Thyristor-System Single-Phase Power Controller

PAC26 Series

INSTRUCTION MANUAL

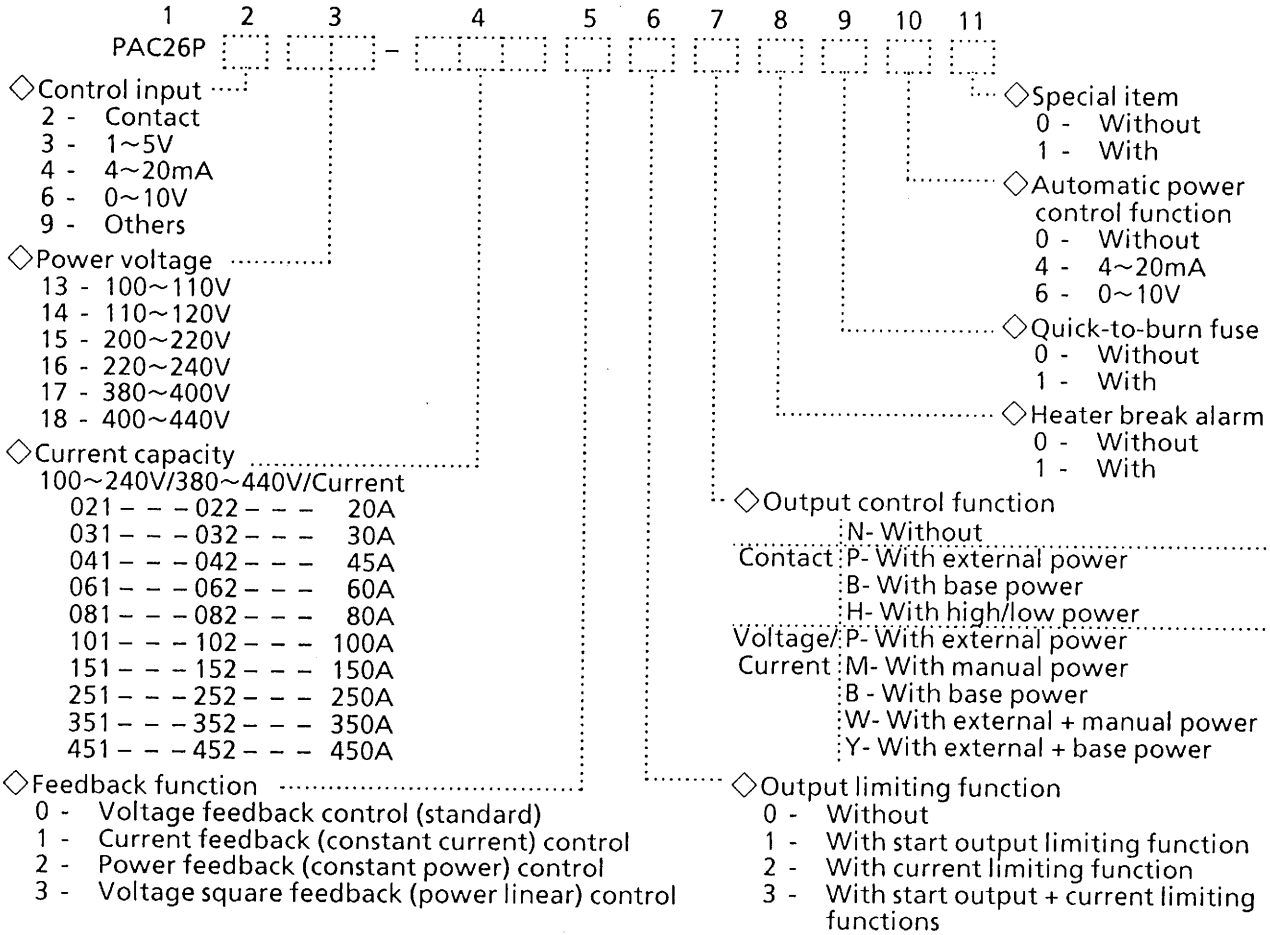
Thank you for having purchased our PAC26 series thyristor-system single-phase power controller.
This instruction manual deals with the basic operation of the instrument. You are requested to read it carefully.
Please see to it that this instruction manual reaches the final user of the controller.

<Contents>

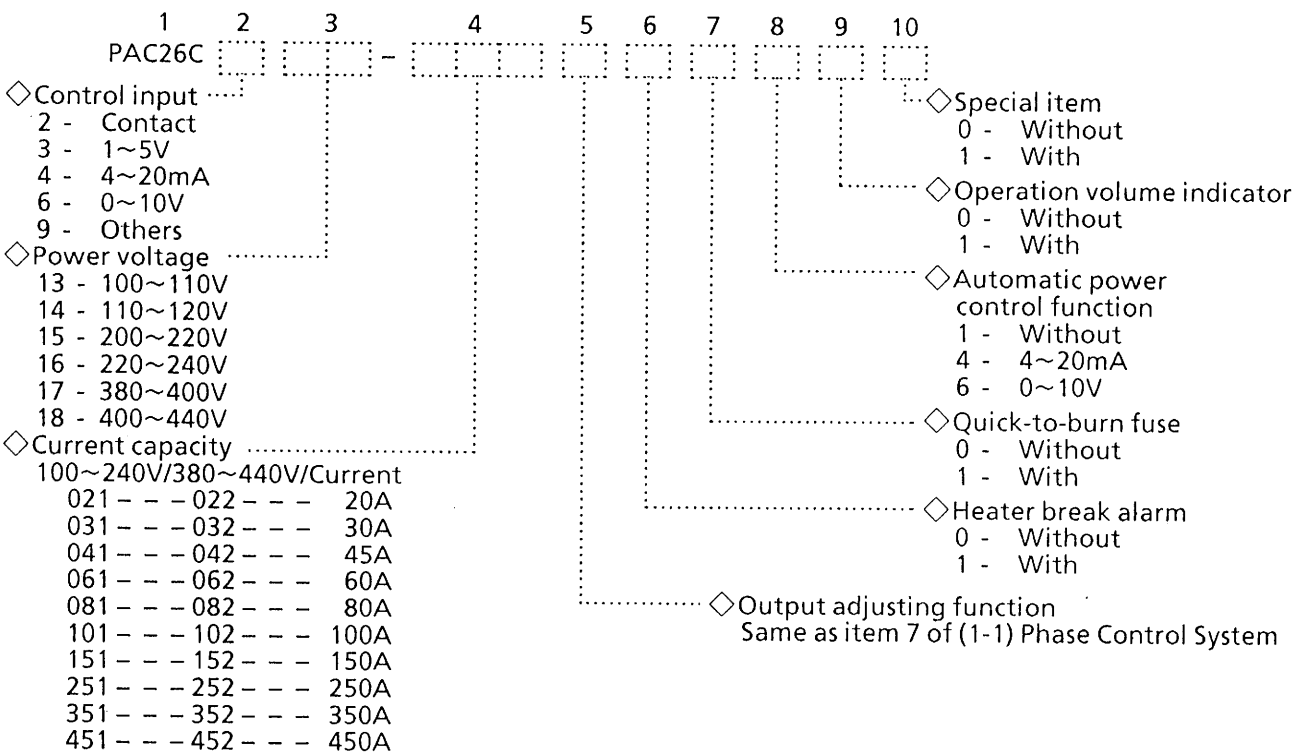
1. Confirmation of Specifications

Please make sure that the delivered product conforms with the specifications of your order. Should there be anything unclear, please contact our nearest office or service center.

(1-1) Codes for Phase Control System



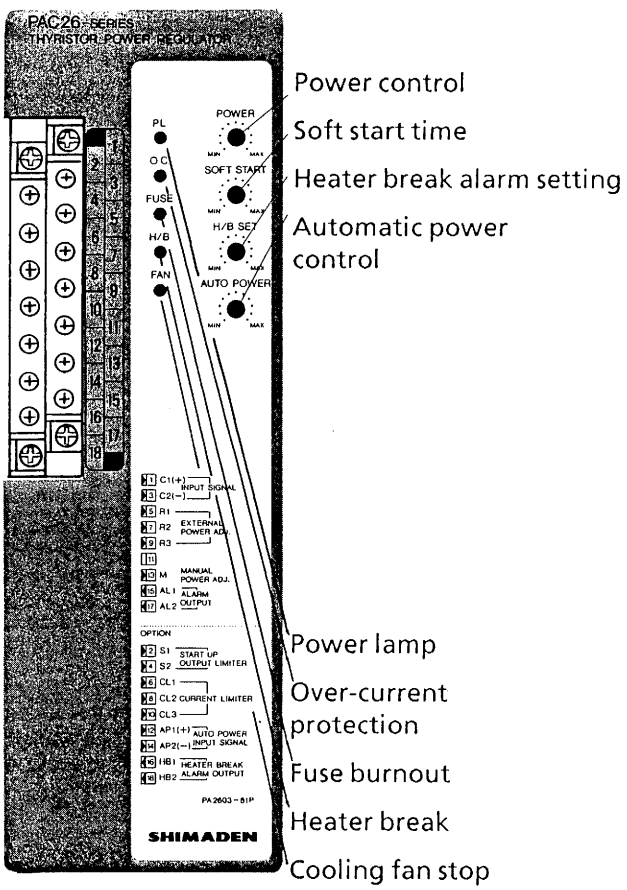
(1-2) Codes for Cycle Operation Zero Voltage Switching System



2. Information about Panels and Terminals

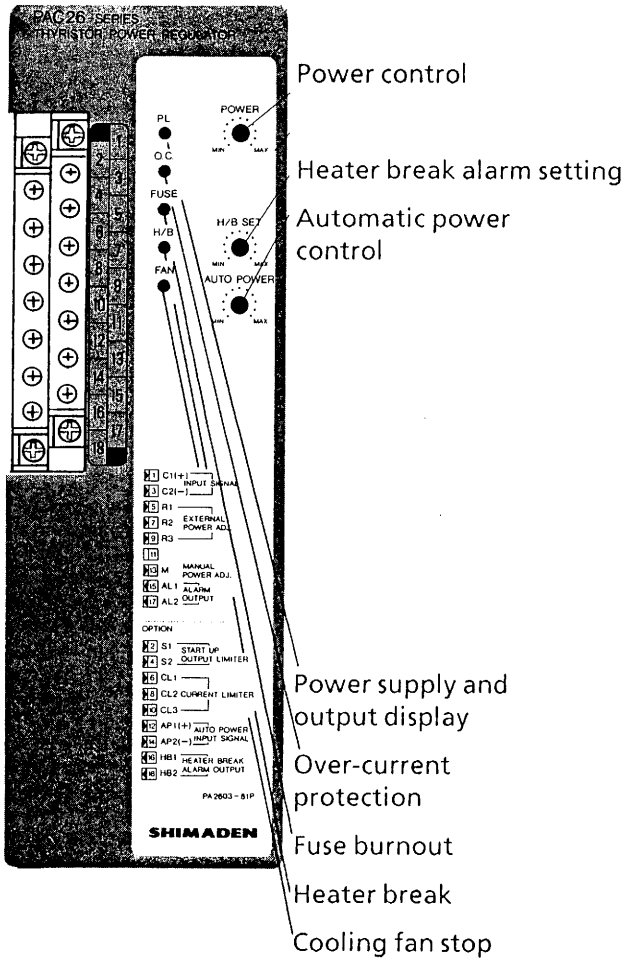
(2-1) Phase Control System

PAC26P



(2-2) Cycle Operation Zero Voltage Switching System

PAC26C



(2-3) Control Terminal Numbers and Codes

Terminal No.	Code	Terminal Code: Voltage/Current	Terminal Code: Contact
Upper terminals	1	C1 (+)	C1
	3	C2 (−)	C2
	5	R1	
	7	R2	
	9	R3	
	11		L2
	13	M	L3
	15	AL1	
	17	AL2	
		Phase Control	Cycle Operation
Lower terminals	2	S1	M01(+)
	4	S2	M02(−)
	6	CL1	
	8	CL2	
	10	CL3	
	12	AP1 (+)	
	14	AP2 (−)	
	16	HB1	
	18	HB2	

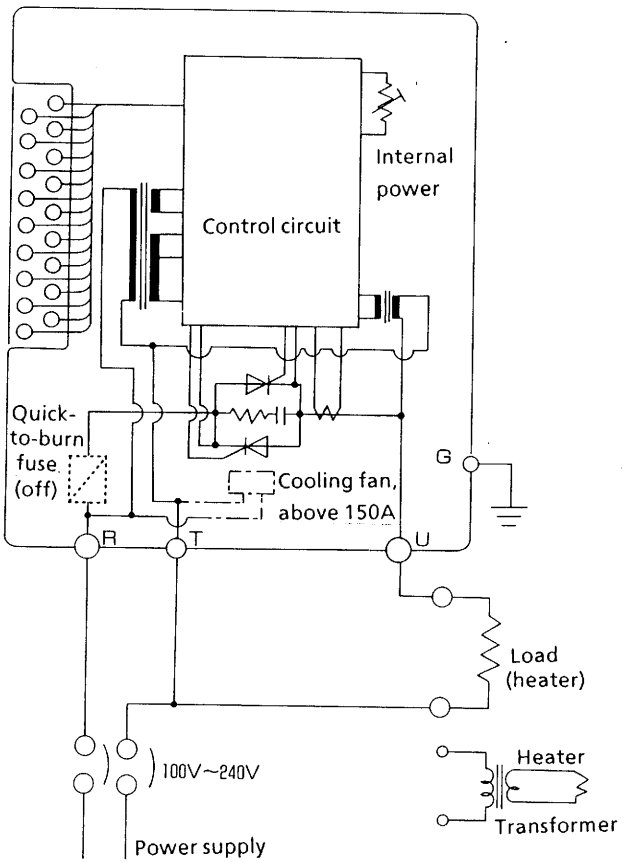
☐ Note terminal numbers and codes, as terminals have different functions for each type of control signal and control system.

☐ Terminals with polarity are marked with (+) or (−).

☐ Alarm terminals (AL1-AL2) and (HB1-HB2) are of strong current circuits. They should be wired separately from other signal lines for protection from noise.

3. Circuit Block Diagram

(3-1) 100~240V Power Supply



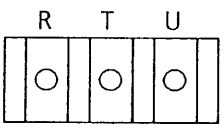
- Terminal Codes -

☐ Control Terminals

No.1~no.18 (See page 2 (2-3).)

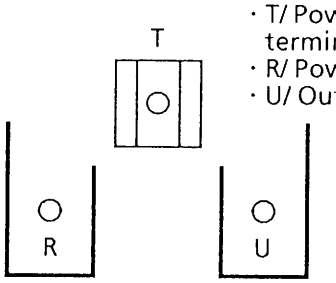
☐ Power/Load Terminals

◇[20A/30A, 45A/60A terminals]



- R/Power terminal
- T/Power and feedback terminal
- U/Output terminals

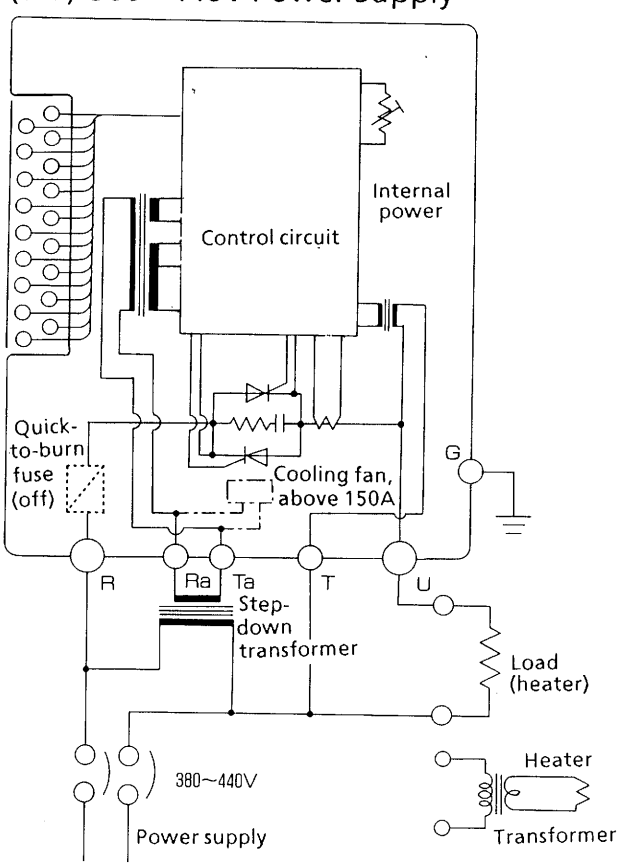
◇[80A/100A, 150A/250A, 350A/450A terminals]



- T/ Power and feedback terminal
- R/ Power terminal
- U/ Output terminal

Bar wiring

(3-2) 380~440V Power Supply



Quick-to-burn fuse is an optional item. Fan is provided in instruments of above 150A.

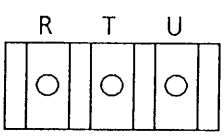
- Terminal Codes -

☐ Control Terminals

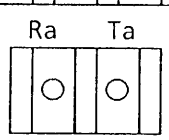
No.1~no.18 (See page 2 (2-3).)

☐ Power/Load Terminals

◇[20A/30A, 45A/60A terminals]

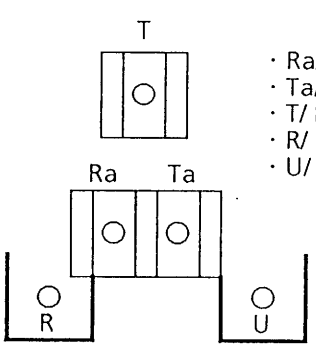


- R/ Power terminal
- T/ Feedback terminal
- U/ Output terminals



- External feed power supply -
- Ra/ 0V (R-phase) terminal
- Ta/ 200V (T-phase) terminal

◇[80A/100A, 150A/250A, 350A/450A terminals]



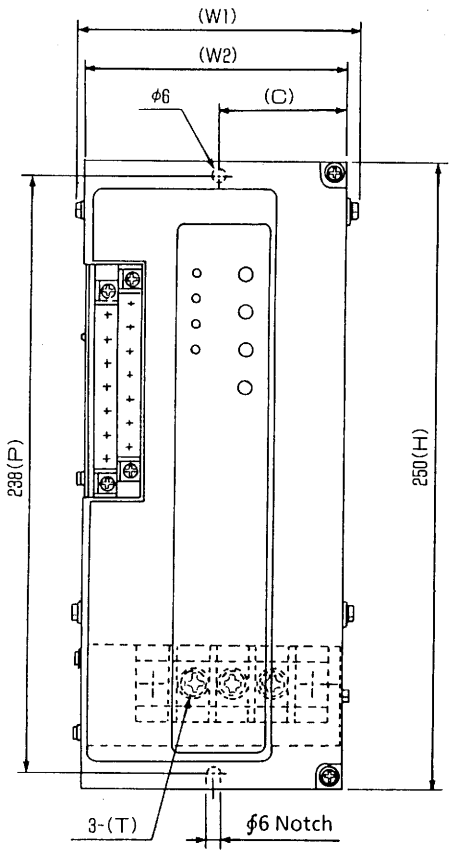
- Ra/ 0V (R-phase) terminal
- Ta/ 200V (T-phase) terminal
- T/ Feedback terminal
- R/ Power terminal
- U/ Output terminal

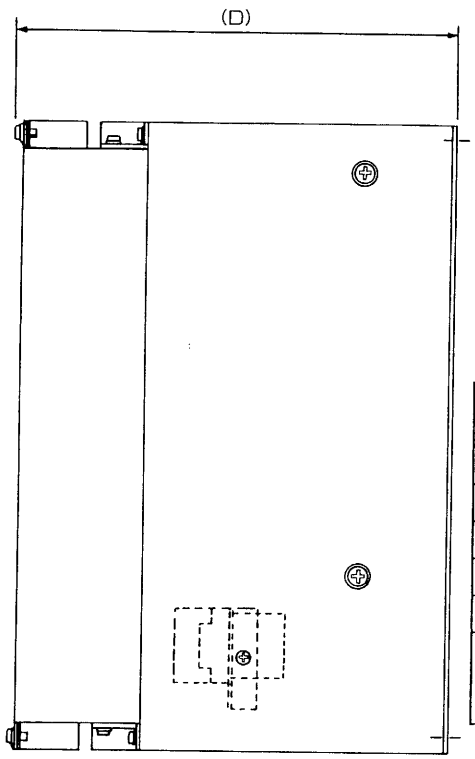
Bar wiring

4. Overall Dimensions, Sizes of Terminals, and Weight

(4-1) 20A/30A, 45A/60A Overall Dimensions

In the case of the instrument for 380V~440V, however, the overall size are 45A~65A instead of 20A~30A.



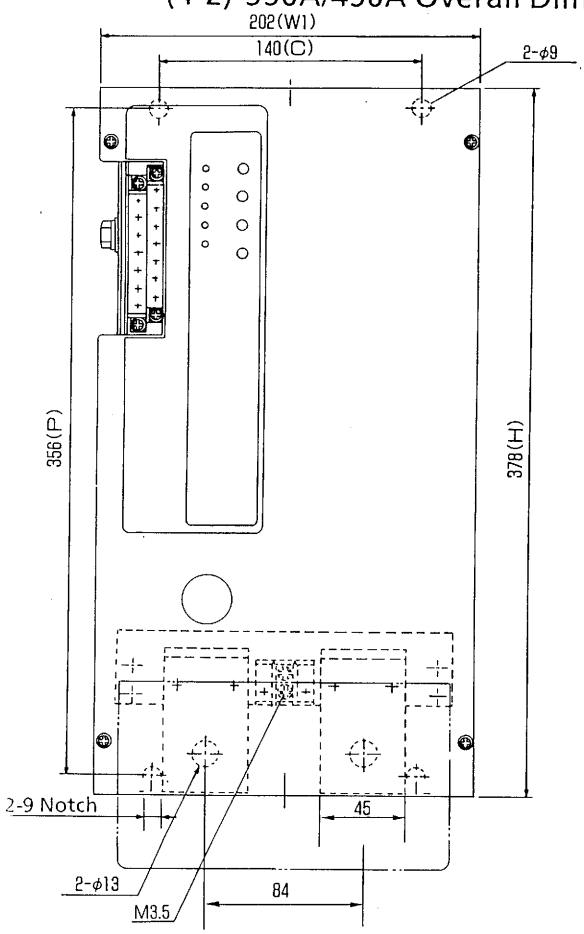


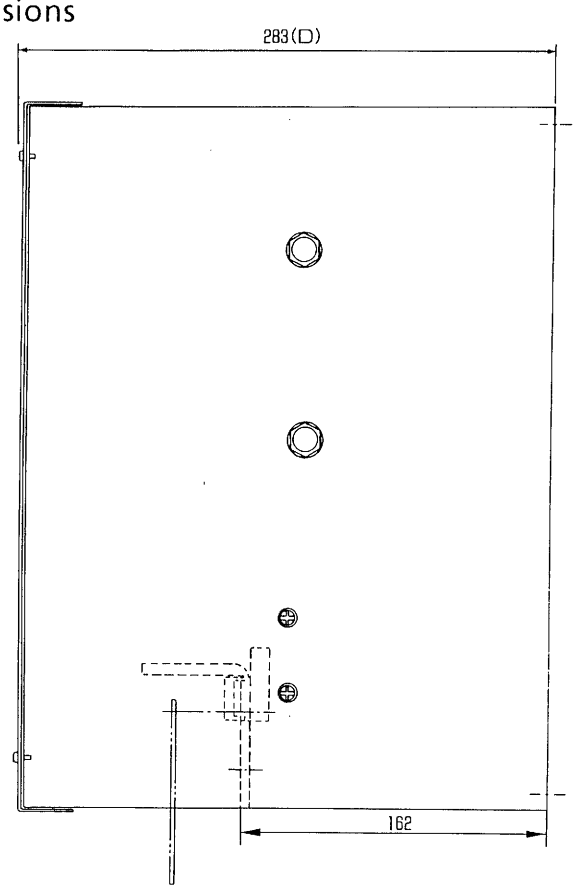
Weight
20A, 30A: About 3kg
45A, 60A: About 3.8kg

Code \ Current	100~240V 20/30A	100~440V 45/60A
W1	87	113
W2	80	105
D	166	176
C	39.5	52.5
T	M4	M6
For an instrument of 20A, 30A and 380~440V, the case for 45A, 60A is used.		

Unit: mm

(4-2) 350A/450A Overall Dimensions



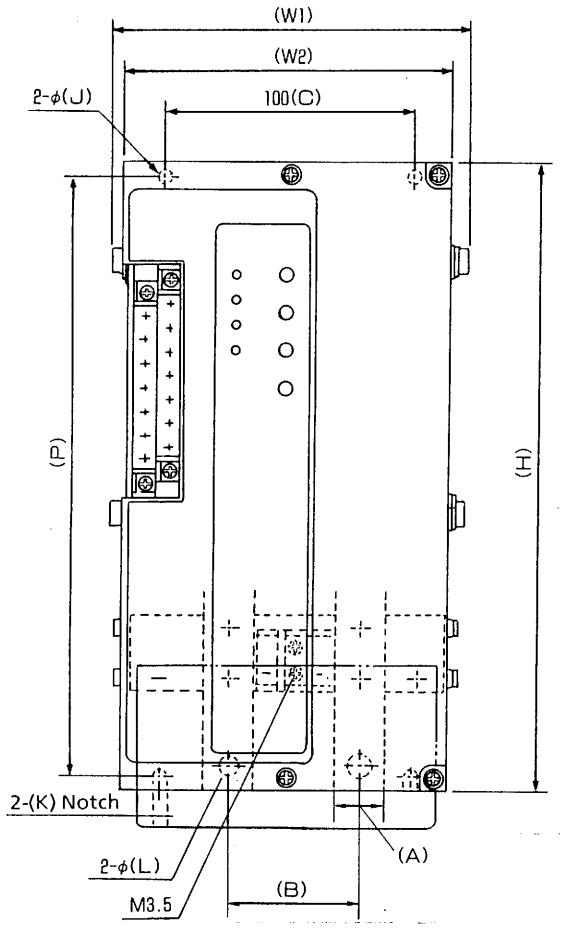


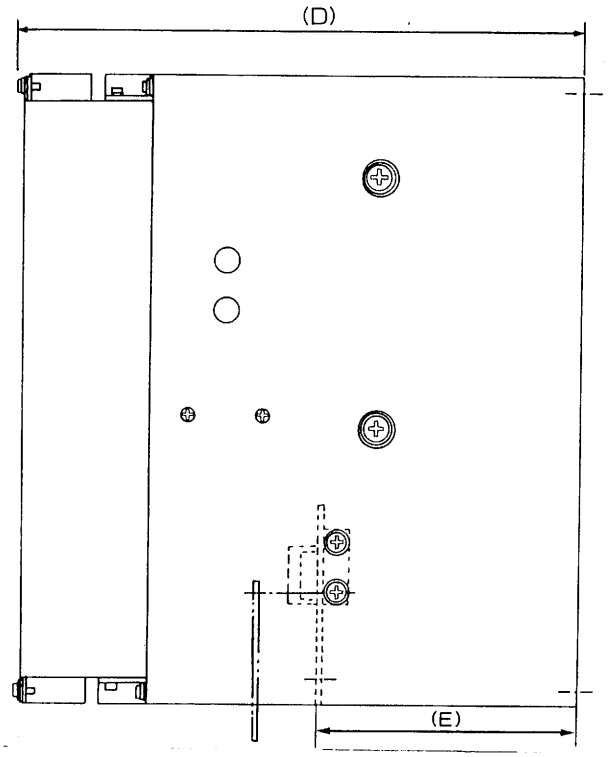
Weight
150A, 250A: About 8.7kg
350A, 450A: About 17kg

Unit: mm

(4-3) 80A/100A, 150A/250A Overall Dimensions

Weight 80A, 100A: About 6.1kg
150A, 250A: About 8.7kg





Unit: mm

Code \ Current	80, 100A	150, 250A
W1	141	140
W2	130.5	128
H	250	300
D	225	274
P	238	286
A	20	25
B	53	58
J	6	7
K	6	7
L	9	11
E	104	165

Unit: mm

5. Installation

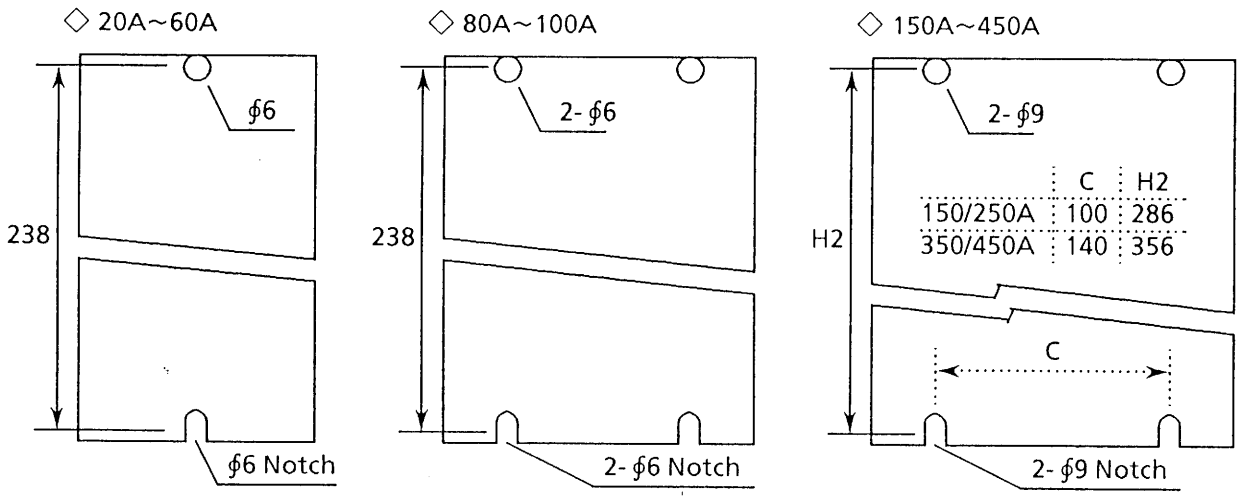
As environmental conditions affect the reliability and life of the instrument, a favorable location environment should be chosen. The following conditions are required:

1) The ambient temperature does not exceed 40°C (ambient temperatures above 50°C are highly unsuitable.)
2) The humidity is below 90%.
3) There is no inflammable or corrosive gas, or gas that impairs insulation, generated or filled in the place of installation.
4) The place allows maintenance work to be carried out safely.

6. Mounting

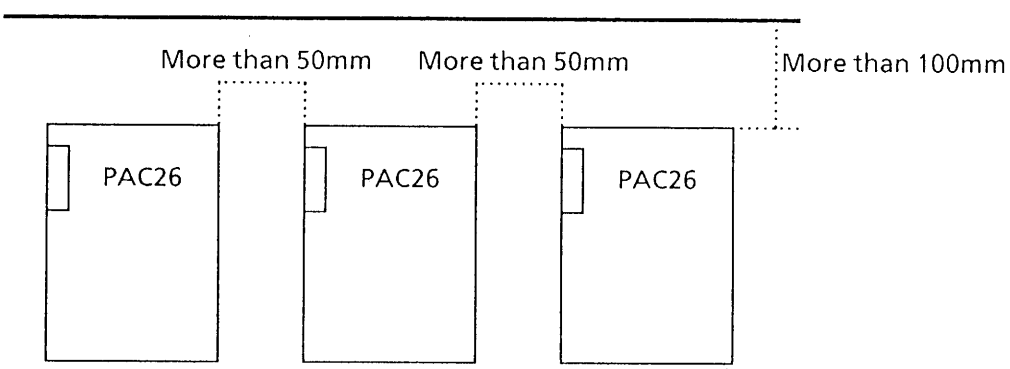
The instrument should be fixed to a control panel, wall, rack, etc. For safety's sake, it should not be easily accessible to people.

(6-1) Mounting Sizes



(6-2) Space Required for Mounting

As the instrument is wired with the cover open, a space of at least 50mm is always necessary for installation.



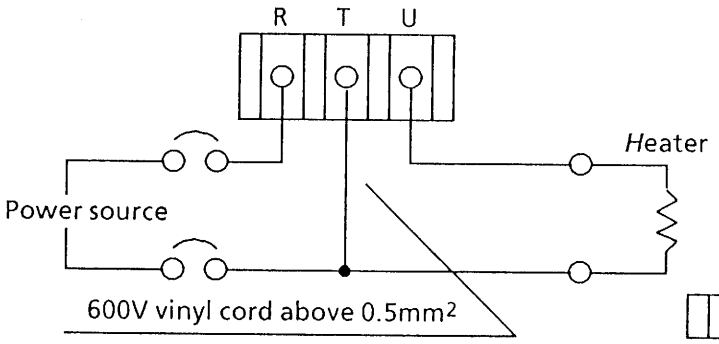
7. Wiring of Power and Load (Main Circuits)

A PAC26 series instrument needs an external supply of 200V-50A if the power voltage is 380~440V (electronic circuit/fan power supply).

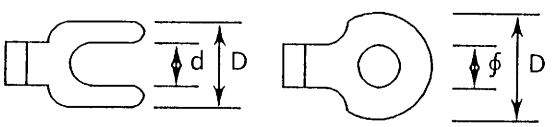
(7-1) For 100~240V Power Source

This voltage range requires three-terminal wiring, as shown below, terminal wiring for 20~60A, and bar wiring and terminal wiring for 100~450A.

7-1-1) 20~60A



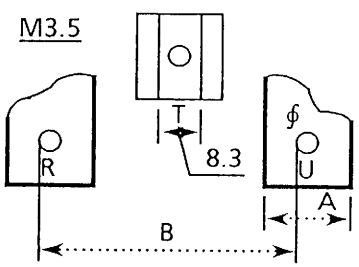
	Current capacity	
	20A/30A	45A/60A
ϕ	Above 4	Above 6
D	Below 10	Below 13
d	Above 4	Above 6



Unit: mm

7-1-2) 80~450A

In this current range, bar wiring for the main circuits (R, U), and terminal wiring for the power and feedback circuit (T) are required. Wire the power and load circuits in the same manner as in 9-1-1).



Bar sizes and clamping bolt holes

	Current capacity		
	80/100A	150/250A	350/450A
A	20	25	45
B	53	58	84
ϕ	9	11	13

Unit: mm

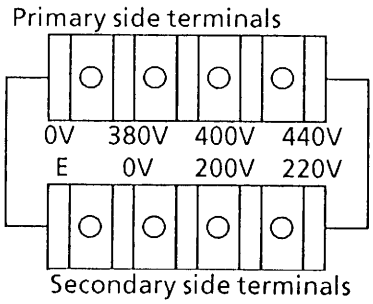
<Note> The main wiring connection should be done with a sufficient clamping torque. Since a quick-to-burn fuse is not cut when a ground fault occurs in the phase on the opposite side of the [R] phase, an [S] phase or earth leakage circuit breaker should be used.

(7-2) For 380~440V Power Source

In this voltage range, the operation circuits (electronic circuit and cooling fan power circuit) require an external supply of 200V. Supply 20VA or more if the current capacity is below 100A, and 50VA if it is above 150A.

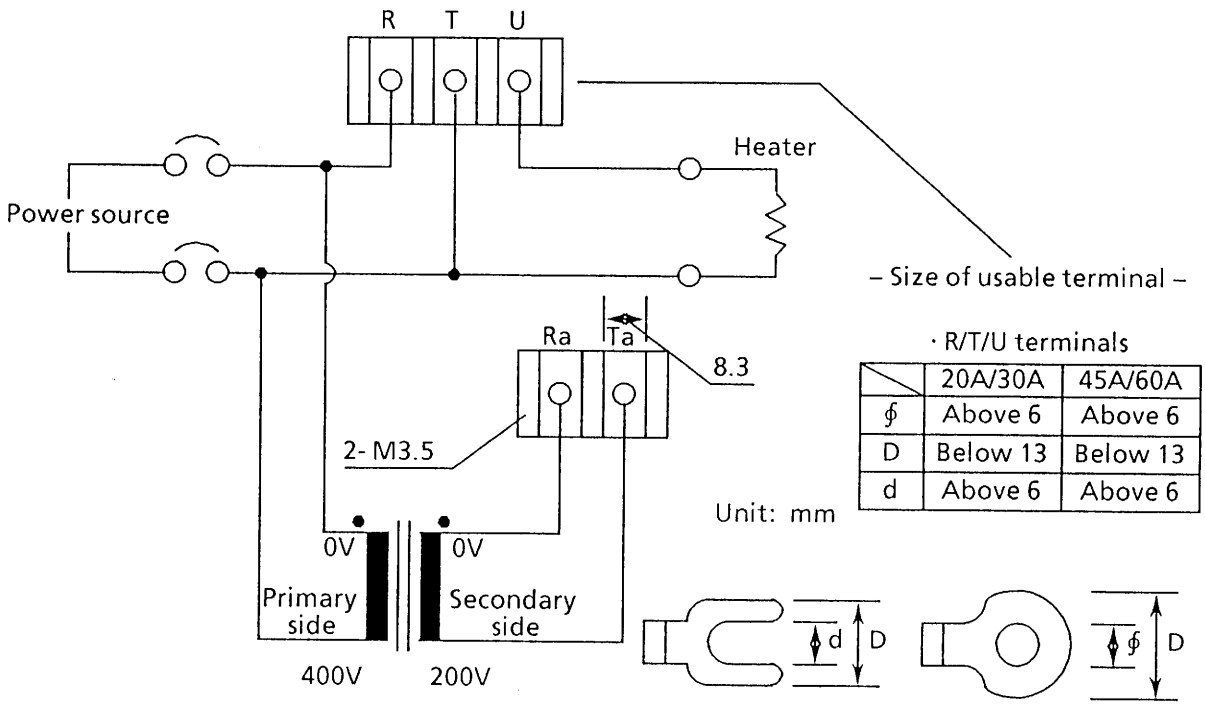
Rating of Transformer for External Power Supply

Model: H40-20R25
Primary voltage: 380V, 400V, 440V
Secondary voltage: 200V, 220V
Capacity: 50VA



◇ Number of instruments that can be connected:
Two for current capacity up to 100A; one for 150A and above

7-2-1) 20~60A



– Size of usable terminal –

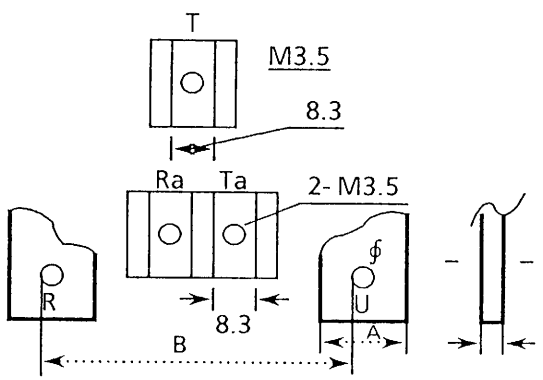
· R/T/U terminals

	20A/30A	45A/60A
ϕ	Above 6	Above 6
D	Below 13	Below 13
d	Above 6	Above 6

Unit: mm

7-2-2) 80~450A

In this capacity range, the <R> and <U> terminals require bar wiring and the Ra/Ta and T terminals M3.5 terminal wiring. The same wiring as in 7-2-1) will suffice.



Unit: mm

· R/U terminal size

	Current capacity		
	80/100A	150/250A	350/450A
A	20	25	45
B	53	58	84
t	2	4	5
ϕ	9	11	13

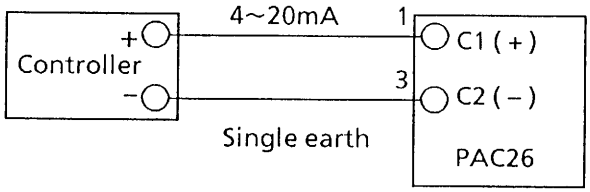
8. Wiring of Control Signal Circuit

The control signal terminals (C1-C2) receive control signals (4~20mA, 1~5V, 0~10V, contact) from the controller. Wire them so as not to allow noise, paying attention to positive or negative polarity.

(8-1) Connection to 4~20mA Output Type Controller

The PAC26 receives either 4~20mA input or 1~5V input.

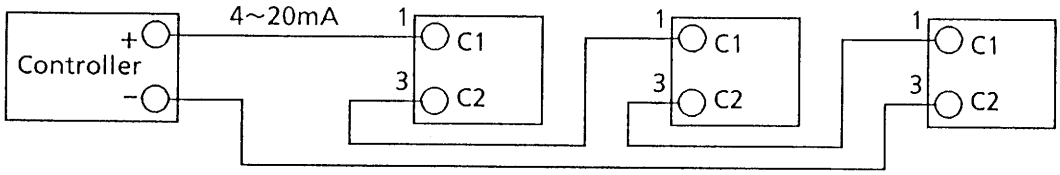
8-1-1) PAC26 □4□□ - for 4~20mA Inputs



When one instrument is connected to one controller, connect the (+) output terminal of the controller to C1 and the (−) terminal to C2, as illustrated.

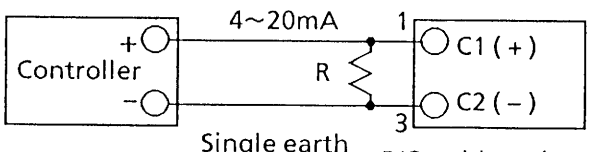
□ Receiving Resistance: 100Ω

□ When multiple PAC26s are connected to a controller, wire them in a series. Six instruments can be connected if the controller has an allowable load resistance range of 600Ω.



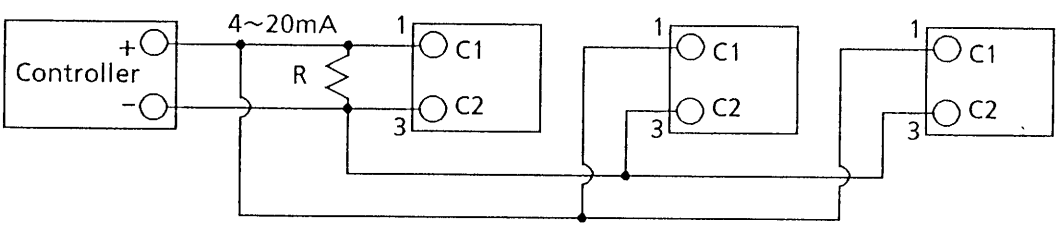
8-1-2) PAC26 □3□□ - for 1~5V Input

There is no rated controller output of 1~5V. Hence, 4~20mA received at 250Ω should be converted to 1~5V for use.



When one instrument is connected to one controller, a 250Ω resistor is connected in parallel with the terminals of the controller, as illustrated, to convert 4~20mA to 1~5V.

◇ The 250Ω resistor rated about ±0.2% 1/2W is sufficient for the purpose.



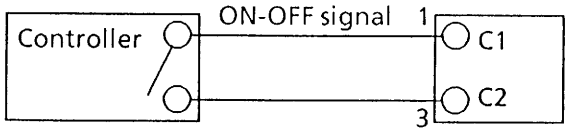
(8-2) Connection to 0~10V Output Type Controller

In this case, the PAC26 for 0~10V input (PAC26□6□□-) is used. As the impedance of input is high in this voltage range, make sure to use two-core shielded cable and exclude the noise by single earthing.

□ All wiring should be in parallel. Connect the (+) terminal of the controller to the input terminal (C1) of the PAC26 and the (−) terminal to the input terminal (C2) of the PAC26. If multiple PAC26s are connected, they should be wired in parallel in the same manner as the lower example in 8-1-2)..

(8-3) Connection to Contact Output Type Controller

For PAC26□2□□-



□ To connect the ON-OFF signal receiving type PAC26 to a PID type controller, wire them so that an output can be produced when C1 and C2 are short-circuited.

9. Standard Alarms (Over-current/Fan Stop)

(9-1) Over-current Protection Alarm

This function is put into action (gate breaking) to stop the current and to start conduction across alarm outputs AL1 and AL2 when the current transformer (built-in CT) detects a current exceeding 130% of the rated current of the thyristor. The monitor lamp (OC) lights.

※ Reset

To reset the OC alarm after it has functioned, turn the power OFF and apply it again after removing the cause of the over-current.

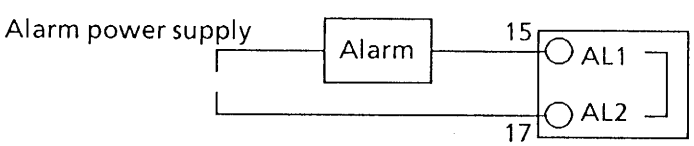
(9-2) Cooling Fan Stop Alarm (above 150A)

If the rated current is above 150A, a fan is provided for forced air cooling. If the fan stops for some reason, the alarms AL1 and AL2 are output, with control output intact, and the [FAN] monitor lamp lights.

Should this happen, turn the power OFF and rotate the fan manually to see whether it rotates smoothly. In some cases, the fan has to be replaced (servicing at your end or repair at factory).

(9-3) Wiring of Alarm Circuit (Over-current/Cooling Fan)

In both over-current and fan stop, a common alarm is output. It is produced at the AL1-AL2 terminals.



- Contact rating -
240VAC
Up to 1A resistive load

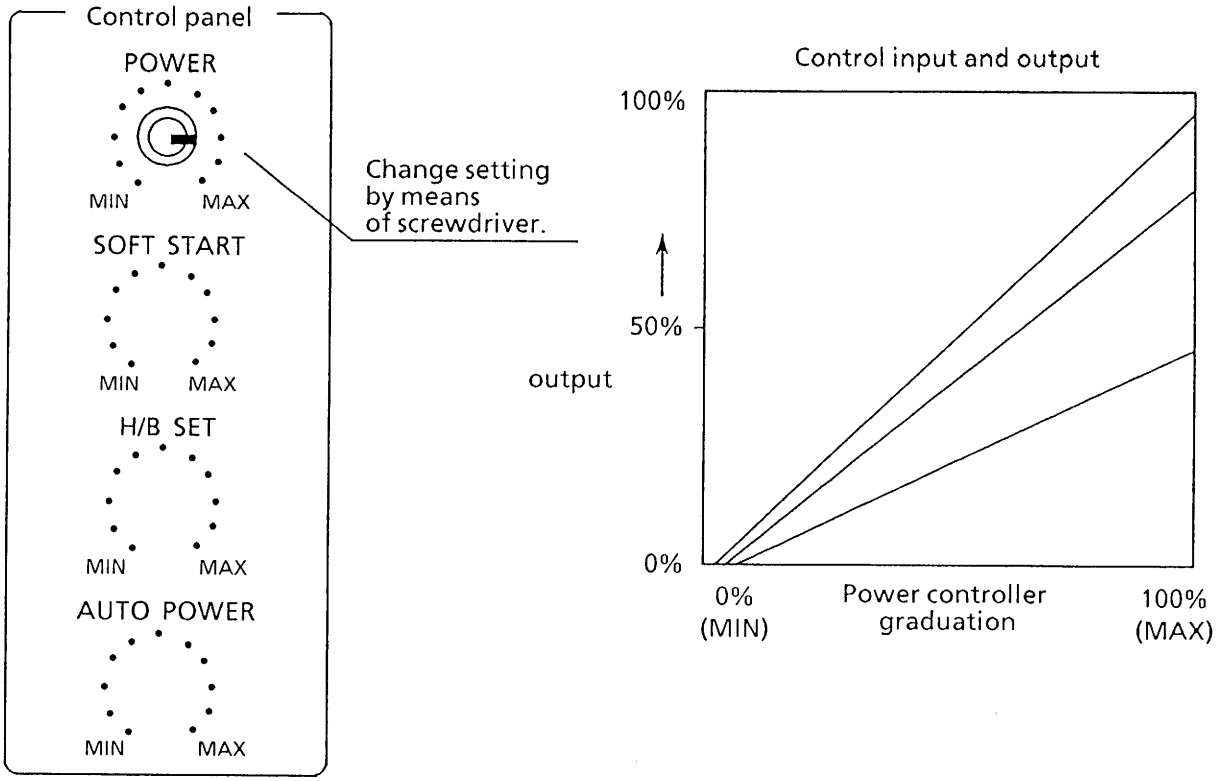
The AL1-AL2 terminals produce outputs common to three alarms.

1. Monitor [OC] lights ..... Over-current protection circuit to function – Standard
2. Monitor [FAN] lights .... Fan stop (above 150A) – Standard
3. Monitor [FUSE] lights ... Fuse break – Option

10. Power Control and Adjustment of Soft Start Time

(10-1) Power Control

Power control sets the thyristor output to an optimum value in the range of 0~100 when control input is at 100%.

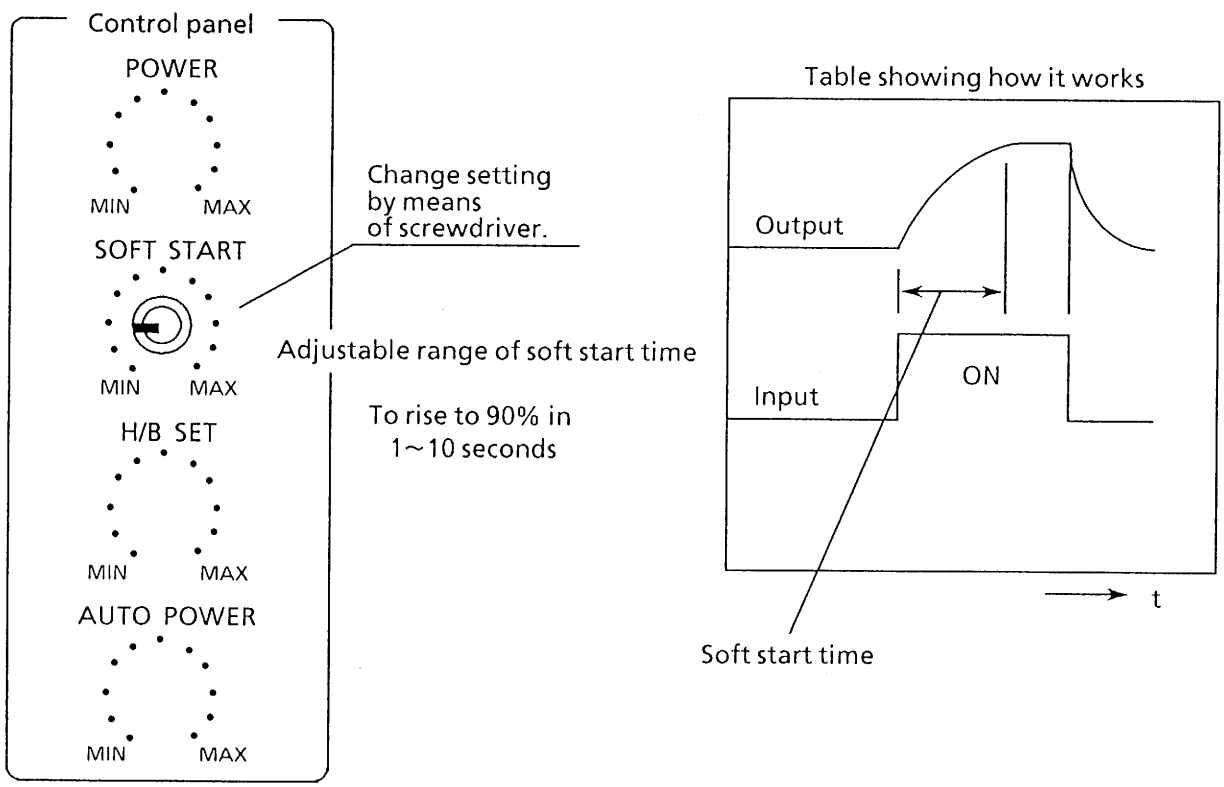


(10-2) Adjustment of Soft Start Time

Soft start is the function for delaying thyristor output by a certain time against a change in control input, as shown in the following table.

The function is used effectively for preventing excessive current from flowing when is applied so as to lighten the burden on the system, and for suppressing rush current of the heater.

The longer the time, the slower the change in output. Select time between 1 and 10 seconds to meet your requirement.



11. Characteristics

(11-1) Current Capacity and Heat Value

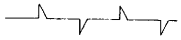
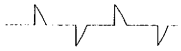
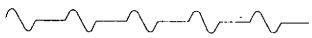
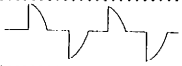
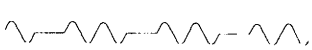
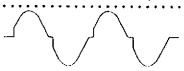
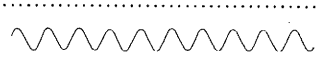
In the case of thyristor voltage/current control, a terminal voltage characteristic of semiconductors is produced (about 1~1.3V). The module heat thus generated, whose amount is in proportion to the product of terminal voltage and current, causes a rise in the temperature of the thyristor element.

Current capacity	Amount of heat, with fuse	Amount of heat, without fuse	Cooling system
20A	32W	29W	Self-cooling
30A	49W	45W	
45A	60W	54W	
60A	75W	65W	
80A	94W	85W	
100A	117W	105W	
150A	193W	175W	Forced air cooling
250A	327W	300W	
350A	420W	385W	
450A	560W	520W	

(11-2) Control of Special Heater by Phase Control and Additional Functions

Types of Heater	Additional Function				
	Constant-current control	Constant-power control	Current limiting	Output limiting at start	Combined use of transformer
Supercantal (phonetic)	○		△		○
platinum	○		△	△	○
molybdenum	○		△	△	○
tungsten	○		△	△	○
carbon		○	△		
soltbas (phonetic)	○		△		
Silicon carbide	△	○	△		○

(11-3) Control System and Output Waveform/Noise

Output/Others	Phase control system (PAC26P)	Cycle operation zero voltage switching system (PAC26C)
0%		
30%		
50%		
70%		
100%		
Noise	Yes	No
Output	Continuous	Intermittent
Output stability	Output remains within 2% against ± 10% fluctuation of input.	Fluctuation directly reflected in output.

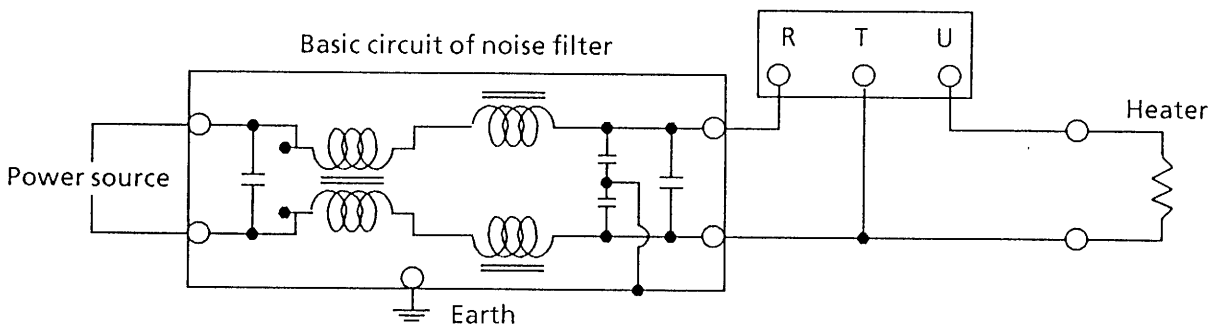
12. Noise Reduction in Phase Control System

Noise can be eliminated simply by employing the cycle operation zero voltage switching system. If a transformer needs to be used in combination or current control is necessary, the phase control system must be employed.

As can be seen from the comparison on page 12 (11-3), noise arises when the phase control system is used as it controls outputs by repeated switching (ON-OFF) of every cycle. The level of noise varies, depending on such diverse operating conditions that quantification is not possible. The following are two simple ways to deal with noise.

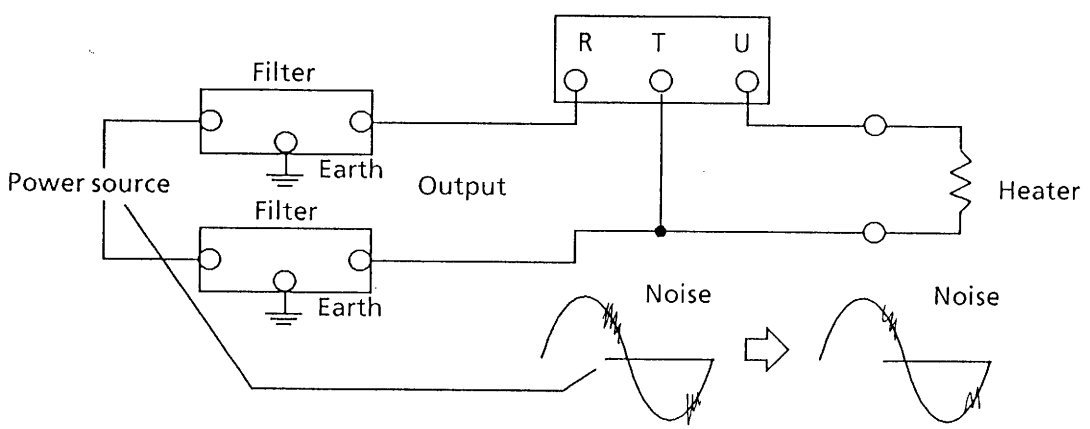
(12-1) Use of Commercially Available Noise Filter

The major manufacturers of noise filters are TDK, TOKIN, and SHOSHIN, among others. For details, please refer to their catalogs.



A noise filter is generally inserted on the power source side, for it prevents noise transmission to the power source side.

Should there be the problem of electromagnetic radiation from the output side, however, it may be inserted on the output side.



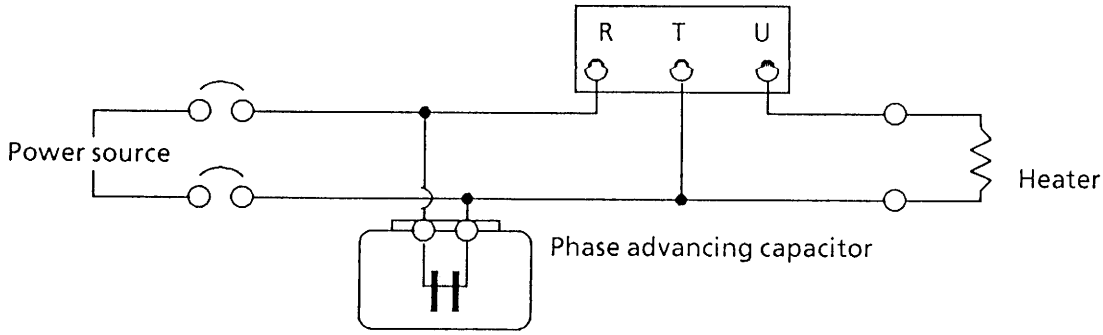
(12-2) Use of Phase Advancing Capacitor

A phase advancing capacitor is always used to improve the power rate of an induction motor. It is available at any electric machinery shop.

There are two types of phase advancing capacitors: for single-phase and three-phase. Wiring should be done as described in the instruction manual.

☐Current Rating and Capacity of Capacitor

The effect is recognized, though, empirically, when the ratio of the current capacity to the capacity (μ F) of the capacitor is 1 to 1. Since no effect is expected from a phase advancing capacitor in a high-frequency band, the combined use of a noise filter is recommended.



13. Note on Use of Transformer

Objectives of Using Transformer

1) To make two voltages match with each other when heater voltage is different from power voltage.
2) To raise withstanding voltage to ground by using a separate type transformer in case insulation to the earth lowers, for example, in a vacuum device.

(13-1) Applicable Control System

Only the PAC26P of the phase control system can be used, not the PAC26C.

(13-2) Magnetic Flux Density of Transformer

If a magnetic circuit is saturated while a transformer is used, the transformer does not function and excess current is allowed (a load is applied to the transformer). This might damage the thyristor.

Since switching (ON-OFF) takes place every cycle in thyristor control, the circuit tends to be saturated easily as the load increases. Therefore, it is necessary to design the magnetic flux to be lower in density than in the ordinary transformer.

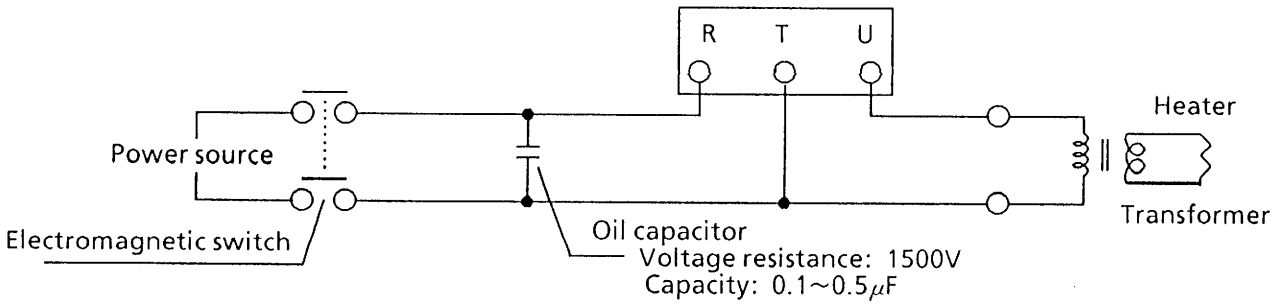
Example) The magnetic flux density of the ordinary transformer is 10,000~12,000 Gs. It should be 7,000~8,000 Gs in combined use of the transformer with a thyristor.
If an ordinary transformer is employed, there will be no problem when it is used at 60~70% of the rated load of the transformer.

(13-3) Use Separate Type Transformer.

If the heater structurally tends to cause ground fault, and the withstanding voltage to ground lowers as in a vacuum device, the use of a separate type transformer is preferable so as to protect the thyristor and power source in a mishap.

(13-4) Note on Use of Electromagnetic Switch

The use of an electromagnetic switch in a circuit connected with a transformer (i.e., inductive load) may cause erroneous operation due to a bound of a contact. In such a case, noise should be absorbed by connecting a capacitor on the power source side of the thyristor, as shown below.



(13-5) Use Transformer with Quick-to-burn Fuse.

To protect the thyristor element from excess current produced by high-frequency noise, or a load problem when a transformer is used, a transformer with a quick-to-burn fuse should be used.

(13-6) Do not Open Secondary Side during Operation.

If a load cannot be connected in a trial run, or for some other reason, disconnect the transformer wiring and operate the instrument connected with a dummy such as an electric heater or a light bulb. It should not be operated without a load on the transformer.
Do not switch the load, etc. (Proper functioning of the soft circuit will be hindered.)

14. Wiring and Use of Addition Functions (Options)

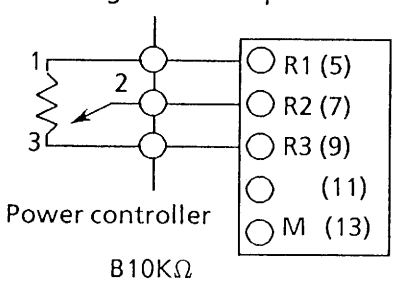
The following description applies to an instrument equipped with optional function(s).

(14-1) Output Control Function (Five Manual Control Methods)

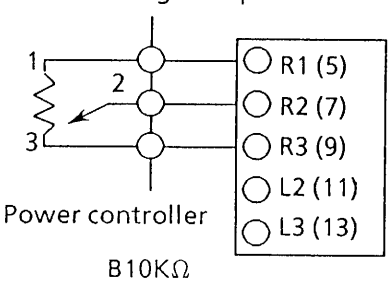
14-1-1) Use of External Power (Ramp) Controller

This function is obtained when a controller (B10KΩ/VR), which can be attached from the outside, is connected to the various terminals; that is, the function can be added after the delivery of the instrument.

☐ Voltage/current input



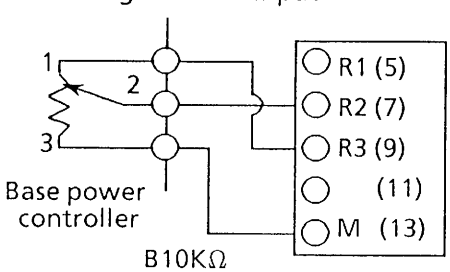
☐ Contact signal input



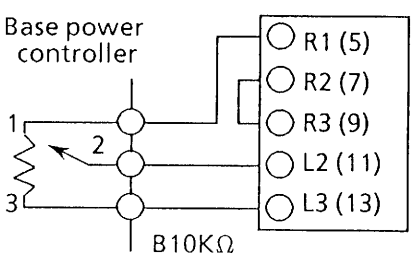
14-1-2) Use of Base (Residual) Power Controller

This function is used to keep output steady even when the control signal is at 0%. The adjustable range being 0~100%, manual control is possible with C1-C2 opened.

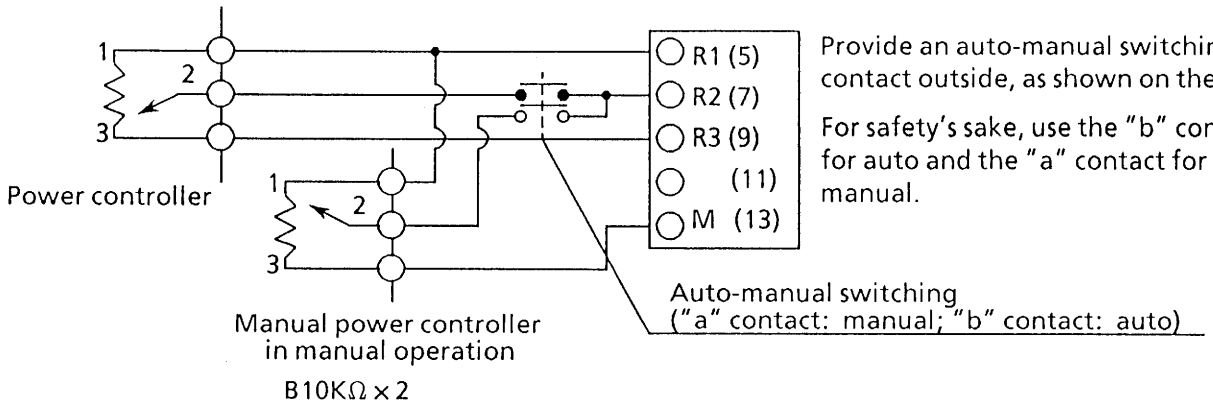
☐ Voltage/current input



☐ Contact input



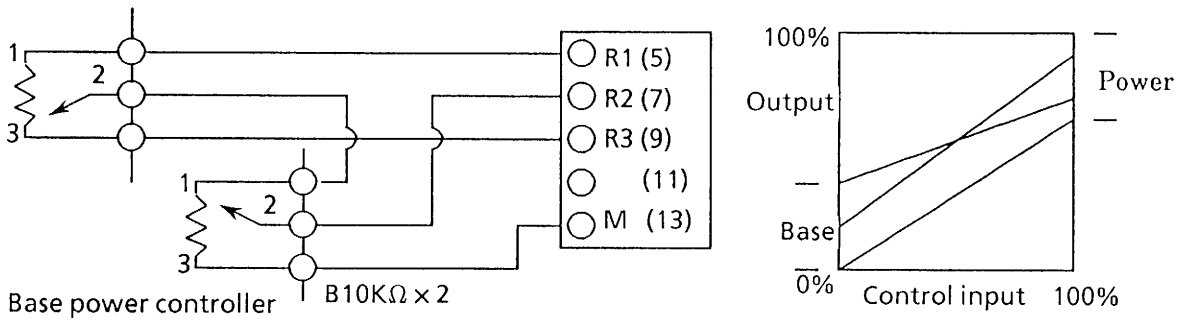
14-1-3) External Power + Manual Power Controller



14-1-4) External Power + Base (Residual) Power Controller

☐ Voltage/current signal input type only

External power controller

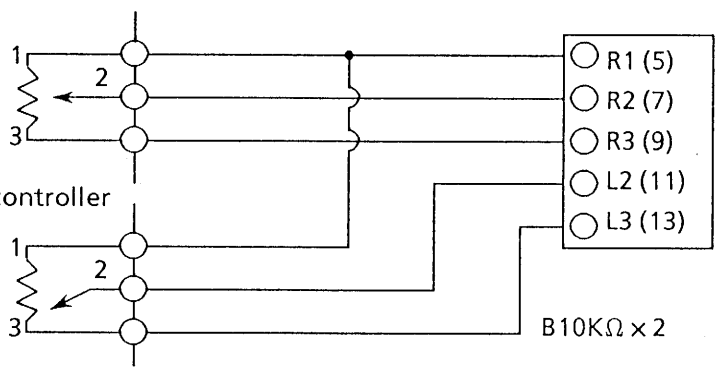


14-1-5) Use of Contact Signal Input Type as High-Low Power Controller

This high-low control is used to prevent the temperature from lowering and to reduce ripple when the two-position (ON-OFF) control system is used.

It is also used when the heater characteristically requires allowing some current to remain during OFF time so as to save rush current upon switching to ON.

☐ High power controller



☐ Low power controller

☐High power control/C1-C2: Output during ON time can be adjusted in the range of 0~100%. Select the power suitable for the set temperature.

☐Low Power Control/C1-C2: Residual output during OFF time is adjustable. Although the controller is graduated from 0 to 100%, a residual output is determined by the following equation.

Residual output = (High power) × (Low power)

Example) With high power = 70% and low power = 40%, the residual output is 70% × 40% = 28%.

Note: When the phase control system is used, power output differs substantially from the readings as compared to the cycle operation zero voltage switching system, since the latter controls electric power. Refer to the following table.

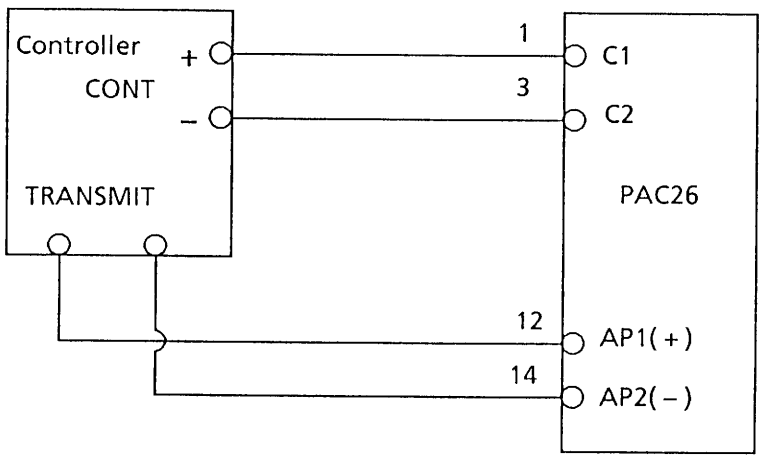
Power Output

VR% / Control System	Scale of Control VR 20%	40%	60%	80%	100%
Phase control	4%	16%	36%	64%	94%
Cycle operation control	20%	40%	60%	80%	95%

(14-2) Automatic Power Adjusting Function

A signal to adjust the maximum value of thyristor output is input from outside to the auto power terminals (AP1-AP2).

14-2-1) Wiring and Control of Auto Power Terminals



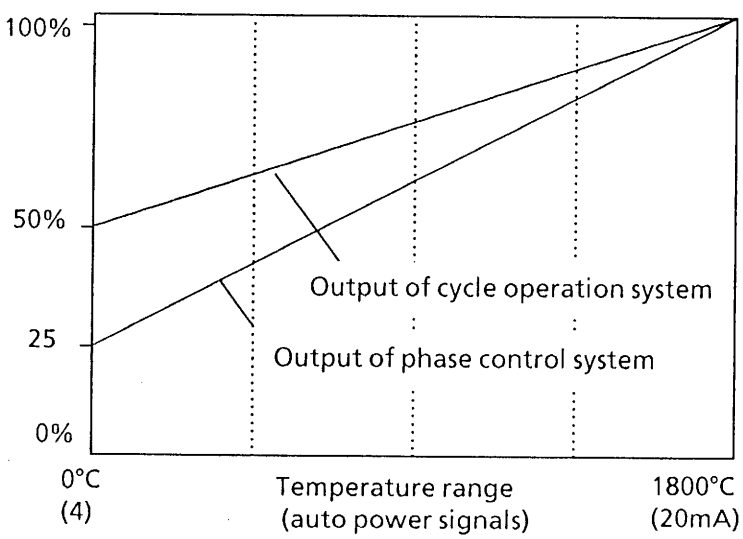
☐ Note the input polarity of control signals (contact signal has no polarity) in wiring the C1 and C2 terminals.

☐ Auto Power Input Terminals
When auto power signals are input to the AP1 and AP2 terminals, attention should be paid to polarity.

☐ Auto Power Adjustment

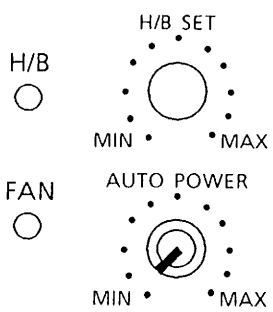
Auto power adjustment means adjusting theinitial (starting point) value. Since it is adjustable in the range of 50 to 100%, set it to the required output value.

Auto Power Characteristics of Phase Control System and Cycle Operation System



☐ Output Characteristics of Phase Control System
As the system controls output voltage, power is characterized as shown in the table on the left. It is adjustable in the range of 25% to 94%.

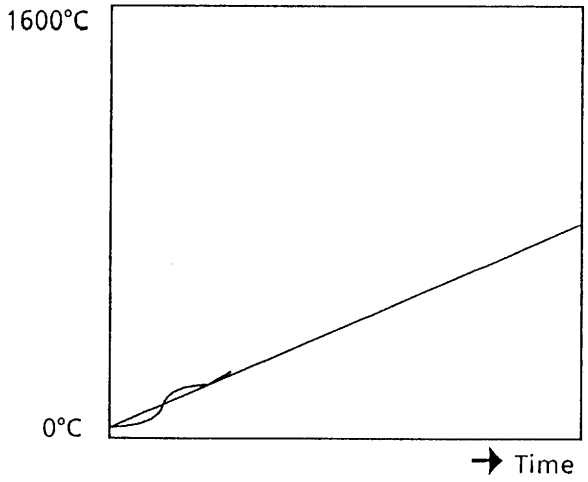
☐ Output Characteristics of Cycle Operation System
As this system controls electric power, it is adjustable in the range of 50% to 97% like the range of characteristics.



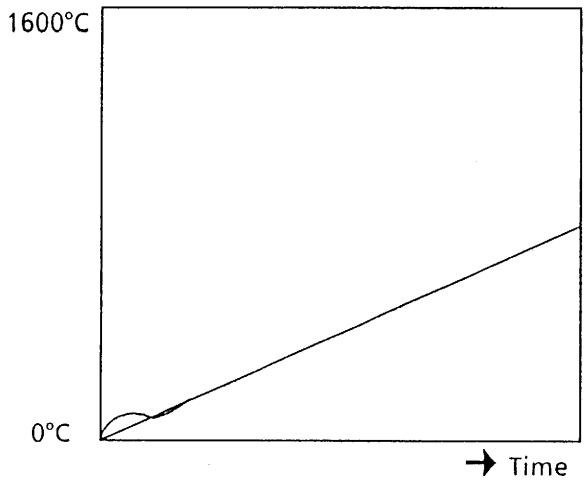
☐ Excess or Insufficient Auto Power Adjustment

When SV analog output is used, a straight line connecting the output value at the start and the one at the highest temperature constitutes the output curve.

◇Start of program with insufficient output



◇Start of program with excess output



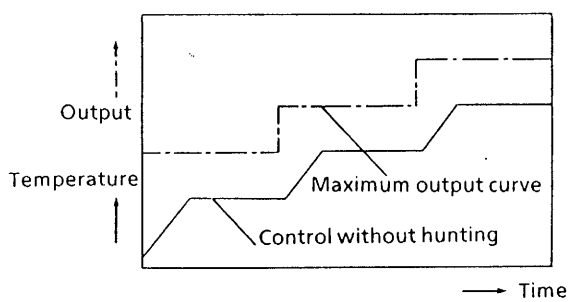
14-2-2) Comparison of Auto Power Functions

Auto power adjustment gives rise to a difference in control results, as shown below. Power should be adjusted to an optimum level.

☐ Comparison of Constant-Value Control Results

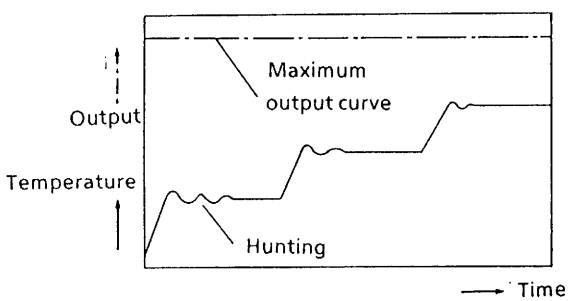
When a set value is changed in constant-value control, as shown below, the optimum power for the set value is set by means of the auto power function and most satisfactory results are obtained from a low through a high range.

· Output and control result with auto power function



Power varies as SV is changed and optimum control without overshooting is carried out.

· Output and control result without auto power function

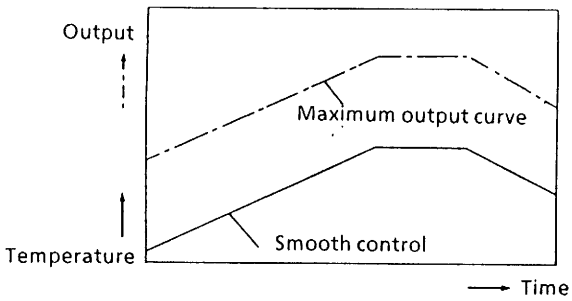


Excess power in a low range tends to give rise to overshooting and/or hunting.

☐ Comparison of Program Control Results

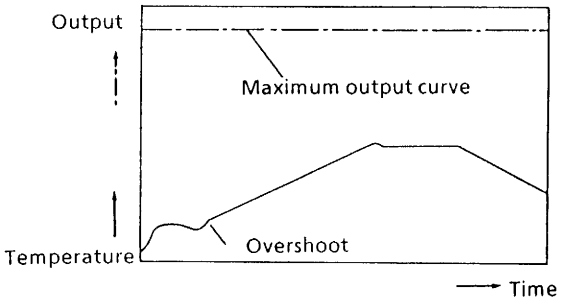
In program control, too, the auto power function can prevent overshooting particularly at the start, and deal with temperature inclines at a very low speed.

· Output and control result with auto power function



Smooth program control without transient characteristics (overshooting) at the start is possible.

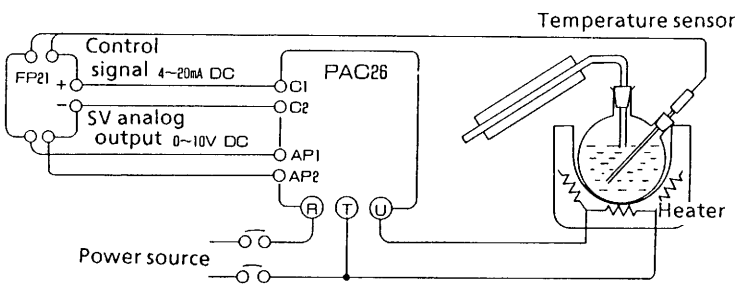
· Output and control result without auto power function

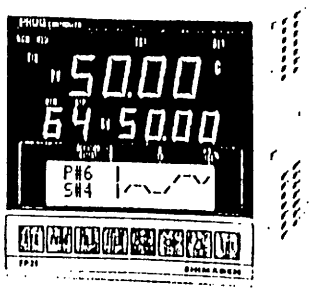


.Excess output at the start tends to give rise to overshooting and deteriorate control characteristics in a low range.

14-2-3) Examples of Auto Power System Structures

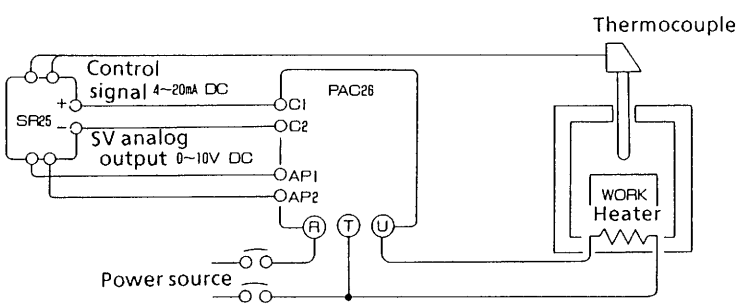
☐ Example of Combination with FP21 Programmable Controller

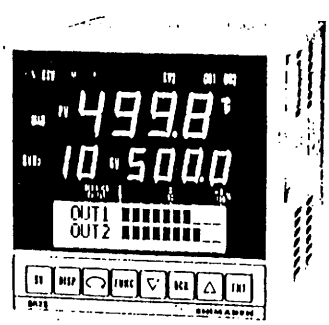




When the SV analog output (4~20mA or 0~10V) of FP21 is input to the auto power terminals (AP1 and AP2) of the PAC26, the maximum power is adjusted by program setting (SV) and program control is carried out smoothly. It is also possible that when an instrument with a long delay time is used, temperature is controlled smoothly in a low range.

☐ Example of Combination with SR25 Controller

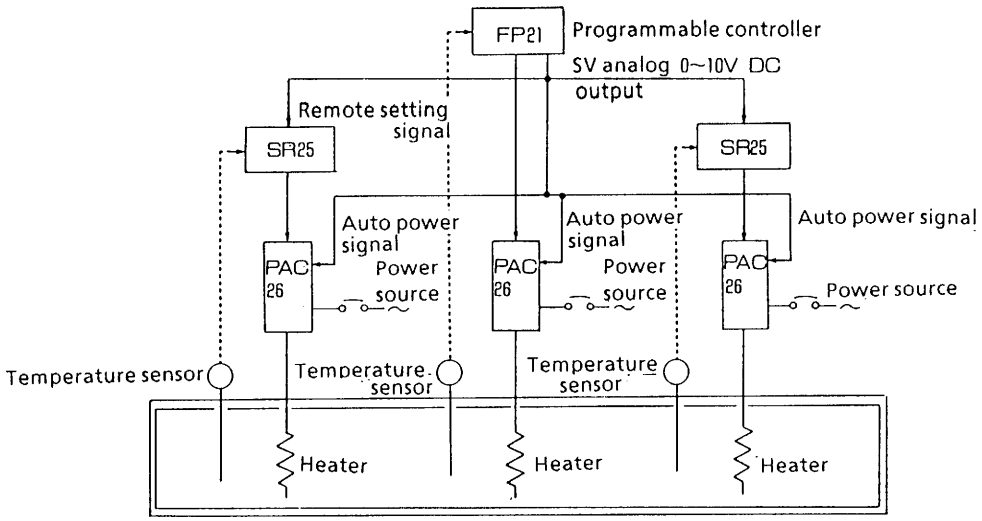




When the SV analog output (4~20mA or 0~10V) of the SR25 controller is input to the auto power terminals (AP1 and AP2) of the PAC26, maximum power (ramping) is set automatically by controller setting (SV) and the efficiency of control is improved. The combination plays another role; it effectively saves a total load when several thyristors are turned ON simultaneously.

☐ Example of Multi-zone Structures

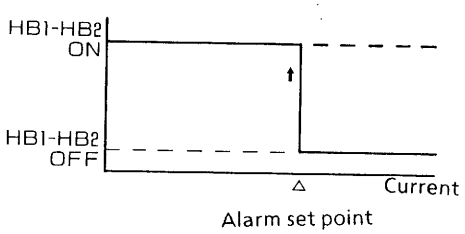
Following is an example of 3-zone program structures.



(14-3) Heater Break Alarm

The heater break alarm is used to output an alarm signal when it is significant if even one heater breaks in a heat source comprising a plurality of heaters. It effectively reduces rejects and protects other heaters from the adverse effects caused by insufficient electric power.

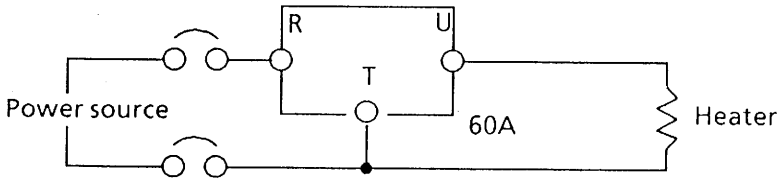
- Alarm Function Chart -



- Specifications -
- Setting range: 0~100% of rated current
- Setting precision: Within ± 5%
- Operation system: To keep alarm signals only
- Output when alarm is functioning: Control output intact
- Resetting of alarm output: Power turned OFF and applied again
- Allowable range of voltage fluctuation: Within ± 10%
- Setting for non-operation: To set at 0%

14-3-1) Setting of Heater Break Alarm

With a thyristor rated of 60A and a heat source using five heaters of the same rating:



- Heater rating -
Voltage: 200V
Current: 10A
Power: 2kW
Type: Nichrome wire

☐ If Alarm is required when One of Five Heaters has Broken

Discussion: Assuming that 40A is the current setting when a heater has broken, if the power voltage is 5 or 10% higher, the amperage with four heaters will be between 42A and 44A, a range in which functioning is unstable. For the alarm to function without fail, a value in a stable range should be set. Assume that it is set at the point marked by △. Setting at 50% (midpoint) of the amperage per heater brings it in a stable range, that is, 45A is the correct set value.

As actual setting is not by amperage but by percentage of the thyristor rating, it comes to 45A divided by the thyristor rating of 60A, i.e. 75%.

Set value in % = { (amperage after breakage) + ($\frac{1}{2}$ of current per heater) } ÷ Thyristor rating

☐ If Alarm is Required when Three of Five Heaters Have Broken

Amperage after breakage = 20A; $\frac{1}{2}$ of current per heater = 5A, then, Set value in % = (20A + 5A) ÷ 60A = 41.66 ∴ Set value in % = 42%

14-3-2) Resetting (Restoring of Alarm Function)

Once the H/B alarm functions, it remains in the state of alarm output even when the break is repaired. Therefore, to reset the alarm, alarm output should be released by turning the power OFF and applying it again.

14-3-3) Setting of SiC Heater Break Alarm

Since SiC heaters have different characteristics from others, the setting should be carried out promptly at the time of start, when the ohm is the highest. Apply an appropriate output and gradually raise the H/B setting dial from MIN to MAX to confirm the functioning point, and set the dial to about 10 degrees back from the point. An alarm is output at the start time if deterioration or a break occurs.
For breakage during operation, actually measure the current and set it in %. Before this setting, however, set 0% at the start. If this is not done, an alarm is output.

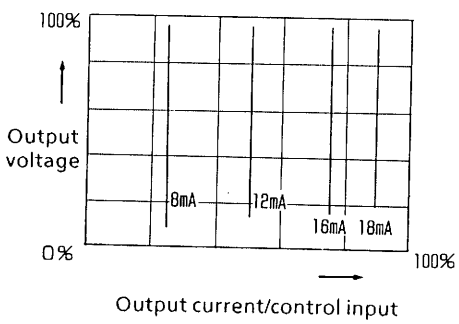
(14-4) Feedback Functions – PAC26P Only

The PAC26P has various feedback controls (constant current/constant power /power linearity), but it is easy to handle as no component is mounted on the outside of the instrument.
The feedback control is another controller which detects current, power, etc., of the thyristor inside the body of the instrument and adjusts them to values set by means of control signals from the controller.
As each output is under control even when there are fluctuations of the primary voltage and on the load side, output does not fluctuate but remains stable. This is a highly effective function to guarantee load characteristics and to carry out precision control.

14-4-1) Constant Current (Current Feedback) Control

As shown in the diagram below, output current is set at a fixed value in response to current setting signals received from the controller. In this case, output voltages ars changed as a matter of course.

- Characteristics Diagram -



This feature computes and controls current setting values given as control signals and current signals from the current transformer (built-in CT). If control inputs are at a fixed level, current is kept constant even if the load and/or power fluctuate. Accordingly, it is suitable for controlling heaters of plutonium, molybdenum, tungsten, supercantal (phonetic), etc.

- Characteristics diagram -
Voltage is controlled so as to be equivalent to the amperages given as control signals. Try, as far as possible, to select the same capacity for the thyristor and load. If a 30A load is connected to a 60A thyristor, control outputs of control input 0~50% (4~20mA) are 0~30A. On the other hand, if a 60A load is connected to a 30A thyristor, the control range is 0 to 30A.

An instrument with the current control function works effectively on the following heaters.

☐ Heaters in which rush current flows:
· Platinum · Molybdenum · Tungsten · Supercantal (Phonetic)

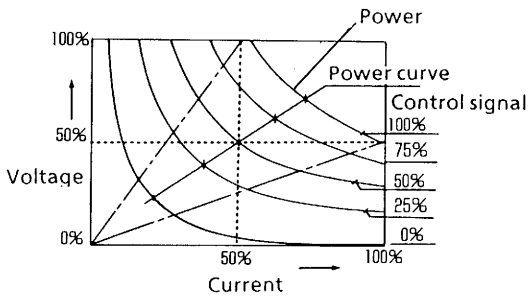
☐ Heaters in which current changes remarkably:
· Carbon · Soltbas (Phonetic)

☐ When electrolytic current needs to be stabilized:
· Plated heaters

14-4-2) Constant Power (Power Feedback) Control

Since the amount of generated heat is proportional to power, stabilizing power means stabilizing temperature.
Hence, this control has the effect of compensating heater characteristics in precision control or when a SiC heater is used.

- Power characteristics diagram -



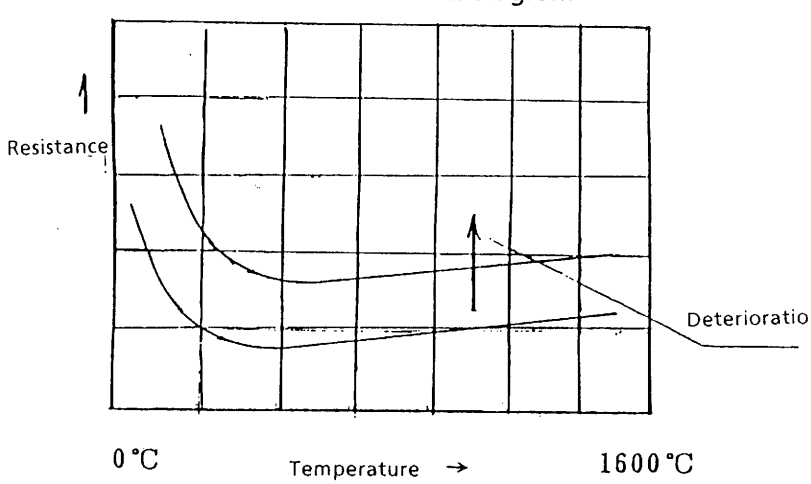
In this control system, power becomes 1/2 of the thyristor rating.

As seen from the diagram on the left, the curves run between the points of 100% voltage × 50% current and those of 50% voltage × 100% current, which means power of 50% of the thyristor rating is controlled.

In other words, even when a thyristor of 200V 100A is used, 10 KVA power can be controlled.

14-4-3) Characteristics of SiC Heater

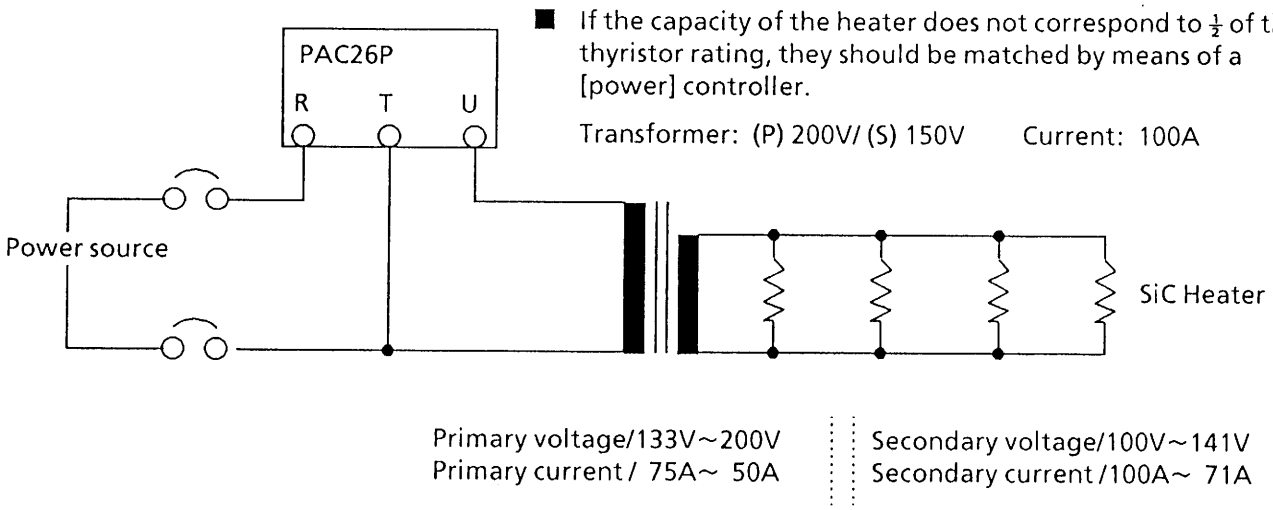
- SiC characteristics diagram -



As shown in the graph on the left, a SiC heater shows an abrupt curve of ohm (power) in some temperature ranges. On top of this, while the ohm increases as time goes by, the power declines and power compensation is required.

An instrument with the power control function is highly effective in heaters which have such characteristics.

☐ Deterioration of Heating Element and Power Compensation



■ If the capacity of the heater does not correspond to $\frac{1}{2}$ of the thyristor rating, they should be matched by means of a [power] controller.

Transformer: (P) 200V/ (S) 150V Current: 100A

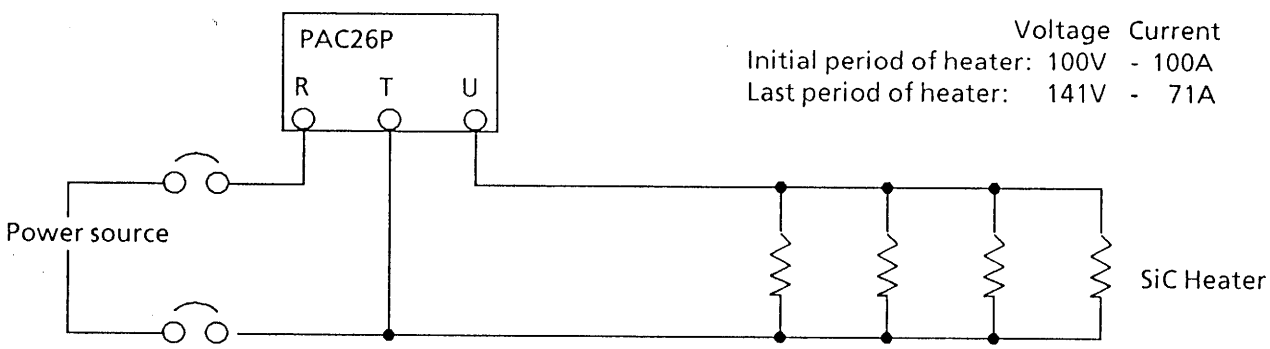
Primary voltage/133V~200V
Primary current / 75A~ 50A

Secondary voltage/100V~141V
Secondary current /100A~ 71A

☐ Table Showing Deterioration of Heat Element in Relation to Primary/Secondary Voltages and Currents

Resistance	Primary side			Secondary side		
	Voltage	Current	Power	Voltage	Current	Power
1.0 Ω	133V	75A	10KVA	100V	100A	10KVA
1.4 Ω	159V	63A		119V	84A	
1.6 Ω	169V	59A		127V	79A	
2.0 Ω	188V	53A		141V	71A	

☐ Problems When Transformer is Not Used



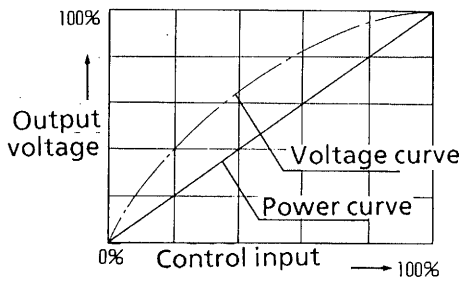
Voltage Current
Initial period of heater: 100V - 100A
Last period of heater: 141V - 71A

Current flowing through the power line reaches 100A maximum. If a heater is directly controlled without using a transformer, a current of 100A flows in the power circuit as shown above. It is also necessary to use a thyristor which has a capacity of 150A. The use of a transformer is recommended unless the power line has a much larger capacity or when the instrument is intended to be used for a long time.

14-4-4) Power Linear (Voltage Square Feedback) Control

In power linear control, electric power is output linearly in response to control signals, as shown in the graph below. This control system is used for nickel, chrome and iron, and chrome heaters.

- Characteristics diagram -



☐ Control signals and output power draw straight line to enhance efficiency of control.

☐ In manual adjustment, power in % can be adjusted as actual values correspond to readings on the controller graduation.

☐ Power formula

$$P = V \times I = V \times \frac{V}{R} \leftarrow \text{constant}$$

$\therefore P \propto V^2$

[P:Power, V:Voltage, I:Current, R:Resistance]

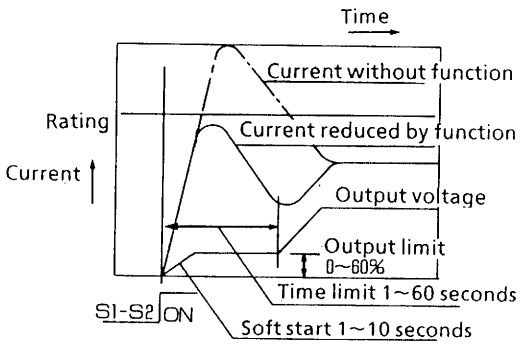
(14-5) Output Limiting Function (Option)

If pure metal heaters or various lamp heaters are used, the output limiting function not only protects the thyristor from over-current by saving rush current at the start time, but also prevents adverse effects (for example, an abnormal decline of voltage) upon the power line. It limits current within the extent of the rating despite fluctuation on the load side.

14-5-1) Start Output Limiting Function

If the heater in use is of a type which allows rush current to flow upon applying power or changing the load (such as a platinum, molybdenum or tungsten heater or a halogen lamp), this function controls output for a fixed period of time to ensure smooth operation.
The constant-current control has a similar function, but the start output limiting function is ideal if a change in load is involved.

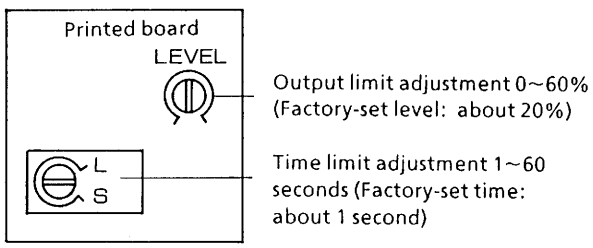
- Characteristics diagram -

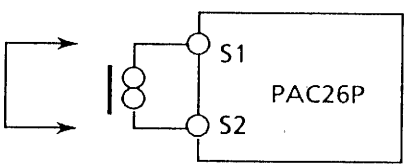


☐ Adjustment
To make an adjustment, open the cover and set a time (1~60 seconds) and a level (0~60%).

☐ Timer Setting
Set a time during which a current raised to a high level when a certain output is applied decreases gradually to reach a value within the rating.

☐ Level Setting
Set a level which enables output to allow the current to drop to a value within the rating during the set time.





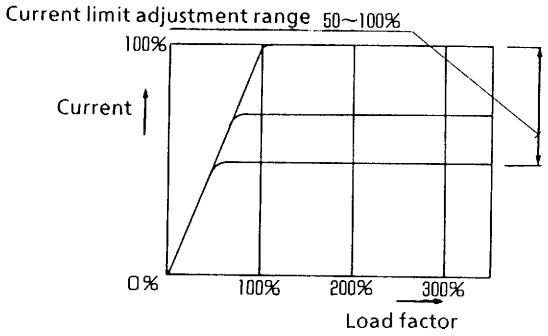
☐ How to make Function Work Upon Applying Power
S1-S2: To be short-circuited

☐ How to Synchronize with External Signals
S1-S2: To be synchronized with signals

14-5-2) Current Limiting Function

This is the function for limiting current within a range of 50 to 100% of the rated current of the thyristor. It is used in case the current exceeds the rating temporarily or continuously because of the characteristics of a heater or when the current needs to be limited for some other reason.

- Characteristics diagram -



☐ Heaters Suitable for This Function
Platinum, tungsten, molybdenum, supercantal (phonetic), etc.

☐ Note: Once the load factor exceeds 100%, the higher the load factor the lower drops.

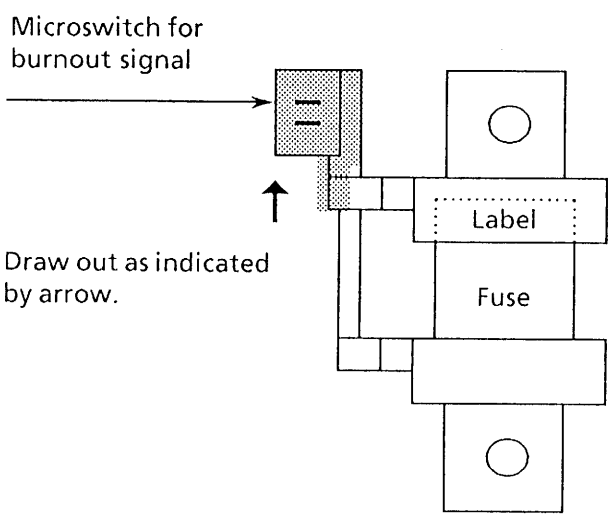
- Table showing relation between load factor and power -

Item	Load factor			
	100%	200%	300%	500%
Current	97%	100%	100%	100%
Voltage	97%	50%	33%	20%
Power	94%	50%	33%	20%

(14-6) Quick-to-burn Fuse

If the fuse monitor lights for some reason and output stops, the fuse has burnt out. It has to be replaced.
The fuse of this instrument is attached with a microswitch for burnout signal. Draw the microswitch out before replacing it with a new one.

- Exterior view of fuse -



- Fuse types -

☐ If there is no spare fuse, please indicate the rated current and fuse type to this company

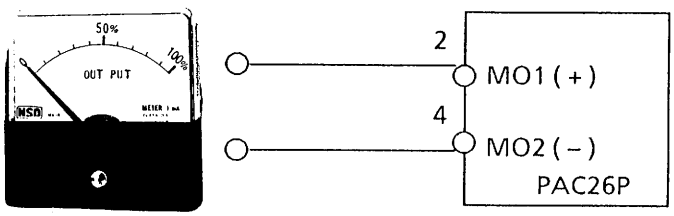
Rated current	Voltage	Fuse types	Fuse amperage
20A	100-240V	25SHA 30S	30A
	380-440V	50SHA 30S	
30A	100-240V	25SHA 40S	40A
	380-440V	50SHA 40S	
45A	100-440V	50SHA 60S	60A
60A		50SHA 80A	80A
80A		50SHA120S	120A
100A		50SHB150S	150A
150A		50SHB200S	200A
250A		50SHB350S	350A
350A		CSSF500	500A
450A		CSSF600	600A

- Manufacturers -
Kyosan Seisakujo: Model 25SHA/50SHA (B)
Fuji Denki Seizo: Model CSSF

(14-7) Operation Volume Indicator

Output is intermittent in the cycle operation zero voltage switching system. Therefore, if an ordinary ammeter and voltmeter are connected on the output side, they do not give stable readings.

This operation volume indicator receives output signals (0~1mA) from the electronic circuit side and displays them in %.



- Rating -

0~100%/0~1mADC

The % gradation shows values to installed power.

15. Troubleshooting

If something goes wrong while the instrument is in use, check it, referring to the following table, and call our closest office or our service center as the occasion demands.

	Problem	Check Point	Solution
1	Output is not produced.	1) Alarm monitor (OC) is lit.	Turn power OFF and reapply. If monitor lights again, turn internal power to zero and reset. If monitor no longer lights, check load side. If it still lights, there may be problem with circuit.
		2) Alarm monitor (FAN) is lit (150A~450A).	Cooling fan may have stopped or there may be dust and dirt sticking to fan sensor. Clean them. If fan still does not rotate and dust is not found, call us.
		3) PL lamp is not lit.	Check power supply. If power is not supplied, examine power source. If power is supplied, there may be circuit problem in instrument. Call us.
		4) See if control signals are received.	Measure C1 and C2 terminals by means of tester, etc., to check their levels. If signals are not received, examine controller side. If proper signals are received, circuits of instrument should be examined.
2	Output keeps being produced.	1) Load circuit remains opened.	When load circuit is opened, panel meter and tester sometimes show high values. Check load circuit. (This occurs in test run from time to time.)
		2) Output continues after disconnecting signal line and turn VRs to 0%.	Call us, as thyristor element might be given conductivity by thermal mishap or insulation failure.
3	Maximum output has lowered.	1) Check power VR readings.	Set internal and external power controllers to 100% and see what happens to output.
		2) What about control signals ?	See whether all control signals are received. If so, observe output waveforms of thyristor to check whether thyristor is in order. When thyristor is out of order, it must be replaced (by maker).
4	Fuse blows or over-current protection circuit (OC) is frequently activated.	1) Are load capacity and thyristor capacity appropriate ?	If load factor is 100%, lower output by about 10% by means of power controller.
		2) Transformer is used.	If electromagnetic switch is used on power source side, insert capacitor between R and T. (See page 14 (13-4).)
			Should there be leakage due to auto-transformer, replace it with separate type one.

16. Specifications

Common Specifications

■ Control Input and Ratings

Contact signal: ..... No-voltage contact signal
Current input: ..... 4~20mA/DC Receiving impedance 100Ω
Voltage input: ..... 1~5V/DC Impedance of input 200kΩ
0~10V/DC Impedance of input 200kΩ

■ Power Voltage and Ratings

100V type: ..... 100~110V ±10% 50/60Hz
110~120V 〃
200V type: ..... 200~220V 〃
220~240V 〃
400V type: ..... 380~400V 〃
400~440V 〃

■ Power Supply for 400V Type and Power Ratings of External Feed

20~100A ..... 200~220V 20VA
150~450A ..... 200~220V 50VA

■ Current Capacity and Cooling System

20,30,45,60,80,100A .. Self-cooling system
150,250,350,450A .... Forced air cooling system

■ Over-current Protection System

System/Working Current Level: .....
Gate breaking system (standard) /about 130% of rated current Quick-to-burn fuse system (option) /130~150% of rated current
Reset: ..... Standard – Turn power OFF and reapply. Quick-to-burn fuse – Replace fuse.

■ Power Control Function

Standard: ..... Power adjustment (internal) 0~100%
Option: ..... External power 0~100%
Manual power 0~100%
Base power 0~100%
High-low power (contact input type)
· High power 0~100%
· Low power High × 0~100%
External power + manual power
External power + base power
Auto power control function/50~100%

■ Alarm Monitors and Rating

Over-current: ..... [O.C] monitor lights. /AL1-AL2 conducted
Fan stop: ..... [FAN] monitor lights. /Same as above
Fuse burnt out: ... [FUSE] monitor lights. /Same as above
Heater break: ..... [H/B] monitor lights /HB1-HB2 conducted
Output contact rating: .... 240V AC 1A/load resistance

■ Operating Environment

Ambient temperature range: ... –10~50°C
Ambient humidity: ..... 90% or less without condensation

■ Insulation Resistance/Withstanding Voltage

Insulation resistance between power terminals and chassis:
..... 500V/DC 20MΩ or above
Withstanding voltage between power terminals and chassis:
100~240V power supply ..... 2000V/AC 1 minute
380~440V power supply ..... 2500V/AC 1 minute

■ Material/Finish: ..... Ordinary steel plate/paint coating (equivalent to N8.5 Munsell N8.5)

■ Overall Dimensions and Weight:
See overall dimension diagrams.

Individual Specifications

■ Phase Control System (PAC26P)

Control system: ..... Phase control system
Soft start time: ..... Adjustable between 1 and 10 sec. (90% rise)
Output voltage control range: .. 0 to more than 97% of input
Voltage output stability: ..... Output fluctuation less than ±2% when input fluctuation is ±10%
Control input/output voltage characteristics:
..... Linear output by voltage feedback
Over-current protection system:
..... Equipped with electronic protective function

Applicable load: ..... All types of heaters (added functions to be selected according to heater characteristics)

◇Additional Functions (options)
Power control function: ..... See "Common Specifications".
Constant-current control (current feedback):
..... For precious metal heaters, supercantal (phonetic), etc.
Constant-power control (power feedback):
..... For SiC and carbon heaters
Voltage square control (voltage^2 feedback):
..... Nichrome wire heaters
Output limiting function:
..... Current limiting – To limit to 50~100% of rated current
Start output limiting – To limit to 0~60% output for 1~60 sec.
Quick-to-burn fuse: .... Equipped with alarm output function
Heater break alarm: ... Setting at 0~100% of rated current

■ Cycle Operation Zero Voltage Switching System (PAC26C)

Control System: ..... Cycle operation zero voltage switching system
Output power control range: ... Zero to more than 95% of load current
Over-current protection system:
..... Equipped with electronic protective function
Applicable load: ..... Constant-resistance heaters such as a nichrome wire heater

◇Additional Functions (options)
Power control function: ..... See "Common Specifications".
Operation volume indicator: ... Graduated from 1 to 100%
Quick-to-burn fuse: .... Equipped with alarm output function
Heater break alarm: ... Setting at 0~100% of rated current