REGULATED DC POWER SUPPLY

PAD1K-0.2L

INSTRUCTION MANUAL

KIKUSUI

Part No. Z1-714-920, IB000453

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.

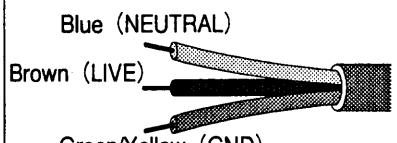
☐ AC power cable

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.

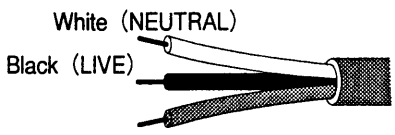
WARNING

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

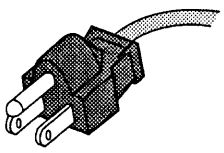
☐ Without a power plug



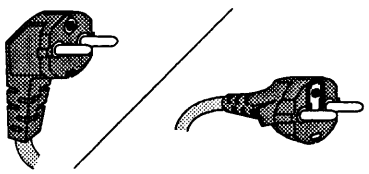
☐ Without a power plug



☐ 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

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SECTION 1. GENERAL

1-1. Description

The PAD-L Power Supply is designed for high operation reliability and excellent electrical performance. It is a universal-purpose industrial power supply which can be used as a variable power source for research and development, or as a fixed power source for long-time aging test. Features of the PAD-L Power Supply can be summarized as follows:

1. Improved power factor at low output voltage:

   A choke input system is used for the rectifier filter circuit, thereby reducing the apparent input current and improving the power factor. This led to a smaller power transformer and consequently to a compact and light power supply.

2. Less waveform distortion caused to the AC input line:

   As the choke input system is used, the input current waveform is less distorted with harmonics, thereby reducing waveform distortion to the AC input line.

3. Excellent temperature coefficient:

   Very low temperature drift characteristics of 100 ppm/°C is attained by using premium-quality parts, improved circuits, and forced air cooling. Time-elapse drift (aging drift) also is very low.

4. Fast transient response:

   A wide-band error amplifier is used to ensure stable frequency - gain, phase characteristics.

5. Low ripple and noise voltages:

   Ripple and noise voltages are low, both is rms and peak values.

The output voltage is finely adjustable from 0 V to the rated voltage with a 10-turns potentiometer and a 1-turn potentiometer.

The power supply has a current/voltage limit switch to preset a current/voltage value. The set value of constant-voltage/constant-current operation can be checked when in operation.

The power supply has internal protector such as voltage detector, current detector and temperature detector.
An overvoltage protector (OVP), with voltage adjustable from the front panel, also is incorporated as a standard feature. A high speed overvoltage protector (a thyristor crowbar protector) is available as an option.

The power supply is housed in a casing for bench top use. It can be installed on a standard 19-inch (500-mm) rack.

The user is requested to read thoroughly this instruction manual before operating the power supply.

* It is highly recommended to use the thyristor crowbar high-speed overvoltage protector OVP (option) for a load whose allowable voltage range is very narrow and which could be damaged when a slight overvoltage is applied.

1-2. Specification

Model . PAD1K-0.2L

Input supply

120 V ±10% 50/60 Hz AC, 1ϕ

Power consumption 120 V AC Rated load

Approx 440 VA

Output

Output voltage range	10 turns (coarse)	1 turn (fine)
		0 - 1000 V
Voltage resolution (theoretical value)		50 mV
Output current range	10 turns	0 - 200 mA
Current resolution (theoretical value)		50 μA

Constant voltage characteristics

Regulation	
Source effect (line regulation)	0.002% + 5 mV
(For ±10% change of line voltage)	
Load effect (load regulation)	0.002% + 5 mV
(For 0 to 100% change of output current)	
Ripple and noise (5 Hz - 1 MHz)	500 μV rms
Transient response (typical) *1	50 μ sec
Temperature coefficient (typical)	100 ppm/°C

Constant current characteristics

Regulation	
Source effect (line regulation)	100 μA
(For ±10% change of line voltage)	
Load effect (load regulation)	100 μA
(For 0 to 100% change of output current)	
Ripple and noise (5 Hz - 1 MHz)	50 μA rms

Operating ambient temperature range 0 - 40°C (32 - 104°F)

Operating ambient humidity range 10 - 90% RH

Cooling method forced air cooling with fan

Output power switch and polarity of output voltage

It is able to change the polarity of output voltage with the rotary switch.

Protections

Operations Input power switch is turned off.

Trip temperature of thermal protector 100℃(212°F)
at cooling Package

Voltage protection (OVP)

Voltage setting range (typical) 20 − 1100V

Trigger pulse width (typical) 50msec

Input fuse rating (AC125V) 10A

Output fuse rating 0.5A

Meters

Voltmeter 4-1/2Digit

Accuracy 1 Output voltage measurements

± (0.05% Of reading +1 digit)(25℃ ± 5℃)
± (0.1% Of reading +2 digit)(0 − 40℃)

But When the Output Voltage is less than 50V, take the following accuracy.

± (0.05% Of reading +3digit) (25℃ ± 5℃)

± (0.1% Of reading +3digit) (0 − 40℃)

2 Voltage limit operating

± 10 digits (25 ± 5℃)

± 20 digits (0 − 40℃)

Polarity Automatically sensed and displayed

Ammeter 3-1/2 Digit

1 Output current measurements

± (0.3% Of reading +1digit) (0 − 40℃)

2 Current limit operating

± 5 digits (0 − 40℃)

Polarity Automatically sensed and displayed

Constant boltage mode indicaton C.V:with LED

Constant current mode indication C.C: with LED

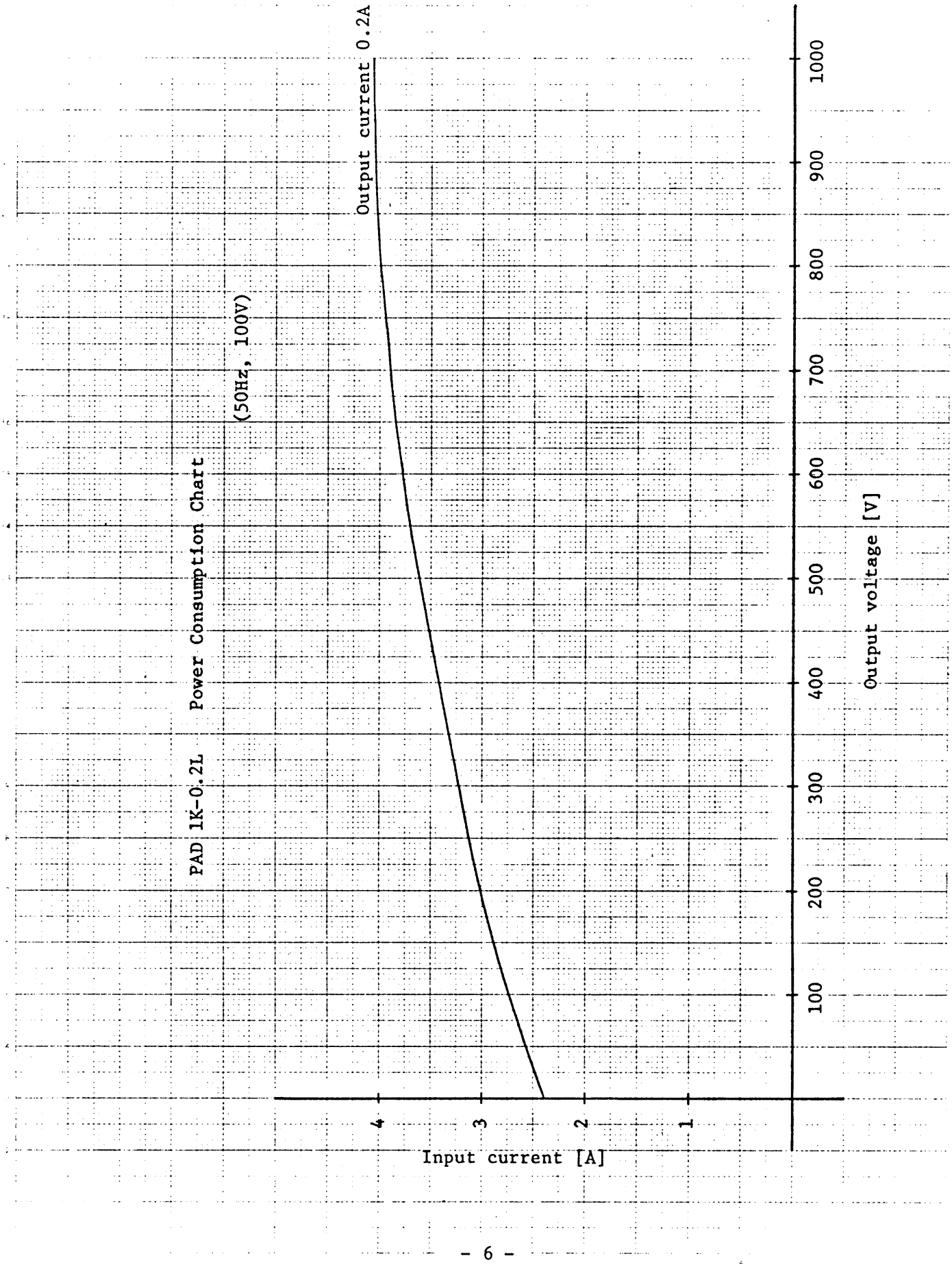
Insulation resistances	Between chassis and line 1000V DC more than 100MΩ
Dimension *2	430W × 88H × 450D mm (16.9W × 3.5H × 17.7D in.)
(Maximum dimension)	435W × 105H × 500D mm (17.1W × 4.2H × 19.7D in.)
Weight	Approx. 22 kg

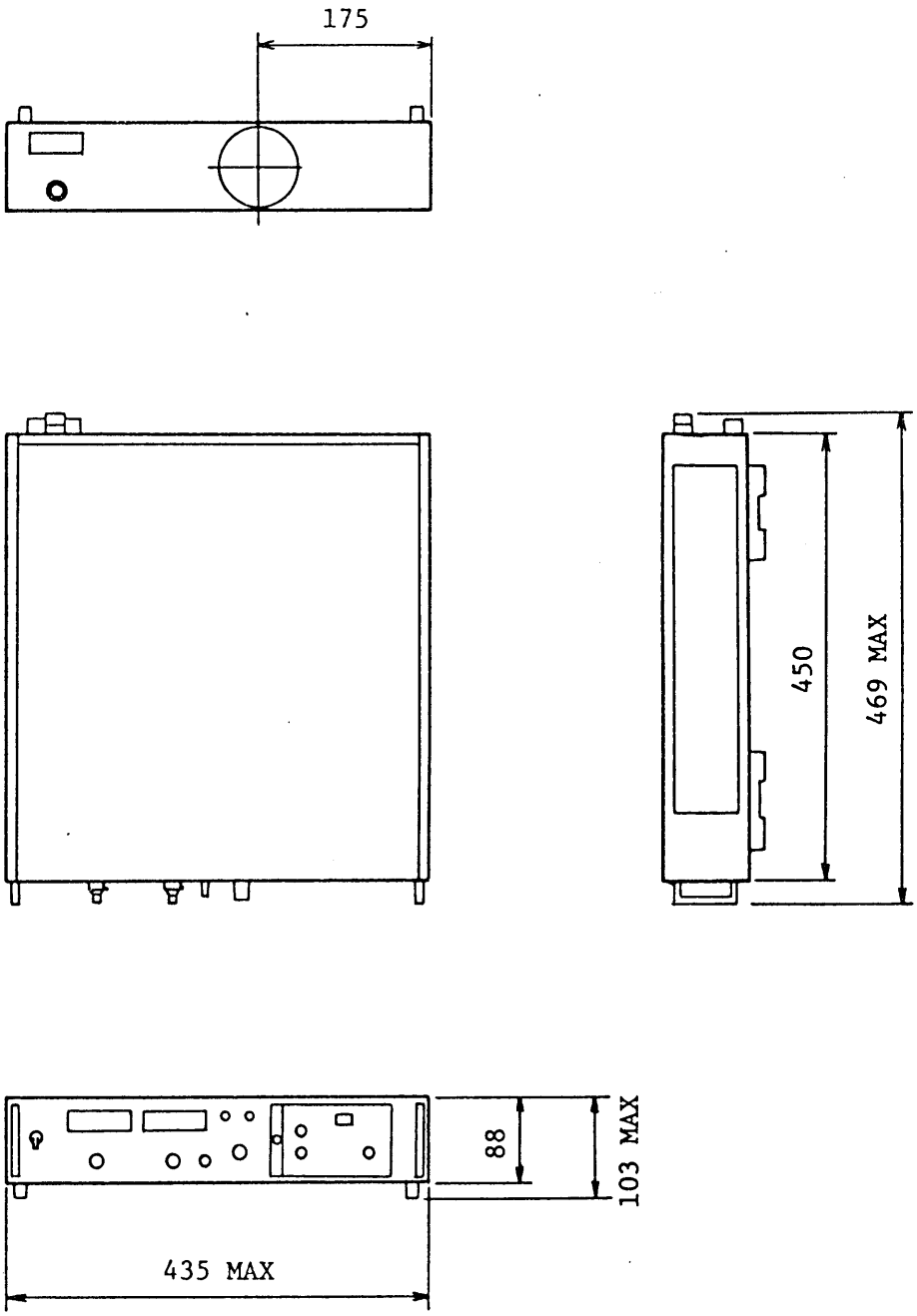
Accessories (in carton)

Instruction manual	1 copy
Input line fuse (spare)	2 ea.
Input coad	
Output coad	

Notes *1 Recovery time within to 0.05% + 100 mV of the output voltage.

*2 With rack mount brackets (option), can be mounted on a standard 19-inch or 500-mm rack.


PAD 1K-0.2L Power Consumption Chart
(50Hz, 100V)
Output current 0.2A
Input current [A]
4
3
2
1
100
200
300
400
500
600
700
800
900
1000
Output voltage [V]



Unit: mm

Figure 1-1 Mechanical Outline Drawing

SECTION 2. OPERATION

2-1. Precaution For Operation (Installation)

1. Input power

   - The input voltage range is 108 - 132 V, 48 - 62 Hz single-phase AC.

   - The input power fuse rating is

     10A for 125 V

2. Output

   - The output power is available at both binding post terminals and at the BNC-HV terminal.

   - The output voltage keeps about zero volt when the output box's door is opened, though the output power switch is turned on.

     The output power will be cut off, if the output box's door is opened in operation. In that case, close the output box's door, and turn the output box's knob to the extreme clockwise position. Once turn off the output power switch, then turn on the output switch again.

3. Ambient temperature

   - The ambient temperature range for the power supply to satisfy the specification performances is 0°C to 40°C. The power supply should be used within this range. If it is operated at a high ambient temperature, the internal temperature detector circuit trips and the input power switch is turned off. If this has happened, cool it and then turn on the power again. There is an exponential relationship between ambient temperature and semiconductor life, electrolytic capacitor life and transformer insulation life. Note that

components are rapidly deteriorated at high temperatures. It is important not to operate the power supply at an abnormally high ambient temperature also from the viewpoint of its life.

- o If the power supply is used at a temperature lower than -10°C, its operation may become unstable. If the power supply is to be used at low temperatures, specify so when ordering.

4. Place for use

- o Pay attention so that the ventilation ports (top and bottom) and the fan air outlet are not blocked.
- o Hot air comes out of the fan air outlet. Do not place near the outlet an object which is not heat resistant.
- o Do not use the power supply in a highly humid or dusty place as such can cause failures.
- o Select a place where is reasonably free from vibration.
- o Do not place a high sensitivity instrument on or near the power supply which produces a strong electric and magnetic fields.

5. Notes for loads:

Note that the output may become unstable depending on characteristics of loads as follows:

(a) When the meter reading (average value) is less than the present value, if the current has peaks which exceed the preset value, the operation is driven into the constant current domain for the short periods of time and the output

voltage falls. Observing carefully, it can be seen that the constant-current indicator lamp becomes dim.

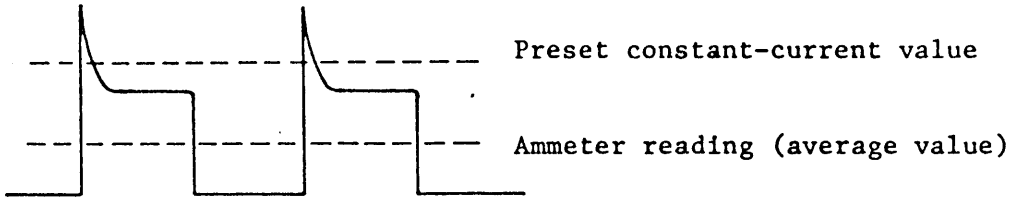


Figure 2-1. Load current with peaks

In this case, raise the preset value or increase the current rating.

(b) When a regenerative load (such as inverter, converter, or transformer) is connected to the power supply, as it cannot absorb the reverse current fed from the load, the output voltage increases and becomes unstable. In such a case, connect a bypass resistor (R) in parallel with the load and feed in this resistor a current larger than the maximum reverse current.

$$R\ [\Omega] \leqq \frac{E_O\ [V]}{I_{RP}\ [A]}$$

where, E_O: Output voltage
I_{RP}: Maximum reverse current

6. Precautions for charging battery

To charge a battery, set the charge end voltage with the constant voltage setting knob and the charge current with the constant current setting knob. When the charge end voltage is reached, the charging operation stops automatically.

- ○ Do not set the output voltage with the constant voltage setting knob to lower than the battery voltage when the battery is connected. The potentiometer may burn.

7. Output switch (output polarity) and indication polarity of meter

- ○ The indication polarity of the meter do not depend on the output switch (output polarity). For example, when the power supply outputs 1000V with setting the output switch to "+" (- grounding) or with setting the output switch to "-" (+ grounding), the meter indicates 1000.0V both.

2-2. Explanation of Front and Rear Panels

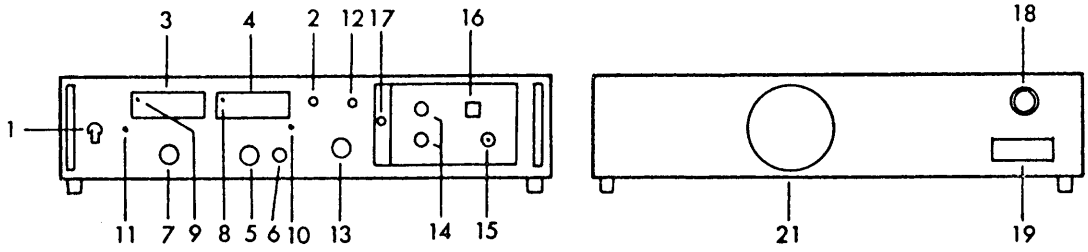


Figure 2-2

Panel items and descriptions

1. POWER switch/Circuit Breaker:

   Serves as AC power switch. When thrown to the upper position, the input power is turned on and C.V. or C.C. lamp lights.

   Note: The input power is automatically turned off when any one of the internal protectors (overvoltage protector, voltage detector, current detector and temperature detector) has tripped. The input power cannot be turned on immediately after it has been turned off by the above cause. Eliminate the cause, wait about 60 seconds and then turn on the input power.

2. CURRENT/VOLTAGE LIMIT switch:

   Push to set crossover point of CV/CC. The ammeter indicates the preset constant-current value and the voltmeter indicates the preset constant-voltage value.

3. Ammeter:

   Monitors the output current.

4. Voltmeter:

   Monitors the output voltage.

5. Voltage setting knob: (Coarse)

   Adjusts output voltage for constant-voltage operation.
   10-turn potentiometer

6. Voltage setting knob: (Fine)

   Adjusts the voltage for constant-voltage operation.
   1-turn potentiometer.

7. Current setting knob:

   Adjusts output current for constant-current operation.
   10-turn potentiometer

8. C.V. (constant-voltage operation indicator lamp):

   Energizes in constant-voltage mode. LED

9. C.C. (constant-current operation indicator lamp):

   Energizes in constant-current mode. LED

10. Voltmeter calibration (R630):

    For voltmeter calibration. (Periodically calibrate the voltmeter referring to SECTION 6 "MAINTENANCE.")

11. Ammeter calibration (R613):

    For ammeter calibration. (Periodically calibrate the ammeter referring to SECTION 6 "MAINTENANCE.")

12. Overvoltage (OVP) (See 3-3 "Operation Method of Overvoltage"):

    When the output voltage has exceeded the set value due to inadvertent operation or instrument failure, the input power switch is instantaneously cut off to protect the load.

13. Output power switch:

14. Output terminal:

    Binding post

15. Output terminal:

    BNC-HV terminal

16. Output power lamp:

17. Output box's knob:

18. Input fuse holder:

    10A for 125 VAC

19. Input terminal board:

    For input power connection. Use the power cord supplied accompanying.

20. Fan exhaust area:

    Air exit of the cooling package. As hot air comes out of this outlet, do not obstruct. The outlet must be positioned 30 cm or over from wall.

2-3. Constant-Voltage Operation

Check first that the AC line voltage is 120V ±10% AC. Then, proceed as follows:

(1) Turn off the output power switch.

(2) Turn counterclockwise the output box's knob and open the door.

(3) Connect the load to the output terminals.

The output power is available at both the binding post terminals and the BNC-HV terminal.

(4) Close the output box's door, and turn the output box's knob to the extreme clockwise position.

(5) Turn on the input power switch. The C.C lamp and the C.V lamp will light indicating that instrument power on.

(6) Keeping depressed the current/voltage limit switch, set the output voltage at the required value with the voltage setting knob. By this procedure, setting of the output voltage is complete.

Setting of current limit

(7) Keeping depressed the current/voltage limit switch, set the required constant current value with the current setting knob. Once this setting is done, no output current larger than the set value flows even when the load is rapidly changed. (The load is protected by automatically changing the instrument operation from the constant-voltage mode to the constant-current mode. This function is called "crossover".)

(8) Turn the output power switch "+" (negative ground) or "-" (positive ground). The C.V lamp and the output power lamp will light and output power is delivered to the output terminals.

Notes:

1. Use the output switch, whenever the output power is cut off.

2. The output voltage keeps about zero volt when the output box's door is opened, though the output power switch is turned on. The output voltage keeps about zero volt when the output box's knob is locked incompletely, too.

3. The output power will be cut off, if the output box's door is opened in operation. In that case, close the output box's door, and turn the output box's knob to the extreme clockwise position. Once turn off the output power switch, then turn on the output switch again.

4. Pay attention when setting the O.V.P. voltage. At the instant the O.V.P. operates, the input power switch is cut off. Set the O.V.P. voltage with an allowance of approximately 10%.

5. When the load resistance is unpredictable or it is predicted to very largely or when it has a large inductance and rapid voltage application is undesirable, gradually increase the output current by increasing the output voltage or by gradually turning the current setting knob from the counterclockwise position in the clockwise direction.

2-4. Constant Current Operation

(1) Make sure that the AC line voltage is 125V ±10% AC. Then, connect the input power.

(2) Make sure that the output cord is securely connected to the load.

(3) Make sure that the output box's knob is locked.

(4) Turn off the output power switch.

(5) Turn on the input power switch. The C.C lamp and the C.V lamp will light indicating that instrument power on.

(6) Keeping depressed the current/voltage limit switch, set the current at the required value with the constant-current knob and, at the same time, set the voltage limit value with the constant-voltage knob. Once this setting is done, the load is protected against overvoltage.

(7) Turn the output power switch "+" (negative ground) or "-" (positive ground). The C.C lamp and the output power lamp will light and the output power is delivered to the output terminals.

Notes: 1. If the load has a large inductance and it is undesirable to apply rapidly a large current, set the current setting knob in the extremely counterclockwise position and, then, turn on the power switch and gradually increase the current.

2. If the current/voltage limit switch is depressed when in the constant-current mode, the output current is reduced by approximately 0.1 mA from the preset value. Pay attention if the load is of such nature that this 0.1 mA change is critical.

SECTION 3. PROTECTORS

3-1. Description

Regulated DC power supplies are used, as their name indicates, to supply regulated powers to loads of various types of electronic equipment. Demands for regulated DC power supplies have rapidly increased in recent years. As is the case for other types of electronic equipment, these instruments are required to include features of fast response, high reliability, high efficiency, high power factor, compactness, light weight, and economical price. Various types of power supplies are available on the market today. When selecting regulated DC power supplies, in addition to satisfying the required performances, special attention must be paid to some particular requirements which are slightly different from those required by other types of electronic equipment which handle electronic signals.

The above difference comes from the fact that regulated DC power supplies handle "powers." Malfunctioning or erroneous operation of the power supply leads to shut down of the overall system, damage to the power supply equipment and expensive load equipment, or to a fire in an extreme case. As the power supply provides the base for the entire electric and electronic circuits of the system to which it supplies the power, its reliability is very important. Protective features, which prevent serious damage when the power supply should fail, are important factors to be taken into consideration when selecting a power supply.

The PAD-L Regulated Power Supplies have been designed fully taking the above matters into consideration, as instruments of very high reliability. They employ premium quality components, with sufficient derating. They are incorporated with protector which lead them to "the safer side" should they fail. Individual protectors are explained in this section.

3-2. Explanation of Protector

(1) Overvoltage protector:

A limiting voltage can be set from the instrument front panel. If the output voltage exceeds the preset voltage, the input power switch is cut off. The operation time is approximately 50 msec.

(2) Voltage detector:

When the rated voltage of the electrolytic filter capacitor is exceeded due to a failure of the rectifier circuit, the input power switch is instantaneously cut off.

(3) Current detector:

When the current limiting circuit has failed, the control transistors are cut off and at the same time the input power switch is cut off or the current is limited at approximately 120% of the rated current.

(4) Temperature detector:

Detects temperature of the cooling package (semiconductor cooling unit). When temperature of the cooling fins have become higher than approximately 100°C due to ambient temperature rise or cooling fan failure, the input power switch is cut off.

(5) High-speed overvoltage protector (option):

When the output voltage has exceeded the preset voltage due to erroneous operation or an external pulse voltage,

a thyristor circuit connected between the output terminals instantaneously conducts to short-circuit the output and, at the same time, the input power switch is instantaneously cut off. The operation time is selectable from a range of several microseconds to several hundreds microseconds.

(6) Power fuse:

Limits the input current.

(7) Output fuse:

Limits the output current.

Both fuses are current limiting type of fuses meeting the requirements of JIS and model-approved by the Electrical Appliance Control Ordinance. The fuses employ a ceramic insulation tube and silica sand arc killer, and are free of flame when blown out.

3-3. Operation Method of Overvoltage Protector (OVP)

Setting procedure

(1) Turn the OVP potentiometer to the extreme clockwise position with a screwdriver.

(2) Set the output voltage at the required operating point of the OVP.

(3) Gradually turn counterclockwise the OVP potentiometer to the point where the input power switch is cut off.

(4) Lower the output voltage and turn on the input power again and check once more the operating point of the OVP circuit before using the power supply for its load. (Once the OVP circuit has tripped, the input power switch can not be turned on again until a period of sereral seconds elapses.)

SECTION 4. APPLICATIONS TO VARIOUS USES

4-1. Constant-current Charge/Discharge of Battery or Capacitor

o Charge (constant current)

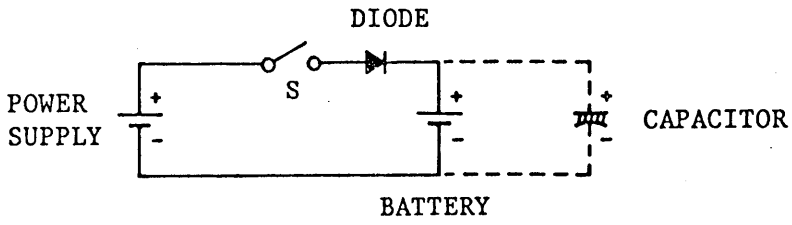


Figure 4-1

1. Keeping depressed the current/voltage limit switch, set the charge end voltage with the constant voltage setting knob and the charge current with the constant-current setting knob.

2. Close switch S so that the charging operation starts. When the charge end voltage is reached, the charging operation stops automatically. (The power supply employs a potentiometer burn protection circuit.)

Notes: 1. Connect the battery in the same polarity with the power supply. (If it is connected in the reverse polarity, the power supply may be damaged.)

2. If the output voltage of power supply is lower than the battery voltage or if the power switch is off, a current of several hundreds milliamperes flows from the battery into the power supply. If this current is not allowable, connect a diode in series with the battery as shown in Figure 4-1 .

o Discharge (constant current)

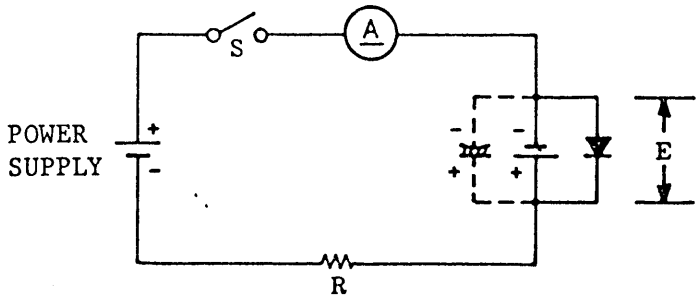


Figure 4-2

Resistance of R: $R = \frac{E[V]}{I[A]}$

Power consumption by R: $P = I^2R$ [W]

where, E: Terminal voltage of battery or capacitor when starting discharge

R: Discharge resistor

I: Discharge current (constant current)

D: Reverse current blocking diode

1. Set the output voltage of the power supply with the constant-voltage setting knob to a voltage higher by several volts than the terminal voltage of the battery or capacitor which is to be discharged. (Once this setting is done, constant-current discharge is done until the voltage of the battery or capacitor becomes zero.)

2. Calculate the resistance of the discharge load resistor (R). Pay attention to the wattage of the resistor.

3. Keeping depressed the current/voltage limit switch, set the discharge current with the constant-current setting knob.

4. Close switch S. Constant-current discharge operation will start.

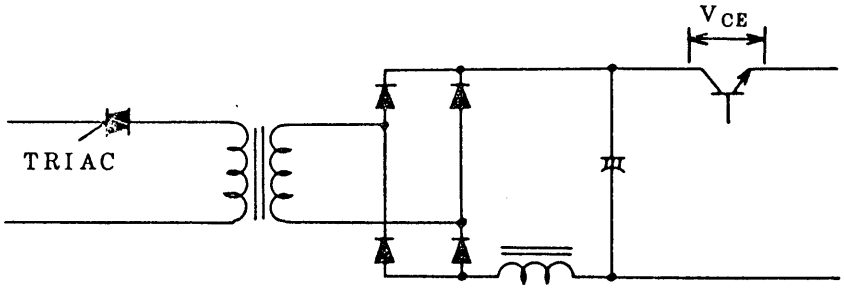
Notes: 1. To stop discharge, open switch S. (Even when the input power switch of the power supply is cut off, the discharge current flows through the diode which is connected in parallel with the output circuit of the power supply.)

2. Be sure to connect the discharge load resistor (R). (If the battery or capacitor is directly connected, the power supply may be damaged.)

3. Be sure to connect the reverse current blocking diode.

SECTION 5. OPERATING PRINCIPLE

5-1. Controlled Rectifier Circuit and Filter Circuit



Full-wave
rectifier circuit

Figure 5-1

- This circuit rectifies the current with phase-controlled TRIAC and the collector-emitter voltage of the series control transistor is maintained constant to reduce the collector loss.
- The filter circuit is a single-stage inversed-L check input type.
- This circuit, when the conducting angle of TRIAC has become narrower, can prevent degradation of power factor (which is inherent to the phase-controlled circuit) more effectively as compared with the capacitor-input filter circuit. It also solves the problems of ripple current of electrolytic filter capacitor and overheating of the transformer, and reduces the rectified output ripples.

5-2. Phase Control Circuit

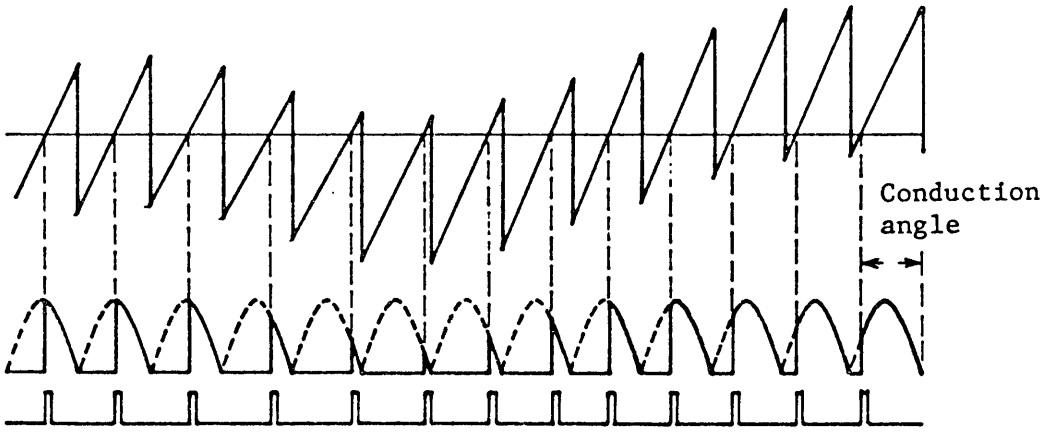
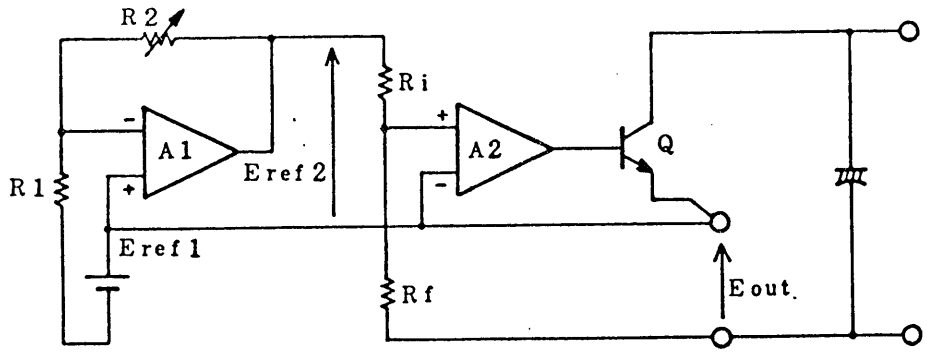


Figure 5-2

This circuit is a pulse phase modulator which operates in synchronization with the AC line frequency. When the collector-emitter voltage (V_{CE}) is large, the generated pulse signal is for a wider conduction angle and, when the voltage is lower, the signal is for a narrower conduction angle and, thus, the circuit so controls TRIAC that V_{CE} becomes constant.

5-3. Constant-voltage Circuit



Eref 1: Reference voltage 1
Eref 2: Reference voltage 2
Ri: Input resistance
Rf: Feedback resistance

Figure 5-3

Output voltage Eout can be expressed as follows (A1 is an ideal amplifier):

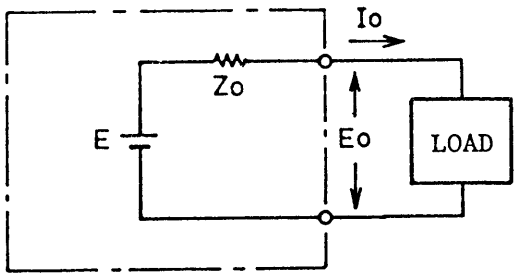
$$Eout = -\frac{Rf}{Ri} Eref\ 2$$

Thus, the output voltage depends only on Eref 2, Ri and Rf. The output voltage is linearly proportional to Rf and Eref 2. For this power supply, Eref 2 is varied to control the output voltage. Eref 2 is produced by amplifying Eref 1, and this voltage is linearly varied by R2.

To obtain a stable output voltage, such components as Eref 1 diode, R1, R2, Ri, Rf, A1 and A2 must be sufficiently stable against change in external conditions. This power supply employs for the Eref 1 diode a zener diode of excellent temperature

characteristics. The resistors are metal-film resistors and wound-wire resistors of excellent temperature coefficient and aging characteristics. Amplifiers A1 and A2 employ monolythic ICs which ensure high gain, wide band and low drift.

The major factors caused by line voltage variation are variation of the operating point of the error amplifier and variation of the reference voltage due to dynamic resistance of the reference diode. To guard against these variations, a stabilized internal auxiliary voltage source is used. Load variation ($\partial Vo/\partial Io$: output variation caused by output current variation) is affected by output impedance (internal resistance) Zo. (See Figure 5-4.)



Eo = E - IoZo

IoZo = Load variation component

Figure 5-4

Denoting by A the open loop gain attained by error amplifier A2 and power transtor Q, output impedance Zo can be expressed as follows:

$$Zo = \frac{Ro}{1 + AB}$$

where, $B = \frac{Ri}{Rf + Ri}$

Ro: Output impedance of the circuit when no error amplifier is connected

The above equation indicates that the output impedance is improved to 1/(1+AB) by connecting amplifier A2 and effecting a feedback circuit.

5-4. Constant-current Circuit

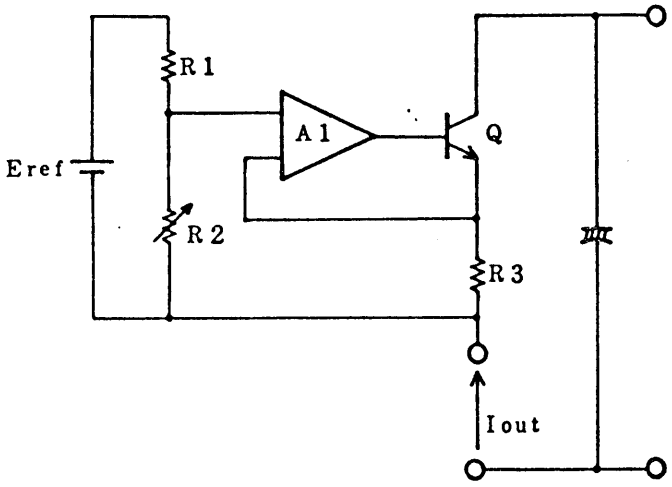


Figure 5-5

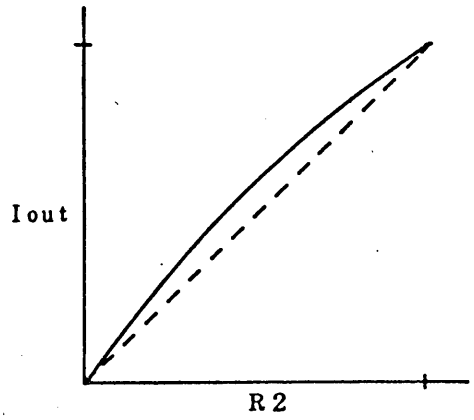


Figure 5-6

Eref: Reference voltage for constant current
R2: Output current control potentiometer
R3: Output current detection resistor

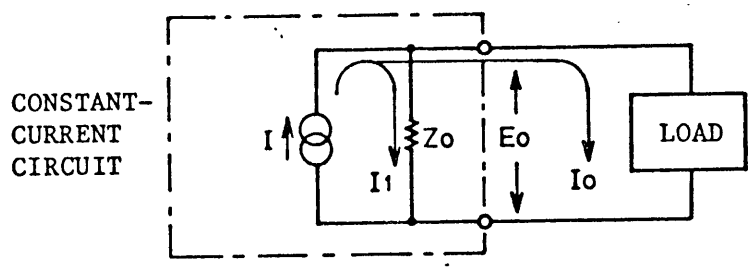
Output current Iout can be expressed as follows (A1 assumes an ideal amplifier):

$$Iout = \frac{R2}{R3(R1 + R2)} \times Eref$$

This equation indicates that the output current depends on Eref, R1, R2 and R3. Of this power supply, the output current is controlled by varying R2. Note that the relationship between R2 and Iout is not linear as indicated with a solid line in Figure 5-6.

To ensure a stable output current, Eref, R1, R2 and R3 must be sufficiently stable against change in external conditions (line voltage change, ambient temperature change, aging, and load change). Error amplifier A1 must be a high-gain wide-band DC amplifier with less drift.

Of the constant-current circuit, the larger the output impedance (Zout), the smaller is the load variation (∂Io/∂Vo: output current variation caused by output voltage variation). (See Figure 5-7).



$Io = I - I1$

where, $I1 = Eo/Zo$ = Load current variation component

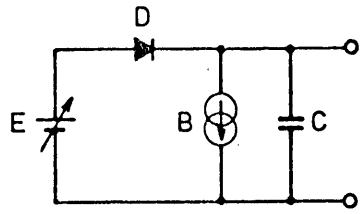
Figure 5-7

Denoting by gm the mutual conductance attained by erro amplifier A1 and power transistor Q, output impedance Zo can be written as follows:

$$Zo = (1 + gm\ R3)\ Ro$$

In this equation, Ro is the output impedance of the circuit before connecting the error amplifier. This equation indicates that the output impedance is improved by (1 + gm R3) times by connecting amplifier A1 and providing negative feedback.

5-5A. Differences from Ideal Constant-voltage Supply



E: Ideal constant-voltage supply
D: Ideal diode
B: Internal bleeder circuit
C: Capacitor

Figure 5-8. Equivalent circuit of series-controlled constant-voltage DC power supply

o Cannot sink current:

Figure 5-8 shows an equivalent circuit of a series-controlled constant-voltage power supply of the type used for this and other power supplies. An ideal diode is connected in series. This type of power supply is for a load of such type that it simply drains the current and does not send back the current. For such load as a battery which sends back a current, however this power supply cannot sink such current.

This problem can be solved by using a parallel-controlled power supply or one which has a bi-polarity output. Such power supplies, however, will provide less efficiency and high cost for the same power.

The problem can be solved by connecting a resistor in parallel with the load and feeding in the resistor a current larger than the maximum reverse current. When the reverse current is small, the problem may be solved by connecting an electrolytic capacitor in parallel with the load. When the load is an inverter, a filter circuit may be provided in the input circuit to reduce the reverse current.

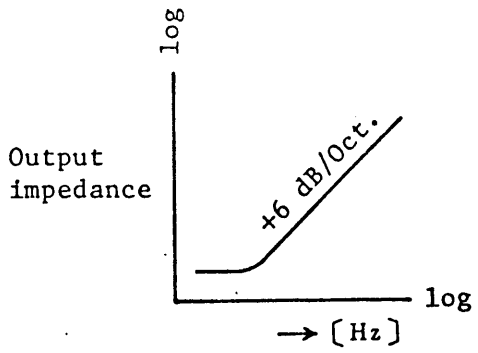


Figure 5-9

Frequency vs output impedance characteristics

o Output impedance is not infinity, with certain frequency characteristics:

Figure 5-9 shows that the output impedance (internal resistance) of this power supply increases as the frequency increases. This is because the gain of the loop including the error amplifier decreases. Better frequency characteristics, as well as DC output impedance characteristics such as for load variation, are a desirable feature for the power supply.

This feature must be such that not only the high gain region of the error amplifier is extended to a higher frequency range but also the phase characteristics are correct.

A shorter transient response time means better frequency characteristics of output impedance. Transient response time is an index for evaluation at the time range and output impedance is that at the frequency range.

5-5B. Difference from Ideal Constant-current Power Supply

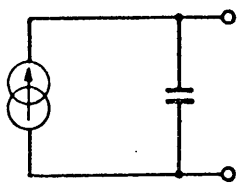


Figure 5-10

Figure 5-10 shows an equivalent circuit of this power supply operating as a constant-current source. A capacitor is connected in parallel with an ideal power supply.

There is no problem when the load is resistive. However, if the load is of such nature that it varies rapidly, pay attention to the fact that the output voltage also varies rapidly and the charge/discharge current of the capacitor is superimposed on the output current.

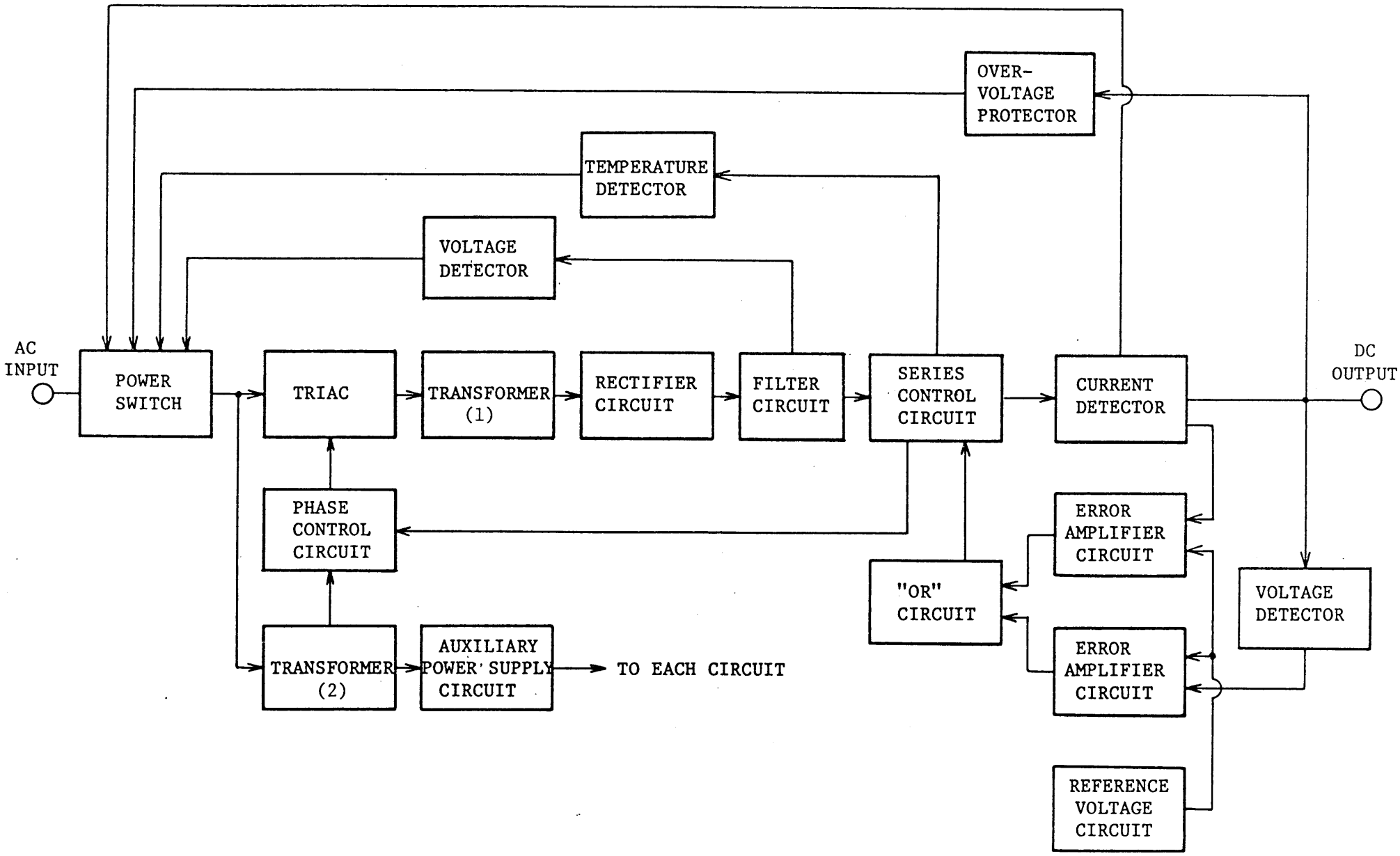


Figure 5-11 Block Diagram

SECTION 6. MAINTENANCE

6-1. Inspection and Adjustment

Periodically inspect and adjust the power supply so that it maintains its initial performance for a long time.

6-1-1. Removing Dust and Dirt

6-1-2. Inspecting the Power Cord and Plug

6-1-3. Calibrating the Voltmeter

6-1-4. Calibrating the Ammeter

6-1-5. Calibrating the Current/Voltage Limit Switch

6-1-6. Adjusting the Maximum Variable Constant-voltage Range

6-1-7. Adjusting the Maximum Variable Constant-current Range

6-1-1. Removing Dust and Dirt

When the instrument panel has become dirty, lightly wipe it with a cloth moistened with diluted neutral soapsuds and, then, wipe it with a dry cloth. Do not use benzine or thinner. Blow away dust collected inside the instrument and in the ventilation holes of the casing, using a compressed air or a vacuum cleaner.

6-1-2. Inspecting the Power Cord and Plug

Check for that the vinyl cover of the cord is not damaged. Check the plug for play , loose screws and damage.

6-1-3. Calibrating the Voltmeter

- o Set R630 to the center.
- o Connect an external voltmeter of an accuracy of 0.01% or better to the output terminals, set the output voltage at 1000.0 V, and calibrate the display of instrument voltmeter between 999.5 and 1000.5 with R628. (See Fig. 6-1)
- o Next, calibrate the display of instrument voltmeter 1000.0 with R630. (See Fig. 6-1)

6-1-4. Calibrating the Ammeter

- o 200 mA Range

  Connect an external ammeter of an accuracy of 0.1% or better in the output circuit, set the output current at 190.0 mA, and calibrate the instrument ammeter with R615. (See Fig. 6-1)

- o 2A Range

  Set the output current at 200.0 mA, and calibrate the instrument ammeter with R613. (See Fig. 6-1)

6-1-5. Calibrating the Current/Voltage Limit Switch

- o Calibration of limit current

  Set the output current at 190.0 mA. Press the current/voltage limit switch and so adjust R222 that the ammeter indicates the set current value.

- o Calibration of limit voltage

  Set the output voltage at 1000.0 V. Press the current/voltage limit switch and so adjust R254 that the voltmeter reads the set voltage value.

6-1-6. Adjustment of Maximum Variable Constant-voltage Range

Connect to the output terminals an external voltmeter of an accuracy of 0.5% or better, set the constant-voltage setting knob in the maximum position (extremely clockwise position), and so adjust R249 on PCB A-313 that the instrument voltmeter reads 1020.0 V.

6-1-7. Adjustment of Maximum Variable Constant-current Range

Connect in the output circuit an external ammeter of an accuracy of 0.5% or better, set the constant-current setting knob in the maximum position (extremely clockwise position), and so adjust R216 on PCB A-313 that the instrument ammeter reads 210 mA.

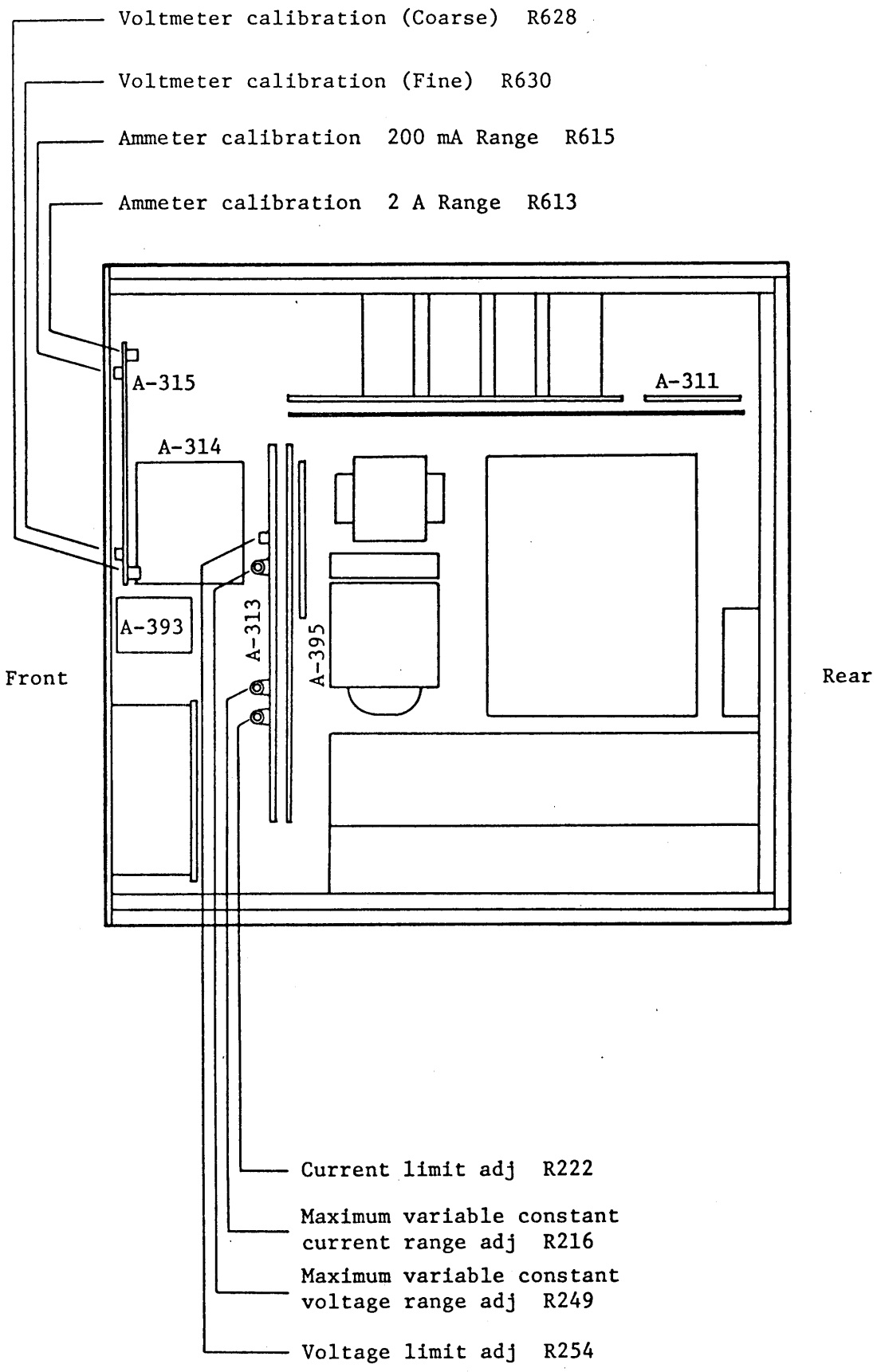


Figure 6-1 (Top view)

6-2. Troubleshooting

The most probable causes of troubles are shown in the following table. When a failure of the power supply is found, contact Kikusui agent in your area.

Symptom	Check item	Probable cause
Power switch cannot be turned off (or turns off soon).	1. Has the overvoltage protector tripped?	o Set voltage too low
	2. Is fan stalled?	o Trip of overheat protector (Replace fan.)
	3. Other than the above	o Trip of protector due to a failure of rectifier circuit
No output (No output is produced at all or only a slight output is produced.)	1. Is the input power fuse blown?	o Input line voltage too high (Replace fuse.) o Failure of rectifier circuit
	2. Is lamp lighted?	If not lighted, o Open-circuiting of power cord
	3. Are the lamps alternately lighting, indicating rapid transitions of operating domains	o Too narrow constant-voltage and constant-current setting ranges
	4. Is the output box's knob completely locked?	o See 2-3

Symptom	Check item	Probable cause
	5. Is the output power fuse blown out?	o Output current flowed exceeding the rated value o Power transistor failure
	6. Is the circuit oscillating?	o Phase inversion caused by remote sensing circuit (Connect an electrolytic capacitor at the load end.) Refer to 4.1. o (Re-adjust)
	7. Is a current flowing despite no load?	If flowing, o Failure of the protective diode connected in parallel with the output (This diode may be damaged if such load as battery is connected in the reverse polarity.)
	8. Is the output power switch off?	o See 2-3.
	9. Other than the above	o Circuit failure
Abnormally high output	1. Output voltage (current) cannot be reduced	o Power transistor failure o Bleeder circuit failure
Unstable output	1. Is the AC line voltage correct?	o AC line voltage not within the specified range
	2. Special type of load	o See 2-4.

Symptom	Check item	Probable cause
	3. When matter of drift is critical	o Allow approximately 30 minutes of stabilization time.
	4. Other than the above	o Circuit failure
Large ripple voltage	1. Is the AC line voltage correct?	o Input voltage too low
	2. Is a strong source of magnetic or electric field present near the power supply? (Is there no nearby auto-transformer, power transformer, or an oscillating source?) (Especially when in the constant-current mode)	o Electromagnetic induction (Move the source of trouble. Strand the wires.)
	3. Other than the above	o Circuit failure o (Re-adjust)

REGULATED DC POWER SUPPLY **PAD1K-0.2L** **INSTRUCTION MANUAL**