



(11) **EP 4 012 292 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
15.06.2022 Bulletin 2022/24

(51) International Patent Classification (IPC):
F25B 1/00 (2006.01) F24F 5/00 (2006.01)

(21) Application number: **19940472.4**

(52) Cooperative Patent Classification (CPC):
F24F 5/00; F25B 1/00

(22) Date of filing: **07.08.2019**

(86) International application number:
PCT/JP2019/031087

(87) International publication number:
WO 2021/024410 (11.02.2021 Gazette 2021/06)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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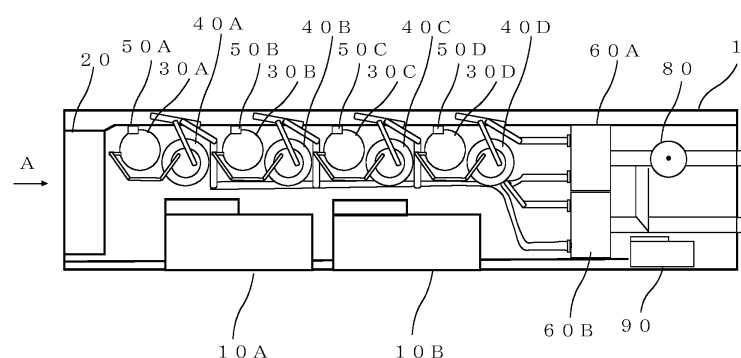
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(54) **CHILLING UNIT AND AIR CONDITIONER**

(57) A chilling unit includes, in a machine chamber, a device included in a refrigerant circuit through which refrigerant is circulated, a plurality of heat-medium heat exchangers, each of which allowing the refrigerant and a heat medium that is a heat delivering medium to exchange heat with each other, a pump that includes a DC

motor, the pump being configured to apply a pressure to the heat medium and deliver the heat medium, and a pump control box that includes an electric device driven by DC power, the electric device being configured to drive or control the pump.

FIG. 3



Description

Technical Field

[0001] The present disclosure relates to a chilling unit and an air-conditioning apparatus. The present disclosure particularly relates to a power supply to be used in the chilling unit.

Background Art

[0002] There is a system including a chilling unit operating as a heat source unit, and an indoor unit installed as a load-side unit. In this system, a heat-medium circulation circuit through which a heat medium including water or brine is circulated is formed between the chilling unit and the indoor unit to perform air-conditioning and other operation. The chilling unit includes a refrigerant circuit through which refrigerant is circulated, and allows the heat medium and the refrigerant to exchange heat with each other to heat or cool the heat medium to supply heat to the indoor unit. The indoor unit provides heat supplied via the heat medium to a heat load. In an air-conditioning system, an indoor unit performs air-conditioning by heating or cooling air in the room. There is a chilling unit including a pump that applies a pressure to a heat medium to circulate the heat medium through a heat-medium circulation circuit (see, for example, Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Patent No. 5401563

Summary of Invention

Technical Problem

[0004] In recent years, an air-conditioning apparatus is available that is not only connected by wires to an AC power supply such as a commercial power supply, but is also connected by wires to a DC power supply such as a solar-power generation power supply so that the air-conditioning apparatus is configured to operate by being supplied with DC-voltage power. Therefore, it is possible for a chilling unit including a refrigerant circuit to be connected by wires to a DC power supply and be supplied with power from the DC power supply. However, a pump and electric devices including an electric device to drive the pump, which are included in the chilling unit, are not designed to receive power supply from the DC power supply.

[0005] The present disclosure has been achieved to solve the above problems, and it is an object of the present disclosure to provide a chilling unit designed to

receive power supply from a DC power supply, and provide an air-conditioning apparatus.

Solution to Problem

[0006] A chilling unit according to one embodiment of the present disclosure includes, in a machine chamber, a device included in a refrigerant circuit through which refrigerant is circulated; a plurality of heat-medium heat exchangers, each of which allowing the refrigerant and a heat medium that is a heat delivering medium to exchange heat with each other; a pump that includes a DC motor, the pump being configured to apply a pressure to the heat medium and deliver the heat medium; and a pump control box that includes an electric device driven by DC power, the electric device being configured to drive or control the pump.

[0007] An air-conditioning apparatus according to another embodiment of the present disclosure forms a heat-medium circulation circuit through which a heat medium is circulated by connecting by pipes the chilling unit described above and an indoor unit that includes an indoor heat exchanger and a flow-rate adjustment device, the indoor heat exchanger allowing indoor air to be air-conditioned and the heat medium to exchange heat with each other, the flow-rate adjustment device being installed to the indoor heat exchanger and configured to adjust a flow rate of the heat medium passing through the indoor heat exchanger.

Advantageous Effects of Invention

[0008] In an embodiment of the present disclosure, the DC motor is employed for the pump, and the electric devices included in the pump control box can be supplied with DC power to drive and control the pump. This configuration allows for reduction in size and weight of the pump and the electric devices configured to drive and control the pump. Therefore, this configuration ensures an increased space in the machine chamber for handling and installing the pipes of the heat-medium circulation circuit, and the layout design of the devices of the heat-medium circulation circuit can be facilitated.

Brief Description of Drawings

[0009]

[Fig. 1] Fig. 1 illustrates the external appearance of a chilling unit according to Embodiment 1.

[Fig. 2] Fig. 2 illustrates the configuration of an air-conditioning apparatus, centering on the chilling unit according to Embodiment 1.

[Fig. 3] Fig. 3 is an explanatory diagram describing the device layout in a machine chamber of the chilling unit according to Embodiment 1.

[Fig. 4] Figs. 4 are explanatory diagrams describing a refrigerant circuit-side control box according to Em-

bodiment 1.

[Fig. 5] Figs. 5 are explanatory diagrams describing a pump control box according to Embodiment 1.

Description of Embodiments

[0010] Hereinafter, a chilling unit and an air-conditioning apparatus according to embodiments of the present disclosure will be described with reference to the drawings. In the drawings below, the same reference signs denote the same or corresponding components, and are common throughout the entire descriptions of the embodiments described below. In addition, the relationship of sizes of the constituent components in the drawings may differ from that of actual ones. The forms of the constituent elements described throughout the entire specification are merely examples, and do not intend to limit the constituent elements to the forms described in the specification. In particular, the combination of constituent elements is not limited to only the combination in each embodiment, and the constituent elements described in one embodiment can be applied to another embodiment. Further, the level of the pressure and temperature is not particularly determined in relation to an absolute value, but is determined relative to the conditions or operation of a device or other factor. When it is not necessary to distinguish or specify a plurality of devices of the same type that are distinguished from each other by subscripts, the subscripts may be omitted.

Embodiment 1.

[0011] Fig. 1 illustrates the external appearance of a chilling unit according to Embodiment 1. In Fig. 1, a chilling unit 100 is described as a typical heat source unit to supply heat to indoor units 200 operating as load-side devices, which will be described later. In Embodiment 1, a heat medium that delivers heat supplied from the chilling unit 100 and provides the heat to the indoor units 200 is specified as water. However, the heat medium is not limited to water, but may be brine or other fluids.

[0012] The chilling unit 100 includes a machine chamber 1, air heat exchangers 2, and outdoor fans 3. The machine chamber 1 is a housing in which devices that form the refrigerant circuit, and other devices are accommodated. The machine chamber 1 in Embodiment 1 is the housing with a cuboid shape. Of the machine chamber 1, the direction extending along the longer side of the housing is defined as a longitudinal direction, while the direction extending along the shorter side of the housing is defined as a shorter-side direction. A direction perpendicular to the longitudinal direction and the shorter-side direction is defined as a height direction. The machine chamber 1 will be described later.

[0013] Each of the air heat exchangers 2 is one of the devices forming the refrigerant circuit. The air heat exchangers 2 are fin-and-tube heat exchangers that allow refrigerant and outdoor air to exchange heat with each

other. As will be described later, the chilling unit 100 in Embodiment 1 includes four systems of refrigerant circuits. With this configuration, in the chilling unit 100 in Embodiment 1, four air heat exchangers 2A to 2D are installed on the top of the machine chamber 1. The air heat exchanger 2A and the air heat exchanger 2B are paired together, while the air heat exchanger 2C and the air heat exchanger 2D are paired together. A pair of air heat exchangers 2 is located facing each other and the spacing between the tops of the air heat exchangers 2 is wide such that the pair of air heat exchangers 2 forms a V-shape when the chilling unit 100 is viewed from the shorter-side of the machine chamber 1 as illustrated by the arrow A. In the chilling unit 100 in Embodiment 1, two pairs of air heat exchangers 2 are located next to each other along the longitudinal direction of the machine chamber 1.

[0014] The outdoor fans 3 are propeller fans to cause the outdoor air to pass through the air heat exchangers 2. Each outdoor fan 3 is located on the tops of the pair of air heat exchangers 2 and located between the tops of the V-shape formed between the pair of air heat exchangers 2. The chilling unit 100 in Embodiment 1 includes four outdoor fans 3A to 3D.

[0015] Fig. 2 illustrates the configuration of an air-conditioning apparatus, centering on the chilling unit according to Embodiment 1. As illustrated in Fig. 2, the chilling unit 100 in Embodiment 1 includes four systems of refrigerant circuits. Two of the four systems of refrigerant circuits are grouped together to share a single unit of a water heat exchanger 60. The chilling unit 100 has two groups, each of which includes two systems of refrigerant circuits. In a heat-medium circulation circuit, two units of the water heat exchangers 60 are connected in series by pipes to cool or heat water that is a heat medium in two stages.

[0016] As illustrated in Fig. 2, in each system of refrigerant circuit in the chilling unit 100 in Embodiment 1, a compressor 30, a four-way valve 50, the air heat exchanger 2, an expansion valve 70, the water heat exchanger 60, and an accumulator 40 are connected by pipes to form the refrigerant circuit. Examples of the refrigerant to be used include a single component refrigerant such as R-22 and R-134a, a nearazeotropic refrigerant mixture such as R-410A and R-404A, and a non-azeotropic refrigerant mixture such as R-407C. Examples of the refrigerant to be used also include a refrigerant having a relatively small value of global warming potential, and represented by the chemical formula $\text{CF}_3\text{CF}=\text{CH}_2$ containing a double bond, a mixture with this refrigerant, and a natural refrigerant such as CO_2 and propane.

[0017] The compressors 30 (compressors 30A to 30D) compress suctioned refrigerant and discharge the compressed refrigerant. The compressors 30 in Embodiment 1 include compressor DC motors 31 (compressor DC motors 31A to 31D), and are driven by the compressor DC motors 31 through compressor inverter devices 13,

which will be described later. Each of the compressors 30 optionally changes the rotation frequency of the motor in accordance with an instruction from a refrigerant circuit-side control device 15, and can thereby change the capacity of the compressor 30, which is the amount of refrigerant to be delivered per unit time. The refrigerant circuit-side control device 15 will be described later. The compressor inverter devices 13 and the refrigerant circuit-side control device 15 are control-system electric devices accommodated in a refrigerant circuit-side control box 10, which will be described later.

[0018] The four-way valves 50 (four-way valves 50A to 50D) each operate as a flowpassage switching device, and each switch between flow directions of refrigerant depending on the mode of operation to be performed, in accordance with an instruction from the refrigerant circuit-side control device 15. For example, during cooling operation, each of the four-way valves 50 allows high-temperature and high-pressure refrigerant discharged from the compressor 30 to flow into the air heat exchanger 2. During heating operation, each of the four-way valves 50 allows high-temperature and high-pressure refrigerant discharged from the compressor 30 to flow into the water heat exchanger 60.

[0019] The air heat exchangers 2 (air heat exchangers 2A to 2D) allow refrigerant and the outside air to exchange heat with each other as described above. During heating operation to heat water, each of the air heat exchangers 2 operates as an evaporator, and allows air and low-pressure refrigerant having flowed into the air heat exchanger 2 through the expansion valve 70 to exchange heat with each other to evaporate and gasify the refrigerant. During cooling operation to cool water, each of the air heat exchangers 2 operates as a condenser, and allows air and low-pressure refrigerant having flowed into the air heat exchanger 2 through the compressor 30 to exchange heat with each other to condense and liquefy the refrigerant. The outdoor fans 3 (outdoor fans 3A to 3D) deliver air to the air heat exchangers 2 to help heat exchange between the refrigerant and the air, as described above. The outdoor fans 3 include fan DC motors 4 (fan DC motors 4A to 4D), and are driven by the fan DC motors 4 through fan inverter devices 14, which will be described later. Each of the outdoor fans 3 optionally changes the rotation frequency of the motor in accordance with an instruction from the refrigerant circuit-side control device 15, and can thereby change the airflow amount. In Fig. 2, the air heat exchanger 2 and the outdoor fan 3 are brought into one-to-one correspondence, but are not particularly limited to this configuration.

[0020] The water heat exchangers 60 (water heat exchangers 60A and 60B) each operate as a heat-medium heat exchanger, and each allow refrigerant and water that is a heat medium to exchange heat with each other. Each of the water heat exchangers 60 is used as a flow passage of the two systems of refrigerant circuits, and also is used as a flow passage of the heat-medium circulation circuit. Therefore, the water heat exchanger 60

is one of the devices forming the refrigerant circuits, and one of the devices forming the heat-medium circulation circuit. For example, the water heat exchanger 60 operates as a condenser during heating operation, and allows water and refrigerant having flowed into the water heat exchanger 60 through the compressor 30 to exchange heat with each other to condense and liquefy the refrigerant, or to condense the refrigerant to be brought into a two-phase gas-liquid state, thereby heating the water. In contrast, the water heat exchanger 60 operates as an evaporator during cooling operation, and allows water and refrigerant having flowed into the water heat exchanger 60 through the expansion valve 70 to exchange heat with each other to evaporate and gasify the refrigerant, thereby cooling the water.

[0021] The expansion valves 70 (expansion valves 70A to 70D) each operate as an expansion device and, for example, each change the opening degree to adjust the pressure and other conditions of refrigerant passing through the water heat exchanger 60. Each of the expansion valves 70 in Embodiment 1 is made up of an electronic expansion valve that changes the opening degree in accordance with an instruction from the refrigerant circuit-side control device described above. However, the expansion valve 70 is not limited to being made up of this electronic expansion valve. For example, the expansion valve 70 may also be a thermosensitive expansion valve that changes the opening degree on the basis of the temperature of refrigerant.

[0022] The accumulators 40 (accumulators 40A to 40D) are provided to the suction ports of the respective compressors 30 to accumulate in the accumulators 40 surplus refrigerant for the refrigerant circuit.

[0023] The pump 80 is one of the devices forming the heat-medium circulation circuit. The pump 80 in Embodiment 1 includes a pump DC motor 81, and draws water and applies a pressure to the water to be delivered and circulated through the heat-medium circulation circuit. As the pump 80 in Embodiment 1 is connected in series to the two units of the water heat exchangers 60 in the heat-medium circulation circuit, the pump 80 has an increased capacity. A pump inverter device 93, which will be described later, optionally changes the rotation frequency of the motor in accordance with an instruction from a pump-side control device 94, and can thereby change the capacity of the pump 80. The pump inverter device 93 and the pump-side control device 94 are control-system electric devices accommodated in a pump control box 90, which will be described later.

[0024] The indoor units 200 deliver conditioned air to a room space to be air-conditioned. The indoor units 200 (indoor units 200A and 200B) in Embodiment 1 illustrated in Fig. 2 include indoor heat exchangers 201 (indoor heat exchangers 201A and 201B), indoor flow-rate adjustment devices 202 (indoor flow-rate adjustment devices 202A and 202B), and indoor fans 203 (indoor fans 203A and 203B). The indoor heat exchangers 201 and the indoor flow-rate adjustment devices 202 are ones of the

devices forming the heat-medium circulation circuit. Fig. 2 illustrates the air-conditioning apparatus including two units of the indoor units 200, however, the number of indoor units 200 is not particularly limited.

[0025] Each of the indoor flow-rate adjustment devices 202 is made up of, for example, a two-way valve that can control the opening degree (opening area) of the valve, and other elements. The indoor flow-rate adjustment device 202 controls the flow rate of water flowing into and out of the indoor heat exchanger 201 by adjusting the opening degree of the valve. On the basis of the temperature of water flowing into the indoor unit 200, and the temperature of water flowing out of the indoor unit 200, the indoor flow-rate adjustment device 202 adjusts the amount of water passing through the indoor heat exchanger 201, such that the indoor heat exchanger 201 allows heat exchange by the amount of heat suitable to a heat load in the room. When the indoor heat exchanger 201 does not need to allow heat exchange with the heat load, such as when the indoor unit 200 stops operation or performs thermo-off, then the indoor flow-rate adjustment device 202 can fully close the valve to stop water supply to prevent the water from flowing into and out of the indoor heat exchanger 201. In Fig. 2, the indoor flow-rate adjustment device 202 is installed in a pipe through which water flows out of the indoor heat exchanger 201. However, the installation of the indoor flow-rate adjustment device 202 is not limited to this location. For example, the indoor flow-rate adjustment device 202 may be installed in a pipe through which water flows into the indoor heat exchanger 201.

[0026] The indoor heat exchanger 201 allows water and the indoor air in the room space supplied from the indoor fan 203 to exchange heat with each other. When water cooler than air passes through a heat transfer tube, then the air is cooled and consequently the room space is cooled. The indoor fan 203 causes the air in the room space to pass through the indoor heat exchanger 201, thereby generating a flow of air returning to the room space.

[0027] Fig. 3 is an explanatory diagram describing the device layout in the machine chamber of the chilling unit according to Embodiment 1. Fig. 3 illustrates the interior of the machine chamber 1 when the interior of the machine chamber 1 is viewed from above. As described above, the machine chamber 1 of the chilling unit 100 in Embodiment 1 includes the devices forming the refrigerant circuit, the devices forming the heat-medium circulation circuit, and the control-system devices configured to control these devices. Fig. 3 illustrates four compressors 30 (compressors 30A to 30D), four accumulators 40 (accumulators 40A to 40D), and four four-way valves 50 (four-way valves 50A to 50D). Fig. 3 also illustrates two water heat exchangers 60 (water heat exchangers 60A and 60B). The machine chamber 1 further includes four expansion valves 70 (expansion valves 70A to 70D) although the four expansion valves 70 are not illustrated in Fig. 3.

[0028] Furthermore, the machine chamber 1 includes the pump 80, which is one of the devices forming the heat-medium circulation circuit through which water that is a heat medium is circulated. The machine chamber 1 further includes two refrigerant circuit-side control boxes 10 (refrigerant circuit-side control boxes 10A and 10B), in each of which the control-system electric device and other devices are accommodated. The machine chamber 1 still further includes the pump control box 90 and a power-supply terminal box 20.

[0029] In the machine chamber 1 of the chilling unit 100 in Embodiment 1, the power-supply terminal box 20 is located closest to the arrow A-side illustrated in Figs. 1 and 3. Next to the power-supply terminal box 20, along one of the sides extending in the longitudinal direction of the machine chamber 1, a plurality of refrigerant circuit-side control boxes 10 are located next to each other along the longitudinal direction of the machine chamber 1. In Embodiment 1, in one refrigerant circuit-side control box 10, the electric devices configured to drive and control a group of two systems of refrigerant circuits are accommodated. Therefore, the chilling unit 100 in Embodiment 1 has two refrigerant circuit-side control boxes 10A and 10B accommodated in the machine chamber 1. A wire (not illustrated) through which DC power is supplied from the power-supply terminal box 20 is connected to each refrigerant circuit-side control box 10.

[0030] In addition, the devices forming the refrigerant circuit are located on the other side of the machine chamber 1 opposite to the side on which the plurality of refrigerant circuit-side control boxes 10 are located. In the machine chamber 1 in Embodiment 1, the compressor 30, the accumulator 40, the four-way valve 50, and the expansion valve 70 are arranged collectively for each system of refrigerant circuit, and the systems of refrigerant circuits are located next to one another along the longitudinal direction. The compressors 30 and the accumulators 40 each have a relatively large volume, and thus are located next to each other along the other side of the machine chamber 1. Further, next to the plurality of refrigerant circuit-side control boxes 10, and next to the compressors 30 and the accumulators 40, a plurality of water heat exchangers 60 are located, that are ones of the devices forming the refrigerant circuits, and one of the devices forming the heat-medium circulation circuit. The pump 80 and the pump control box 90, both of which are one of the devices forming the heat-medium circulation circuit, are located at a position furthest from the arrow A-side. Therefore, the devices of the refrigerant circuit, and the devices of the heat-medium circulation circuit are located separately from each other with the water heat exchangers 60 defined as the boundary between these devices.

[0031] In the power-supply terminal box 20, a power-supply terminal (not illustrated) is accommodated. In the refrigerant circuit-side control boxes 10 and the pump control box 90, the electric devices, such as an inverter device including a power module to drive the devices,

and a control board including a controller, are supplied with power through the power-supply terminal connected to the outside wire. For example, in Embodiment 1, the power-supply terminal box 20 includes a DC power-supply terminal through which power of DC voltage of 12 volts is supplied to the electric devices. As will be described later, DC power can be supplied to the devices in the pump control box 90. With this configuration, the power-supply terminal box 20 in Embodiment 1 does not need to be provided with a power-supply terminal for AC power. In a case where a plurality of chilling units 100 are installed next to each other along the shorter-side direction, the power-supply terminal box 20 is accommodated in the machine chamber 1 at an end portion of the machine chamber 1 located closest to the arrow A-side, such that the power-supply terminal can be seen from the shorter-side face of the machine chamber 1, and thus the outside wire is easily connected to the power-supply terminal.

[0032] In contrast, the pump 80 is accommodated in the machine chamber 1 at another end portion of the machine chamber 1 located furthest from the arrow A-side on the other side of the end portion in which the power-supply terminal box 20 is accommodated. The pump 80 is one of the devices forming the heat-medium circulation circuit. Next to the pump 80, the plurality of water heat exchangers 60 are located, which are ones of the devices forming the refrigerant circuit, and also forming the heat-medium circulation circuit. For example, the pump 80 and the plurality of water heat exchangers 60 accommodated in the machine chamber 1 of the chilling unit 100 need to be connected by pipes to another device including one of the devices forming the heat-medium circulation circuit. In view of that, the pump 80 is accommodated in the machine chamber 1 at another end portion of the machine chamber 1 located furthest from the arrow A-side, such that heat-medium pipes connected to the pump 80 and the plurality of water heat exchangers 60 can be seen from the shorter-side face of the machine chamber 1, and thus the another device is easily connected to the heat-medium pipes. The pump control box 90 is located at a position adjacent to the pump 80 on one of the sides extending in the longitudinal direction of the machine chamber 1, that is, on the same side on which the plurality of refrigerant circuit-side control boxes 10 are located.

[0033] In Embodiment 1, in one refrigerant circuit-side control box 10, the electric devices configured to drive and control a group of two systems of refrigerant circuits are accommodated. Therefore, the chilling unit 100 in Embodiment 1 has the two refrigerant circuit-side control boxes 10A and 10B accommodated in the machine chamber 1. A power supply line (not illustrated) extending from the power-supply terminal box 20 is connected to each refrigerant circuit-side control box 10.

[0034] Figs. 4 are explanatory diagrams describing the refrigerant circuit-side control box according to Embodiment 1. Fig. 4(a) illustrates the devices located on the

control board inside the refrigerant circuit-side control box 10. As illustrated in Fig. 4(a), the refrigerant circuit-side control box 10 includes two refrigerant circuit-side DC reactors 11 (refrigerant circuit-side DC reactors 11A and 11B). The refrigerant circuit-side control box 10 further includes two refrigerant circuit-side noise filters 12 (refrigerant circuit-side noise filters 12A and 12B). The refrigerant circuit-side control box 10 still further includes two compressor inverter devices 13 (compressor inverter devices 13A and 13B). The refrigerant circuit-side control box 10 still further includes the fan inverter device 14. The refrigerant circuit-side control box 10 still further includes the refrigerant circuit-side control device 15.

[0035] Each of the refrigerant circuit-side DC reactors 11 includes an inductor, and boosts the voltage, improves the power factor, reduces harmonics, and performs other duties. As the devices in the refrigerant circuit-side control box 10 are supplied with DC power from the power-supply terminal box 20, the refrigerant circuit-side DC reactors 11 are supposed to be DC reactors. Each of the refrigerant circuit-side noise filters 12 includes a capacitor and other elements, and reduces noise components generated in the inverter device. In Embodiment 1, the refrigerant circuit-side DC reactors 11 and the refrigerant circuit-side noise filters 12 are installed to the respective compressor inverter devices 13A and 13B.

[0036] Each of the compressor inverter devices 13 includes a power module and other devices, the power module including switching elements and other elements. The compressor inverter device 13 converts the voltage to supply power of the converted voltage to the compressor 30. In Embodiment 1, as described above, as the compressors 30 in a group of two systems of refrigerant circuits are driven, the refrigerant circuit-side control box 10 includes two compressor inverter devices 13. The fan inverter device 14 includes a power module and other devices, the power module including switching elements and other elements. The fan inverter device 14 converts the voltage to supply power of the converted voltage to the outdoor fans 3. The fan inverter device 14 with a relatively low output includes a DC reactor and a noise filter. In the present embodiment, the fan inverter device 14 drives two outdoor fans 3. The refrigerant circuit-side control device 15 controls the refrigerant circuit in its entirety. In Embodiment 1, the refrigerant circuit-side control device 15 controls a group of two systems of refrigerant circuits.

[0037] Fig. 4(b) is an explanatory diagram describing the devices located on the outside of the refrigerant circuit-side control box 10. As illustrated in Fig. 4(b), each refrigerant circuit-side control box 10 includes compressor heat sinks 16 (compressor heat sinks 16A and 16B) and a fan heat sink 17 on the outside of the refrigerant circuit-side control box 10.

[0038] Each of the compressor heat sinks 16 (compressor heat sinks 16A and 16B) is in contact with the power module and other devices included in each of the compressor inverter devices 13 accommodated in the

refrigerant circuit-side control box 10 to allow heat generated by the power module driving the devices to be transferred. The fan heat sink 17 is in contact with the power module and other devices included in the fan inverter device 14 accommodated in the refrigerant circuit-side control box 10 as described above to allow heat generated by the power module driving the devices to be transferred. These heat sinks are air-cooled by a cooling fan (not illustrated) installed on the bottom of the heat sinks.

[0039] Figs. 5 are explanatory diagrams describing the pump control box according to Embodiment 1. Fig. 5(a) illustrates the devices located inside the pump control box 90. The pump control box 90 includes a DC power-supply terminal 90A, and also includes electric devices supplied with DC power through the power-supply terminal box 20 to drive and control the pump. As illustrated in Fig. 5(a), the pump control box 90 includes a pump-side DC reactor 91, a pump-side noise filter 92, the pump inverter device 93, and the pump-side control device 94.

[0040] The pump-side DC reactor 91 includes an inductor, similarly to the refrigerant circuit-side DC reactors 11, and boosts the voltage, improves the power factor, reduces harmonics, and performs other duties. In the chilling unit 100 in Embodiment 1, the devices in the pump control box 90 are also supplied with DC power from the power-supply terminal box 20. With this configuration, the pump-side DC reactor 91 is supposed to be a DC reactor. DC reactors are more effective in improving the power factor and reducing harmonics, compared to AC reactors. When a DC reactor is employed, the device size can be reduced compared to that of an AC reactor. This configuration can achieve space saving in the pump control box 90 and reduce the size and weight of the pump control box 90. As the volume of the pump control box 90 is decreased, this configuration ensures an increased space in the machine chamber 1 accordingly for handling and installing the pipes of the heat-medium circulation circuit to be connected to the water heat exchangers 60 and the pump 80. Therefore, in the machine chamber 1, particularly the layout design of the devices of the heat-medium circulation circuit can be facilitated. As the pump control box 90 is directly supplied with DC power, a transformer and other components are eliminated from the pump control box 90, and accordingly the space where components are located and costs of the components can both be reduced.

[0041] The pump-side noise filter 92 includes a capacitor and other elements, and reduces noise components generated in the pump inverter device 93. The pump inverter device 93 includes a power module and other devices, the power module including switching elements and other elements. The pump inverter device 93 converts the voltage to supply power of the converted voltage to the pump 80. The pump inverter device 93 in Embodiment 1 includes a terminal to which the pump-side DC reactor 91 is connected. The pump-side control device 94 drives the pump inverter device 93 to control the pump

80.

[0042] Fig. 5(b) is an explanatory diagram describing the devices located on the outside of the pump control box 90. As illustrated in Fig. 5(b), the pump control box 90 includes a pump heat sink 95 on the outside of the pump control box 90. The pump heat sink 95 is in contact with the power module and other devices included in the pump inverter device 93 to allow heat generated by the power module driving the devices to be transferred. Electric devices in the pump control box 90 are directly supplied with DC power, so that the amount of heat generation is decreased in the pump control box 90. With this structure, the configuration of the pump heat sink 95 is more simplified than the configuration of some heat sink, and the volume of the pump heat sink 95 is decreased accordingly. As the volume of the pump heat sink 95 is decreased, an increased space for handling and installing the pipes of the heat-medium circulation circuit is ensured accordingly, simultaneously with reduction in size and weight of the pump control box 90. Thus, the layout design of the devices of the heat-medium circulation circuit can be facilitated.

[0043] As described above, in the chilling unit 100 in Embodiment 1, the pump 80 includes the pump DC motor 81, and the devices included in the pump control box 90 are configured to be directly supplied with DC power to drive and control the pump 80. With this configuration, the pump-side DC reactor 91, which is effective in improving the power factor and reducing harmonics, can be located in the pump control box 90. The pump-side DC reactor 91 is smaller in device size than an AC reactor. In the pump control box 90, components such as a transformer do not need to be installed. With this configuration, the pump control box 90 can be reduced in size. The volume of the pump control box 90 is decreased by reducing the pump control box 90 in size, and accordingly this configuration ensures an increased space in the machine chamber 1 for handling and installing the pipes of the heat-medium circulation circuit to be connected to the water heat exchangers 60 and the pump 80. Therefore, in the machine chamber 1, particularly the layout design of the devices of the heat-medium circulation circuit can be facilitated. The pump 80 and the pump control box 90 are designed to receive DC power, and thus can reduce the weights of the pump 80 and the pump control box 90. With this weight reduction, the level of durability required for attaching legs to the pump control box 90 can be reduced.

[0044] As the amount of heat generation in the pump control box 90 is decreased, the volume of the pump heat sink 95 can also be decreased accordingly. This configuration ensures an increased space in the machine chamber 1 for handling and installing the pipes of the heat-medium circulation circuit, and the layout design of the devices of the heat-medium circulation circuit can be facilitated. Particularly, the pump heat sink 95 can be prevented from interfering with the water heat exchangers 60. This also leads to facilitation of the device layout

in the machine chamber 1 in its entirety. The power-supply terminal box 20 does not need to be provided with a power-supply terminal and other element for AC power.

Embodiment 2.

[0045] In Embodiment 1 described above, the chilling unit 100 of a commonly-called "dual configuration" has been explained, in which two systems of refrigerant circuits are grouped together to share a single unit of the water heat exchanger 60. However, the configuration of the chilling unit 100 is not limited to such a configuration. The chilling unit 100 may be of a commonly-called "single configuration" in which refrigerant is circulated through a single system of refrigerant circuit such that a single unit of the water heat exchanger 60 allows the refrigerant and a heat medium to exchange heat with each other.

Reference Signs List

[0046] 1: machine chamber, 2, 2A, 2B, 2C, 2D: air heat exchanger, 3, 3A, 3B, 3C, 3D: outdoor fan, 4, 4A, 4B, 4C, 4D: fan DC motor, 10, 10A, 10B: refrigerant circuit-side control box, 11, 11A, 11B: refrigerant circuit-side DC reactor, 12, 12A, 12B: refrigerant circuit-side noise filter, 13, 13A, 13B: compressor inverter device, 14, 14A, 14B: fan inverter device, 15, 15A, 15B: refrigerant circuit-side control device, 16, 16A, 16B: compressor heat sink, 17: fan heat sink, 20: power-supply terminal box, 30, 30A, 30B, 30C, 30D: compressor, 31, 31A, 31B, 31C, 31D: compressor DC motor, 40, 40A, 40B, 40C, 40D: accumulator, 50, 50A, 50B, 50C, 50D: four-way valve, 60, 60A, 60B: water heat exchanger, 70, 70A, 70B, 70C, 70D: expansion valve, 80: pump, 81: pump DC motor, 90: pump control box, 90A: DC power-supply terminal, 91: pump-side DC reactor, 92: pump-side noise filter, 93: pump inverter device, 94: pump-side control device, 95: pump heat sink, 100: chilling unit, 200, 200A, 200B: indoor unit, 201, 201A, 201B: indoor heat exchanger, 202, 202A, 202B: indoor flow-rate adjustment device, 203, 203A, 203B: indoor fan

Claims

1. A chilling unit comprising:

in a machine chamber,
a device included in a refrigerant circuit through which refrigerant is circulated;
a plurality of heat-medium heat exchangers, each of which allowing the refrigerant and a heat medium that is a heat delivering medium to exchange heat with each other;
a pump that includes a DC motor, the pump being configured to apply a pressure to the heat medium and deliver the heat medium; and
a pump control box that includes an electric de-

vice driven by DC power, the electric device being configured to drive or control the pump.

2. The chilling unit of claim 1, wherein on an outside of the pump control box, a heat sink is installed, the heat sink allowing heat generated by the electric device to be transferred.

3. The chilling unit of claim 1 or 2, wherein

the machine chamber includes
a compressor driven by a DC motor, the compressor being a device included in the refrigerant circuit, and
a refrigerant circuit-side control box that includes an electric device driven by DC power, the electric device being configured to drive or control a device included in the refrigerant circuit including the compressor.

4. The chilling unit of any one of claims 1 to 3, wherein the plurality of heat-medium heat exchangers are connected in series to the pump in a flow passage of the heat medium.

5. An air-conditioning apparatus forming a heat-medium circulation circuit through which a heat medium is circulated by connecting by pipes

the chilling unit of any one of claims 1 to 4 and an indoor unit that includes an indoor heat exchanger and a flow-rate adjustment device, the indoor heat exchanger allowing indoor air to be air-conditioned and the heat medium to exchange heat with each other, the flow-rate adjustment device being installed to the indoor heat exchanger and configured to adjust a flow rate of the heat medium passing through the indoor heat exchanger.

FIG. 1

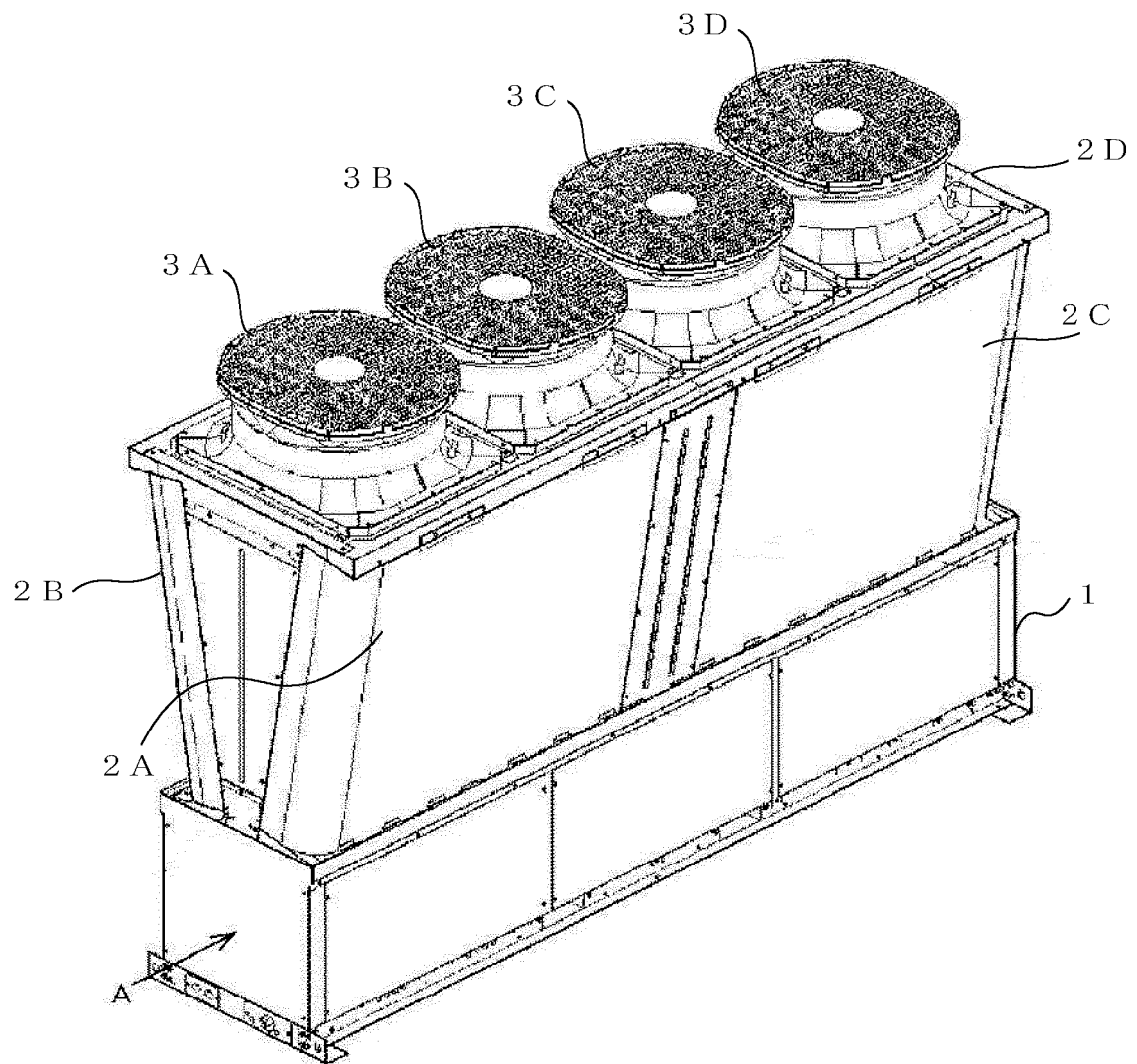


FIG. 2

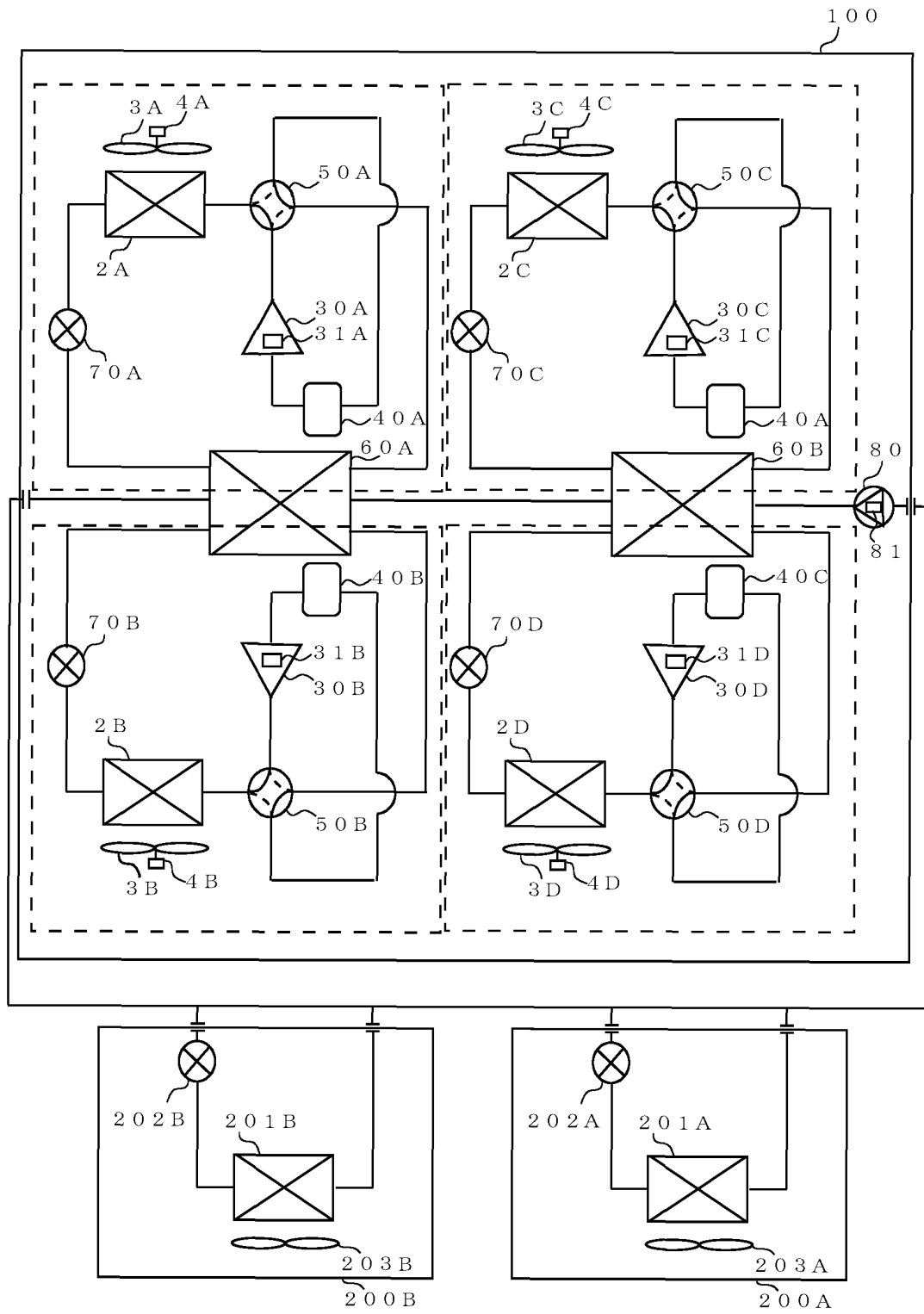


FIG. 3

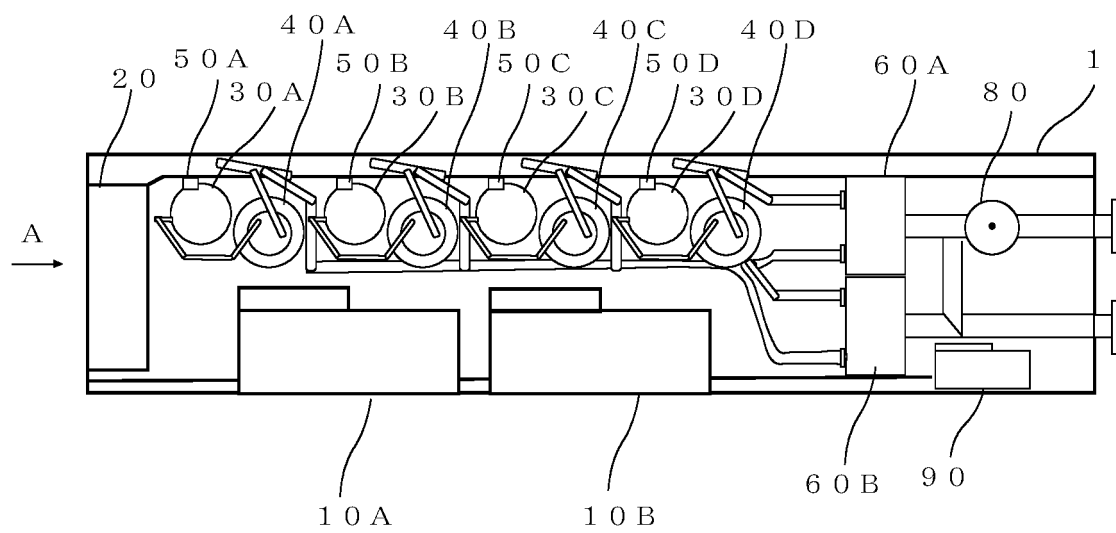
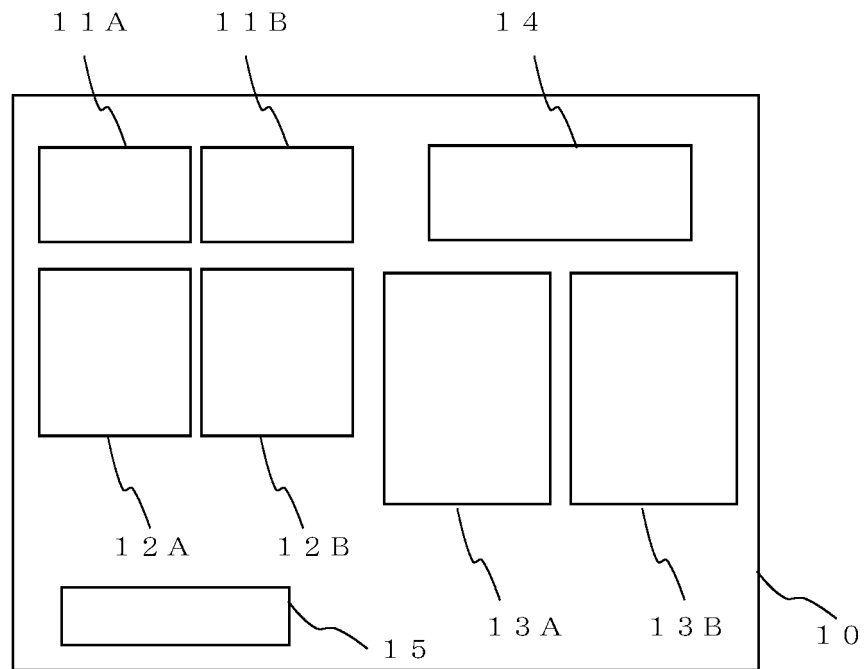


FIG. 4

(a)



(b)

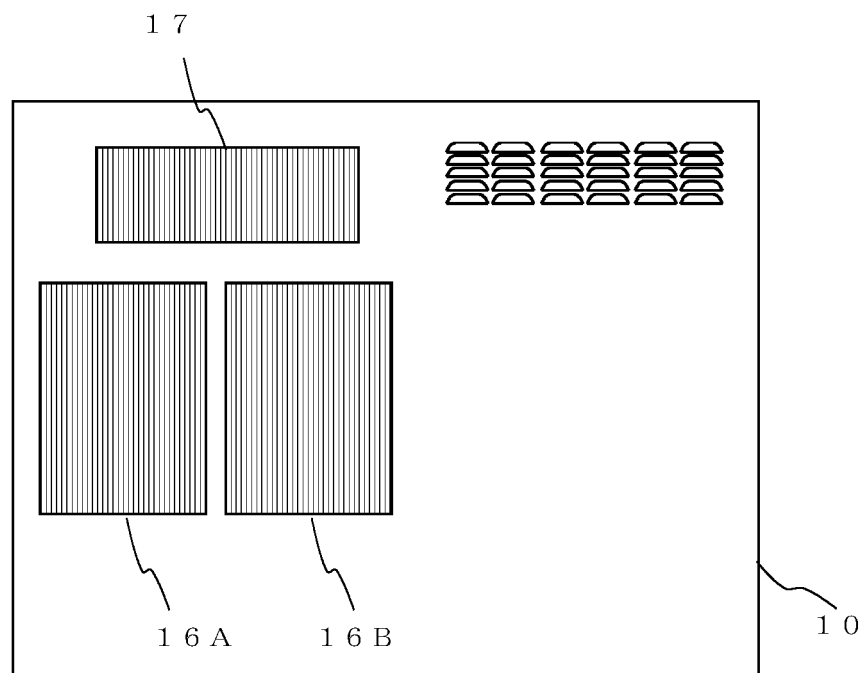
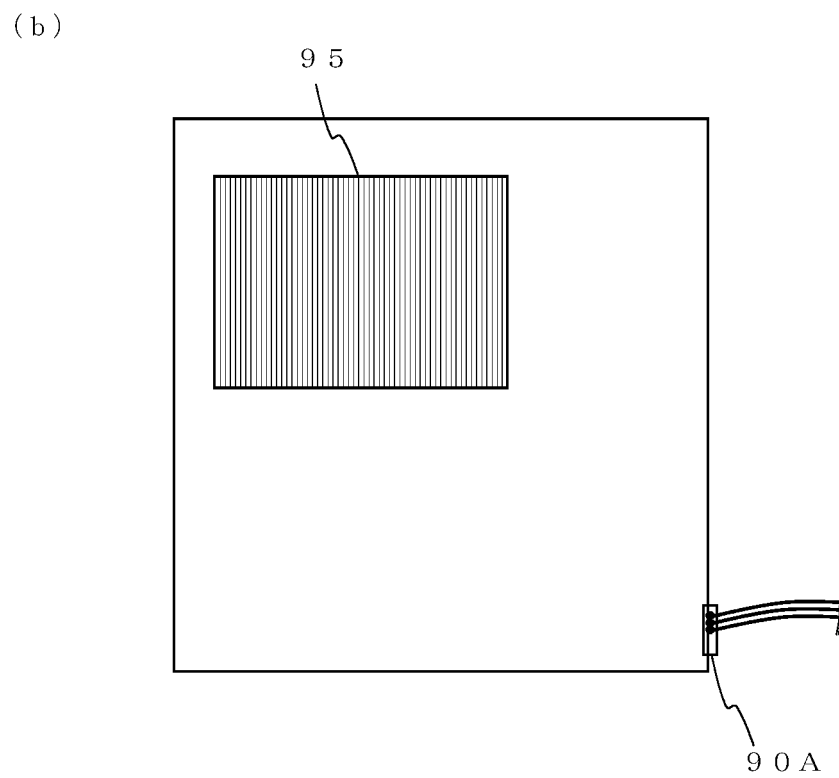
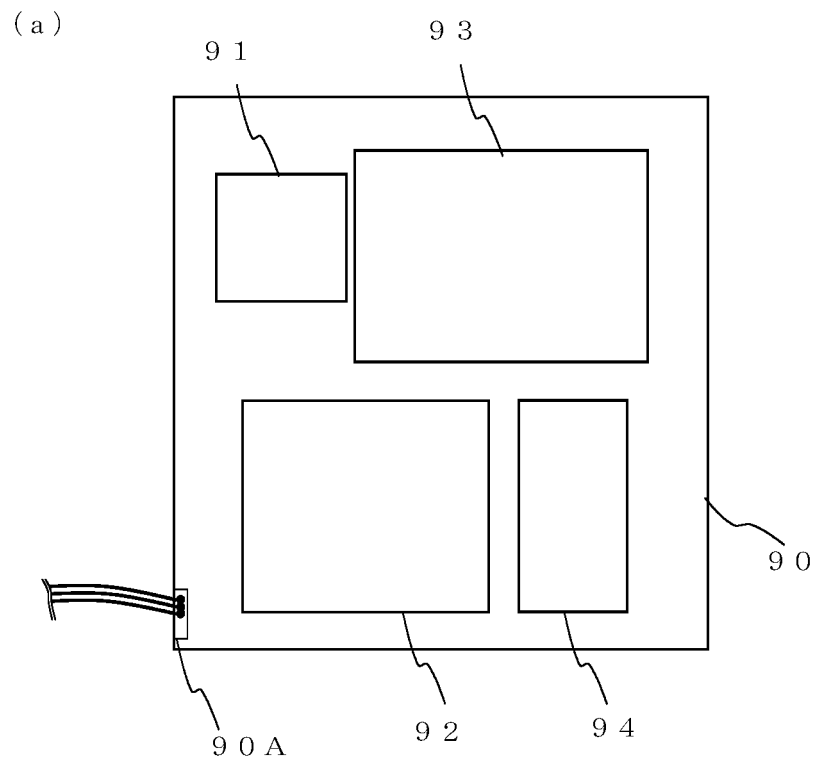


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/031087

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. F25B1/00 (2006.01) i, F24F5/00 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl. F25B1/00, F24F5/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2019

Registered utility model specifications of Japan 1996-2019

Published registered utility model applications of Japan 1994-2019

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2011/099629 A1 (TOSHIBA CARRIER CORP.) 18 August 2011, paragraphs [0012]-[0096], fig. 1-10 & CN 102753895 A & KR 10-2012-0116973 A	1-5
Y	JP 2012-233605 A (MITSUBISHI ELECTRIC CORP.) 29 November 2012, paragraphs [0015]-[0020], fig. 1 (Family: none)	1-5
Y	JP 2007-327725 A (HITACHI APPLIANCES, INC.) 20 December 2007, paragraphs [0022]-[0029], fig. 1 (Family: none)	1-5
Y	JP 2014-222113 A (MITSUBISHI ELECTRIC CORP.) 27 November 2014, paragraph [0016], fig. 2 (Family: none)	2

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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Date of the actual completion of the international search
18.09.2019Date of mailing of the international search report
01.10.2019Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/031087

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2017-203575 A (MITSUBISHI HEAVY INDUSTRIES THERMAL SYSTEMS LTD.) 16 November 2017, paragraphs [0032]-[0035], fig. 5-7 & WO 2017/195712 A1 & EP 3401608 A1, paragraphs [0035]-[0038], fig. 5-7 & CN 108603671 A	2
Y	JP 2013-113476 A (MITSUBISHI ELECTRIC CORP.) 10 June 2013, paragraphs [0011]-[0014], [0041], fig. 1, 3 (Family: none)	3
Y	JP 2016-080245 A (FUJI ELECTRIC CO., LTD.) 16 May 2016, paragraphs [0017], [0053], fig. 1 (Family: none)	3
Y	JP 2016-090178 A (HITACHI APPLIANCES, INC.) 23 May 2016, paragraphs [0012]-[0020], fig. 1 (Family: none)	5
A	JP 2018-054248 A (DAIKIN INDUSTRIES, LTD.) 05 April 2018, entire text, all drawings & US 2019/0219309 A1 & WO 2018/061548 A1 & EP 3502586 A1 & CN 109791002 A	1-5
A	WO 2011/013672 A1 (TOSHIBA CARRIER CORP.) 03 February 2011, entire text, all drawings & JP 2013-231590 A & US 2012/0125033 A1 & US 2013/0333409 A1 & EP 2461111 A1 & CN 102472536 A & KR 10-2012-0031227 A	1-5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 5401563 B [0003]