TITLE OF THE INVENTION

ELECTRIC POWER CONVERTING APPARATUS AND ELEVATOR

FIELD OF THE INVENTION

The present invention relates to an electric power converting apparatus that includes a rectification circuit (converter) and an inverting circuit (inverter) and to an elevator driven by the electric power converting apparatus.

BACKGROUND OF THE INVENTION

Recently, a general method of driving an elevator or the like at variable velocity is to convert power from a commercially available AC power supply to DC current by using a converter, further convert smoothed DC power to variable-frequency AC current through an inverter, and drive a motor at variable velocity.

As for the heat dissipating structures of the converter and inverters, when the converter is structured only with diodes, in the structure in Patent Document 1, radiating fins are used in the converter, which causes a small loss, and a radiator that utilizes heat pipes for heat transfer is used only in the inverter, which causes a large loss.

In elevators in high-rise buildings and the like,

however, the converter often has the same circuit structure as the inverter to regenerate positional energy; since both the converter and the inverter use a semiconductor module structured with semiconductor switching devices, heat dissipation from the semiconductor module is necessary. In Patent Document 2, therefore, to reduce the number of parts, a semiconductor module constituting a converter is attached to one surface of a radiator and a semiconductor module constituting an inverter is attached to the opposite surface.

In another example in which semiconductor modules are attached to both surfaces of the heat receiving part of a radiator, a semiconductor module constituting an inverter is attached to one surface and a semiconductor module for a snubber circuit, which causes a small loss, is attached to the opposite surface, as described in Patent Document 3; the number of parts is reduced in comparison with a case in which semiconductor modules for snubber circuits are attached to separate radiators.

A method of reducing a loss of a semiconductor module is to perform switching only for two of the three phases and leave the remaining one phase turned on or off (this method is called two-phase modulation).

In two-phase modulation, when an output voltage is low, the pulse width is extremely narrow, so there is actually a risk that a semiconductor switching device may not operate and current distortion may thereby be generated; to cope with this, there is a method of switching between three-phase modulation and two-phase modulation according to the output, as described in Patent Document 4.

(Prior Art Documents)

(Patent Documents)

[Patent Document 1] Japanese Patent Laid-open No. 2007-197094

[Patent Document 2] Japanese Patent Laid-open No. 2002-84766

[Patent Document 3] Japanese Patent Laid-open No. 2001-24123

[Patent Document 4] Japanese Patent Laid-open No. 2007-110780

SUMMARY OF THE INVENTION

In heat pipe cooling, however, motor output, which is determined by a product of torque and an angular frequency, is small when an elevator is driven by being accelerated from a stopped state, so the current in the converter is small and its loss is low; by contrast, the inverter generates large torque, so a large current

is required and the loss of the semiconductor module thereby becomes large. In some situations, the water in the heat pipes, which are heat transfer means, may not be boiled, in which case the base temperature of the semiconductor module is transiently raised. After that, when the acceleration period is terminated, the current is reduced and the loss is thereby reduced, suppressing the temperature rise. Repetition of this transient temperature rise may cause a crack in the solder between the base plate of the semiconductor module and the insulating substrate in the module, and the life of the semiconductor module may be shortened. To eliminate the repetitive transient temperature rise, therefore, it is necessary to enlarge the thermal capacity of the heat receiving part extending from a portion of the heat receiving part to which the semiconductor module has been attached to the heat pipes. However, a problem with enlarging the thermal capacity is that the size of the radiator becomes large.

Therefore, the structure in Patent Document 1 cannot be applied when a semiconductor switching device is used in the converter, because heat dissipation performance is inadequate.

In Patent Document 2, the structure of the radiator has not been sufficiently studied.

The structure in Patent Document 3 causes the problem of cracking due to the repetitive transient temperature rise as described above.

Even when two-phase modulation is carried out on the inverter side as described in Patent Document 4, two-phase modulation cannot be carried out in a very low velocity area because current distortion becomes large. Since there is a period during which two-phase modulation cannot be carried out, therefore, there is a period during which loss cannot be reduced, so the problem of cracking due to the repetitive transient temperature rise cannot be avoided.

The problem to be solved by the present invention is to reduce a transient temperature rise of a semiconductor module in an electric power converting apparatus without greatly increasing the size of the apparatus.

Problems other than the above problem will be clarified from the entire contents of the description of this application or from the drawings.

To solve the above problems, in the present invention, a first semiconductor module, which is at least part of a converter, and a second semiconductor module, which is at least part of an inverter, are attached to a heat receiving part of a radiator in

which a heat transfer means that causes a phase change is used; the thermal capacity per unit area of the heat receiving part extending from the second semiconductor module to the heat transfer means is larger than the thermal capacity per unit area of the heat receiving part extending from the first semiconductor module to the heat transfer means. In this case, the thermal capacity per unit area on the second semiconductor module side is preferably larger than the thermal capacity per unit area on the first semiconductor module side by increasing a thickness of the heat receiving part extending from the semiconductor module to the heat transfer means.

The structure described above is just an example; the present invention can be appropriately modified within a scope not departing from the technical concept. Exemplary structures of the present invention other than the structure described above will be clarified from the entire contents of the description of this application or from the drawings.

In the above structure, the transient temperature rise in the semiconductor module in an electric power converting apparatus can be suppressed without the need to greatly enlarge the size of the apparatus and the life of the semiconductor module can be prolonged.

Other advantages of the present invention will be clarified from the entire contents of the description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically shows the structure of an electric power converting apparatus in a first embodiment of the present invention.

FIG. 2 illustrates the relation between a velocity ratio v/Vo to a rated velocity and a loss ratio Q2/Q1 in the first embodiment of the present invention.

FIG. 3 schematically shows the circuit structure of the electric power converting apparatus in the present invention and an elevator driven by it.

FIG. 4 illustrates the operation of the elevator in the present invention.

FIG. 5 schematically shows the structure of an electric power converting apparatus in a second embodiment of the present invention.

FIG. 6 schematically shows the structure of an electric power converting apparatus in a third embodiment of the present invention.

FIG. 7 schematically shows the structure of an electric power converting apparatus in a fourth embodiment of the present invention.

FIG. 8 shows the detailed structure of a heat

receiving part of a radiator in the fourth embodiment of the present invention.

FIG. 9 schematically shows the structure of an electric power converting apparatus in a fifth embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will be described with reference to the drawings. In the drawings and the embodiments, the same or like elements are denoted by the same reference numerals and repeated descriptions will be omitted.

[First embodiment]

First, FIG. 3 schematically shows the circuit structure of the electric power converting apparatus in the present invention and an elevator driven by it. The electric power converting apparatus shown in FIG. 3 is structured so that arbitrary electric power is supplied to a motor 90 by converting AC current input from a power supply 8, which is a commercially available power supply with a fixed frequency, through an inductor 81 to DC current by means of a PWM rectification circuit (first converting circuit) (converter) formed with semiconductor switching devices (IGBTs, which are typical as semiconductor switching devices, are used here as an example) 111 to 132 (111, 112, 121, 122, 131,

and 132) and by converting DC current smoothed by a smoothing capacitor 3 to AC current having a variable frequency by means of an inverting circuit (second converting circuit) (inverter) formed with semiconductor switching devices (IGBTs) 211 to 232 (211, 212, 221, 222, 231, and 232). The motor 90 rotates a sheave 91, and an elevator car 92 and a balancing weight 93 suspended by a rope 94 are lifted or lowered.

FIG. 4 illustrates the operation of the elevator in the present invention. FIG. 4(A) illustrates changes in velocity with time during the powering operation of the elevator, FIG. 4(B) illustrates changes in the current amplitude of the converter with time, and FIG. 4(C) illustrates changes in the current amplitude of the inverter with time. Acceleration starts at time To, at which the elevator is in a halt state, and reaches a rated velocity Vo at time T3. In the initial period of acceleration (up to time T1), jerk (acceleration differentiated by time) is constant, acceleration from time T1 to time T2 is constant, and jerk (negative value) is constant from time T2 to time T3 so that riding comfort is obtained. After that, the elevator is run at a constant velocity to time T4, after which the elevator is decelerated and arrives at the target floor at time T5. Although not illustrated in time series,

acceleration is also changed at the beginning and at the end of deceleration so that riding comfort is obtained.

As illustrated in FIG. 4(B), the converter current is increased as acceleration proceeds, and is maximized at time T2, after which the current is decreased from time T3 to time T4, during which the velocity is constant, and is further decreased during deceleration. As illustrated in FIG. 4(C), the inverter current is increased from time To to time T1 and the increased state continues up to time T2. The inverter current starts to be lowered at time T2 and becomes, at time T3, a value necessary for the running at the rated velocity Vo. The rated capacity of the motor is generally determined from the current at that time. The current during acceleration is often two to three times the rated current at that time.

FIG. 1 schematically shows the structure of an electric power converting apparatus in a first embodiment of the present invention. FIG. 1(a) is a side view, and FIG. 1(B) is a view as taken along line A-A'. These drawings show an example in which the electric power converting apparatus in FIG. 3 is placed in a case 4, the semiconductor switching devices 111 to 132, which constitute the converter, are structured

with a single semiconductor module 10, and the semiconductor switching devices 211 to 232, which constitute the inverter, are structured with a single semiconductor module 20. Both the semiconductor modules 10 and 20 are attached to both sides of a heat receiving part 52 of a single radiator 5, as shown in FIG. 1(A). The radiator 5 transfers heat generated from the semiconductor modules 10 and 20 to the upper portion in the drawing through heat pipes 51, and dissipates the heat from radiating fins by using air inhaled through an inlet port 61 by a fan 6. The air exiting from the radiating fins passes through the clearance between the rear surface of the case 4 and the radiator 5 in a ventilation duct 62, and is exhausted from an outlet port 63 to the outside. The heat pipe 51 is one type of a heat transfer means that causes a phase change, the interior of which includes water, for example. The radiator 5 is structured so that the heat receiving part 52 is disposed around the heat transfer means that causes a phase change.

Peripheral circuits 71 and 72 such as driving circuits are connected in the vicinity of the semiconductor modules 10 and 20, and the smoothing capacitor 3 is disposed at the bottom of the radiator 5. In these drawings, wiring conductors between the

semiconductor modules 10 and 20 and the smoothing capacitor 3 are omitted to simplify the drawings.

When the thickness of the heat receiving part 52 extending from the heat pipes 51 to a surface on the side on which the semiconductor module 10 on the converter side is attached is denoted D1 and the thickness from the heat pipes 51 to a surface on the side on which the semiconductor module on the inverter side is attached is denoted D2, D2 is larger than D1. Accordingly, the thermal capacity per unit area of the heat receiving part 52 extending from the semiconductor module 20 on the inverter side to the heat pipes 51 can be made larger than the thermal capacity per unit area of the heat receiving part 52 extending from the semiconductor module 10 on the converter side to the heat pipes 51. On the converter side, since AC current with a fixed frequency is converted to DC current, a repetitive transient temperature rise is less likely to occur; by contrast, on the inverter side, since DC current is converted to AC current with a variable frequency, a repetitive transient temperature rise is likely to occur. However, even if heat transfer cannot be adequately carried out by the heat pipes 51 due to, for example, a transient temperature rise in a short period, the large thermal capacity per unit area of the

heat receiving part 52 enables the transient temperature rise to be eliminated and thereby enables the temperature rise in the semiconductor modules to be reduced, so the problem of the occurrence of cracks in solder can be avoided and another advantage is that since the thickness of the heat receiving part 52 on the inverter side on which a problem is likely to occur is larger than on the converter side, the apparatus size is not so large.

FIG. 1(C) is a variation of FIG. 1(A); FIG. 1(C) differs from FIG. 1(A) in that the thick inverter side of the heat receiving part 52 is disposed on the intake side (on the left in the drawing) and the thin converter side of the heat receiving part 52 is disposed on the opposite side (on the right in the drawing). In this case, the peripheral circuit 72 on the inverter side extends beyond the fan 6 toward the left in the drawing, and the radiator is displaced toward the rear surface side accordingly. As a result, since a width DB2 of the duct to the outlet port is smaller than a width DB1 in FIG. 1(A), and a pressure loss is increased and an air velocity is lowered. Therefore, when air is inhaled from the front surface and exhausted from the top surface, the semiconductor module 20 on the inverter side is preferably disposed

on the rear surface side as shown in FIG. 1(A) to increase the thickness of the heat receiving part. However, there is an advantage in FIG. 1(C) as well; when the thickness of the heat receiving part 52 on the side on which the fan 6 is attached is increased, an amount by which the fan 6 is exceeded in the depth direction is small and a spatial margin is produced on the front surface side (on the left in the drawing) in FIG. 1(C), so a dimension (not shown) in the depth direction of the case 4 of the electric power converting apparatus in FIG. 1(C) can be reduced accordingly in comparison with FIG. 1(A).

The losses (thermal loads) generated by the semiconductor modules on the converter side and inverter side in FIG. 4 have almost linear relations with current values; the loss of the converter is increased from time To to time T2, but the loss of the inverter is rapidly increased from time To to time T1. Therefore, a temperature rise is suppressed by increasing the thickness of the heat receiving part 52 to increase its thermal capacity. Meanwhile, there is the risk that when the thickness of the heat receiving part 52 is increased, the weight of the radiator 5 is increased. Accordingly, since it is not necessary to increase the thermal capacity of the heat receiving

part on the converter side where the increase ratio of the current amplitude is not larger than that of the inverter, the thermal capacity only on the inverter side is enlarged to minimize an increase in the weight of the radiator 5.

FIG. 2 illustrates the relation in a general elevator between a ratio v/Vo of velocity v at time t to a rated velocity (velocity at a constant velocity) Vo and a ratio of a loss Q2 on the inverter side to a loss Q1 on the converter side at time t. Although the degree of a transient temperature rise varies depending on the thermal capacity and thermal resistance of the radiator 5, the heat transfer by the heat pipes 51 becomes steady after a point in time at which the velocity v is accelerated to about half of the rated velocity Vo (v/Vo is 0.5 or more), after which the advantage of suppressing the temperature rise by increasing the thermal capacity of the heat receiving part 52 is reduced. Accordingly, it can be said that if the thickness ratio of the heat receiving part D2/D1 is equal to or greater than 1.2, there is an advantage brought by increasing the thermal capacity of the heat receiving part.

[Second embodiment]

FIG. 5 schematically shows the structure of an

electric power converting apparatus in a second embodiment of the present invention. In this embodiment, a pair of the upper and lower semiconductor switching devices for one phase in FIG. 3 is structured with one semiconductor module as in a case in which the current is higher than in the example in FIG. 1; a semiconductor module 11 is formed with the semiconductor switching devices 111 and 112 in FIG. 3, a semiconductor module 12 is formed with the semiconductor switching devices 121 and 122, and a semiconductor module 13 is formed with the semiconductor switching devices 131 and 132. The inverter side is similarly formed; a semiconductor module 21 is formed with the semiconductor switching devices 211 and 212, a semiconductor module 22 is formed with the semiconductor switching devices 221 and 222, and a semiconductor module 23 is formed with the semiconductor switching devices 231 and 232.

As shown in FIG. 5(A), one phase on the converter side and one phase on the inverter side are attached to both surfaces of the heat receiving part 52 of the same radiator 5; as shown in the view, in FIG. 5(C), as taken along line A-A', the heat receiving parts 52 of three radiators 5 are horizontally aligned to form the electric power converting apparatus. Smoothing

capacitors 31 to 33 are also separated for each phase, and connected with wiring conductors (not shown).

As shown in FIG. 5(A), the thickness D2 of the heat receiving part on the inverter side to which the semiconductor module 23 is attached is larger than the thickness D1 of the heat receiving part on the converter side to which the semiconductor module 13 is attached, as in the first embodiment, to suppress the temperature rise in the period in which the elevator starts to be accelerated.

In the structure in this embodiment, the air inhaled from the inlet port 61 by the fan 6 passes through the radiating fins of the radiator and directly exits to the outlet port 63 (the structure is such that air is inhaled from the front surface and is exhausted from the rear surface). In FIG. 5(A), the heat receiving part on the inlet port side (on the left side in the drawing) was thickened and the semiconductor module 23 on the inverter side was attached thereto (this is also true for the semiconductor modules 21 and 22); the heat receiving part on the outlet side (on the right side in the drawing) was thinned and the semiconductor module 13 on the converter side was attached thereto (this is also true for the semiconductor modules 11 and 12).

FIG. 5(B) shows a case in which the converter side is attached to the inlet port side (on the left side in the drawing) and the inverter side is attached to the outlet port side (on the right side in the drawing). In FIG. 5(B), since the thickness of the heat receiving part on the rear surface side is large, a peripheral circuit 723 on the inverter side extends beyond the bottom of the radiator 5. Accordingly, a case depth DC2 in FIG. 5(B) is larger than a case depth DC1 in the arrangement in FIG. 5(A) and the arrangement in FIG. 5(B) is not thereby suitable for compactness. For this reason, it is preferable to thicken the heat receiving part 52 on the inlet port side (on the left side in the drawing) and to attach the semiconductor module on the inverter side as shown in FIG. 5(A). From another viewpoint, it is preferable to thicken the heat receiving part 52 on the side to which the fan 6 is attached.

[Third embodiment]

FIG. 6 schematically shows the structure of an electric power converting apparatus in a third embodiment of the present invention. The same places as in FIG. 1 are denoted by the same reference numerals and repeated descriptions will be omitted; only differences will be described. In this embodiment, heat

pipes 511 to 515 are arranged in two rows in the radiator 5. As shown in FIG. 6(C), which is viewed along line B-B' in FIG. 6(A), two heat pipes denoted 512 and 514 are disposed closer to the semiconductor module 10 on the converter side, and a straight line interconnecting the centers of the cross sections of these heat pipes is denoted L1. By contrast, three heat pipes denoted 511, 513, and 515 are disposed closer to the semiconductor module 20 on the inverter side, and a straight line interconnecting the centers of the cross sections of these heat pipes is denoted L2.

When perpendiculars from the heat pipes to the heat receiving part 52 are assumed to be D11 to D52 as shown in the drawing, the average D1 of the lengths to the contact surface of the semiconductor module 10 on the converter side is calculated from equation 1. The average D2 of the lengths to the contact surface of the semiconductor module 20 on the inverter side is calculated from equation 2.

(Equation 1)

$$D1 = (D11 + D21 + D31 + D41 + D51)/5$$

(Equation 2)

$$D2 = (D12 + D22 + D32 + D42 + D52)/5$$

Since D2 is made larger than D1, the thermal capacity for the transient heat generated from the

semiconductor module 20 on the inverter side is increased to suppress the temperature rise.

[Embodiment 4]

FIG. 7 schematically shows the structure of an electric power converting apparatus in a fourth embodiment of the present invention. The same places as in FIG. 1 are denoted by the same reference numerals and repeated descriptions will be omitted; only differences will be described. In this case, the heat pipes 511 to 513 are inclined rather than being vertical. The directions in which the fan 6 inhales and exhausts air are also inclined, rather than being horizontal, so that the exhaust direction is inclined upward. When air is inhaled from the front surface and exhausted from the top surface, this structure reduces the pressure loss in the air exhausted from the radiating fins of the radiator 5 to the outlet port 63 disposed on the upper surface of the case 4 of the apparatus.

The semiconductor module 10 on the converter side and the semiconductor module 20 on the inverter side are attached to the same surface of the heat receiving part 52 of the radiator 5. The smoothing capacitors 3 are connected by a printed circuit board 70 in the vicinity of the semiconductor modules 10 and 20. FIG.

7(B) shows the cross section of the heat receiving part 52 of the radiator 5 substantially at the center of the semiconductor module 10 on the converter side, and FIG. 7(C) shows that cross section substantially at the center of the semiconductor module 20 on the inverter side. FIG. 7(B) is a cross sectional view as taken along line A-A' in FIG. 7(A), and FIG. 7(C) is a cross sectional view as taken along line B-B' in FIG. 7(A). The distance from the semiconductor module 20 on the inverter side to the heat pipes 511 to 513 is longer than the distance from the semiconductor module 10 on the converter side to the heat pipes 511 to 513.

FIG. 8 shows the detailed structure of the heat receiving part 52 of the radiator 5. FIG. 8(B) is a cross sectional view as taken along line A-A' in FIG. 8(A), and FIG. 8(C) is a cross sectional view as taken along line B-B' in FIG. 8(A). The area 1 in FIG. 8, which is hatched, contributes to the thermal capacity for the heat generated from the semiconductor module 10 on the converter side, and the area 2 in the drawing contributes to the thermal capacity for the heat generated from the semiconductor module 20 on the inverter side. The area 1 is an area enclosed when the contact surface between the semiconductor module 10 on the converter side and the heat receiving part 52 is

projected on a plane that passes through the centers of the cross sections of the heat pipes 511 to 513 and is parallel to the longitudinal direction LP of the heat pipes 511 to 513. The area 2 is an area enclosed when the contact surface between the semiconductor module 20 on the inverter side and the heat receiving part 52 is projected on a plane that passes through the centers of the cross sections of the heat pipes 511 to 513 and is parallel to the longitudinal direction LP of the heat pipes 511 to 513. The area 2 has a larger volume than the area 1 to suppress the transient temperature rise in the semiconductor module 20 on the inverter side.

[Fifth embodiment]

FIG. 9 schematically shows the structure of an electric power converting apparatus in a fifth embodiment of the present invention. FIG. 9(B) is a view as taken along line A-A' in FIG. 9(A). In these drawings as well, the same places as in FIG. 1 are denoted by the same reference numerals and repeated descriptions will be omitted; only differences will be described. In this example, the heat receiving parts 521 and 522 of the radiator 5 are made of different materials and are joined with joining parts 53 (such as screws) so as to place the heat pipes 511 to 513 between them. The material of the heat receiving part

522 to which the semiconductor module 20 on the inverter side is attached has a higher specific heat than the material of the heat receiving part 521 to which the semiconductor module 10 on the inverter side is attached. Then, it is possible to increase the thermal capacity for the heat from the semiconductor module 20 on the inverter side, suppressing the temperature rise in the semiconductor module 20 on the inverter side.

Although the transient temperature rise in the semiconductor module 20 on the inverter side can be suppressed by forming the entire heat receiving part of the radiator 5 with a material having a high specific heat as with the heat receiving part 522 to which the semiconductor module 20 on the inverter side is attached, the entire weight of the radiator 5 is increased because materials having a high specific heat generally have a high density. Accordingly, to suppress an increase in the entire weight of the radiator 5, a material (copper, for example) having a high specific heat and a high specific gravity is used only on the inverter side and a material (aluminum, for example) having a low specific heat and a low specific gravity is used on the converter side, as shown in FIG. 9.

Although radiators that utilize heat pipes have

been described as examples of radiators having a heat transfer means that causes a phase change, in which the heat pipes are oriented substantially vertically, even if the heat pipes are placed substantially horizontally, the advantage of suppressing the transient temperature rise due to the load on the inverter side can be obtained in the structure in the present invention.

To reduce heat due to a loss, it is preferable in the first to fifth embodiments to have a period during which the number of times the semiconductor module 10 on the converter side performs switching is smaller than the number of times the semiconductor module 20 on the inverter side performs switching. For example, the semiconductor module 10 on the converter side preferably undergoes two-phase modulation control and the semiconductor module 20 on the inverter side preferably has at least a period of three-phase modulation control. Specifically, it is desirable for the converter to always undergo two-phase modulation control and for the inverter to undergo three-phase modulation control in a low-frequency area and two-phase modulation control in a high-frequency area.

So far, the present invention has been described by using embodiments, but the structures described in these embodiments are just examples; the present

invention can be appropriately modified within a scope not departing from the technical concept. The structures described in these embodiments may be combined if no conflict occurs among them.

WHAT IS CLAIMED IS:

1. An electric power converting apparatus comprising:

a first converting circuit that converts an AC current to a DC current, and

a second converting circuit that converts the DC current converted by the first converting circuit to an AC current with a variable frequency;

the electric power converting apparatus being characterized by including:

a radiator in which a heat receiving part is provided around a heat transfer means that causes a phase change;

a first semiconductor module, which is at least part of the first converting circuit, and a second semiconductor module, which is at least part of the second converting circuit, are attached to the heat receiving part;

a thermal capacity per unit area of the heat receiving part extending from the second semiconductor module to the heat transfer means is larger than a thermal capacity per unit area of the heat receiving part extending from the first semiconductor module to the heat transfer means;

at least one heat pipe is used as the heat transfer

means; an average length of perpendiculars drawn from the centers of cross sections of the heat pipe to a contact surface between the second semiconductor module and the heat receiving part is larger than an average length of perpendiculars drawn from the centers of cross sections of the heat pipe to a contact surface between the first semiconductor module and the heat receiving part.

2. The electric power converting apparatus according to claim 1, characterized in that a thickness of the heat receiving part extending from the second semiconductor module to the heat transfer means is larger than a thickness of the heat receiving part extending from the first semiconductor module to the heat transfer means.

3. The electric power converting apparatus according to claim 2, characterized in that the thickness of the heat receiving part extending from the second semiconductor module to the heat transfer means is at least 1.2 times the thickness of the heat receiving part extending from the first semiconductor module to the heat transfer means.

4. An electric power converting apparatus comprising:

a first converting circuit that converts an AC

current to a DC current, and

a second converting circuit that converts the DC current converted by the first converting circuit to an AC current with a variable frequency;

the electric power converting apparatus being characterized by including:

a radiator in which a heat receiving part is provided around a heat transfer means that causes a phase change;

a first semiconductor module, which is at least part of the first converting circuit, and a second semiconductor module, which is at least part of the second converting circuit, are attached to the heat receiving part;

a thermal capacity per unit area of the heat receiving part extending from the second semiconductor module to the heat transfer means is larger than a thermal capacity per unit area of the heat receiving part extending from the first semiconductor module to the heat transfer means;

the heat receiving part from the second semiconductor module to the heat transfer means has a higher specific heat than the heat receiving part from the first semiconductor module to the heat transfer means.

5. The electric power converting apparatus according to claim 1, characterized in that a surface of the radiator to which the first semiconductor module and a surface of the radiator to which the second semiconductor module are opposite to each other with the heat transfer means intervening there between.

6. An electric power converting apparatus comprising:

a first converting circuit that converts an AC current to a DC current, and

a second converting circuit that converts the DC current converted by the first converting circuit to an AC current with a variable frequency;

the electric power converting apparatus being characterized by including:

a radiator in which a heat receiving part is provided around a heat transfer means that causes a phase change;

a first semiconductor module, which is at least part of the first converting circuit, and a second semiconductor module, which is at least part of the second converting circuit, are attached to the heat receiving part;

a thermal capacity per unit area of the heat receiving part extending from the second semiconductor

module to the heat transfer means is larger than a thermal capacity per unit area of the heat receiving part extending from the first semiconductor module to the heat transfer means;

a surface of the radiator to which the first semiconductor module and a surface of the radiator to which the second semiconductor module are opposite to each other with the heat transfer means intervening there between.

7. The electric power converting apparatus according to claim 6, characterized in that the radiator performs cooling by forcible air-cooling; cooling air that has been inhaled from a front surface of the electric power converting apparatus and has passed through a radiating fin of the radiator exiting to a rear surface side, after which the cooling air is exhausted from a top surface of the electric power converting apparatus; the surface of the radiator to which the second semiconductor module is attached is on the rear surface side.

8. The electric power converting apparatus according to claim 6, characterized in that the radiator performs cooling by forcible air-cooling in which a fan is used; the second semiconductor module is attached to the heat receiving part on a side on which

the fan of the radiator is disposed and the first semiconductor module is attached to the heat receiving part on a side on which the fan of the radiator is not disposed.

9. The electric power converting apparatus according to claim 8, characterized in that cooling air that has been inhaled from a front surface of the electric power converting apparatus and has passed through a radiating fin of the radiator is exhausted from a rear surface; the surface of the radiator to which the second semiconductor module is attached is on the front surface side.

10. An electric power converting apparatus comprising:

a first converting circuit that converts an AC current to a DC current, and

a second converting circuit that converts the DC current converted by the first converting circuit to an AC current with a variable frequency;

the electric power converting apparatus being characterized by including:

a radiator in which a heat receiving part is provided around a heat transfer means that causes a phase change;

a first semiconductor module, which is at least

part of the first converting circuit, and a second semiconductor module, which is at least part of the second converting circuit, are attached to the heat receiving part;

a thermal capacity per unit area of the heat receiving part extending from the second semiconductor module to the heat transfer means is larger than a thermal capacity per unit area of the heat receiving part extending from the first semiconductor module to the heat transfer means;

at least one heat pipe is used as the heat transfer means; a second area enclosed when a second contact surface between the second semiconductor module and the heat receiving part is projected on a plane that passes through the center of the cross section of the heat pipe and is parallel to the longitudinal direction of the heat pipe has a larger volume than a first area enclosed when a first contact surface between the first semiconductor module and the heat receiving part is projected on a plane that passes through the center of the cross section of the heat pipe and is parallel to the longitudinal direction of the heat pipe.

11. The electric power converting apparatus according to claim 10, characterized in that the longitudinal direction of the heat pipe is inclined

with respect to the vertical direction.

12. The electric power converting apparatus according to claim 1, characterized in that there is a period during which the number of times the first semiconductor module, which is part of the first converting circuit, performs switching is smaller than the number of times the second semiconductor module, which is part of the second converting circuit, performs switching.

13. The electric power converting apparatus according to claim 12, characterized in that the first semiconductor module, which is part of the first converting circuit, undergoes two-phase modulation control and the second semiconductor module, which is part of the second converting circuit, has at least a period of three-phase modulation control.

14. An elevator characterized in that, to drive the elevator, the electric power converting apparatus in any one of claims 1 to 13 is used, the first converting circuit is connected to a power supply, and electric power is supplied from the second converting circuit to a motor.