

INSTRUCTION MANUAL

REGULATED DC POWER SUPPLY

PAD 35-5 LC

KIKUSUI ELECTRONICS CORPORATION

82.3.5

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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.

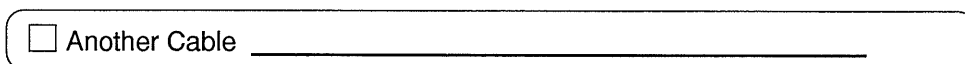
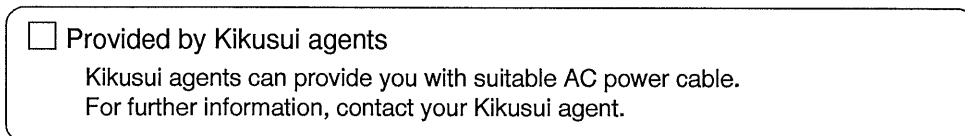
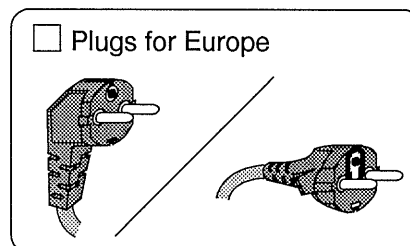
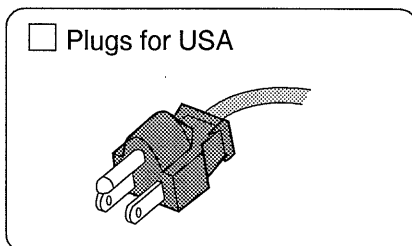
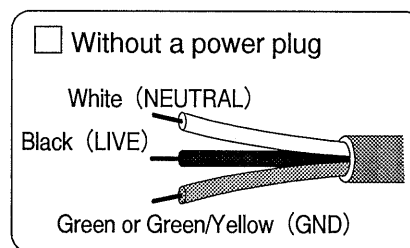
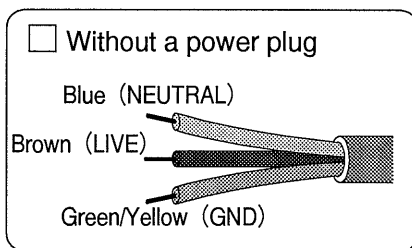


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SECTION 1. GENERAL

1-1. Description

The PAD-L Power Supply is an instrument with high operation reliability and excellent electrical performance. Its circuits are rationally designed and provided with sufficient allowances. 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 power line.

3. Excellent temperature coefficient:

Low temperature drift characteristics of 100 ppm/°C is attained by using premium-quality parts, improved circuits. 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 and to provide a sufficient loop gain up to a high frequency. The output impedance

of the instrument is low and the instrument rapidly responds to transient load change.

5. Low ripple and noise voltages:

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

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

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

The power supply has internal protective circuits such as voltage detector circuit, current detector circuit and temperature detector circuit. An overvoltage protection circuit (OVP), the set voltage of which is adjustable from the front panel, also is incorporated as a standard feature. A high speed overvoltage protector (a thyristor crowbar protection circuit) 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 protection circuit OVP (option) for a load the allowable voltage range of which is very narrow and which could be damaged when a slight overvoltage is applied or for a load which is required to be operated day and night unattended.

1-2. Specifications

Model		PAD 35-5 LC
Input		
	Input AC line	100V +10%, 50/60Hz, 1 ϕ
	Power consumption (100V AC, rated load)	Approx. 360 VA
Output		
	Output voltage range (10 turns)	0 - 35 V
	Voltage resolution (theoretical value)	7 mV
	Output current range (1 turn)	0 - 5 A
	Current resolution (theoretical value)	18 mA
Constant-voltage characteristics		
	Regulation *1	
	Source effect (line regulation) (For +10% change of line voltage)	0.005% + 1 mV
	Load effect (load regulation) (For 0 to 100% change of output current)	0.005% + 1 mV
	Ripple and noise (5 Hz - 1 MHz) rms *2	500 μ V
	Transient response (typical) *3	50 μ sec
	Temperature coefficient (typical)	100 ppm/ $^{\circ}$ C
	Remote control resistance and voltage	Approx. 0 - 10 k Ω , 0 - 9 V, 0 - -10 V
Constant-current characteristics		
	Regulation	
	Source effect (line regulation) (For +10% change of line voltage)	1 mA
	Load effect (load regulation) (For 0 to 100% change of output voltage)	3 mA
	Ripple and noise (5 Hz - 1 MHz) rms *2	1 mA
	Remote control resistance	0 - 1 k Ω
	Operating ambient temperature range	0 - 40 $^{\circ}$ C (32 - 104 $^{\circ}$ F)
	Cooling method	Convection cooled
	Polarity of output voltage	Positive or negative grounded
	Isolation from ground	\pm 150 V

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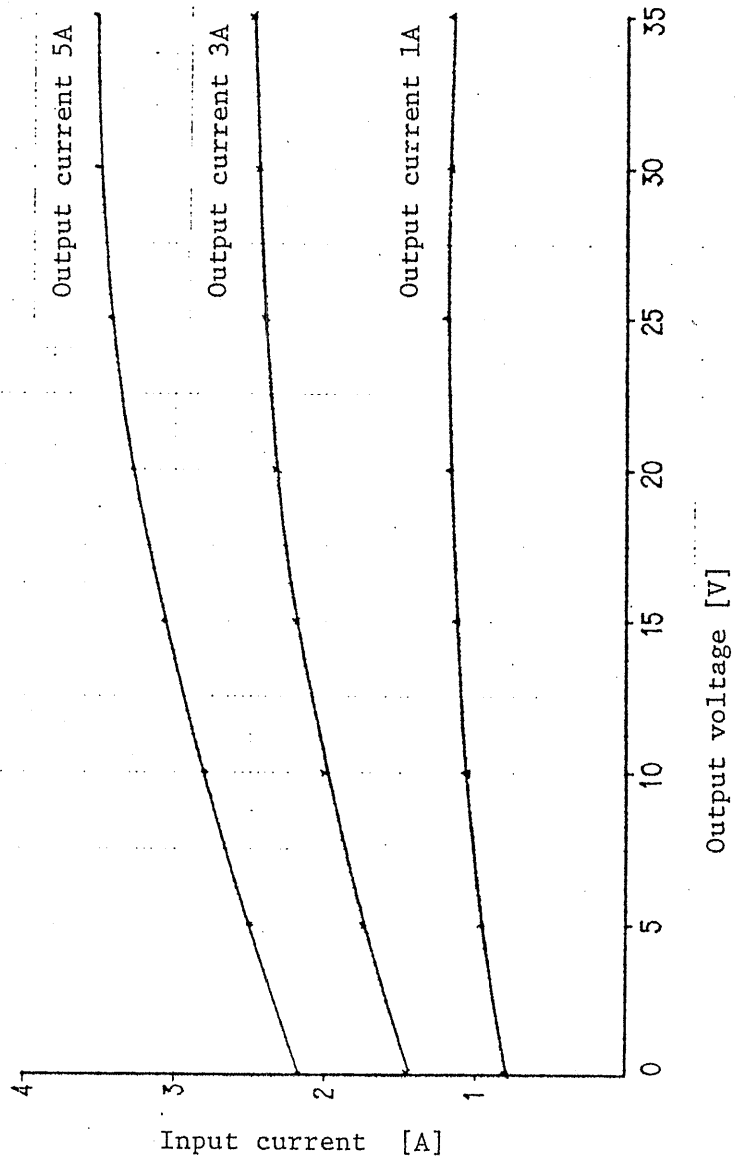
Protections		
Operation		Control transistors cut off and rectifier circuit turned off
Trip temperature of thermal protector		100°C (212°F) at cooling package
Over voltage protection (OVP)		
Voltage setting range		6 - 38 V
Trigger pulse width		50 msec
Input fuse rating (6.4mm dia. 32mm ma (6.4 mm dia. × 32 mm max.))		
100V AC source		7 A
Output fuse rating (6.4 mm dia. × 32 mm max.)		5 A
Meters		
Voltmeter, Class 2.5		35 V DC
Ammeter, Class 2.5		6 A DC
Constant-voltage mode indication		C.V: With green LED
Constant-current mode indication		C.C: With red LED
Insulation resistances		
Between chassis and line		500V DC, 30MΩ or over
Between chassis and output terminal		500V DC, 20MΩ or over
Dimensions	*5	
		210W × 140H × 260D mm (8.27W × 5.51H × 10.24D in.)
Maximum dimensions		215W × 165H × 300D mm (8.46W × 6.50H × 11.81D in.)
Weight		Approx. 11 kg (24 lbs.)
Accessories (in carton)		
Instruction manual		1 copy
Input line fuse (spare), for 100 V		7 A, 1 ea.
Input cord		Approx. 2.5 m (8.2 ft.) vinyl-covered wires, nominal core cross section 1.25 square mm
Others		Guard cap 1 set

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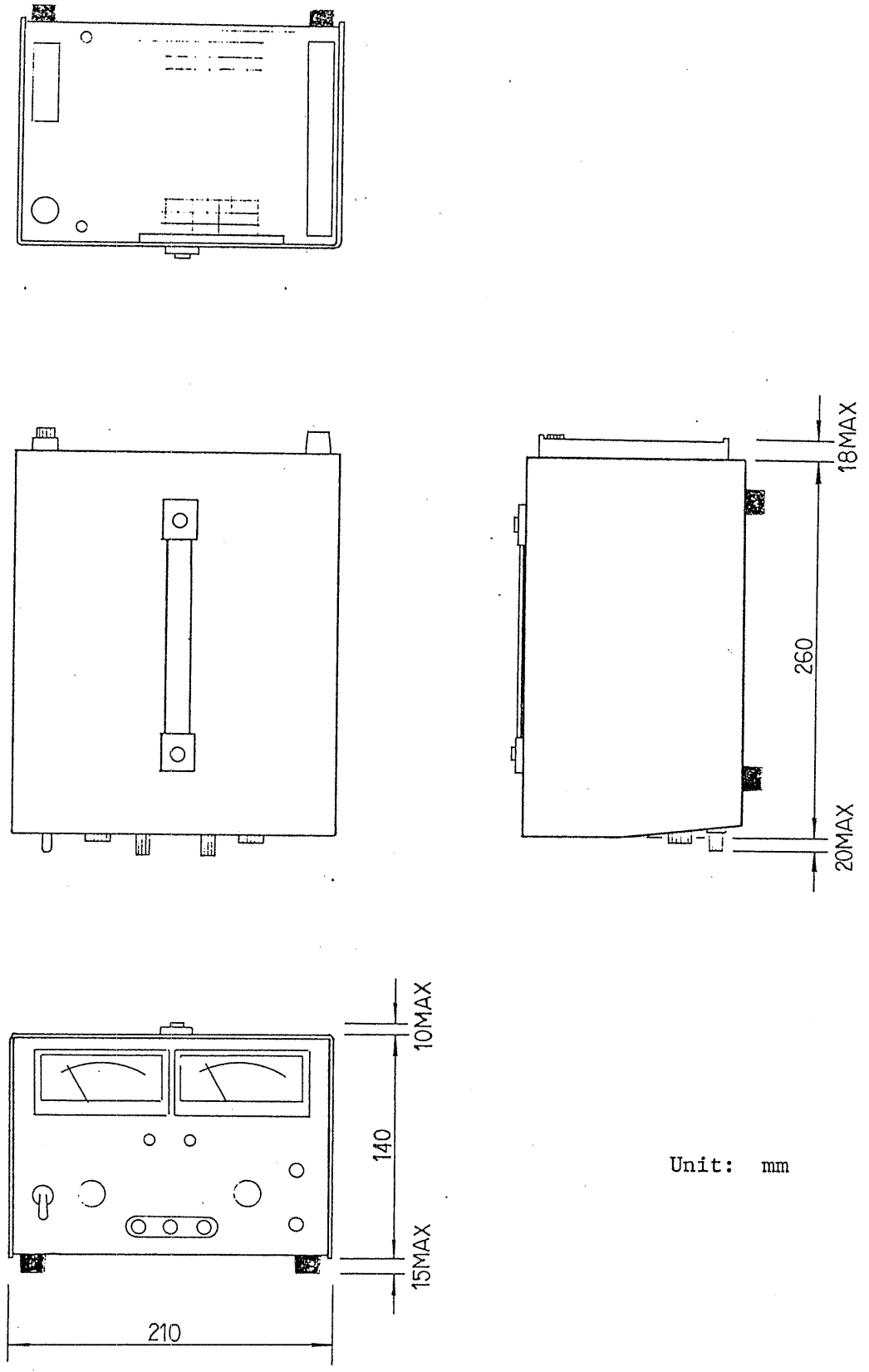
Notes:

- *1. Measured using the sensing terminals.
- *2. Measured with the positive or negative output terminal grounded.
- *3. Time required for resetting to $0.05\% + 10 \text{ mV}$ of the output voltage.
- *4. Typical value
- *5. With rack mount brackets (option), can be mounted on a standard 19-inch or 500-mm rack.

Current Consumption Chart 100V AC, 50Hz/60Hz



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Unit: mm

Figure 1-1. Mechanical outline drawing

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SECTION 2. OPERATION METHOD

2-1. Notes Before Use

1. Input power

- o The input line voltage range is 90 - 110 V, 48 - 62 Hz single-phase AC.
- o The input power fuse rating is 7 A.
- o For current consumption, see the current consumption charts.

2. Power cord

- o A power cord (core wires 1.25 mm²) accompanies the power supply.

3. Output

- o Make it sure that the jumpers of the terminal block on the rear panel are securely connected as shown in Figure 2-1.

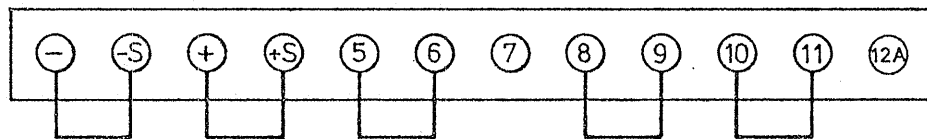


Figure 2-1

- o Normally, connect either one of the output terminals to the GND terminal with the shorting bar.
- #### 4. Ambient temperature
- o The ambient temperature range for the power supply to satisfy the specification performances is 0°C to 40°C (32°F to 104°F). The power supply should be used within this

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range. If it is operated at a high ambient temperature, the internal temperature detector circuit trips and the input power switch is turned off. When this has happened, cool the power supply and then turn on the power again. There are exponential relationships 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 (14°F), its operation may become unstable. If the power supply is to be used at low temperatures, specify so when ordering.

5. Place for use

- o Pay attention so that the ventilation ports (top and bottom) are not blocked.
- 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.

Note for carrying.

- o The center of gravity of the power supply is at a leftward position. The instrument weighs approximately 15 kg (33 lbs.). Be careful when raising the power supply without using the handles.

6. Note for battery charging

- o Battery charging may be done by setting the charged-up voltage of the battery with the constant-current setting knob and the charging current with the constant-current knob. When this setting is done, charging automatically stops when the battery is charged up.

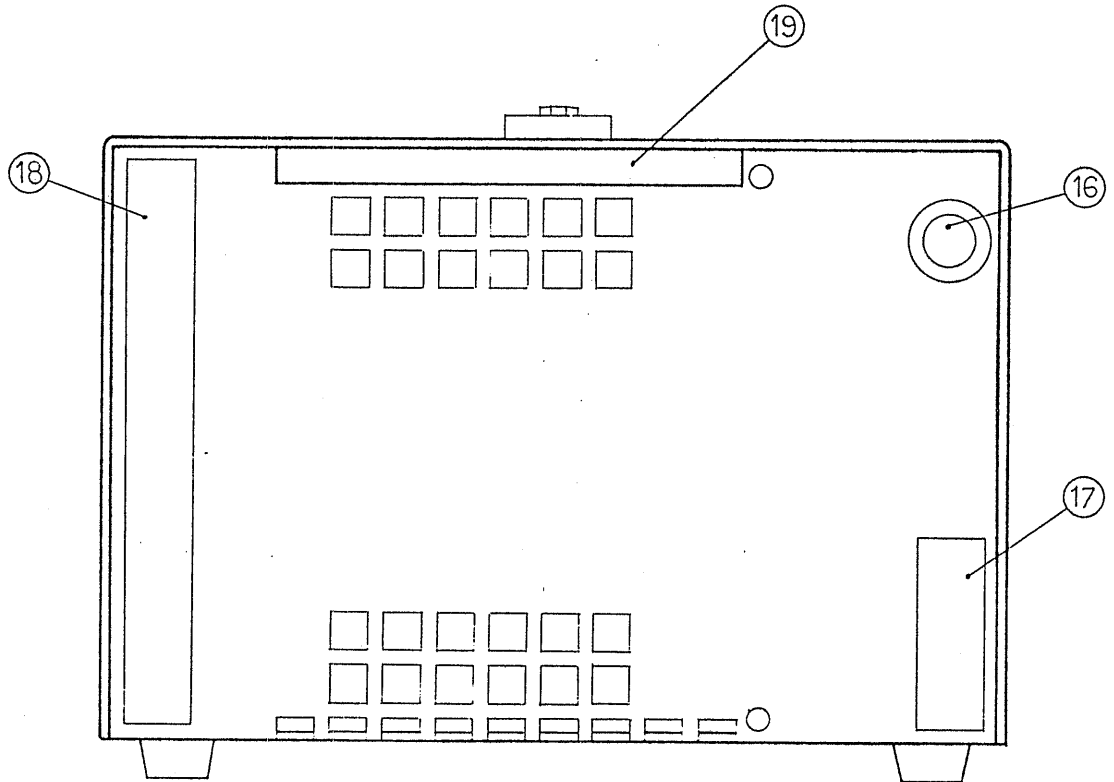
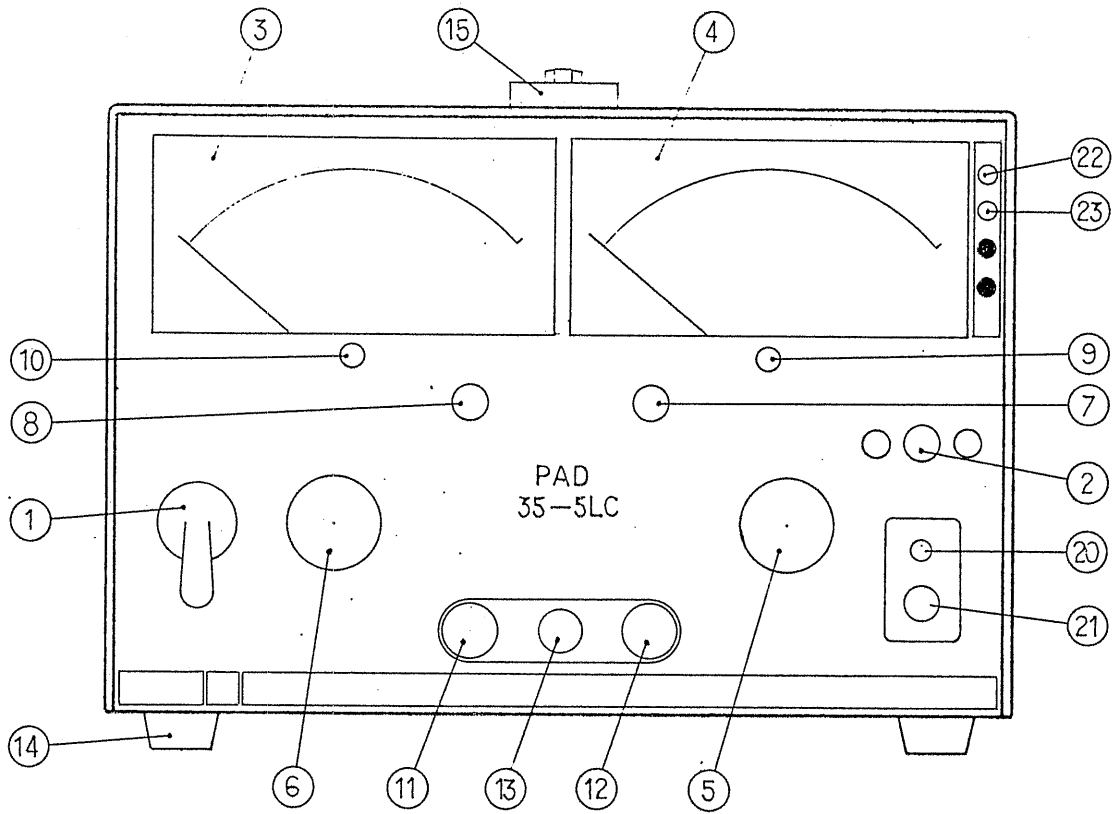


Figure 2-2. Front panel and rear panel

2-2. Explanation of Front and Rear

Panel items and descriptions

1. POWER switch:

For on-off control of input power. When thrown to the upper position, the input power is turned on and C.V. or C.C. lamp lights.

Note: The input power cannot be turned on immediately after it has been turned off by the OVP function or other cause. Wait about five seconds and then turn on the input power.

2. CURRENT/VOLTAGE LIMIT switch:

When this switch is kept depressed, the ammeter indicates the preset constant-current value and the voltmeter indicates the preset constant-voltage value.

3. Ammeter:

Indicates the output current. Class 2.5

4. Voltmeter:

Indicates the output voltage. Class 2.5

5. Voltage setting knob:

Sets the voltage for constant-voltage operation.
10-turn potentiometer

6. Current setting knob:

Sets the current for constant-current operation.
1-turn potentiometer

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

Indicates that the instrument is operating in the constant-voltage mode. Green LED

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

Indicates that the instrument is operating in the constant-current mode. Red LED

9. Voltmeter zero adjustment:

For zero-volt indication adjustment of the voltmeter.

10. Ammeter zero adjustment:

For zero-ampere indication adjustment of the ammeter.

11. Output terminal (- terminal):

White binding post

12. Output terminal (+ terminal):

Red binding post

13. GND terminal

14. Rubber stud

15. Carrying handle:

For carrying the instrument.

16. Line fuse holder:

Houses a fuse (100 V AC, 7 A) for the AC input power line.

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17. Input terminal block:

Terminals for the input AC line power. To be connected with input power cord (1.25 mm) supplied.

18. Terminal block:

Terminals for -, -S, +, +S, remote control, and one-control parallel operation. (See SECTION 4 "APPLICATIONS.")

19. Ventilator:

Air exit of the cooling package. As hot air comes out of this outlet, do not place near it any object which is not heat resistant. The outlet must be positioned 30 cm or over from wall.

20. OVP indicator lamp:

Turns on when the overvoltage protection circuit or the temperature detector circuit has tripped.

21. OVP voltage setting:

Setting procedure for OVP

- (1) Turn the OVP resistor to the extreme clockwise position with a screwdriver.
- (2) Set the output voltage at the required OVP operation point.
- (3) Turn gradually the OVP resistor counterclockwise to the point where the OVP lamp turns on.
- (4) Turn off the power switch to lower the output voltage. Then, turn on the power switch and ensure the operating point of the OVP function. Allow five seconds or more resetting time before turning on the power switch again.

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22. Voltmeter calibration resistor:

For voltmeter calibration. (See Section 5-1-3.)

23. Ammeter calibration resistor:

For ammeter calibration. (See Section 5-1-4.)

2-3. Constant-voltage Operation

Method I

- (1) Check first that the AC line voltage is $100V \pm 10\%$ AC. Then, connect the input power cord.
- (2) Turn on the input power switch. The indicator lamp will light indicating that the instrument power is on.
- (3) Keeping depressed the current/voltage limit switch, set the output current at the required value with the current setting knob. By this procedure, setting of the output current is complete. 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" function.)

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- (4) Set the output voltage at the required value with the VOLTAGE setting knob.
- (5) Turn off the power switch, connect the power, and then turn on the power switch.

Note: When the load resistance is unpredictable or it is predicted to vary largely or when it has a large inductance and application of a rapidly changing voltage is undesirable, use such method that the power switch is turned on while keeping the set voltage at zero and then the voltage is gradually raised or that, keeping the voltage at the set value, the power switch is turned on while keeping the current setting knob at the extremely counterclockwise position and then the current is gradually increased.

This instrument does not produce overshoots when its power is turned on or off.

This instrument is incorporated with a voltage limiting feature. This feature can be effectively utilized in the following type of operation.

Method II

- (1) Connect the load to the instrument.
- (2) Turn the constant-current knob to the extremely counterclockwise position. Turn on the power switch.
- (3) Keeping depressed the current/voltage limit switch, set the voltage at the required value with the constant voltage knob.
- (4) Turn clockwise the constant-current knob to the point where the constant-voltage indicator lamp (green) turns on.

Notes for loads:

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

- (a) Even when the meter reading (average value) is less than the preset value, if the current has peaks which exceed the preset value, the operation is driven into the constant-current domain for short periods and therefore the output voltage falls. Observing carefully, it can be seen that the constant-current indicator lamp becomes dim.

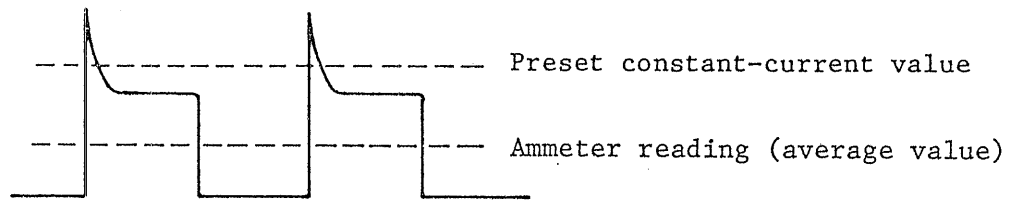


Figure 2-3. Load current with peaks

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 this 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.

$$R [\Omega] \leq \frac{E_0 [V]}{I_{RP} [A]}$$

where, E_0 : Output voltage

I_{RP} : Maximum reverse current

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2-4. Constant-current Operation

- (1) Make it sure that the AC line voltage is $100V \pm 10\%$. Then, connect the input power.
- (2) Turn on the input power switch. The C.V. or C.C. lamp will turn on indicating that the power supply is in the operating state.
- (3) 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.
- (4) Turn off the input power switch. Connect the load to the output terminals of the power supply and, then, turn on the input power switch.

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

- * In order to ensure adjustment down to 0 V, a negative voltage of approximately -0.6 V is produced and a current of up to approximately 10 mA may flow when the constant-voltage knob or the constant-current knob is turned to the extremely counterclockwise position. Pay attention to this fact when the load is of such nature that the voltage of this low level matters.

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SECTION 3. PROTECTORS

3-1. Description

Regulated DC power supplies are used, as their name indicates, to supply regulated DC powers to various types of loads. 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 high accuracy, 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 precious 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 vary high reliability. They employ premium quality components, with sufficient derating. They are incorporated with protective circuits which lead them to "the safer side" should they fail. Individual protective circuits are explained in the following:

(1) Overvoltage protector:

A limiting voltage can be set from the instrument front panel. If the output voltage exceeds the preset voltage, the control transistor is cut off, the rectifier circuit is shut down and the OVP lamp turns on. The operation time is approximately 50 msec.

(2) Voltage detection circuit:

When the rated voltage of the electrolytic filter capacitor is exceeded due to such erroneous operation as disconnected jumper of the terminal block on the rear panel or due to a failure of the rectifier circuit, the rectifier circuit is instantaneously shut down.

(3) Temperature detection circuit:

Detects temperature of the cooling package (semiconductor cooling unit). When temperature of the cooling fins have become higher than approximately 100°C (212°F) due to ambient temperature rise or other reason, the control transistor is cut off and the rectifier circuit is shut down, and the OVP lamp turns on.

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

When the output voltage has exceeded the preset voltage due to erroneous operation or an external pulse voltage, the thyristor circuit connected between the output terminals instantaneously conducts to short-circuit the output and, at the same time, the control transistor is cut off and the rectifier circuit is shut down, and the OVP lamp turns on. The operation time is selectable from a range of several microseconds to several hundred microseconds.

(5) Power fuse:

Limits the input current.

(6) Output fuse:

Limits the output current.

(7) Thermal fuse:

Mounted on the power transformer to guard it against
overheat caused by layer-short of its secondary winding,
etc. The thermal fuse cuts out the input power at approxi-
mately 130°C (266°F).

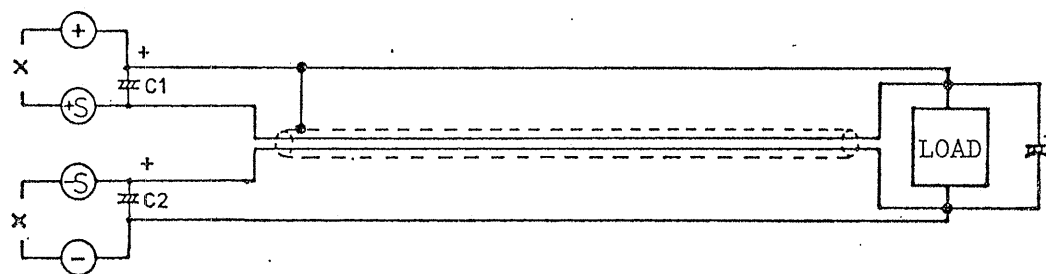
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SECTION 4. APPLICATIONS

4-1. Remote Sensing (Sampling)

Voltage drop caused by the load connection wire resistance and contact resistance can be compensated for.

1. Turn off the input power switch.
2. Disconnect the jumper wires from between \oplus and \oplus terminals and between \ominus and \ominus terminals on the instrument rear panel.
3. Connect the \oplus and \ominus wires to the point where the output voltage drop is required to be compensated for. (Use a shielded cable in order to prevent induction of ripple noise voltage. Connect the external shielding wire to the \oplus line of the output.)



C1, C2: Several hundreds μ F, 16WV

Figure 4-1

- Notes: 1. By this remote sensing feature, up to approximately 1.2 V of voltage drop can be compensated for. Note that, if the voltage drop is larger than 300 mV, the maximum rated voltage is reduced by the corresponding amount.

2. If the load connection cable is longer than 3 - 5 meters, phase shift caused by inductance and capacitance of the cable wires becomes noticeable and the circuit may oscillate. In such a case, connect an electrolytic capacitor of several hundred microfarads in parallel with the load as shown in Figure 4-1. (If oscillation cannot be eliminated still, disconnect the electrolytic capacitor at the back of the output terminals of this instrument or connect capacitors C1 and C2 as shown in Figure 4-1.

4-2. Output Voltage Control with an External Voltage or Resistance

- o Control with an external resistance - I

The output voltage can be controlled in proportion to an external resistor.

1. Turn off the input power switch. (Be sure to turn off the input power switch before connecting or disconnecting wires of the rear terminals.)
2. Disconnect the jumper from between terminals (5) and (6).
3. Connect a 100-ohm potentiometer and another potentiometer (R1) between terminals (5) and (7).
4. Set R1 at zero and so adjust the 100-ohm potentiometer that the output voltage becomes zero.

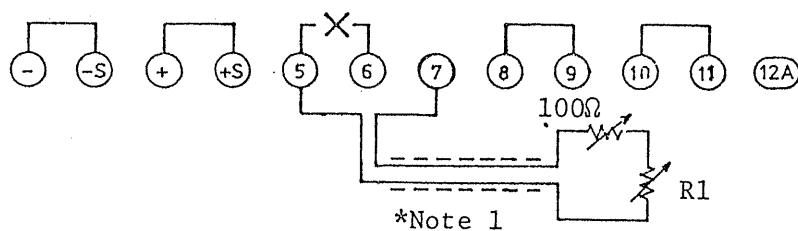


Figure 4-2

$$\text{Output voltage } E_o = \frac{E_{\text{max}} \cdot R_1}{10} \text{ [V]}$$

where, $10 \geq R_1$ [k Ω]

E_{max} : Rated output voltage [V]

For fine adjustment of E_o with respect to R_1 , use R_4 shown in Figure 5-1.

*Note 1: Use a 2-core shielded cable or a pair of stranded wires. Connect the shield wire to the "+" output terminal.

Application

- o By using a fixed resistor and a potentiometer, the voltage can be varied by plus or minus several percent of the set voltage.
- o Resolution of the output voltage depends on resistor R_1 . Therefore, required resolution can be obtained by using an appropriate value of potentiometer for R_1 .
- o A programmed voltage can be obtained by varying the resistance with switch setting. (For this purpose, use switches of a closed circuit type or a continuous type which do not cause momentary open circuit.)
- o Control with an external resistance - II

(This method is a fail-safe method free from overshoots even when resistors are switched.)

1. Turn off the input power switch.
2. Disconnect the jumper from between terminals (8) and (9).
3. Connect a resistor (potentiometer R_1') between terminals (8) and (9).

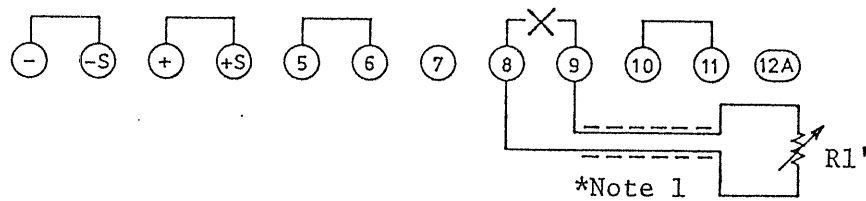


Figure 4-3

$$\text{Output voltage } E_o = \frac{9 E_{\max}}{9 + R_{1'}} - \frac{R_F}{10}$$

where, $0 \leq R_{1'} \text{ [k}\Omega\text{]} \leq \infty$ (infinite)

E_{\max} : Rated output voltage [V]

R_F : Resistance of constant-voltage setting resistor [0 - 10 k Ω] (on the front panel)

For fine adjustment of E_o with respect to $R_{1'}$, use R_4 shown in Figure 5-1.

*Note 1: Use a 2-core shielded cable or a pair of stranded wires. Connect the shield wire to the "+" output terminal.

The output voltage (E_o) is inversely proportional to the resistance ($R_{1'}$) as shown below. Therefore, when the circuit has become open due to switching of resistors or a circuit failure and the resistance has become infinity, the output is reduced to zero.

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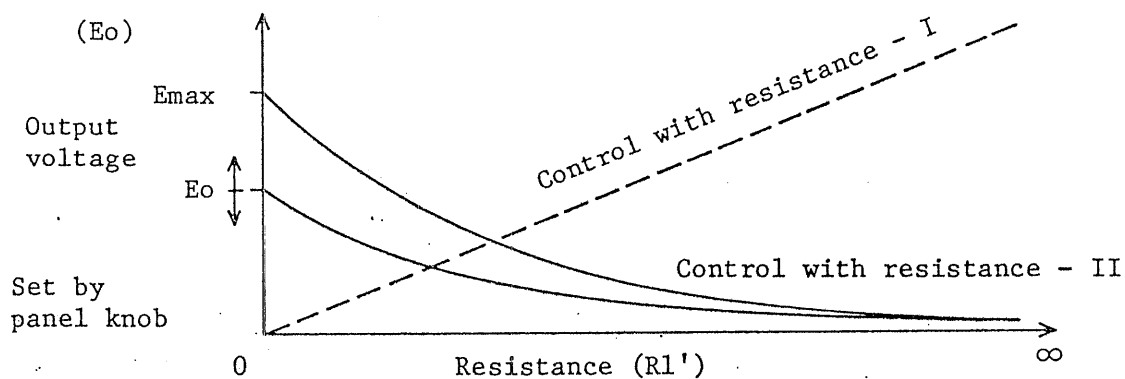


Figure 4-4

- o As shown in the above, output voltage can be varied also by varying the constant-voltage knob (R_F) on the front panel. When the knob on the front panel is required to be made ineffective, disconnect the shorting bar from between terminals (5) and (6) and connect a 10-k Ω or lower resistor of a good temperature coefficient between terminals (5) and (7) as is the case for "control with resistance - I.")
 - o The primary objective of this mode of operation is to attain such a fail-safe feature that the output voltage drops when the output circuit is inadvertently made open. A disadvantage of this mode of operation is that an inhibitingly high resistor is required when programming for operation at low voltages. In general, a potentiometer of 200 k Ω or thereabout is suitable for $R_{l'}$. (When using a high resistor, pay attention to its temperature coefficient and noise property.)
 - o Control with an external voltage
- * The instrument may be damaged if there is a wrong connection or if an abnormally large voltage is applied. Check for them once more before turning on the instrument power.

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A. Control with a positive external voltage

1. Turn off the input power switch.
2. Disconnect the jumper from between terminals (5) and (6), connect a resistor R2 between (5) and (7).
3. Disconnect the jumper from between terminals (8) and (9).
4. Apply an external control voltage between terminals (+S) and (8). (Pay attention to the polarity.)

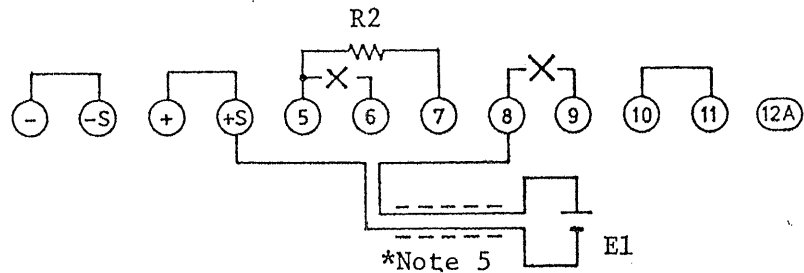


Figure 4-5

The resistance of resistor R2 [kΩ] is calculated with the following equation:

$$R2 \text{ [k}\Omega\text{]} = \frac{90 E_o}{E_{\max} E_1} \dots\dots\dots (1)$$

where, E_o: Output voltage [V]

E₁: External control voltage [V]

E_{max}: Maximum rated voltage [V]

For fine adjustment of E_o with respect to E₁, use R4 shown in Figure 5-1.

- Notes:
1. Make sure that the output voltage does not exceed the maximum rated voltage. ($E_o \leq E_{\max}$)
 2. Make sure that the external control voltage is within a range of 0 to 27 V. ($0 \leq E_1 \leq 27$)

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3. The resistance of R2 must not be greater than 100 k Ω . ($R2 \leq 100 \text{ k}\Omega$)
4. The input resistance of the circuit between terminals (+S) and (8) is approximately 9 k Ω .
5. Use a 2-core shielded cable or a pair of stranded wires. Connect the shield wire to the "+" output terminal.

[Example]: To control the output voltage of PAD35-10L for a range of 0 - 30 [V] with an external signal of 0 - 30 [V].

Substituting terms of equation (1) as $E_o = 30 \text{ [V]}$, $E_1 = 10 \text{ [V]}$ and $E_{max} = 35 \text{ [V]}$, the resistance is calculated as $R2 \doteq 7.7 \text{ k}\Omega$.

When the above method is used, the ratio between external control voltage and instrument output voltage can be varied. The input versus output characteristics are as shown in Figure 4-6 due to the offset voltage of the reference voltage circuit. The input offset voltage is approximately 50 mV.

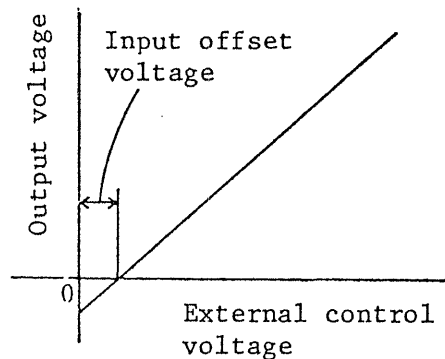


Figure 4-6

For a load for which the above input offset voltage matters, it is recommended to control the output voltage with a negative external voltage as explained in Method B which follows. With this method the offset voltage can be suppressed at less than 6 mV.

In either case, to reduce the offset voltage, a minor modification to the instrument is required. Contact Kikusui's agent in your area.

B. Control with a negative external voltage

1. Turn off the input power switch.
2. Disconnect the jumper from between terminals (5) and (6).
3. Short between terminals (+S) and (7).
4. Apply an external control voltage between terminals (+S) and (5), observing that the polarity is correct.

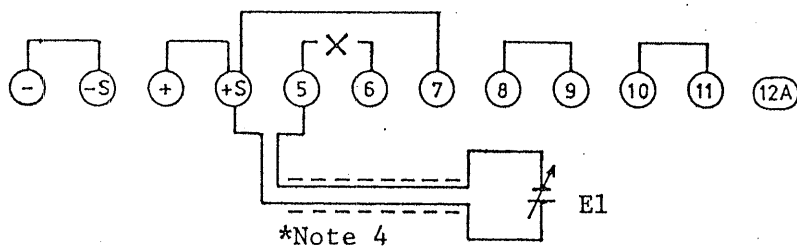


Figure 4-7

The output voltage can be expressed with the following equation:

$$E_o = \frac{E_1 E_{max}}{10} \text{ [V]}$$

where, E_o : Input voltage [V]

E_1 : External control voltage [V]

E_{max} : Maximum rated voltage [V]

- Notes:
1. Make sure that the output voltage does not exceed the maximum rated voltage. ($E_o \leq E_{max}$)
 2. Make sure that the external control voltage does not exceed 11 V. ($E_1 \leq 11$)
 3. The input resistance of the circuit between terminals (+S) and (5) is approximately 100 k Ω . When in the voltage limit state, however, the input resistance becomes approximately 30 k Ω .
 4. Use a 2-core shielded cable or a pair of stranded wires. Connect the shield wire to the "+" terminal.

Caution: Before operating the instrument in the above mode, be sure to set the OVP circuit. Also be sure to pay attention to noise of the external control signal because this noise is amplified and superimposed on the output voltage of the instrument.

4-3. On-off Control of Output (with External Switch)

- A. For voltage preset with voltage limit switch when output is off.
1. Turn off the input power switch.
 2. Connect an external switch between terminals (11) and (12A).
 3. Turn on the input power switch. If the external switch is turned on, the output becomes almost zero. If it is turned off, the output power is delivered.

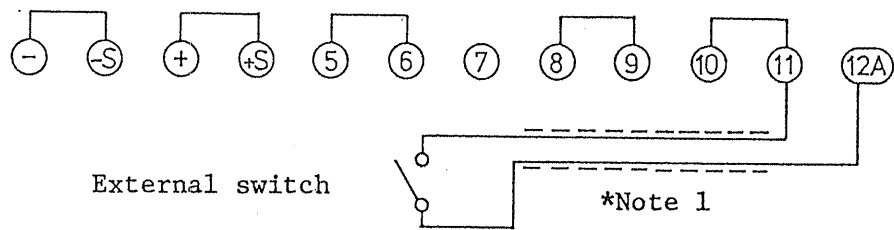


Figure 4-8

*Note 1: Use a 2-core shielded cable or a pair of stranded wires. Connect the shield wire to the "+" output terminal.

Notes: When the output is off, the current limit switch cannot be used. However, as the voltage limit switch can be used, presetting of the output voltage can be done.

When the output is in the off state, the output voltage of less than 0.6 V in the reverse polarity may be produced and a current of several tens milliamperes may flow. If such voltage is not allowable, use method B explained in the next paragraph.

B. To make the output voltage accurately zero volts

1. Turn off the power switch.
2. Connect an external switch and a 100-ohm potentiometer between terminals (6) and (7).
3. Turn on the input power switch. Next, turn on the external switch.
4. Adjust the output voltage to zero volts with the potentiometer.

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5. If the external switch is turned on, the output voltage becomes zero; if it is turned off, the output power is delivered.

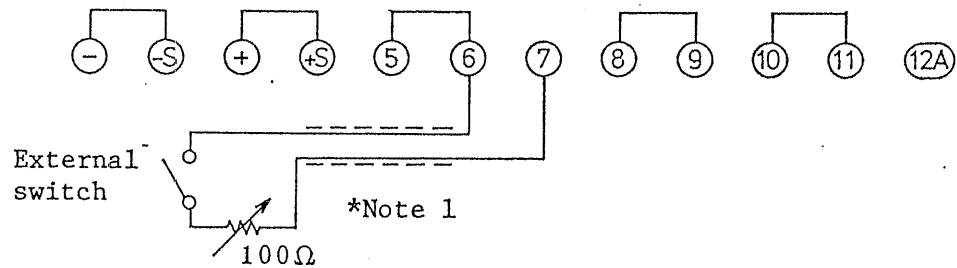


Figure 4-9

*Note 1: Use a 2-core shielded cable or a pair of stranded wires. Connect the shielded wire to the "+" output terminal.

Note: When the output is off, the voltage limit switch cannot be used although the current limit switch can be used.

4-4. Output Current Control with an External Voltage or Resistance

A. Control with an external resistance

1. Turn off the input power switch. (Be sure to turn off the power switch before connecting or disconnecting wires of the rear terminals.)
2. Disconnect the jumper from between terminals (10) and (11).
3. Connect a 10-ohm potentiometer and resistor R3 between terminals (11) and (12A).
4. Adjust the 10-ohm potentiometer so that the output current becomes zero when R3 is zero.

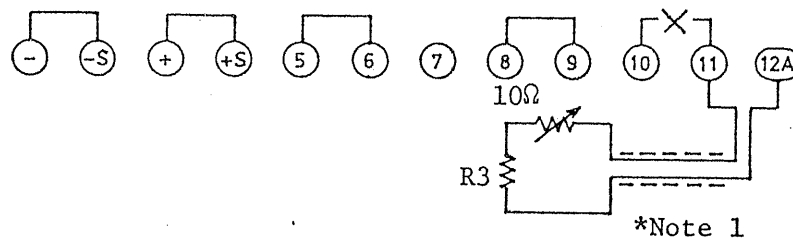


Figure 4-10

$$\text{Output current } I_o = R3 \times I_{\text{max}} \text{ [A]}$$

where, $R3 \text{ [k}\Omega] \leq 1$

I_{max} : Rated output current [A]

For fine adjustment of I_o with respect to $R3$, use $R2$ shown in Figure 5-1.

*Note 1: Use a 2-core shielded cable or a pair of stranded wire. Connect the shield wire to the "+" output terminal.

Notes: Make sure that the output current does not exceed the maximum rated output current. ($I_o \leq I_{\text{max}}$)

Note that the current limit function will become utterly ineffective if the circuit between terminals (11) and (12A) is made open when the jumper is disconnected from between terminals (10) and (11).

B. Control with an external voltage

1. Turn off the power switch. Remove the cover of the main unit.
2. Throw switch SW1 on PCB A-141 board in the arrowhead direction as shown in Figure 5-1. Set and fix the cover.

3. Disconnect the jumper from between terminals (10) and (11).
4. Apply the external control voltage between terminals (11) and (12A), observing the polarity.

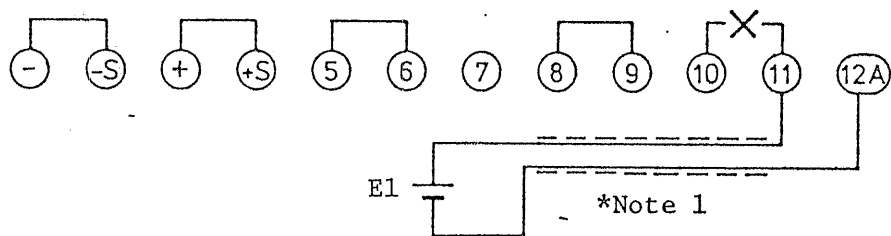


Figure 4-11

$$\text{Output current } I_o = 10 \cdot E_1 \text{ [A]}$$

where, E_1 : External control voltage [V]

*Note: Use a 2-core shielded cable or a pair of stranded wires. Connect the shield wire to the "+" output terminal.

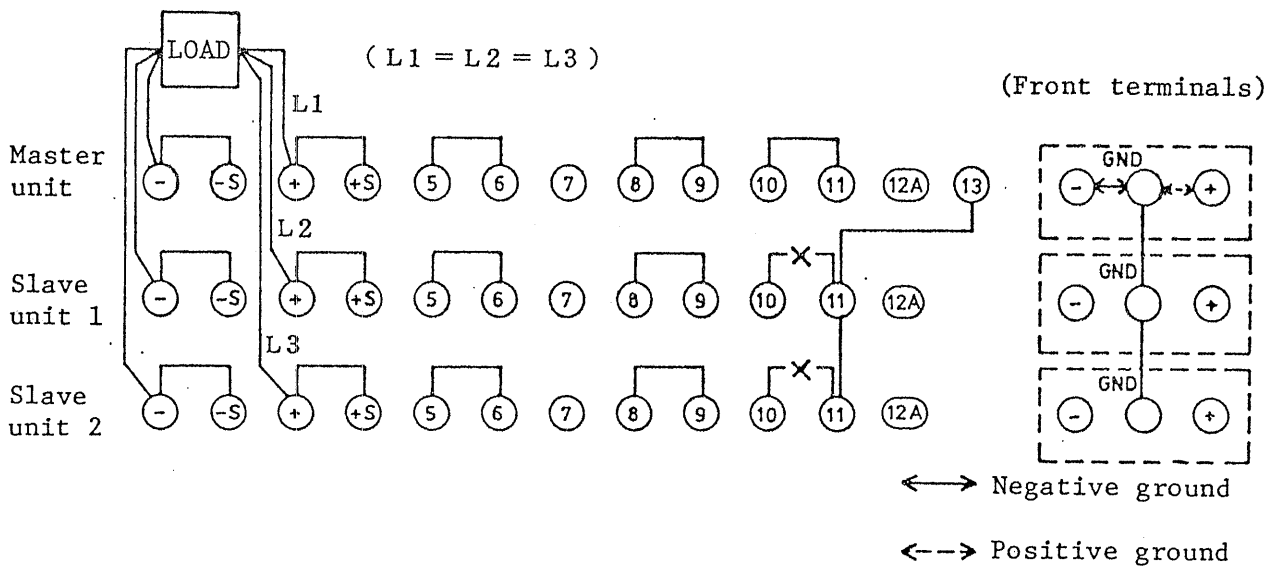
Notes: Make sure that the output current does not exceed the maximum rated output current. Note that, if an excessively large control signal is applied, an abnormally large current may flow and the instrument may be damaged.

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4-5. One-control Parallel Operation

One master unit and any number of slave units can be operated in parallel to increase the current capacity, controlled by one unit (master unit) for operation.

1. Turn off the input power switches and remove the cover of the master unit.
2. Disconnect the jumper from between terminals (10) and (11) of each slave unit.
3. Connect terminal (13) of the master unit to terminal (11) of each slave unit through the electrical connection hole. Put on and fix the cover. (Terminal (13) is located on printed board A-227 by the side of input fuse.)
(See Figures 4-13 and 5-1.)
4. Connect in parallel the output terminals of all instruments, for respective polarities. Use wires of the same length in order to maintain balance among the instruments.



Set the constant-voltage setting knobs of all slave units to the maximum position. Of the slave units, the red LED lamps constantly light to indicate the constant-current mode.

Figure 4-12

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5. For grounding, use the GND terminal on the front panel. For one-control parallel operation, connect the GND terminals as shown in Figure 4-12.
6. For one-control parallel operation with remote sensing, disconnect the jumper wires from between (+S) and (+) terminals and between (-S) and (-) terminals, and make the required connections only for the master unit, as explained in 4-1 "Remote Sensing."

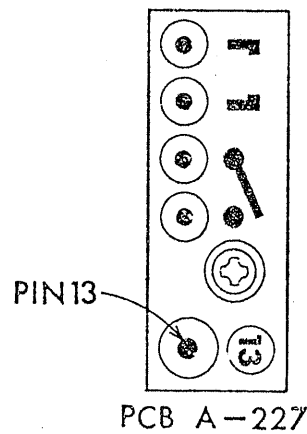


Figure 4-13

Note: Set the constant-voltage setting knobs of the slave units to the maximum position. For the wire gauges for the required currents, see the following table.

Nominal cross section area	Current rating recommended by Kikusui	Current rating specified by the Technical Ordinance for Electrical Installations (Article 29) JAPAN
5.5 mm ²	20 A	49 A
8 mm ²	30 A	61 A
14 mm ²	50 A	88 A
22 mm ²	80 A	115 A
38 mm ²	100 A	162 A
80 mm ²	200 A	257 A

Ta = 30°C

4-6. One-control Series Operation

One master unit and any slave units can be operated in series to obtain a higher output voltage.

1. Turn off the input power switch.
2. Disconnect the jumper from between terminals (8) and (9) of each slave unit.
3. Connect external resistor as shown in Figure 4-14.
4. Connect in series the rear output terminals as shown in Figure 4-14. (Use wires of sufficient current rating.)
5. Connect together the GND terminals of the units to the required potential line.
6. Set the current setting knobs of the slave units to the maximum position.
7. Set the voltage setting knobs of all slave units to the maximum position. (The output voltage can be controlled with these knobs.)

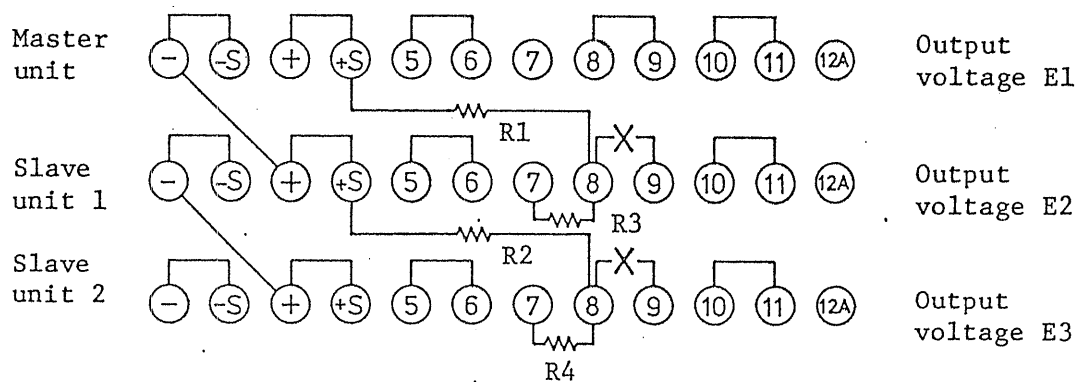


Figure 4-14

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Calculation of external resistor R1 (R2)

$$R1 = \left(\frac{E1}{E2} \times A \right) - B$$

where, $R1 \geq 0$ [k Ω]

$$E2 \leq \frac{A}{B} E1 \dots\dots \text{(condition for E2)}$$

E1: Output voltage [V] of master unit

E2: Output voltage [V] of slave unit 1
which depends on output voltage E1
of master unit

A, B: Constants of slave unit 1. (See
the table below.)

R3, R4: 72 k Ω

The value of R2 also can be calculated in a similar manner
as above, substituting E1 with E2 and E2 with E3.

Model	PAD35-5LC
A	35
B	9

- Notes:
1. Make the total series output voltage not higher than the withstanding voltage to the ground of instruments involved.
 2. Set the constant-current setting knobs of the slave units to the maximum position.
 3. Pay attention to the wattage of the external resistors R1 (R2, R3, R4). Use resistors of 2-watt or over and of good temperature characteristics and less aging degradation.
 4. For one-control series operation, units of different models can be connected if they are of the same type.

822643

5. For the remote sensing operation, use the +S terminal of the highest voltage unit (master unit) and the -S terminal of the lowest voltage unit (slave unit).

4-7. Constant-current Discharge of Battery or Capacitor

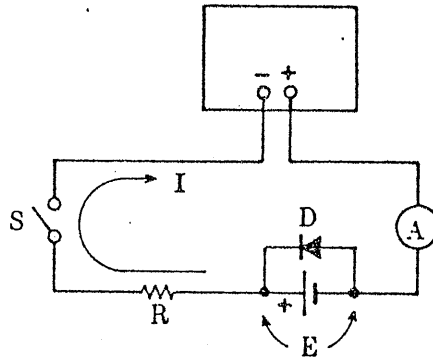


Figure 4-15

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

Power consumption by R: $P = I^2R \text{ [W]}$

where, E: Terminal voltage of battery or capacitor at the beginning of 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. (By this setting, constant-current discharge can be done until the voltage of the battery or capacitor becomes zero.)

82264A

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 the discharge operation, 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.

Charging of a battery or a capacitor can be done in a similar method as shown in Figure 4-15, the only differences being that the polarity must be inverted and R, D and S are not required. The charge-up voltage can be set with the voltage setting knob and the charge current with the current setting knob. The charging operation automatically stop when the battery is charged up.

SECTION 5. MAINTENANCE

5-1. Inspection and Adjustment

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

- 5-1-1. Removing Dust and Dirt
- 5-1-2. Inspecting the Power Cord and Plug
- 5-1-3. Calibrating the Voltmeter
- 5-1-4. Calibrating the Ammeter
- 5-1-5. Calibrating the Current/Voltage Limit Switch
- 5-1-6. Adjusting the Maximum Variable Constant-voltage Range
- 5-1-7. Adjusting the Maximum Variable Constant-current Range

5-1-1. Removing Dust and Dirt

When the instrument panel has become dirty, lightly wipe it with a cloth moistened with diluted neutral soapsuds or alcohol 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.

5-1-2. 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.

5-1-3. Calibrating the Voltmeter

Connect an external voltmeter of an accuracy of 0.5% or better to the output terminals, set the output voltage at the value indicated on Table 5-1, and calibrate the instrument voltmeter with R6 (V) at the right-hand section on the front panel.

(See Figure 5-1.)

5-1-4. Calibrating the Ammeter

Connect an external ammeter of an accuracy of 0.5% or better in the output circuit, set the output current at the value indicated on Table 5-1, and calibrate the instrument ammeter with R5 (A) at the right-hand section on the front panel.

(See Figure 5-1.)

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

o Calibration of limit voltage

Set the output voltage at the value indicating on Table 5-1. Press the current/voltage limit switch and so adjust R3 on PCB A-141 that the voltmeter reads the set voltage value. (See Figure 5-1.)

o Calibration of limit current

Set the output current at the value indicated on Table 5-1. Press the current/voltage limit switch and so adjust R1 on PCB A-141 that the ammeter indicates the set current value.

5-1-6. 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 R4 on PCB A-141 that the instrument voltmeter reads the value indicated on Table 5-1. (See Figure 5-1.)

5-1-7. 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 R2 on PCB A-141 that the instrument ammeter reads the value indicated on Table 5-1. (See Figure 5-1.)

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Table 5-1

Model	PAD35-5LC
Voltmeter adj	35.0 V
Ammeter adj	5.0 A
Voltage limit adj	35 V
Current limit adj	5 A
Maximum voltage adj	36 V
Maximum current adj	5.2 A

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- R1: Current limit adjusting potentiometer
- R2: Maximum current adjusting potentiometer
- R3: Voltage limit adjusting potentiometer
- R4: Maximum voltage adjusting potentiometer
- R5: Ammeter adjusting potentiometer
- R6: Voltmeter adjusting potentiometer

To control output current with an external voltage, throw this switch in the arrowhead direction.

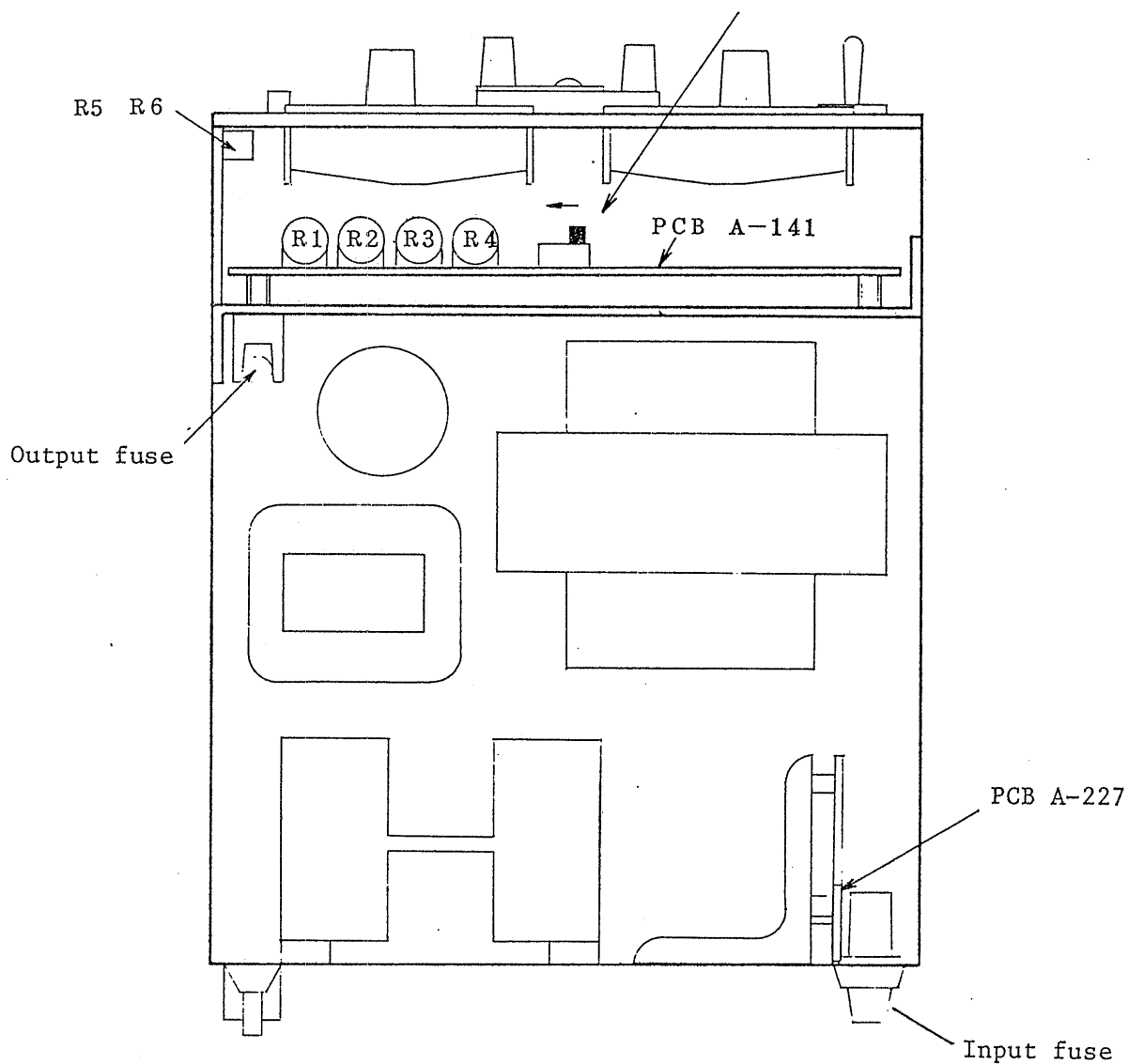


Figure 5-1

5-2. 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
No output (No output is produced at all or only a slight output is produced.)	1. Has the overvoltage protector tripped?	o Set voltage too low
	2. Shorting bar disconnected?	o Disconnected or loose shorting-bar
	3.	o Trip of overheat protector
	4. Does voltage drop slowly when light load is connected?	o Trip of protective circuit due to failure of rectifier circuit
	5. Is the input power fuse blown?	o Input line voltage too high (Replace fuse.) o Failure of rectifier circuit
	6. Is lamp lighted?	If not lighted, o Open-circuiting of power cord
	7. Are the lamps alternately lighting, indicating rapid transitions of operating domains?	o Too narrow constant-voltage and constant-current setting ranges

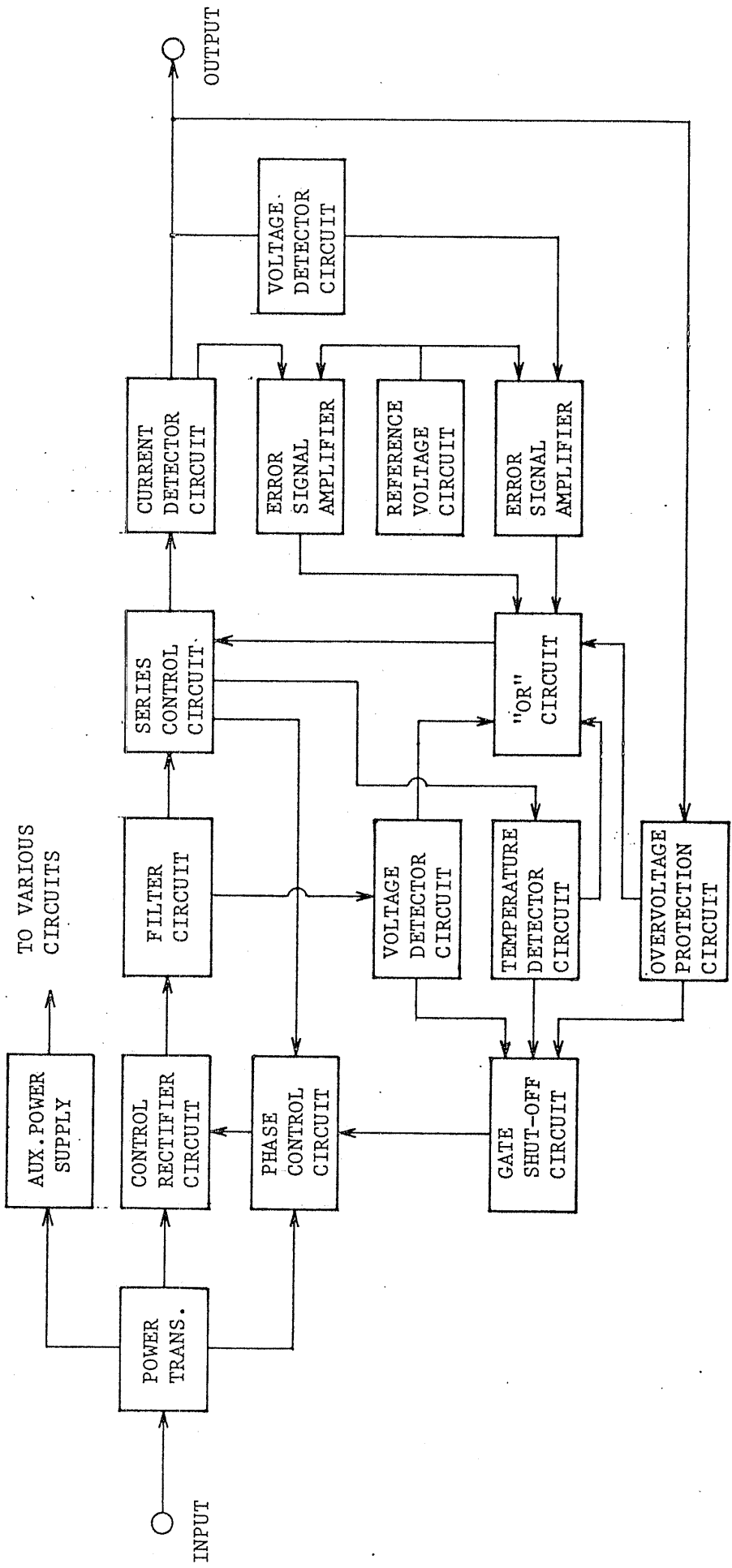
Symptom	Check item	Probable cause
	8. Are the shorting-bars correctly connected?	o Wrong connection of shorting-bar(s)
	9. Is the output power fuse blown?	o Output current exceeding the rated value o Power transistor failure
	10. Is the circuit oscillating?	o Phase inversion caused by remote sensing circuit (Connect an electrolytic capacitor at the load end.) (See Figure 4-1.) o Re-adjustment
	11. 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.)
	12. Other than the above	o Circuit failure
OVP circuit trips.	1. Is the shorting-bar disconnected? (Between ⑤ and ⑥.)	o Disconnected or loose shorting-bar
	2. Can output voltage (current) be reduced?	o Power transistor failure o Bleeder circuit failure

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Symptom	Check item	Probable cause
Unstable output	1. Is the shorting-bar(s) loose?	o Incorrect connection of shorting-bar(s)
	2. Is the AC line voltage correct?	o AC line voltage not within the specified range
	3. Special type of load	o See 2-3 (Loads).
	4. When matter of drift is critical	o Allow more than 30 minutes of stabilization time.
	5. Other than the above	o Circuit failure
Large ripple voltage	1. Is the AC line voltage correct?	o Input voltage too low
	2. Are the output terminal or ground terminal floated?	o 50/60 Hz induction (If possible, ground the terminal with a capacitor of 1 μ F or over.)
	3. Is strong source of magnetic or electric field present near the power supply? (Is there 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.)
	4. Other than the above	o Circuit failure o (Re-adjust)

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Block diagram of the power supply