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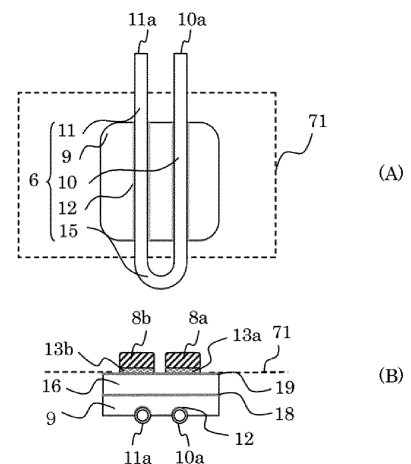
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(54) **AIR CONDITIONING DEVICE**

(57) A refrigerant cooler disposed in a refrigerant circuit of a refrigeration cycle has a heat rejecting plate and a heat rejecting pipe through which refrigerant flows, the heat rejecting pipe has a refrigerant inlet pipe, a refrigerant outlet pipe, and at least one bent portion connecting the refrigerant inlet pipe and the refrigerant outlet pipe, a component of a power conversion device is in surface contact with one surface of the heat rejecting plate, the heat rejecting pipe is in surface contact with the other surface of the heat rejecting plate, and a path of a heat source side heat exchanger is located above a contact portion between the refrigerant cooler and the component of the power conversion device.

FIG. 2



Description

Technical Field

[0001] The present invention relates to an air-conditioning apparatus using refrigerant and particularly relates to a technology to reject heat loss generated by a component of a power conversion device that drives a compressor or a fan. In the present application, the air-conditioning apparatus includes another cooling energy device using refrigerant and a compressor.

Background Art

[0002] An air-conditioning apparatus that performs a refrigeration cycle often uses a compressor that compresses refrigerant and a fan that generates wind for exchanging heat with outdoor air through a heat exchanger. An electric motor is typically used to rotationally drive the compressor and the fan, and a power conversion device is used to control operation of the electric motor. Driving of the power conversion device is associated with heat generation of components, such as a power module, forming the power conversion device, and thus it is necessary to cool the components to prevent abnormally high temperatures.

[0003] As an existing cooling method, there is an air cooling method in which a heat rejecting surface of each component of the power conversion device is brought into close contact with a finned heat sink mounted on a controller including the power conversion device in the air-conditioning apparatus, heat loss is transmitted and rejected to air, and wind at the heat exchanger secondary side is used to cool each component. In addition, there is also a refrigerant cooling method in which a pipe that is used in a refrigeration cycle and through which refrigerant flows and the heat rejecting surface of each component of the power conversion device are brought into close contact with each other with a plate interposed between the pipe and the component, and heat loss is transmitted to the refrigerant.

[0004] In the above air cooling method, even in a state where the compressor is not driven, wind passes through the finned heat sink as long as the fan is driven. Thus, it is possible to cool the heat generated by the component of the power conversion device for driving the fan.

[0005] Meanwhile, in the refrigerant cooling method, in a state where the compressor is not driven, the refrigerant for cooling does not flow to a refrigerant cooler. Thus, for example, when the power conversion device for rotating the fan is driven, there is a possibility that the component of the power conversion device exceeds its heat resistance range to be destroyed due to generated heat loss. For addressing this problem, there is a configuration in which a refrigerant pipe at a heat rejecting surface of each component of a power conversion device is bent on the outside of an electrical component box to avoid any component that inhibits heat rejection in the

vertical direction, and natural heat rejection from the bent portion is promoted in a state where no refrigerant flows (for example, Patent Literature 1).

5 Citation List

Patent Literature

[0006] Patent Literature 1: Japanese Patent No. 5125355 (pages 5 to 7, Fig. 2, Fig. 3)

Summary of Invention

Technical Problem

[0007] However, in the configuration of Patent Literature 1, heat loss generated in a state where the compressor is not driven is rejected to the atmosphere via a pipe or a plate forming a part of the refrigerant cooler. Consequently, a pipe and a plate surface area need to be designed in consideration of maximum heat loss and the temperature of the use environment such that generated heat loss can be sufficiently rejected, and complication of the configuration, an increase in size, and an increase in material cost and processing cost of the refrigerant cooler are problems.

[0008] The present invention has been made to address the above problem, and a main object of the present invention is to allow heat (also referred to as heat loss) generated in a component of a power conversion device to be cooled, even in a state where a compressor of an air-conditioning apparatus is not driven, by using a refrigerant cooler having as simple configuration as possible and as small size as possible.

Solution to Problem

[0009] An air-conditioning apparatus according to an embodiment of the present invention includes a refrigerant circuit in which a compressor driven by an electric motor, a use side heat exchanger, at least one expansion device, and a heat source side heat exchanger are connected to each other by a pipe and through which refrigerant circulates to execute a refrigeration cycle, a power conversion device configured to supply driving force to the electric motor, and a refrigerant cooler through which the refrigerant flowing through the refrigerant circuit flows to cause the refrigerant to receive heat rejected from a component of the power conversion device. The refrigerant cooler has a heat rejecting plate and a heat rejecting pipe through which the refrigerant flows, the heat rejecting pipe has a refrigerant inlet pipe, a refrigerant outlet pipe, and at least one bent portion connecting the refrigerant inlet pipe and the refrigerant outlet pipe, the component of the power conversion device is in surface contact with one surface of the heat rejecting plate, the heat rejecting pipe is in surface contact with the other surface of the heat rejecting plate, and a path of the heat source

side heat exchanger is located above a contact portion between the refrigerant cooler and the component of the power conversion device. Advantageous Effects of Invention

[0010] The air-conditioning apparatus according to an embodiment of the present invention is able to cool heat generated by the component of the power conversion device by causing the refrigerant used in the refrigeration cycle to flow to the refrigerant cooler.

[0011] The component of the power conversion device and the refrigerant cooler are brought into surface contact with each other such that thermal resistance is low, and the pipe that forms a part of the refrigerant cooler is provided with the bent portion to allow liquid refrigerant to easily accumulate in the refrigerant cooler. Furthermore, the positional relationship between the refrigerant cooler and the heat exchanger is established such that the path of the heat source side heat exchanger is present above the contact portion between the refrigerant cooler and the component of the power conversion device. Thus, even in a state where the compressor does not operate, it is possible to move refrigerant remaining in the refrigerant cooler, between the refrigerant cooler and the heat source side heat exchanger by natural convection. Consequently, it is possible to cool the component of the power conversion device with a smaller size of the refrigerant cooler than that in the related art without complicating the configuration of the refrigerant cooler.

Brief Description of Drawings

[0012]

[Fig. 1] Fig. 1 is a refrigerant circuit diagram of an air-conditioning apparatus according to Embodiment 1 of the present invention.

[Figs. 2] Figs. 2 show the structure of a refrigerant cooler according to Embodiment 1 of the present invention, Fig. 2(A) is a front view seen from a refrigerant pipe installation surface side, and Fig. 2(B) is a plan view seen from above.

[Fig. 3] Fig. 3 is an explanatory diagram showing a state where the refrigerant cooler is mounted on an outdoor unit.

[Fig. 4] Fig. 4 is an explanatory diagram showing a state of refrigerant flow between the refrigerant cooler and a heat exchanger in a state where the compressor stops.

[Fig. 5] Fig. 5 is a refrigerant circuit diagram of an air-conditioning apparatus according to Embodiment 2 of the present invention.

[Fig. 6] Fig. 6 is a refrigerant circuit diagram of an air-conditioning apparatus according to Embodiment 3 of the present invention.

Description of Embodiments

Embodiment 1

[0013] Fig. 1 is a refrigerant circuit diagram of an air-conditioning apparatus according to Embodiment 1 of the present invention. The air-conditioning apparatus according to Embodiment 1 has a refrigerant circuit 17 in which a compressor 1, a four-way valve 2, a use side heat exchanger 3, a use side expansion device 4a, a heat source side expansion device 4b, a heat source side heat exchanger 5, and an accumulator 14 are connected to each other by refrigerant pipes. In addition, as shown in Fig. 1, the use side heat exchanger 3 is normally provided with a fan 3a that sends air to the use side heat exchanger 3 and the heat source side heat exchanger 5 is normally provided with a fan 5a that sends air to the heat source side heat exchanger 5.

[0014] In Fig. 1, the accumulator 14 is provided. However, the accumulator 14 is not necessarily needed in the present invention. In addition, only either the use side expansion device 4a or the heat source side expansion device 4b may be used.

[0015] Furthermore, a refrigerant cooler 6 is disposed on a point of the refrigerant circuit between the use side expansion device 4a and the heat source side expansion device 4b. The refrigerant cooler 6 will be described in detail later.

[0016] The compressor 1 and the fans 3a and 5a are driven by respective electric motors, and these electric motors are driven by use of a power conversion device 7. The power conversion device 7 has components such as a power semiconductor, a reactor, a coil, a cement resistor, a power relay, and a transformer that are heat sources. In these heat sources, heat loss is caused due to switching loss, Joule heat, and iron loss. Thus, in the case where no radiator is present, a high temperature of 100 degrees C or higher may be caused, so that there is a possibility that the temperature exceeds the heat-resistant temperature of an insulating element of the component, leading to destruction.

[0017] Hereinafter, when the components of the power conversion device 7 are collectively called, the components are designated by reference sign 8, a compressor component of the power conversion device 7 is designated by reference sign 8a, and a fan component of the power conversion device 7 is designated by reference sign 8b. Here, the components 8, 8a, and 8b of the power conversion device are disposed on a power conversion device sheet metal 71. The power conversion device sheet metal 71 is preferably mounted on the refrigerant cooler 6 with heat transfer parts 13, 13a, and 13b interposed between the power conversion device sheet metal 71 and the refrigerant cooler 6.

[0018] As shown in Figs. 2(A) and (B), the refrigerant cooler 6 includes a first plate 16 to which the components 8 of the power conversion device are fixed, and a second plate 9 to which a pipe through which refrigerant flows is

fixed. The pipe that forms a part of the refrigerant cooler 6 and through which the refrigerant flows includes a refrigerant inlet pipe 10, a refrigerant outlet pipe 11, and a bent portion 15 connecting the refrigerant inlet pipe 10 and the refrigerant outlet pipe 11 and has a shape in which the bent portion 15 is located at a lower end.

[0019] A heat rejecting part 18 may be provided between the first plate 16 and the second plate 9 and a heat rejecting part 19 may be provided between the first plate 16 and the power conversion device sheet metal 71. Examples of the heat rejecting parts 18 and 19 include heat rejecting sheets and heat rejecting grease.

[0020] The components 8 of the power conversion device placed on the power conversion device sheet metal 71 are disposed to be in surface contact with the first plate 16 with the power conversion device sheet metal 71 interposed between the components 8 and the first plate 16, and heat is exchanged between the first plate 16 and the components 8 of the power conversion device. The heat of the first plate 16 is transmitted to the second plate 9, and further the heat of the second plate 9 is transmitted through the pipe that forms a part of the refrigerant cooler 6, to the refrigerant in the pipe.

[0021] To improve heat transmission efficiency, in the refrigerant cooler 6, the second plate 9 and the pipe through which the refrigerant in the refrigerant circuit flows are brought into contact with each other such that thermal resistance is low. To this end, the refrigerant inlet pipe 10 and the refrigerant outlet pipe 11 are fixed to the second plate 9 to be in contact with each other in as large area as possible. Preferably, half or more of the peripheral surfaces of the refrigerant inlet pipe 10 and the refrigerant outlet pipe 11 is brought into contact with the second plate 9. Specifically, as shown in Fig. 2(b), grooves are preferably formed in the second plate 9, and the refrigerant inlet pipe 10 and the refrigerant outlet pipe 11 are preferably inserted into the grooves.

[0022] The second plate 9 and the first plate 16 of the refrigerant cooler 6 are made of a metal having a high thermal conductivity, such as aluminum and copper. The refrigerant inlet pipe 10 and the refrigerant outlet pipe 11 that form parts of the refrigerant cooler 6 are similarly made of a metal having a high thermal conductivity, such as aluminum and copper. To decrease the thermal resistance, the refrigerant inlet pipe 10 and the refrigerant outlet pipe 11 may be brought into contact with the second plate 9 by use of brazing or pressure welding or with a heat rejecting sheet, heat rejecting grease, or other material interposed between the refrigerant inlet pipe 10 and the refrigerant outlet pipe 11 and the second plate 9. The second plate 9 and the first plate 16 are preferably detachably brought into contact with each other with a heat rejecting sheet or heat rejecting grease that is a heat rejecting part, to be easily serviced.

[0023] Of the components 8 of the power conversion device, the surfaces of components that generate heat are thermally brought into contact with the first plate 16, and thus it is possible to cool the components 8 of the

power conversion device. At this time, the components 8 are preferably detachably brought into contact with the first plate 16 with the heat rejecting part 19 such as a heat rejecting sheet and heat rejecting grease between the components 8 and the first plate 16. However, when the thermal resistance increases, the first plate 16 may be omitted, and the components 8 of the power conversion device may be mounted directly on the second plate 9. It is possible to decrease the thermal resistance by an amount corresponding to the first plate 16 and the heat rejecting part 19, accordingly.

[0024] In addition, the first plate 16, the second plate 9, and the power conversion device sheet metal 71 that form parts of the refrigerant cooler 6 may be fixed by using a fastening part such as a screw and by using a fixing tool or other instrument as necessary, such that thermal contact is not lost due to vibration or external force.

[0025] Next, the shape of the pipe that forms a part of the refrigerant cooler 6 and through which the refrigerant flows will be described. In the example shown in Figs. 2, the refrigerant inlet pipe 10 and the refrigerant outlet pipe 11 are formed in a U shape to be connected by one turn (bent portion). However, the number of turns of the refrigerant pipe that forms a part of the refrigerant cooler 6 is not limited to one, and may be a plural number as in a W shape. By increasing the number of turns, it is possible to increase the area of contact between the second plate 9 and the pipe through which the refrigerant flows, thereby increasing the heat rejection efficiency.

[0026] The purpose of providing a turn to the refrigerant pipe that forms a part of the refrigerant cooler 6 is to obtain the effect of increasing the area of contact and is also to allow liquid refrigerant to easily accumulate in a state where the compressor stops. As a matter of course, as the purpose is to obtain the effect of increasing the area of contact, the diameter of the pipe may be increased and a groove may be provided on the second plate surface that is in contact with the pipe, to be formed along the shape of the pipe. Alternatively, a pipe having a shape that can increase the area of contact with the second plate, such as a flattened pipe, may be used.

[0027] Next, the position at which the refrigerant cooler 6 is mounted will be described with reference to Fig. 3. As, in a state where the compressor of the air-conditioning apparatus stops, a mechanism that forcedly circulates the refrigerant is not present, liquid refrigerant is caused to accumulate in the refrigerant cooler 6 due to gravity. To this end, the refrigerant pipe that forms a part of the refrigerant cooler 6 has one or more bent portions 15 at the lower end portion between the refrigerant inlet pipe 10 and the refrigerant outlet pipe 11.

[0028] In Fig. 3, the pipe that forms a part of the refrigerant cooler 6 has a U shape having one bent portion 15 at the lower end between the refrigerant inlet pipe 10 and the refrigerant outlet pipe 11. Furthermore, to accumulate a large amount of the refrigerant, the refrigerant cooler 6 is mounted such that a contact portion between the

refrigerant cooler 6 and the components 8 of the power conversion device is present below a heat source side heat exchanger path. Thus, the liquid refrigerant accumulates in the refrigerant cooler 6, and in a state where the compressor 1 stops, even if heat is generated in the components of the power conversion device, thermal contact with the refrigerant cooler 6 is maintained, so that the heat generated in the components 8 of the power conversion device is transmitted to the liquid refrigerant.

[0029] The refrigerant pipe from the refrigerant cooler 6 to the use side heat exchanger 3 is preferably extended as perpendicularly as possible to the ground such that the refrigerant flows through a shortest path and easily accumulates in the refrigerant cooler 6. However, the bent portion 15 may be provided depending on the structure of an outdoor unit.

[0030] The shorter the distance is between the heat source side heat exchanger 5 and a pipe end portion 10a of the refrigerant inlet pipe 10 and a pipe end portion 11a of the refrigerant outlet pipe 11 that are connected to the heat source side heat exchanger 5, the more efficiently heat can be moved.

[0031] Next, heating operation of the air-conditioning apparatus according to Embodiment 1 will be described. High-temperature and high-pressure refrigerant having flowed out from the compressor 1 is condensed by the use side heat exchanger 3 and rejects heat to the use side at this time, and further the refrigerant becomes a low-temperature and low-pressure liquid or two-phase gas-liquid state at the use side expansion device 4a. Subsequently, the refrigerant becomes low-temperature and low-pressure gas at the heat source side heat exchanger 5, flows through the accumulator 14, and returns to the compressor 1. The refrigerant cooler 6 causes the entire flow amount of the refrigerant used in the refrigeration cycle to flow through the pipe of the refrigerant cooler 6 to cool the components 8 of the power conversion device. In the cooling by the refrigerant cooler 6, it is possible to adjust the cooling ability of the refrigerant cooler 6 by adjusting the temperature of the refrigerant flowing into the refrigerant cooler 6, using an electronic expansion valve, a capillary tube, a double pipe, a solenoid valve, or a thin pipe on the refrigerant circuit. Consequently, it is possible to avoid condensation and insufficiency of the cooling ability.

[0032] Next, cooling operation of the air-conditioning apparatus according to Embodiment 1 will be described. High-temperature and high-pressure refrigerant having flowed out from the compressor 1 becomes high-pressure liquid at the heat source side heat exchanger 5, flows through the pipe of the refrigerant cooler 6 to cool the components of the power conversion device, and is sent to the use side heat exchanger 3 side. At the use side heat exchanger 3 side, the refrigerant becomes low-temperature and low-pressure liquid at the use side expansion device 4a, exchanges heat and becomes low-temperature and low-pressure gas at the use side heat exchanger 3, flows through the accumulator 14, and re-

turns to the compressor 1. The pipe of the refrigerant cooler 6 allows the entire flow amount of the refrigerant used in the refrigeration cycle to flow through the pipe of the refrigerant cooler 6 to cool the components 8 of the power conversion device. In the cooling by the refrigerant cooler 6, it is possible to adjust the cooling ability of the refrigerant cooler 6 by adjusting the temperature of the refrigerant flowing into the refrigerant cooler 6, using an electronic expansion valve, a capillary tube, a double pipe, a solenoid valve, or a thin pipe on the refrigerant circuit. Consequently, it is possible to avoid condensation and insufficiency of the cooling ability.

[0033] Next, the following three operation modes that are one of the functions of the outdoor unit of the air-conditioning apparatus will be described for describing refrigerant cooling in a state where the compressor 1 stops. The following modes are merely examples, and the operation modes are not limited to these modes. In Embodiment 1, all heat generated in a state where the compressor does not operate can be a target to be cooled.

- (1) Snow sensor operation mode
- (2) Inverter superheat operation mode
- (3) Operation mode in which a compressor connected to another system is driven

[0034] The snow sensor operation mode in (1) is a mode in which only the fan 5a for the heat source side heat exchanger 5 is driven in a state where the compressor 1 stops such that snow does not accumulate or accumulated snow is blown away. As the power conversion device for driving the fan 5a operates, heat loss of the component 8b of the power conversion device occurs.

[0035] The inverter superheat operation mode in (2) is operation in which, when the refrigerant accumulates in the compressor 1 in a state where the outdoor unit stops, the liquid refrigerant in the compressor 1 is gasified by heating the compressor 1, and the compressor 1 is heated by applying a current to a motor winding in the compressor 1 without rotating the compressor 1. At this time as well, the power conversion device operates, and thus heat loss of the component 8a of the power conversion device occurs.

[0036] In the operation mode in (3) in which the compressor connected to the other system is driven, when a compressor connected to a second system different from a first system in which the refrigerant cooler 6 for cooling the power conversion device is provided is driven by using the power conversion device used in the first system, for example, for trial operation or confirmation of operation of the air-conditioning apparatus, the refrigerant does not circulate in the first system in which the compressor is not driven, and thus the components of the power conversion device generate heat loss.

[0037] Next, cooling the components 8 of the power conversion device, which are in contact with the refrigerant cooler 6, during operation of the above (1) to (3)

will be described with reference to Fig. 4.

[0038] When heat loss is generated in the components 8 of the power conversion device, the heat loss is removed in the vicinity of a heat generating portion 30 by liquid refrigerant remaining in a pipe interior 31 that forms a part of the refrigerant cooler 6, and the refrigerant that has received the heat changes in state to become gas. The gas refrigerant 32 flows upward through a pipe center portion and reaches the heat source side heat exchanger 5. A plurality of fins are typically mounted on a pipe at a heat source side heat exchanger path to reject heat, so that a wide area in which heat can be rejected to the air is provided. Thus, it is possible to efficiently reject heat loss when gas refrigerant moves into the path of the heat source side heat exchanger 5. Natural circulation is repeated in which the refrigerant that has rejected the heat becomes liquid refrigerant 33, and flows on a pipe inner wall surface 34, and returns to the refrigerant cooler 6 due to gravity. Consequently, even in a state where the compressor 1 stops, it is possible to move the heat loss of the components 8 of the power conversion device to the heat exchanger and reject the heat loss.

[0039] When heat loss is low, gasified refrigerant may reject the heat loss from the pipe surface and return to liquid before reaching the heat source side heat exchanger 5. In this case as well, the liquid refrigerant returns to the refrigerant cooler 6 due to gravity, and thus continuous cooling is possible.

[0040] When the fan 5a is driven to obtain a state in which wind flows, the heat exchange ability of the heat source side heat exchanger 5 improves, and thus it is possible to efficiently change gas refrigerant into liquid refrigerant.

[0041] When the components 8 of the power conversion device generate heat as the fan 5a is driven, forced air cooling is performed by the heat source side heat exchanger 5, and thus the effect of more efficiently rejecting heat loss to the outdoor air is achieved. These effects are also achieved in Embodiments described later.

Embodiment 2

[0042] Fig. 5 is a refrigerant circuit diagram of an air-conditioning apparatus according to Embodiment 2 of the present invention. The air-conditioning apparatus according to Embodiment 2 is basically the same as in Embodiment 1 and is different from Embodiment 1 in the following points.

[0043] Specifically, no heat source side expansion device is present, and a bypass 17A that branches from a point of a refrigerant circuit 17 between a heat source side heat exchanger 5 and a use side expansion device 4a and is connected to the suction side of a compressor 1 (via the accumulator, in the case where the accumulator 14 is provided) is provided. A refrigerant cooler 6 that is the same as in Embodiment 1 is provided on the bypass 17A, and a bypass expansion device 4c and a bypass

expansion device 4d are provided in front and in rear of the refrigerant cooler 6.

[0044] The configuration of the refrigerant cooler 6, the position at which the refrigerant cooler 6 is mounted, and other aspects may be the same as in Embodiment 1.

[0045] Heating operation of the air-conditioning apparatus according to Embodiment 2 will be described. High-temperature and high-pressure refrigerant having flowed out from the compressor 1 is condensed by a use side heat exchanger 3 to reject heat to the use side. Subsequently, the refrigerant becomes a low-temperature and low-pressure liquid or two-phase gas-liquid state at the use side expansion device 4a, further becomes low-temperature and low-pressure gas at the heat source side heat exchanger 5, flows through the accumulator 14, and returns to the compressor 1.

[0046] The refrigerant cooler 6 cools components 8 of a power conversion device through the refrigerant that has branched from any point between the use side expansion device 4a and the heat source side heat exchanger 5 in the refrigerant circuit 17 and has flowed through the bypass expansion device 4c. The refrigerant having passed through the refrigerant cooler 6 is further throttled by the bypass expansion device 4d and enters the accumulator 14 at the low pressure side. In the cooling by the refrigerant cooler 6, it is possible to avoid condensation and insufficiency of the cooling ability by controlling intermediate pressure with the bypass expansion devices 4c and 4d. An electronic expansion valve, a capillary tube, a double pipe, a solenoid valve, a thin pipe, or other component may be used as the expansion device in this case.

[0047] Next, cooling operation of the air-conditioning apparatus according to Embodiment 2 will be described. High-temperature and high-pressure refrigerant having flowed out from the compressor 1 becomes high pressure liquid at the heat source side heat exchanger 5 and is sent to the use side heat exchanger 3 side. At the use side heat exchanger side, the refrigerant becomes low-temperature and low-pressure liquid at the use side expansion device 4a, exchanges heat and becomes low-temperature and low-pressure gas at the use side heat exchanger 3, flows through the accumulator 14, and returns to the compressor 1.

[0048] In addition, an amount of the refrigerant having flowed out from the heat source side heat exchanger 5 flows through the bypass 17A depending on amounts of throttling of the bypass expansion devices 4c and 4d, and flows into the pipe of the refrigerant cooler 6. The refrigerant having passed through the refrigerant cooler 6 cools the components 8 of the power conversion device, then flows through the bypass expansion device 4d and the accumulator 14, and returns to the compressor 1. In the cooling by the refrigerant cooler 6, it is possible to avoid condensation and insufficiency of the cooling ability by controlling intermediate pressure with the bypass expansion devices 4c and 4d. An electronic expansion valve, a capillary tube, a double pipe, a solenoid

valve, a thin pipe, or other component may be used as the expansion device in this case.

[0049] Cooling the components 8 of the power conversion device during operation of the above (1) to (3) in Embodiment 2 is performed by the following action.

[0050] When heat loss is generated in the components 8 of the power conversion device, the heat loss is removed by liquid refrigerant remaining in the pipe that forms a part of the refrigerant cooler 6, and the refrigerant changes in state to become gas. As the specific gravity of the refrigerant that has become gas is lower than that of the air, the refrigerant flows upward through the bypass 17A and the refrigerant circuit 17 and reaches the interior of the heat source side heat exchanger 5. The gas refrigerant that has moved into the path of the heat source side heat exchanger 5 rejects the heat loss to become liquid refrigerant. Natural circulation is repeated in which the liquid refrigerant flows through the refrigerant circuit 17 and the bypass 17A and returns to the refrigerant cooler 6 due to gravity. Consequently, even in a state where the compressor 1 stops, it is possible to move the heat loss of the components 8 of the power conversion device to the heat source side heat exchanger 5.

[0051] At this time, as the bypass expansion device 4c is present between the refrigerant cooler 6 and the heat source side heat exchanger 5, it is necessary to bring the bypass expansion device 4c into an opened state to circulate the refrigerant. In addition, as the bypass expansion device 4d at the rear stage is connected to the suction side of the compressor 1 or the path leading to the inlet of the accumulator 14, the bypass expansion device 4d is preferably brought into a closed state to continuously cool the refrigerant.

Embodiment 3

[0052] Fig. 6 is a refrigerant circuit diagram of an air-conditioning apparatus according to Embodiment 3 of the present invention. In Embodiments 1 and 2, in a state where the compressor 1 stops, movement of heat is made by the liquid refrigerant and the gas refrigerant moving in the same pipe interior. However, in the configuration of Fig. 6, it is made possible to efficiently circulate the refrigerant in a refrigerant cooler 6 by making paths for the liquid refrigerant and the gas refrigerant different from each other.

[0053] The configuration, heating operation, and cooling operation of the air-conditioning apparatus of Embodiment 3 are basically the same as in Embodiment 1 and are different from Embodiment 1 in the following points.

[0054] Specifically, a bypass 17B that branches from a point of a refrigerant circuit 17 between the refrigerant cooler 6 and a use side expansion device 4a and is connected to the inlet of a heat source side heat exchanger for the refrigerant during cooling operation is provided. A bypass expansion device 42 is provided on the bypass 17B.

[0055] In addition, an opening-closing valve 43 for

blocking flow of the refrigerant is provided on a point of the refrigerant circuit between the connection point of the bypass 17B with the refrigerant inlet side of the heat source side heat exchanger 5 and the discharge side of a compressor 1 during cooling operation.

[0056] The configuration of the refrigerant cooler 6, the position at which the refrigerant cooler 6 is mounted, and other aspects may be the same as in Embodiment 1.

[0057] Cooling the components 8 of the power conversion device during operation of the above (1) to (3) in Embodiment 3 is performed as described below.

[0058] When heat loss is generated in the components 8 of the power conversion device, the heat loss is removed by liquid refrigerant remaining in the pipe that forms a part of the refrigerant cooler 6, and the refrigerant changes in state to become gas. As the specific gravity of the refrigerant that has become gas is lower than that of the air, when the expansion device 42 is opened, the gas refrigerant 32 flows upward through the bypass 17B and reaches the pipe in the heat source side heat exchanger 5. A plurality of fins are typically mounted on the pipe at the path of a heat source side heat exchanger 5 to reject heat, so that a wide area in which heat can be rejected to the air is provided. Consequently, when the gas refrigerant moves into the heat source side heat exchanger path, the heat loss is efficiently rejected, and the gas refrigerant becomes liquid refrigerant. Natural circulation is repeated in which the liquid refrigerant 33 flows through the refrigerant circuit 17 and returns to the refrigerant cooler 6 due to gravity. Consequently, even in a state where the compressor 1 stops, it is possible to move the heat loss of the components 8 of the power conversion device to the heat source side heat exchanger 5.

[0059] At this time, as the heat source side expansion device 4b is present between the heat source side heat exchanger 5 and the refrigerant cooler 6, it is necessary to bring the heat source side expansion device 4b into an opened state to circulate the refrigerant. In addition, as the use side expansion device 4a is connected to the path leading to the use side heat exchanger 3, the use side expansion device 4a is preferably brought into a closed state to continuously cool the refrigerant. Furthermore, when the refrigerant flowing through the bypass 17B moves toward the inlet side of the accumulator 14 or the suction side of the compressor 1 during heating or moves toward the discharge side of the compressor 1 during cooling, the opening-closing valve 43 is preferably closed.

Reference Signs List

[0060] 1 compressor 2 four-way valve 3 use side heat exchanger 3a fan 4a use side expansion device 4b heat source side expansion device 4c, 4d bypass expansion device 5 heat source side heat exchanger 5a fan 6 refrigerant cooler 7 power conversion device 8 component of power conversion device 8a compressor component

of power conversion device 8b fan component of power conversion device 9 second plate 10 refrigerant inlet pipe 10a refrigerant inlet pipe end portion 11 refrigerant outlet pipe 11a refrigerant outlet pipe end portion 12 thermal contact surface 13 heat transfer part 13a compressor heat transfer part 13b fan heat transfer part 14 accumulator 15 bent portion 16 first plate 17 refrigerant circuit 17A, 17B bypass 18 heat rejecting part 19 heat rejecting part 30 heat generating portion 31 pipe interior 42 bypass expansion device 43 opening-closing valve 71 power conversion device sheet metal 100 outdoor unit

Claims

1. An air-conditioning apparatus, comprising:

a refrigerant circuit in which a compressor driven by an electric motor, a use side heat exchanger, at least one expansion device, and a heat source side heat exchanger are connected to each other by a pipe and through which refrigerant circulates to execute a refrigeration cycle; a power conversion device configured to supply driving force to the electric motor; and a refrigerant cooler through which the refrigerant flowing through the refrigerant circuit flows to cause the refrigerant to receive heat rejected from a component of the power conversion device, the refrigerant cooler having a heat rejecting plate and a heat rejecting pipe through which the refrigerant flows, the heat rejecting pipe having a refrigerant inlet pipe, a refrigerant outlet pipe, and at least one bent portion connecting the refrigerant inlet pipe and the refrigerant outlet pipe, the component of the power conversion device being in surface contact with one surface of the heat rejecting plate, the heat rejecting pipe being in surface contact with an other surface of the heat rejecting plate, a path of the heat source side heat exchanger being located above a contact portion between the refrigerant cooler and the component of the power conversion device.

2. The air-conditioning apparatus of claim 1, wherein the heat rejecting pipe forming a part of the refrigerant cooler is housed in a groove formed on the heat rejecting plate, and an outer peripheral surface of the heat rejecting pipe and an inner peripheral surface of the groove are in surface contact with each other.

3. The air-conditioning apparatus of claim 1 or 2, wherein the component of the power conversion device is

fixed on a sheet metal and disposed on the heat rejecting plate with the sheet metal interposed between the component and the heat rejecting plate, and the sheet metal and the heat rejecting plate are fixed by a fastening part.

4. The air-conditioning apparatus of any one of claims 1 to 3, wherein the heat rejecting plate includes a first plate to which a cooling surface of the component of the power conversion device is fixed, and a second plate to which the heat rejecting pipe is fixed, and both the first plate and the second plate are fixed to each other with a heat rejecting part interposed between the first plate and the second plate.

5. The air-conditioning apparatus of any one of claims 1 to 4, wherein the refrigerant cooler is disposed in the refrigerant circuit, and an amount of the refrigerant flowing through the refrigerant cooler is an entire amount of the refrigerant used in the refrigeration cycle.

6. The air-conditioning apparatus of any one of claims 1 to 4, further comprising a bypass branching from a point of the refrigerant circuit between the heat source side heat exchanger and the use side heat exchanger and connected to a suction side of the compressor, wherein the refrigerant cooler is disposed on the bypass.

7. The air-conditioning apparatus of claim 6, further comprising a refrigerant expansion device each provided in front and in rear of the refrigerant cooler on the bypass.

8. The air-conditioning apparatus of any one of claims 1 to 4, wherein the refrigerant cooler is disposed in the refrigerant circuit, the air-conditioning apparatus further comprises:

a bypass branching from a point between the refrigerant cooler and the use side heat exchanger and connected to a refrigerant inlet side of the heat source side heat exchanger during cooling operation; and a bypass expansion device provided on the bypass, and the bypass expansion device is opened only when the compressor is not driven.

9. The air-conditioning apparatus of claim 8, further comprising an opening-closing valve provided on a point of the refrigerant circuit between a connection point at which the bypass is connected to the refrig-

erant inlet side of the heat source side heat exchanger and a discharge side of the compressor during cooling operation, the opening-closing valve being configured to block flow of the refrigerant.

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10. The air-conditioning apparatus of any one of claims 1 to 9, further comprising:

a fan configured to send air to the heat source side heat exchanger; and
a fan electric motor configured to drive the fan, wherein
the fan electric motor is driven by use of the power conversion device.

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FIG. 1

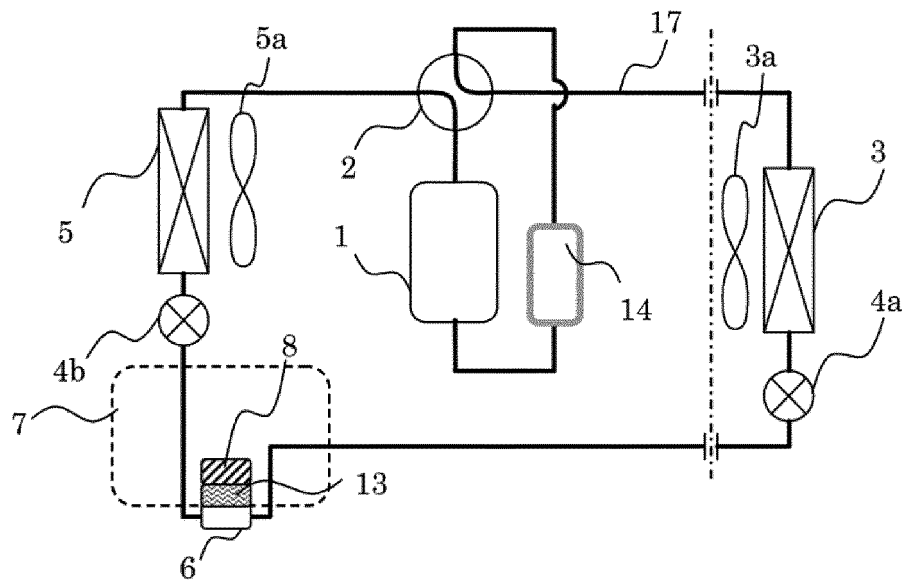


FIG. 2

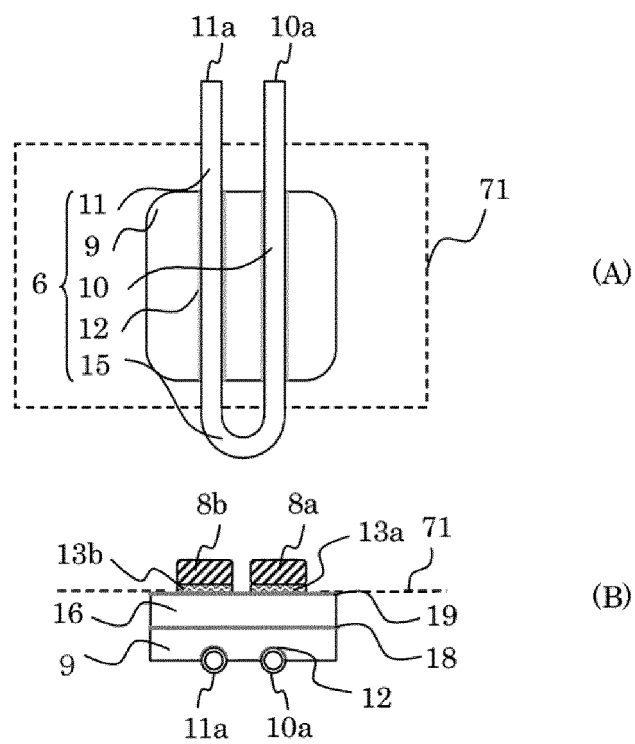


FIG. 3

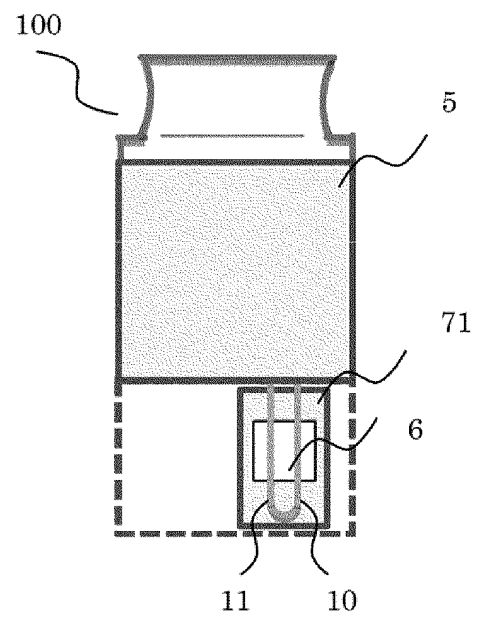


FIG. 4

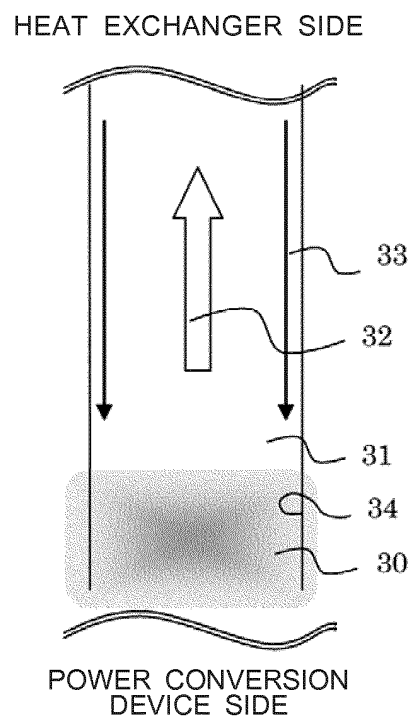


FIG. 5

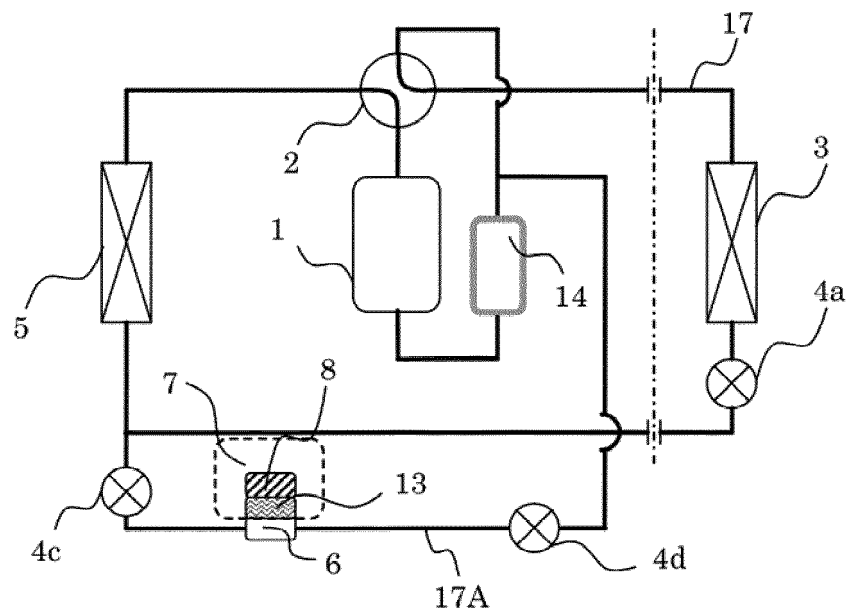
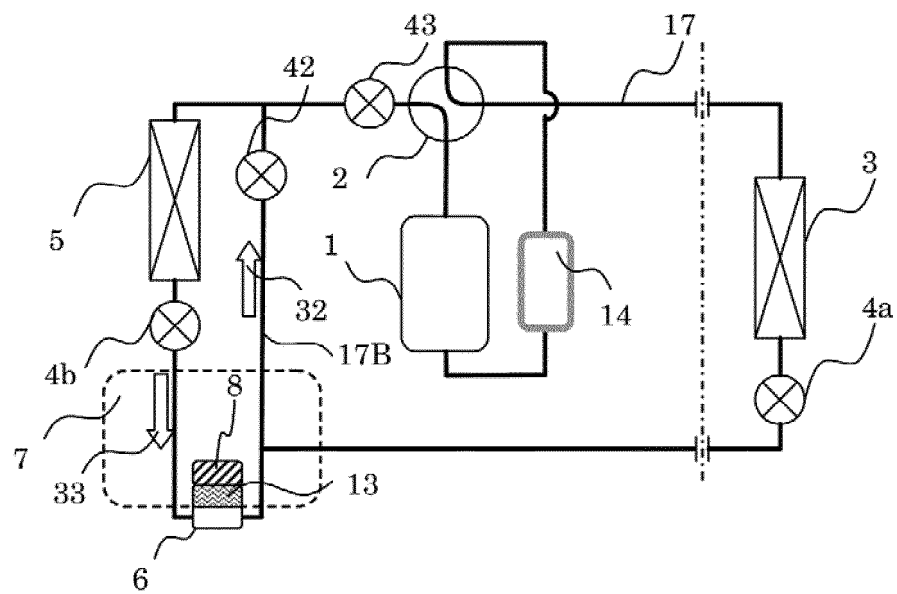


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/055348

A. CLASSIFICATION OF SUBJECT MATTER

F25B1/00(2006.01)i, F24F1/24(2011.01)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)

F25B1/00, F24F1/24

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

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 Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

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	JP 2013-232519 A (Daikin Industries, Ltd.), 14 November 2013 (14.11.2013), claims; paragraphs [0024] to [0050]; fig. 1 to 4 (Family: none)	1-10
Y	WO 2012/105047 A1 (Toyota Motor Corp.), 09 August 2012 (09.08.2012), claims; paragraphs [0057] to [0069], [0102]; fig. 6 to 11, 18 to 19 & US 2013/0298588 A1 & EP 2672200 A1 & CN 103370583 A	1-10

☒ 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
16 May 2016 (16.05.16)Date of mailing of the international search report
24 May 2016 (24.05.16)Name and mailing address of the ISA/
Japan Patent Office
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Tokyo 100-8915, Japan

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 2011-099577 A (Daikin Industries, Ltd.), 19 May 2011 (19.05.2011), paragraph [0059]; fig. 7 to 10 (Family: none)	3
Y	JP 2010-114121 A (Daikin Industries, Ltd.), 20 May 2010 (20.05.2010), paragraphs [0015] to [0028]; fig. 1 to 2 (Family: none)	4
Y	WO 2011/077720 A1 (Daikin Industries, Ltd.), 30 June 2011 (30.06.2011), paragraphs [0123] to [0124], [0322]; fig. 1, 27 & US 2012/0255318 A1 & EP 2518422 A1 & CN 102667368 A	6-7
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REFERENCES CITED IN THE DESCRIPTION

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