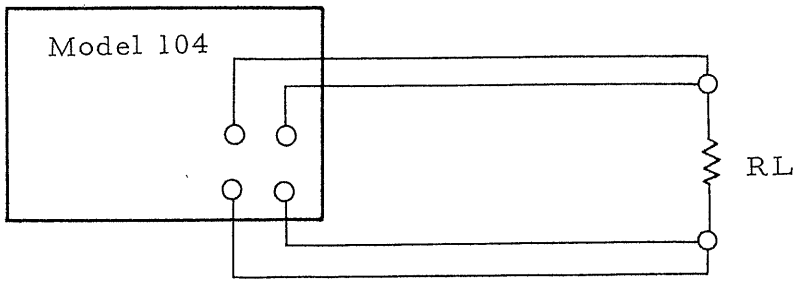
Assuming the output voltage is 1V and the resistance of the lead wire on one side is 0.5 ohm, the voltage at the terminals when a load current of 10mA flows can be calculated as follows.

$$E'_o = 1V - 2 \times 0.5 \times 10 \times 10^{-3} = 0.09V$$

Thus an error of 0.01V is detected.

The SAMPLING terminals are provided to prevent any voltage drop which may be caused by the lead wire.

Remove short bars as shown in Fig. 3-4 and connect the SAMPLING terminals to the load terminals (for voltage detection).



Remove short bar

Fig. 3-4

3.4 Cautions

The chassis is of floating type and is connected to the red output terminal when the polarity switch is set to "+". When the switch is set to "-", the chassis is connected to the white output terminal. Be careful when operating the case since there is electric potential.

Be sure to tighten the short bars attached to the output SAMPLING terminals when these terminals are not in use. If the bars are loose, an output voltage may not be accurately attained.

4. PLINCIPLE OF OPERATION

Fig. 4-1 is a block diagram of Model 104 Voltage Standard.

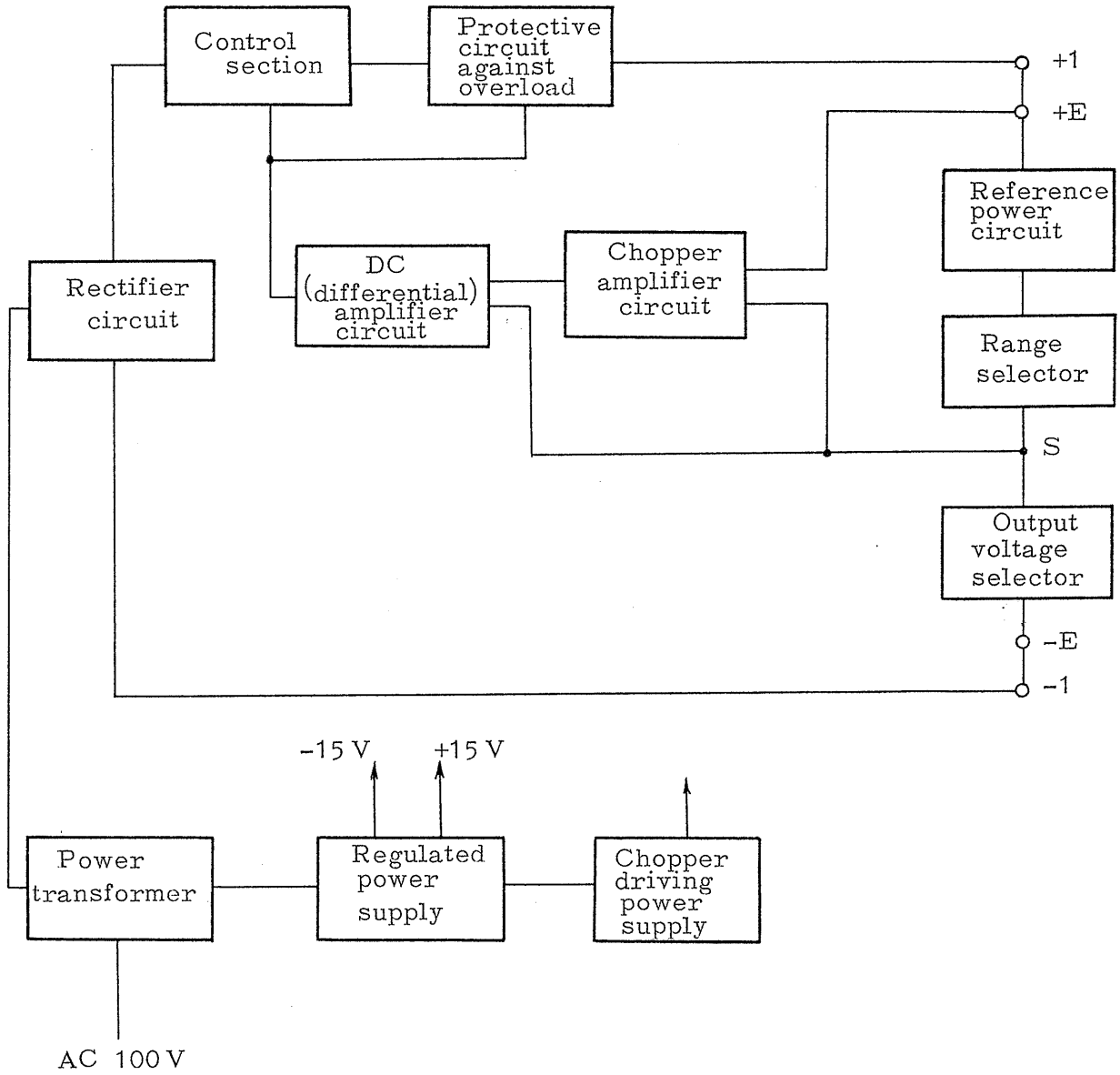


Fig. 4-1

In Fig. 4-1, +I and -I indicate the current output terminals, and +E and -E the Output sensing terminals (SAMPLING) respectively.

Assuming a load is connected to the current terminals, or the voltage at the voltage sencing terminals drops due to a fluctuation of the AC line, the potential at the summation point S for the reference power supply and the output terminal (-E) increases, and the DC amplifier and the chopper amplifier amplify the error signal to increase the collector current of the control transistors.

As a result, an output voltage drop is compensated for, and the original condition prior to the change is restored.

The chopper amplifier is driven by a rectangular wave of approximately 220 Hz produced by MOS FET's with an excellent offset voltage.

Metal-filmed resistors with a low temperature coefficient are used to select an output voltage and range. In the case of the reference voltage power supply, temperature compensation zener diodes are placed in the thermostatic oven to improve the stability.

The current flowing to the resistor for selecting output voltages is varied by selecting ranges. Output voltages are varied by the resistor.

The protective circuit detects a voltage drop of the resistor inserted in series with the control circuit to limit the maximum output current.

5. MAINTENANCE

5.1 Removal of case

Remove the four screws shown in Fig. 5-1 and take out the shoes at the rear to carefully pull out the side top and bottom plates.

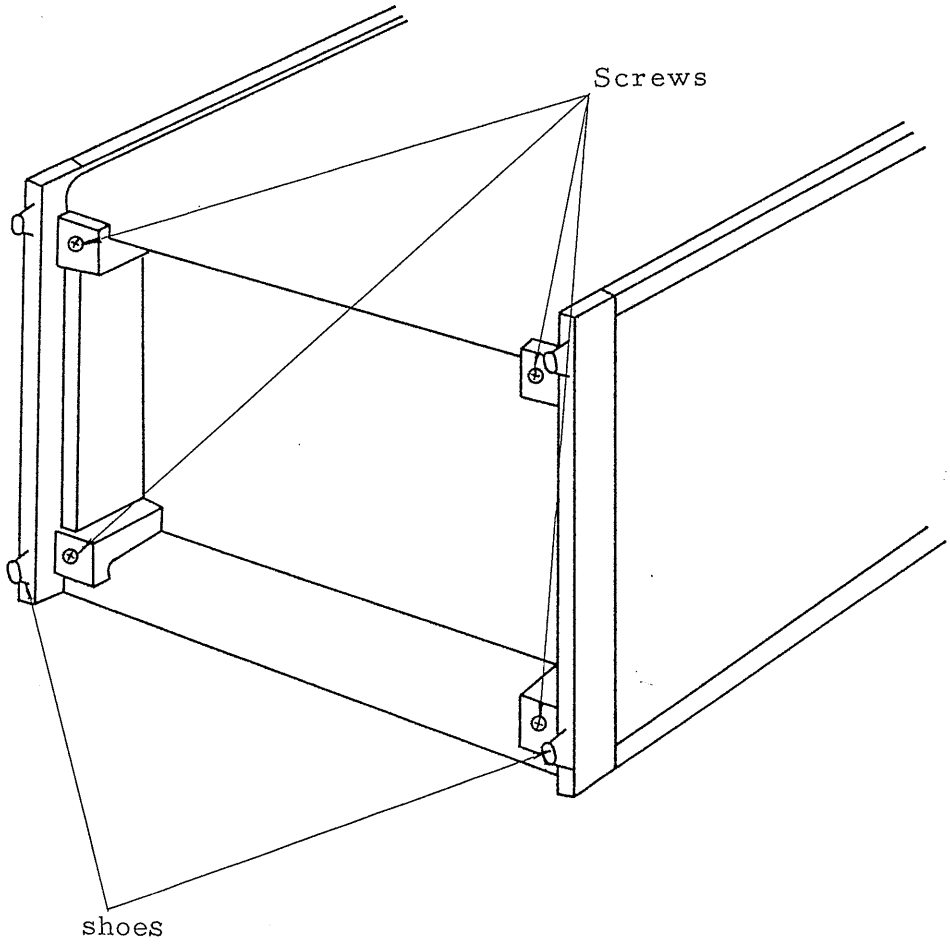


Fig. 5-1

Note: Be careful since the top plate is detached from the frame if the set is tilted forward by holding the handle with no shoes attached to the rear.

5.2 Layout

Fig. 5-2 shows the overall layout, and Figs. 5-3 to 5-8 the arrangement of components on PCB's.

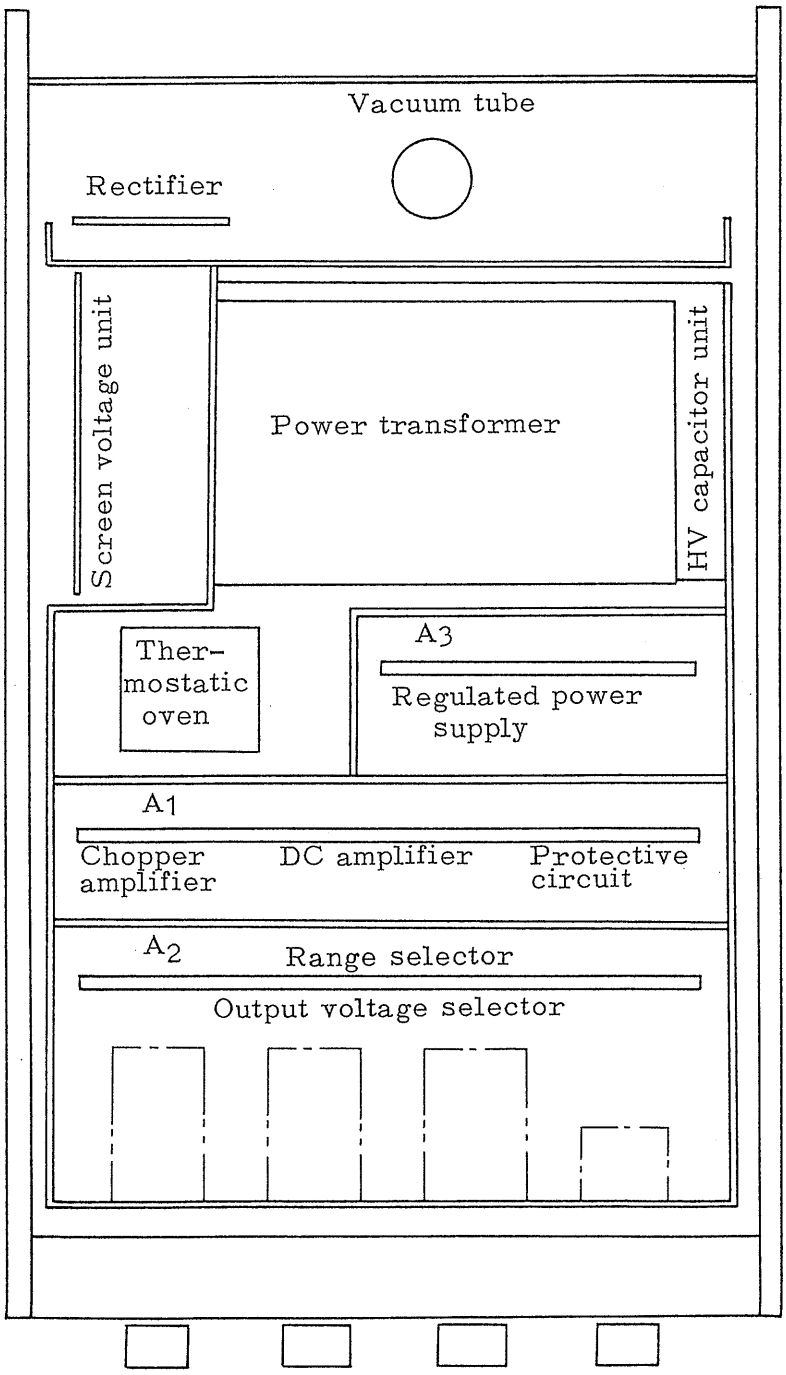


Fig.5-2

PCB A_1, DC amplifier, chopper amplifier and protective circuit

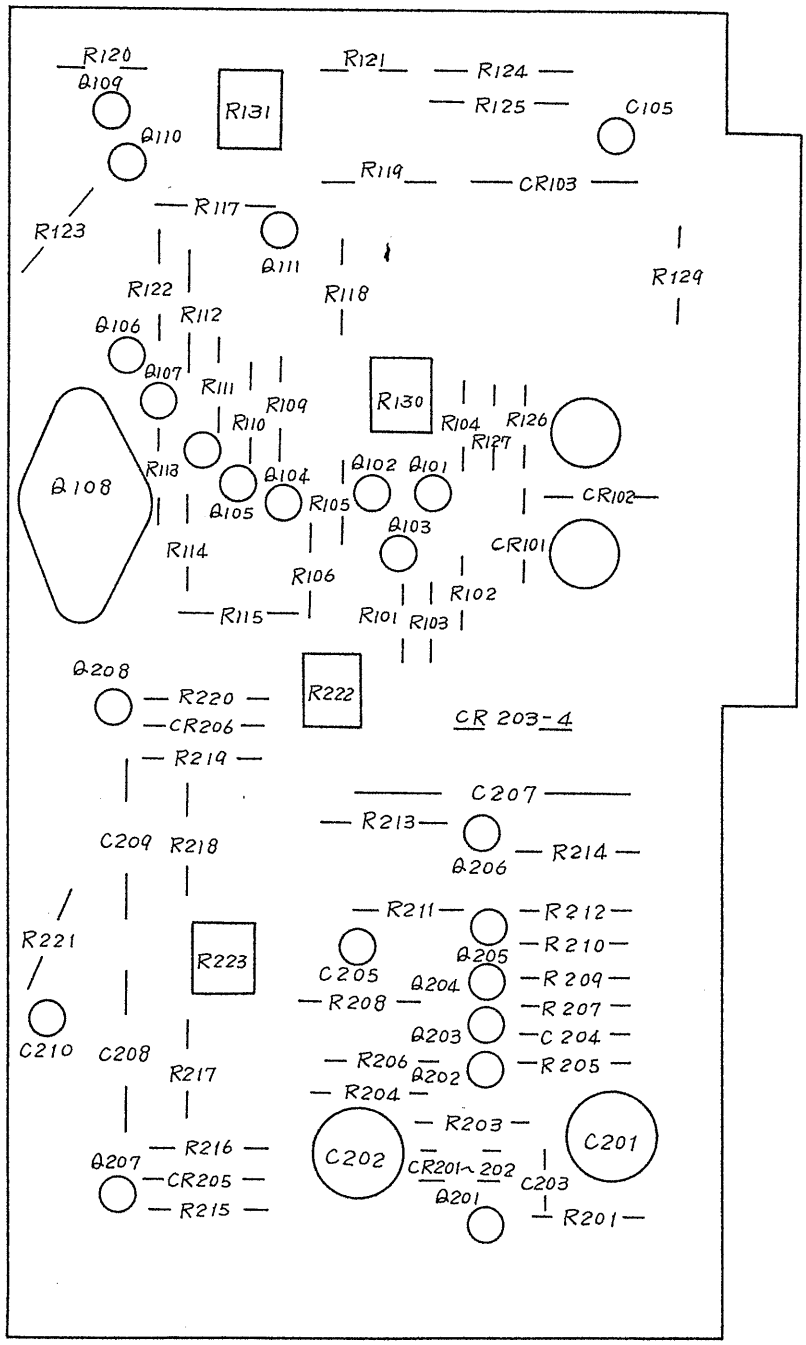


Fig. 5-3

PCB A_2 and range selector

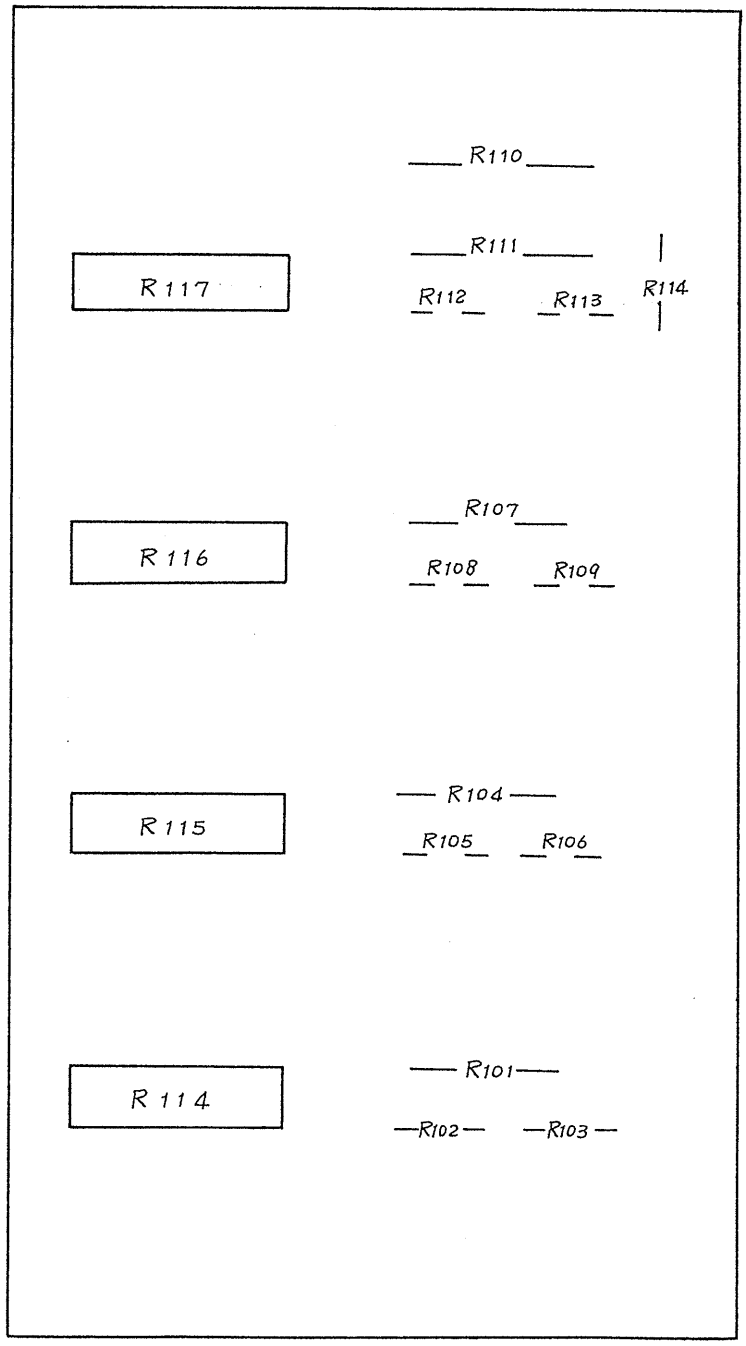


Fig. 5-4

PCB A_3 and regulated power supply

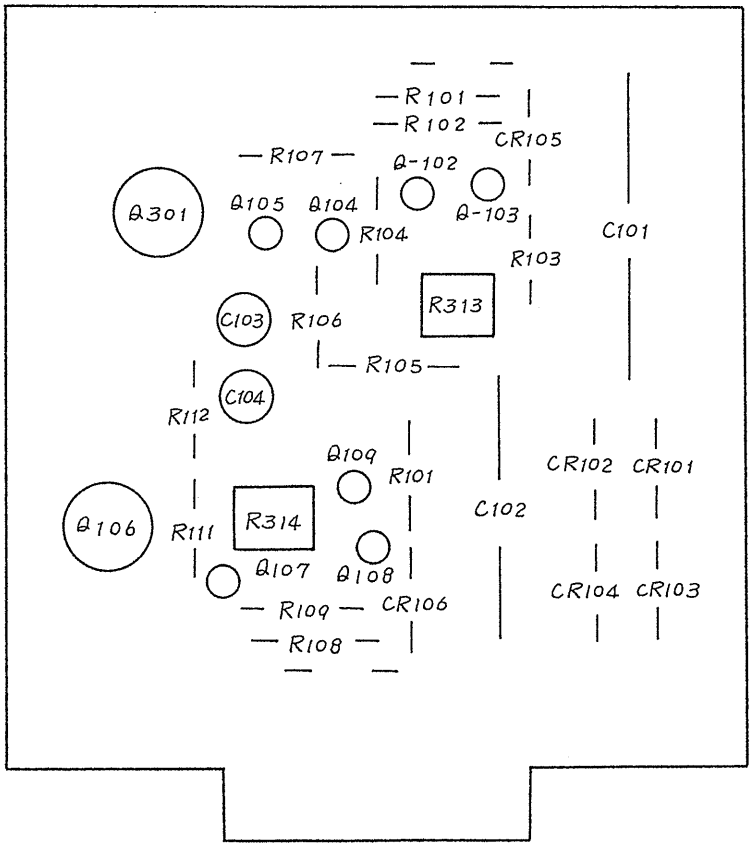


Fig. 5-5

PCB A_4

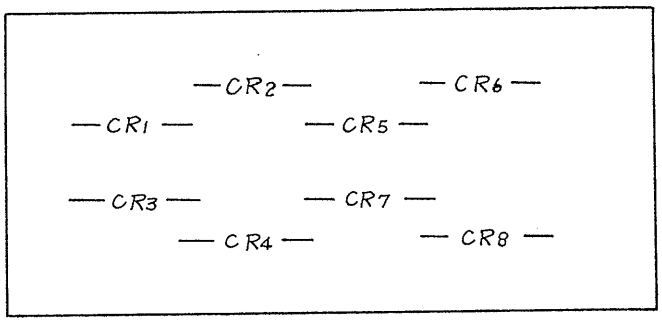


Fig. 5-6

PCB A_5

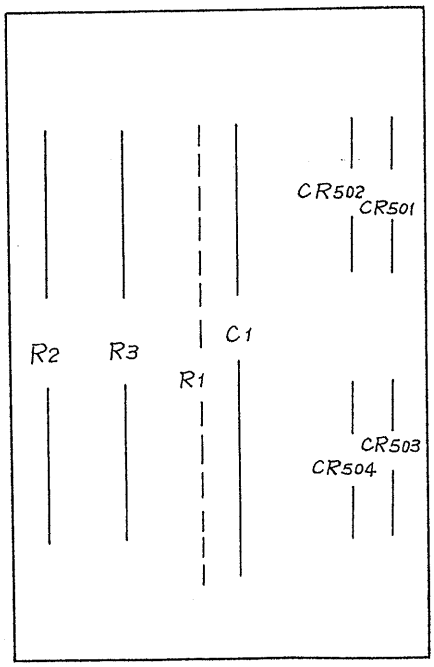


Fig. 5-7

PCB A_6

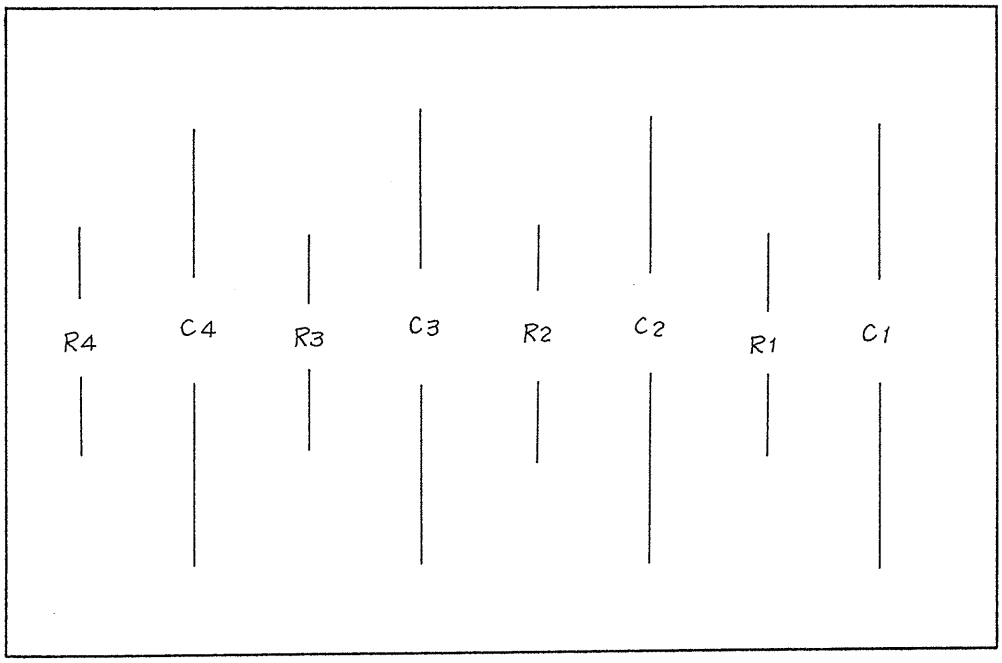


Fig. 5-8

5.3 Adjustment and calibration

It is recommended to check, adjust and calibrate regularly (once in 6 months or once in 12 months) to maintain the accuracy of this regulated power supply over a long time. Calibrate it at a place with a temperature of approximately 25 °C and subject to minimum ambient temperature fluctuations in order to attain high calibration accuracy.

For adjustment and calibration, observe the following procedure after more than one hour of pre-heating.

1. +15V adjustment of regulated power supply

   Connect a DC voltmeter to connector pins Nos. 5 (0V) and 2 of PCB A_3 and adjust variable resistor R_{313} for +15.

2. -15V adjustment of regulated power supply

   Connect a DC voltmeter to connector pins Nos. 5 and 3 and adjust variable resistor R_{314} for -15V.

3. Adjustment of astable multivibrator

   Connect an oscilloscope across Q_{208} (collector) and the ground (connector pin No. 4) of PCB A_1 to adjust variable resistor R_{223} in order to obtain a symmetrical rectangular wave.

   Connect an electronic counter to the same points to calibrate the oscillation frequency to 220 Hz with variable resistor R_{222}.

4. 0V adjustment of output voltage (in 1V range)

   Set the dials and the fine tuning knob to zero and the polarity switch to "+". Connect a DC voltmeter (with a selectivity of more than 1.5 mV F.S) to the output terminals to attain 0V with variable resistor R_{130} (PCB A_1)

5. Calibration of 1V range (PCB A_2)

   Set the range switch to the 1V range and the dials to 999 and turn the fine tuning knob fully clockwise. Measure output voltages with a precision potentiometer with an accuracy of better than 0.01% or a differential voltmeter to attain 1.0000V with R_{117}.

6. 10V range (PCB A_2)

   Set the range switch to the 10V range with the dials and knob in the above condition to attain 10.000V with R_{116}.

7. 100V range (PCB A_2)

   Set the range switch to the 100V range with the dials and knob in the same condition to attain 100.00V with R_{115}.

8. 1000V range (PCB A_2)

   Set the range switch to the 1000V range with the dials and knob in the same condition to attain 1000.0V with R_{114}.

9. Adjustment of protective circuit

Set the range switch to the 1000V range, connect a variable resistor to the output to increase the current and adjust R_{124} so that the OVERLOAD lamp lights when the current reaches 11mA.

5.4 Check and repair

For check and repair, see 4. PLINCIPLE OF OPERATION

In the example below, measurement is based, unless otherwise specified, upon the power voltage of 0V as the reference.

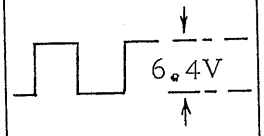
Set the regulated power supply to the maximum output in the 1,000V range without any load connected.

The values are measured with a VTVM with an internal resistance of 11M ohms.

1. Chopper amplifier (PCB A_1)

Transistor	Collector (V)	Base (V)	Emitter (V)
Q202	7.5	-0.65	0.6
203	0.58	0.6	0.1
204	0.63	0.58	0
205	3.8	0.63	0.1

2. Astable multivibrator

Transistor	Collector	Base	Emitter
Q207			DC-6.5V

3. DC amplifier (PCB A_1)

Transistor	Collector (V)	Base (V)	Emitter (V)
Q101	7.6	0	0.85
102	7.6	0	0.85
103	0.85	- 7.5	- 8.1
104	10.5	7.6	7
105	13.6	7.6	7
106	15	15	14.4
107	5.2	13.7	14.4
108	35	0.76	0.15

4. Protective circuit (PCB A_1)

Transistor	Collector (V)	Base (V)	Emitter (V)
Q109	15	- 3.15	- 0.65
110	14.4	0	- 0.65
111	0	14.8	15

5. Regulated voltage circuit (PCB A_3)

Transistor	Collector (V)	Base (V)	Emitter (V)
Q101	33	16	15
102	33	16.8	16
103	16.8	29	29.5
104	16.8	8.8	8.2
105	15	8.8	8.2
106	-15	-34.6	-35
107	-34.6	-16	-15
108	-16	-30	-30.6
109	-16	- 0.64	0