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(54) REFRIGERATION CYCLE APPARATUS

(57) Providing a refrigeration cycle apparatus that cools or heats water flowing in a water circuit on a utilization side with a refrigerant flowing in a refrigerant circuit, and that is configured to inhibit, even when the refrigerant enters the water circuit, the refrigerant from being sent to the utilization side through the water circuit. A refrigeration cycle apparatus 100 includes a refrigerant circuit 10, a water circuit 30, a gas-liquid separator 40, a first gas vent valve 52, and a second gas vent valve 54. In the refrigerant circuit, a compressor 12 compressing a refrigerant and a first heat exchanger 20 in which heat is exchanged between the refrigerant and water are connected via a pipe P. In the water circuit, the water having exchanged heat with the refrigerant in the first heat exchanger flows. The gas-liquid separator is connected to the water circuit. The first gas vent valve and the second gas vent valve are attached to the gas-liquid separator and are each configured to vent air from the gas-liquid separator.

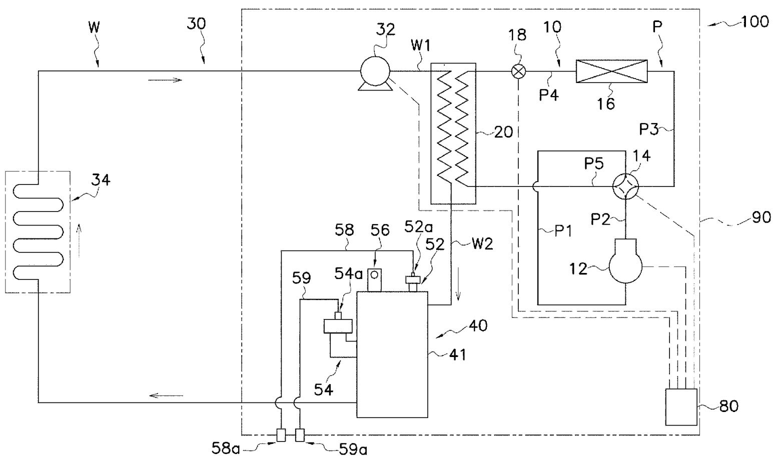

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a refrigeration cycle apparatus.

BACKGROUND ART

[0002] There has been known a refrigeration cycle apparatus including a refrigerant circuit and a water circuit, in which the refrigeration cycle apparatus is configured to cool or heat water flowing in the water circuit with a refrigerant flowing in the refrigerant circuit to condition air, supply hot water, or heat a floor with the water cooled or heated by the refrigerant.

[0003] In such a refrigeration cycle apparatus, a trouble that the refrigerant gets into the water in a heat exchanger or the like, which is configured to exchange heat between the refrigerant and the water, might occur. In view of such a situation, Japanese Laid-Open Patent Publication No. 2016-95130 provides a safety measure by disposing an air vent valve on a pipe of a water circuit to cause a refrigerant having flowed into the water circuit to be released out of the water circuit via the air vent valve.

SUMMARY OF THE INVENTION

<Technical Problem>

[0004] According to Japanese Laid-Open Patent Publication No. 2016-95130, the air vent valve provided at the water circuit is also configured to release air, for example air generated in the water circuit, to outside so as to prevent air entrainment at a water circulation pump. Such an air vent valve has a relatively small diameter, in order to inhibit a large amount of water from being exhausted to outside when air in the water circuit is exhausted to outside.

[0005] Therefore, in a case where a relatively large amount of refrigerant enters the water circuit, the amount of refrigerant that can be exhausted from the water circuit to outside may be insufficient in comparison to the amount of the refrigerant entering the water circuit and the refrigerant may be sent to a utilization side of the water circuit.

<Solution to Problem>

[0006] A refrigeration cycle apparatus according to a first aspect includes a refrigerant circuit, a water circuit, a gas-liquid separator, a first gas vent valve, and a second gas vent valve. The refrigerant circuit includes a compressor configured to compress a refrigerant, and a first heat exchanger configured to exchange heat between a refrigerant and water, and the compressor and the first heat exchanger are connected via a pipe. In the water circuit, the water having exchanged heat with the refrigerant in the first heat exchanger flows. The gas-liquid separator is connected to the water circuit. The first gas vent valve and the second gas vent valve are attached to the gas-liquid separator and are each configured to vent air from the gas-liquid separator.

[0007] The refrigeration cycle apparatus according to the first aspect includes the gas-liquid separator in order to easily trap the refrigerant. Furthermore, as the gas-liquid separator includes the two gas vent valves, the amount of the refrigerant exhausted to outside the water circuit is unlikely to be insufficient even when a relatively large amount of refrigerant enters the water.

[0008] A refrigeration cycle apparatus according to a second aspect is the refrigeration cycle apparatus according to the first aspect, in which the second gas vent valve operates, when gas in the gas-liquid separator exceeds first volume, to communicate inside of the gas-liquid separator and outside of the gas-liquid separator. The first gas vent valve operates, before the gas in the gas-liquid separator exceeds the first volume, to communicate inside of the gas-liquid separator and outside of the gas-liquid separator.

[0009] In the refrigeration cycle apparatus according to the second aspect, when the gas flowing into the gas-liquid separator increases, the second gas vent valve operates to exhaust the gas to outside the gas-liquid separator. Therefore, the amount of the refrigerant exhausted to outside the water circuit is unlikely to be insufficient even when a relatively large amount of refrigerant enters water.

[0010] A refrigeration cycle apparatus according to a third aspect is the refrigeration cycle apparatus according to the first or second aspect, in which the second gas vent valve has a diameter larger than a diameter of the first gas vent valve.

[0011] In the refrigeration cycle apparatus according to the third aspect, the gas-liquid separator includes, in addition to the first gas vent valve, the second gas vent valve having the diameter larger than the that of the first gas vent valve, to quickly exhaust the refrigerant to outside the water circuit even when a relatively large amount of refrigerant enters the water.

[0012] A refrigeration cycle apparatus according to a fourth aspect is the refrigeration cycle apparatus according to any one of the first to third aspects, in which the second gas vent valve is disposed below the first gas vent valve.

[0013] In the refrigeration cycle apparatus according to the fourth aspect, when the gas flowing into the gas-liquid separator increases to lower a water level in the gas-liquid separator, the second gas vent valve operates to exhaust the gas to outside the gas-liquid separator. Therefore, the amount of refrigerant exhausted to outside the water circuit is unlikely to be insufficient even when a relatively large amount of refrigerant enters the water.

[0014] A refrigeration cycle apparatus according to a fifth aspect is the refrigeration cycle apparatus according to the fourth aspect, in which the gas-liquid separator has an inlet port allowing the water to flow thereinto from the water circuit, and an outlet port allowing the water to flow out to the water circuit. A connecting portion at which the second gas vent valve and the gas-liquid separator is connected is disposed below the inlet port.

[0015] In the refrigeration cycle apparatus according to the fifth aspect, the second gas vent valve does not operate while the gas-liquid separator has a high liquid level inside, to inhibit outflow of water from the second gas vent valve along with gas.

[0016] A refrigeration cycle apparatus according to a sixth aspect is the refrigeration cycle apparatus according to the fifth aspect, in which the connecting portion at which the second gas vent valve and the gas-liquid separator is connected is disposed above the outlet port.

[0017] The refrigeration cycle apparatus according to the sixth aspect causes gas flow out via the second gas vent valve before the liquid level descends to the level of the outlet port, to inhibit the refrigerant from mixing with water flowing out of the outlet port.

[0018] A refrigeration cycle apparatus according to a seventh aspect is the refrigeration cycle apparatus according to any one of the first to sixth aspects, in which the gas-liquid separator is disposed in a casing. The casing is disposed outdoors.

[0019] In the refrigeration cycle apparatus according to the seventh aspect, as the casing accommodating the gas-liquid separator is disposed outdoors, it is likely to inhibit the refrigerant exhausted from the gas vent valves from being stagnant at a high concentration around the casing.

[0020] A refrigeration cycle apparatus according to an eighth aspect is the refrigeration cycle apparatus according to any one of the first to seventh aspects, and further includes a first exhaust pipe connected to an exhaust port of the first gas vent valve. The first exhaust pipe has an exhaust end that allows exhaust of gas having passed through the first exhaust pipe. The exhaust end of the first exhaust pipe is disposed outdoors.

[0021] In the refrigeration cycle apparatus according to the eighth aspect, the exhaust end of the first exhaust pipe is disposed outdoors, to inhibit the refrigerant exhausted through the first gas vent valve from being retained at a high concentration in the casing.

[0022] A refrigeration cycle apparatus according to a ninth aspect is the refrigeration cycle apparatus according to any one of the first to eighth aspects, and further includes a second exhaust pipe connected to an exhaust port of the second gas vent valve. The second exhaust pipe has an exhaust end that allows exhaust of gas having passed through the second exhaust pipe. The exhaust end of the second exhaust pipe is disposed outdoors.

[0023] In the refrigeration cycle apparatus according to the ninth aspect, the exhaust end of the second exhaust pipe is disposed outdoors, to inhibit the refrigerant exhausted through the second gas vent valve from being retained at a high concentration in the casing.

[0024] A refrigeration cycle apparatus according to a tenth aspect is the refrigeration cycle apparatus according to any one of the first to ninth aspects, and further includes a utilization facility connected to the water circuit and configured to utilize heat of the water. The gas-liquid separator is disposed downstream of the first heat exchanger and upstream of the utilization facility in a flow direction of the water in the water circuit.

[0025] In the refrigeration cycle apparatus according to the tenth aspect, even when the refrigerant enters water in the first heat exchanger, the refrigerant is inhibited from being sent to the utilization facility.

[0026] A refrigeration cycle apparatus according to an eleventh aspect is the refrigeration cycle apparatus according to any one of the first to tenth aspects, and further includes a pressure relief valve attached to the gas-liquid separator.

[0027] The refrigeration cycle apparatus according to the eleventh aspect inhibits high pressure in the gas-liquid separator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028]

FIG. 1 is a schematic configuration diagram of a refrigeration cycle apparatus according to an embodiment;

FIG. 2 is a schematic view of a gas-liquid separator included in the refrigeration cycle apparatus depicted in FIG. 1;

FIG. 3 is a conceptual view in a state where the gas-liquid separator depicted in FIG. 2 fully contains water;

FIG. 4 is a conceptual view in a state where the gas-liquid separator depicted in FIG. 2 contains small amount of gas in an upper portion; and

FIG. 5 is a conceptual view in a state where the gas-liquid separator depicted in FIG. 2 contains a relatively large amount of gas.

DESCRIPTION OF EMBODIMENTS

[0029] Description is made hereinafter to a refrigeration cycle apparatus according to an embodiment.

(1) Entire configuration

[0030] Described below with reference to FIG. 1 is a refrigeration cycle apparatus 100 according to an embodiment. FIG. 1 is a schematic configuration diagram of the refrigeration cycle apparatus 100.

[0031] The refrigeration cycle apparatus 100 includes a refrigerant circuit 10 in which a refrigerant circulates, and a water circuit 30 in which water circulates (see FIG. 1). The refrigeration cycle apparatus 100 cools or heats water circulating in the water circuit 30 with the refrigerant circulating in the refrigerant circuit 10, and condition air, supply hot water, heat a floor, or the like with the water cooled or heated by the refrigerant. The following description exemplifies a case where the refrigeration cycle apparatus 100 is an air conditioner configured to cool and heat air.

[0032] The refrigeration cycle apparatus 100 principally includes, in addition to the refrigerant circuit 10 and the water circuit 30, a gas-liquid separator 40, a first gas vent valve 52, a second gas vent valve 54, a pressure relief valve 56, a utilization facility 34, and a controller 80. The gas-liquid separator 40 and the utilization facility 34 are connected to the water circuit 30. The first gas vent valve 52, the second gas vent valve 54, and the pressure relief valve 56 are attached to the gas-liquid separator 40. The refrigerant circuit 10 and part of the water circuit 30 (including a pump 32 and the gas-liquid separator 40 connected to the water circuit 30) are accommodated in a casing 90.

[0033] The refrigerant circuit 10, the water circuit 30, the utilization facility 34, the controller 80, and the casing 90 will be summarized herein. The gas-liquid separator 40, the first gas vent valve 52, the second gas vent valve 54, and the pressure relief valve 56 will be described later.

(1-1) Refrigerant circuit

[0034] The refrigerant circuit 10 performs a vapor compression refrigeration cycle. The vapor compression refrigeration cycle includes repeating steps of compressing a gas refrigerant having low temperature and low pressure to have a high temperature and high pressure in the refrigeration cycle, causing the refrigerant to radiate heat at a radiator (condenser), causing the refrigerant to expand at an expansion mechanism to have low temperature and low pressure, causing the refrigerant to absorb heat at an evaporator, and compressing again the gas refrigerant having low temperature and low pressure having absorbed heat at the evaporator.

[0035] The refrigerant circuit 10 principally includes a compressor 12, a flow path switching mechanism 14, a heat source heat exchanger 16, an expansion mechanism 18, and a first heat exchanger 20 (see FIG. 1). The compressor 12, the flow path switching mechanism 14, the heat source heat exchanger 16, the expansion mechanism 18, and the first heat exchanger 20 are connected via a pipe P as depicted in FIG. 1.

[0036] Described herein is the refrigerant circuit 10 having a merely exemplary configuration. For example, the refrigerant circuit 10 may further include a receiver configured to reserve a refrigerant, a device configured to subcool a refrigerant, or the like. Exemplarily described herein is a case where the refrigeration cycle apparatus 100 functions as an air conditioner configured to cool and heat air, and the refrigeration cycle apparatus 100 accordingly includes the flow path switching mechanism 14. In another exemplary case where the refrigeration cycle apparatus 100 functions as an air conditioner configured to only cool air or only heat air, the refrigeration cycle apparatus 100 may not include the flow path switching mechanism 14.

[0037] The refrigerant according to the present embodiment is combustible. Examples of the combustible refrigerant in this case include refrigerants categorized in Class 3 (higher flammability), Class 2 (lower flammability), and Subclass 2L (slight flammability) in the standards according to ASHRAE 34 Designation and safety classification of refrigerant in the U.S.A. or the standards according to ISO 817 Refrigerants - Designation and safety classification. The refrigerant herein is exemplarily R290 (propane) having high flammability and low global warming potential (GWP). The refrigerant is not limited in type to the combustible refrigerant.

(1-1-1) Pipe

[0038] The pipe P of the refrigerant circuit 10 includes a suction pipe P1, a discharge pipe P2, a first gas pipe P3, a liquid pipe P4, and a second gas pipe P5 (see FIG. 2).

[0039] The suction pipe P1 connects a suction port (not depicted) of the compressor 12 and the flow path switching mechanism 14. The suction pipe P1 is provided with an accumulator (not depicted). The discharge pipe P2 connects a discharge port (not depicted) of the compressor 12 and the flow path switching mechanism 14. The first gas pipe P3 connects the flow path switching mechanism 14 and a gas side of the heat source heat exchanger 16. The liquid pipe P4 connects a liquid side of the heat source heat exchanger 16 and the first heat exchanger 20. The liquid pipe P4 is provided with the expansion mechanism 18. The second gas pipe P5 connects the first heat exchanger 20 and the flow path switching mechanism 14.

(1-1-2) Compressor

[0040] The compressor 12 sucks a low-pressure refrigerant in the refrigeration cycle via the suction pipe P1, causes a compression mechanism (not depicted) to compress the refrigerant, and discharges a compressed high-pressure refrigerant in the refrigeration cycle via the discharge pipe P2. The compressor 12 is exemplarily of a scroll type. The compressor 12 should not be limited in type to the scroll type. Alternatively, the compressor 12 may be of a screw type, a rotary type, or the like. The compressor 12 exemplary has variable capacity, or may alternatively have a constant capacity.

(1-1-3) Flow path switching mechanism

[0041] The flow path switching mechanism 14 is configured to switch a refrigerant flow direction in the refrigerant circuit 10 in accordance with an operating mode of the refrigeration cycle apparatus 100. The refrigeration cycle apparatus 100 has operating modes including a mode of cooling water in the water circuit 30 with use of a refrigerant (hereinafter, called a cooling mode), and a mode of heating the water in the water circuit 30 (hereinafter, called a heating mode).

[0042] The flow path switching mechanism 14 according to the present embodiment is configured as a four-way switching valve. The flow path switching mechanism 14 should not be limited to the four-way switching valve, but may alternatively combine a plurality of electromagnetic valves and pipes so as to switch the refrigerant flow direction as follows.

[0043] In the cooling mode, the flow path switching mechanism 14 switches the refrigerant flow direction in the refrigerant circuit 10 such that the refrigerant discharged from the compressor 12 is sent to the heat source heat exchanger 16. Specifically, in the cooling mode, the flow path switching mechanism 14 allows the suction pipe P1 and the second gas pipe P5 to communicate with each other, and allows the discharge pipe P2 and the first gas pipe P3 to communicate with each other (see solid lines in the flow path switching mechanism 14 in FIG. 1).

[0044] In the heating mode, the flow path switching mechanism 14 switches the refrigerant flow direction in the refrigerant circuit 10 such that the refrigerant discharged from the compressor 12 is sent to the first heat exchanger 20. Specifically, in the heating mode, the flow path switching mechanism 14 allows the suction pipe P1 and the first gas pipe P3 to communicate with each other, and allows the discharge pipe P2 and the second gas pipe P5 to communicate with each other (see broken lines in the flow path switching mechanism 14 in FIG. 1).

(1-1-4) Heat source heat exchanger

[0045] The heat source heat exchanger 16 is exemplarily configured to exchange heat between air around the casing 90 accommodating the heat source heat exchanger 16 and the refrigerant flowing in the heat source heat exchanger 16. Specifically, the casing 90 accommodates a fan (not depicted) configured to receive air from outside the casing 90 and send the air to the heat source heat exchanger 16, and heat is exchanged between the air sent from the fan and the refrigerant flowing in the heat source heat exchanger 16.

[0046] The heat source heat exchanger 16 is exemplarily a fin-and-tube heat exchanger of a cross-fin type, though not limited in terms of its type.

[0047] The heat source heat exchanger 16 functions as a radiator (condenser) for a refrigerant when the refrigeration cycle apparatus 100 is in the cooling mode as its operating mode. Furthermore, the heat source heat exchanger 16 functions as a heat absorber (evaporator) for a refrigerant when the refrigeration cycle apparatus 100 is in the heating mode as tits operating mode.

[0048] The heat source heat exchanger 16 may not necessarily be configured to exchange heat between air and a refrigerant. Alternatively, the heat source heat exchanger 16 may be configured to exchange heat between the refrigerant flowing in the heat source heat exchanger 16 and fluid (e.g., cooling water or warm water) sent to the heat source heat exchanger 16. The heat source heat exchanger 16 is exemplarily a plate heat exchanger in this case, though not limited in terms of its type.

(1-1-5) Expansion mechanism

[0049] The expansion mechanism 18 is configured to expand the refrigerant flowing in the liquid pipe P4 to control pressure and/or a flow rate of the refrigerant. The expansion mechanism 18 according to the present embodiment is configured as an electronic expansion valve having an adjustable opening degree.

[0050] The expansion mechanism 18 should not be limited to the electronic expansion valve. Alternatively, the expansion mechanism 18 may be a temperature automatic expansion valve including a temperature sensitive cylinder, or may be a capillary tube.

(1-1-6) First heat exchanger

[0051] In the first heat exchanger 20, heat is exchanged between the refrigerant flowing in the refrigerant circuit 10 and water flowing in the water circuit 30. The first heat exchanger 20 according to the present embodiment is configured as a plate heat exchanger. The first heat exchanger 20 should not be limited to the plate heat exchanger in terms of its type, but may be appropriately selected from heat exchangers of types applicable to heat exchange between a refrigerant and water.

[0052] The first heat exchanger 20 is connected with the liquid pipe P4 and the second gas pipe P5 of the refrigerant circuit 10. The first heat exchanger 20 is connected with a first pipe W1 and a second pipe W2 of the water circuit 30.

[0053] When the refrigeration cycle apparatus 100 is in the cooling mode, the refrigerant flows into the first heat exchanger 20 via the liquid pipe P4 and flows out to the second gas pipe P5. When the refrigeration cycle apparatus 100 is in the heating mode, the refrigerant flows into the first heat exchanger 20 via the second gas pipe P5 and flows out to the liquid pipe P4.

[0054] Regardless of whether the refrigeration cycle apparatus 100 is in the cooling mode or in the heating mode, water flows into the first heat exchanger 20 via the first pipe W1 and flows out of the second pipe W2. When the refrigeration cycle apparatus 100 is in the cooling mode, water flowing from the first pipe W1 is cooled by the refrigerant flowing into the first heat exchanger 20, and flows out to the second pipe W2. When the refrigeration cycle apparatus 100 is in the heating mode, water flowing from the first pipe W1 is heated by the refrigerant flowing into the first heat exchanger 20, and flows out to the second pipe W2.

(1-2) Water circuit

[0055] The water circuit 30 is a water flow path in which water having exchanged heat with the refrigerant in the first heat exchanger 20 flows.

[0056] The water circuit 30 is principally connected with the pump 32, the first heat exchanger 20, the gas-liquid separator 40, and the utilization facility 34. The pump 32, the first heat exchanger 20, the gas-liquid separator 40, and the utilization facility 34 are connected via a pipe W as depicted in FIG. 1.

[0057] Water circulating in the water circuit 30 should not be limited to pure water. For example, the water may be brine or the like. Examples of the brine include an aqueous solution of calcium chloride, an aqueous solution of ethylene glycol, and an aqueous solution of propylene glycol.

[0058] The pipe W of the water circuit 30 includes the first pipe W1 and the second pipe W2 (see FIG. 2). The first pipe W1 connects the utilization facility 34 and the first heat exchanger 20, to allow water to flow from the utilization facility 34 to the first heat exchanger 20. The second pipe W2 connects the utilization facility 34 and the first heat exchanger 20, to allow water to flow from the first heat exchanger 20 to the utilization facility 34.

[0059] The first pipe W1 is connected with the pump 32. Examples of the pump 32 include a constant speed volute pump, and may alternatively include a variable flow pump. The pump 32 should not be limited to the volute pump, but may be of an appropriately selected type. The pump 32 according to the present embodiment is disposed on the first pipe W1 upstream of the first heat exchanger 20 in a water flow direction. However, the pump 32 should not be limited to this case, but may alternatively be disposed downstream of the first heat exchanger 20 in the water flow direction, in other words, on the second pipe W2.

[0060] The second pipe W2 is connected with the gas-liquid separator 40. The gas-liquid separator 40 should not be limitedly disposed on the second pipe W2, but may alternatively be disposed on the first pipe W1. In view of inhibiting the refrigerant from being sent to the utilization facility 34, the gas-liquid separator 40 is preferably connected to the second pipe W2. The gas-liquid separator 40 will be described later.

(1-3) Utilization facility

[0061] The utilization facility 34 utilizes water cooled or heated in the first heat exchanger 20. Particularly in this case, examples of the utilization facility 34 include an air handling unit and a fan coil unit configured to exchange heat between air and water cooled or heated in the first heat exchanger 20.

[0062] The utilization facility in the refrigeration cycle apparatus should not be limited, in terms of its type, to the air handling unit or the fan coil unit, but may be appropriately selected for its purpose of use. Alternatively, in a case where the refrigeration cycle apparatus is used in a plant or the like, the utilization facility 34 may be a manufacturing facility configured to cool or heat a manufacturing apparatus or a product with use of water cooled or heated in the first heat exchanger 20. Alternatively, when the refrigeration cycle apparatus is a water heater, the utilization facility 34 may be a tank configured to reserve water cooled or heated in the first heat exchanger 20. Water reserved in the tank as the utilization facility 34 is sent to a device or the like using water with a pump (not depicted) or the like.

[0063] FIG. 1 depicts only one utilization facility 34. The refrigeration cycle apparatus 100 may alternatively include a plurality of utilization facilities such that water cooled or heated in the first heat exchanger 20 is sent to the plurality of utilization facilities. When the refrigeration cycle apparatus 100 includes the plurality of utilization facilities, the utilization facilities may be of an identical type, or may include a plurality of types of facilities.

(1-4) Controller

[0064] The controller 80 includes a CPU (not depicted), a memory such as a ROM or a RAM, various electric components, and electronic components.

[0065] As depicted in FIG. 1, the controller 80 is electrically connected to the compressor 12, the flow path switching mechanism 14, the expansion mechanism 18, and the pump 32. When the CPU executes a program stored in the memory, the controller 80 controls behavior of various configurations in the refrigeration cycle apparatus 100 such as the compressor 12, the flow path switching mechanism 14, the expansion mechanism 18, and the pump 32 in order to make the refrigeration cycle apparatus 100 execute desired behaviors.

(1-5) Casing

[0066] The casing 90 accommodates the compressor 12, the flow path switching mechanism 14, the heat source heat exchanger 16, the expansion mechanism 18, the pump 32, the gas-liquid separator 40, and the controller 80. The casing 90 also accommodates part of the pipe P of the refrigerant circuit 10 and part of the pipe W of the water circuit 30.

[0067] The casing 90, though not being limited, is disposed in an outdoor space such as on a roof of a building or around the building. Examples of the outdoor space include an open space other than a closed space surrounded with a ceiling and walls. Specifically, examples of the outdoor space in this case include a place provided with a ceiling but having at least one of four sides not covered with any wall so as to be opened outside.

[0068] The casing 90 may alternatively be disposed indoors. In such a case, the casing 90 is preferably disposed in a space well ventilated by a ventilation fan or the like, in consideration of safety in case of refrigerant leakage.

[0069] The casing 90 is provided with an intake port (not depicted) from which a fan, being configured to send air to the heat source heat exchanger 16, intakes air, and a blow-out port (not depicted) from which the fan exhausts air. The casing 90 is further provided with an opening allowing a first exhaust pipe 58 and a second exhaust pipe 59 to be described later, to penetrate and extend therethrough.

(2) Details of gas-liquid separator and ancillary equipment for gas-liquid separator

[0070] Description is made, with reference to FIG. 2 to FIG. 5, to the gas-liquid separator 40 and ancillary equipment (the first gas vent valve 52, the second gas vent valve 54, and the pressure relief valve 56 attached to the gas-liquid separator 40) for the gas-liquid separator 40. FIG. 2 is a schematic view of the gas-liquid separator 40 in the refrigeration cycle apparatus 100. FIG. 3 is a conceptual view in a state where the gas-liquid separator 40 fully contains water (a state where the gas-liquid separator 40 is filled with water). FIG. 4 is a conceptual view in a state where the gas-liquid separator 40 is mostly filled with water but contains small amount of gas in an upper portion. FIG. 5 is a conceptual view in a state where the gas-liquid separator 40 has water in a lower portion provided with but contains relatively large amount of gas. FIG. 3 to FIG. 5 each indicate, with dots, a region provided with water.

[0071] The gas-liquid separator 40 separates gas from inflow water, and exhausts the separated gas to outside. Initially described is a reason why the gas-liquid separator 40 is provided.

[0072] Typically, water flows in the water circuit 30 but gas does not flow in the water circuit 30. However, for example, when the refrigeration cycle apparatus 100 is installed, air exists in the pipe W. In such a case, air may mix with water flowing in the pipe W. Also after the refrigeration cycle apparatus 100 is installed, air may enter the water circuit 30, or water may partially evaporate to generate vapor in the water circuit 30. The water circuit 30 is thus preferably provided with a mechanism configured to exhaust such gas from the water circuit 30. However, typically, the timing at which relatively large amount of air exists in the pipe W is only when the refrigeration cycle apparatus 100 is installed. As the amount of air entering the water circuit 30 or the amount of vapor generated in the water circuit 30 after installation of the refrigeration cycle apparatus 100 is not so large, such air or vapor is releasable only by providing an air vent valve on the pipe W.

[0073] The disclosing person of the present application has found that a large amount of gas (refrigerant gas) may flow into water if any partition wall between a refrigerant flow path and a water flow path is damaged in the first heat exchanger 20 and the refrigerant flows from the refrigerant circuit 10 into the water circuit 30. The refrigeration cycle apparatus 100 according to the present disclosure thus includes the gas-liquid separator 40 so as to easily trap the refrigerant in a case where a relatively large amount of gas flows into the water circuit 30. Furthermore, in the refrigeration cycle apparatus 100, the gas-liquid separator 40 connected to the water circuit 30 has following configuration so as to collectively exhaust a large amount of gas (refrigerant gas) from the water circuit 30 in the case where a relatively large amount of gas flows into the water circuit 30.

[0074] The gas-liquid separator 40 principally includes a body 41 having an internal space to receive water. The body 41 is a vertically extending tubular member having upper and lower closed ends. Examples of the body 41 include a vertically extending cylindrical member (container). However, the body 41 may have an appropriately selected shape not limited to the cylindrical shape.

[0075] The body 41 of the gas-liquid separator 40 is disposed in the casing 90 as depicted in FIG. 1. As depicted in FIG. 2, the body 41 is attached near an outlet 20a for water having exchanged heat with the refrigerant in the first heat exchanger 20. The body 41 may be fixed to an outer wall of the first heat exchanger 20. The body 41 may alternatively be attached to the second pipe W2, at a position distant from the first heat exchanger 20. Though not depicted, the body 41 may still alternatively be disposed outside the casing 90.

[0076] As depicted in FIG. 2, the body 41 is provided with an inlet port 42 allowing water to flow thereinto from the water circuit 30, and an outlet port 44 allowing water to flow out to the water circuit 30. The inlet port 42 is provided in an upper portion of the body 41. The inlet port 42 is exemplarily provided in a side wall of the body 41, at a position adjacent to a top of the body 41. The outlet port 44 is provided in a lower portion of the body 41. The outlet port 44 is exemplarily provided in a side wall of the body 41, at a position adjacent to a bottom of the body 41.

[0077] The inlet port 42 and the water outlet 20a of the first heat exchanger 20 are connected via the second pipe W2 as exemplarily depicted in FIG. 2. Alternatively, the inlet port 42 and the water outlet 20a of the first heat exchanger 20 may be directly connected to each other. As depicted in FIG. 2, the outlet port 44 is connected with the second pipe W2 connecting the outlet port 44 and the utilization facility 34.

[0078] The body 41 of the gas-liquid separator 40 is provided with a gas vent valve configured to discharge, from the gas-liquid separator 40, air flowing into the gas-liquid separator 40 (exhaust air to the atmosphere). The gas vent valve should not be limited in terms of its structure, but exemplarily includes, as principal configurations, a body, and a float-shaped valve body accommodated in the body. In a case where the body is filled with liquid, the valve body is pushed upward by the liquid to close an exhaust port provided in an upper portion of the body, in order to inhibit the liquid from flowing out of the exhaust port. In another case where gas flows into the valve body to lower a liquid level, the valve body descends to keep the exhaust port opened, to allow mainly gas to flow out of the exhaust port for the liquid.

[0079] A typical gas-liquid separator has only one gas vent valve provided at a top of the body of the gas-liquid separator.

[0080] In contrast, the gas-liquid separator 40 according to the present disclosure is provided with a plurality of gas vent valves. Specifically, as depicted in FIG. 2, the gas-liquid separator 40 is provided with the first gas vent valve 52 and the second gas vent valve 54. With the plurality of gas vent valves provided to the gas-liquid separator 40 in this case, even if the refrigerant flows into water in the first heat exchanger 20 and a relatively large amount of gas (gas refrigerant) flows into the gas-liquid separator 40 as described above, the gas will not flow out of the outlet port 44 along with water but can be exhausted to outside the gas-liquid separator 40.

[0081] In order to prevent the gas from flowing out of the outlet port 44 along with water when a relatively large amount of gas flows into the gas-liquid separator 40, the gas-liquid separator may include only one gas vent valve having a relatively large diameter and provided at the top of the body of the gas-liquid separator. However, as the gas vent valve in this configuration has a large exhaust port, there is a risk that water flows out of the largely opened exhaust port of the gas-liquid separator along with the gas even when only a relatively small amount of gas flows into the gas-liquid separator,. Furthermore, when the gas vent valve having a large diameter is provided at the top of the body of the gas-liquid separator, it may cause a problem that the size of body of the gas-liquid separator increases.

[0082] In the refrigeration cycle apparatus 100 according to the present disclosure, each of the first gas vent valve 52 and the second gas vent valve 54 are preferably configured to operate at different timing. Preferably, the first gas vent valve 52 may operate in a state where gas in the gas-liquid separator 40 has relatively small volume, and the second gas vent valve 54 may operate in a state where gas in the gas-liquid separator 40 has relatively increased volume. With such a configuration, it is possible to reduce the occurrence of a situation in which the two gas vent valves opens simultaneously when only a relatively small amount of gas flows into the gas-liquid separator and a relatively large amount of water flows out of the exhaust ports of the two gas vent valves along with the gas.

[0083] According to an embodiment achieving this configuration, the second gas vent valve 54 is disposed below the first gas vent valve 52 as depicted in FIG. 2. The first gas vent valve 52 is exemplarily disposed at the top of the body 41 of the gas-liquid separator 40 as depicted in FIG. 2. The second gas vent valve 54 is disposed at a side surface of the body 41 of the gas-liquid separator 40 as depicted in FIG. 2. In other words, a connecting portion J between the second gas vent valve 54 and the body 41 of the gas-liquid separator 40 is disposed on the side surface of the gas-liquid separator 40 as depicted in FIG. 2. The connecting portion J between the second gas vent valve 54 and the gas-liquid separator 40 is preferably disposed below the inlet port 42 of the body 41 as depicted in FIG. 2. The connecting portion J between the second gas vent valve 54 and the gas-liquid separator 40 is preferably disposed above the outlet port 44 of the body 41 as depicted in FIG. 2.

[0084] In such a configuration, each of the first gas vent valve 52 and the second gas vent valve 54 operates at different timing as follows.

[0085] In a state depicted in FIG. 3 where the inside of the body 41 is filled with only with water, neither the first gas vent valve 52 nor the second gas vent valve 54 is in operation. In other words, in the state of FIG. 3 where the inside of the body 41 is filled only with water, an exhaust port 52a (gas outlet) of the first gas vent valve 52 is closed by a valve body (not depicted), and exhaust port 54a (gas outlet) of the second gas vent valve 54 is also closed by a valve body (not depicted).

[0086] When a small amount of gas subsequently flows into the body 41 and the gas exists in the upper portion of the body 41 as depicted in FIG. 4, the first gas vent valve 52 operates whereas the second gas vent valve 54 does not operate. In other words, in the state depicted in FIG. 4, the exhaust port 52a of the first gas vent valve 52 is opened and the exhaust port 54a of the second gas vent valve 54 is closed by the valve body (not depicted). As a result, the gas existing in the upper portion of the body 41 is exhausted from the exhaust port 52a of the first gas vent valve 52.

[0087] When gas flows into the body 41 and a relatively large amount of gas exists in the body 41 as depicted in FIG. 5, both the first gas vent valve 52 and the second gas vent valve 54 operate. In other words, in the state depicted in FIG. 5, the exhaust port 52a of the first gas vent valve 52 and the exhaust port 54a of the second gas vent valve 54 are opened. As a result, the gas existing in the upper portion of the body 41 is exhausted from the exhaust port 52a of the first gas vent valve 52 and the exhaust port 54a of the second gas vent valve 54.

[0088] Specifically, the second gas vent valve 54 operates when the amount of gas in the body 41 of the gas-liquid separator 40 exceeds first amount V (see FIG. 5), to communicate the inside of the body 41 of the gas-liquid separator 40 and outside of the body 41 of the gas-liquid separator 40 with each other. In other words, the second gas vent valve 54 operates when a liquid level in the body 41 of the gas-liquid separator 40 reaches a position lower than an upper end 54c of an inlet 54b (an opening disposed at the connecting portion J between the second gas vent valve 54 and the body 41 of the gas-liquid separator 40) of the second gas vent valve 54, to allow inside and outside the body 41 of the gas-liquid separator 40 to communicate with each other (see FIG. 5). In contrast, the first gas vent valve 52 operates before the amount of the gas in the body 41 of the gas-liquid separator 40 exceeds the first amount V, to allow inside and outside the body 41 of the gas-liquid separator 40 to communicate with each other.

[0089] The state (depicted in FIG. 4) where only the first gas vent valve 52 operates and the second gas vent valve 54 does not operate occurs when the volume of gas in the body 41 of the gas-liquid separator 40 is small. In this state, the first gas vent valve 52 exhausts only a small amount of gas. In contrast, the state (depicted in FIG. 5) where the first gas vent valve 52 and the second gas vent valve 54 operate occurs when the volume of the gas in the body 41 of the gas-liquid separator 40 is large. The first gas vent valve 52 and the second gas vent valve 54 preferably exhaust a relatively large amount of gas in this state. Accordingly, the second gas vent valve 54 preferably has a diameter D2 larger than a diameter D1 of the first gas vent valve 52. In other words, the second gas vent valve 54 has a fluid passage preferably larger in sectional area than a fluid passage of the first gas vent valve 52.

[0090] Gas exhausted from the exhaust port 54a of the second gas vent valve 54 is highly possibly a gas refrigerant in this case. The gas exhausted from the exhaust port 54a of the second gas vent valve 54 is thus preferably exhausted not into the casing 90 but outdoors. More preferably, the gas exhausted from the exhaust port 52a of the first gas vent valve 52 is also exhausted not into the casing 90 but outdoors. Such a configuration inhibits a high concentration of the refrigerant in the casing 90 when the refrigerant flows into the body 41 of the gas-liquid separator 40.

[0091] To achieve this, in an exemplary case where the casing 90 is disposed outdoors, the second gas vent valve 54 attached to the gas-liquid separator 40 may be disposed outside the casing 90. Further, in the exemplary case where the casing 90 is disposed outdoors, the first gas vent valve 52 attached to the gas-liquid separator 40 may be disposed outside the casing 90.

[0092] According to a different aspect as depicted in FIG. 1, the second exhaust pipe 59 may be connected to the exhaust port 54a of the second gas vent valve 54, and has an exhaust end 59a that allows exhaust of gas having passed through the second exhaust pipe 59 and may be disposed outdoors. Further, as depicted in FIG. 1, the first exhaust pipe 58 may be connected to the exhaust port 52a of the first gas vent valve 52, and has an exhaust end 58a that allows exhaust of gas having passed through the first exhaust pipe 58 and may be disposed outdoors.

[0093] Though not basically aiming to release gas as a principal object, the pressure relief valve 56 is provided to release water in the body 41 of the gas-liquid separator 40 to outside when the water circuit 30 has high pressure exceeding a predetermined pressure value. For example, the pressure relief valve 56 is provided at the top of the body 41 of the gas-liquid separator 40, though not being limited in terms of its installed position. If a gas refrigerant flows into the body 41 of the gas-liquid separator 40 and pressure in the body 41 increases, the pressure relief valve 56 also exhausts the gas refrigerant to outside the gas-liquid separator 40, which is likely to inhibit a defective flow of the gas refrigerant into the utilization facility 34 via the second pipe W2.

(3) Characteristics

[0094] (3-1)

The refrigeration cycle apparatus 100 includes the refrigerant circuit 10, the water circuit 30, the gas-liquid separator 40, the first gas vent valve 52, and the second gas vent valve 54. The refrigerant circuit 10 includes the compressor 12 configured to compress the refrigerant, and the first heat exchanger 20 configured to exchange heat between the refrigerant and water, and the compressor 12 and the first heat exchanger 20 are connected via the pipe P. In the water circuit 30, the water having exchanged heat with the refrigerant in the first heat exchanger 20 flows. The gas-liquid separator 40 is connected to the water circuit 30. The first gas vent valve 52 and the second gas vent valve 54 are attached to the gas-liquid separator 40 and are each configured to vent air from the gas-liquid separator 40.

[0095] The refrigeration cycle apparatus 100 includes the gas-liquid separator 40 in order to easily trap the refrigerant. Furthermore, as the gas-liquid separator 40 includes the two gas vent valves 52 and 54, the amount of the refrigerant exhausted to outside the water circuit 30 is unlikely to be insufficient even when a relatively large number of refrigerant enters the water.

[0096] (3-2)

In the refrigeration cycle apparatus 100, the second gas vent valve 54 operates, when the gas in the gas-liquid separator 40 exceeds the first amount V, to communicate inside of the gas-liquid separator 40 and outside of the gas-liquid separator 40. The first gas vent valve 52 operates, before the gas in the gas-liquid separator 40 exceeds the first amount V, to communicate inside of the gas-liquid separator 40 and outside of the gas-liquid separator 40.

[0097] In the refrigeration cycle apparatus 100, when gas flowing into the gas-liquid separator 40 increases, the second gas vent valve 54 operates to exhaust the gas to outside the gas-liquid separator 40. Therefore, the amount of the refrigerant exhausted to outside the water circuit 30 is unlikely to be insufficient even when a relatively large amount of refrigerant enters the water.

[0098] (3-3)

In the refrigeration cycle apparatus 100, the diameter D2 of the second gas vent valve 54 is larger than the diameter D1 of the first gas vent valve 52.

[0099] In the refrigeration cycle apparatus 100, the gas-liquid separator 40 includes, in addition to the first gas vent valve 52, the second gas vent valve 54 having the diameter D2 larger than the diameter of the first gas vent valve 52, to quickly exhaust the refrigerant to outside the water circuit 30 even when a relatively large amount of refrigerant enters the water.

[0100] (3-4)

In the refrigeration cycle apparatus 100, the second gas vent valve 54 is disposed below the first gas vent valve 52.

[0101] In the refrigeration cycle apparatus 100, when gas flowing into the gas-liquid separator 40 increases to lower a water level in the gas-liquid separator 40, the second gas vent valve 54 operates to exhaust the gas to outside the gas-liquid separator 40. Therefore, in the refrigeration cycle apparatus 100 thus configured, the amount of refrigerant exhausted to outside the water circuit 30 is unlikely to be insufficient even when a relatively large amount of refrigerant enters the water.

[0102] (3-5)

In the refrigeration cycle apparatus 100, the gas-liquid separator 40 has the inlet port 42 allowing inflow of water from the water circuit 30, and the outlet port 44 allowing outflow of water to the water circuit 30. The connecting portion J at which the second gas vent valve 54 and the gas-liquid separator 40 is connected is disposed below the inlet port 42.

[0103] In the refrigeration cycle apparatus 100, the second gas vent valve 54 does not operate while the liquid level in the gas-liquid separator 40 is high, to inhibit outflow of water from the second gas vent valve 54 along with water.

[0104] (3-6)

In the refrigeration cycle apparatus 100, the connecting portion J at which the second gas vent valve 54 and the gas-liquid separator 40 is connected is disposed above the outlet port 44.

[0105] The refrigeration cycle apparatus 100 causes gas flow out via the second gas vent valve 54 before the liquid level descends to the outlet port 44, to inhibit the refrigerant from mixing with water flowing out of the outlet port 44.

[0106] (3-7)

In the refrigeration cycle apparatus 100, the gas-liquid separator 40 is disposed in the casing 90. The casing 90 is disposed outdoors.

[0107] In the refrigeration cycle apparatus 100, as the casing 90 accommodating the gas-liquid separator 40 is disposed outdoors, it is likely to inhibit the refrigerant exhausted through the gas vent valves 52 and 54 from being stagnant at a high concentration around the casing 90.

[0108] (3-8)

The refrigeration cycle apparatus 100 includes the first exhaust pipe 58 connected to the exhaust port 52a of the first gas vent valve 52. The first exhaust pipe 58 has the exhaust end 58a that allows exhaust of gas having passed through the first exhaust pipe 58. The exhaust end 58a of the first exhaust pipe 58 is disposed outdoors.

[0109] In the refrigeration cycle apparatus 100, the exhaust end 58a of the first exhaust pipe 58 is disposed outdoors, to inhibit the refrigerant exhausted through the first gas vent valve 52 from being retained at a high concentration in the casing 90.

[0110] Even in a case where the casing 90 is disposed indoors, when the exhaust end 58a of the first exhaust pipe 58 allowing exhaust of gas having passed through the first exhaust pipe 58 is disposed outdoors, the refrigerant is inhibited from being retained at a high concentration in and around the casing 90.

[0111] (3-9)

The refrigeration cycle apparatus 100 includes the second exhaust pipe 59 connected to the exhaust port 54a of the second gas vent valve 54. The second exhaust pipe 59 has the exhaust end 59a that allows exhaust of gas having passed through the second exhaust pipe 59. The exhaust end 59a of the second exhaust pipe 59 is disposed outdoors.

[0112] In the refrigeration cycle apparatus 100, the exhaust end 59a of the second exhaust pipe 59 is disposed outdoors, to inhibit the refrigerant exhausted through the second gas vent valve 54 from being retained at a high concentration in the casing 90.

[0113] Even in the case where the casing 90 is disposed indoors, when the exhaust end 59a of the second exhaust pipe 59 allowing exhaust of gas having passed through the second exhaust pipe 59 is disposed outdoors, the refrigerant is inhibited from being retained at a high concentration in and around the casing 90

[0114] (3-10)

The refrigeration cycle apparatus 100 includes the utilization facility 34 connected to the water circuit 30 and configured to utilize heat of water. The gas-liquid separator 40 is disposed downstream of the first heat exchanger 20 and upstream of the utilization facility 34 in the water flow direction in the water circuit 30.

[0115] In the refrigeration cycle apparatus 100, even when the refrigerant enters water in the first heat exchanger 20, the refrigerant is inhibited from being sent to the utilization facility 34.

[0116] (3-11)

The refrigeration cycle apparatus 100 includes the pressure relief valve 56 attached to the gas-liquid separator 40.

[0117] The refrigeration cycle apparatus 100 inhibits high pressure in the gas-liquid separator 40.

(4) Modification examples

[0118] Modification examples of the above embodiment will be described hereinafter. Any of the following modification examples may be combined to be applied within a range having no contradiction.

(4-1) Modification example A

[0119] The casing 90 accommodates the refrigerant circuit 10, the pump 32, and the gas-liquid separator 40 in the above embodiment. However, the configuration of the refrigeration cycle apparatus 100 is not limited to this configuration. At least one of the refrigerant circuit 10, the pump 32, and the gas-liquid separator 40 may alternatively be disposed outside the casing 90.

(4-2) Modification example B

[0120] In the above embodiment, the second gas vent valve 54 is disposed below the first gas vent valve 52 such that each of the first gas vent valve 52 and the second gas vent valve 54 operates at different timing.

[0121] However, the configuration for allowing each of the two gas vent valves to operate at different timing is not limited to such an aspect.

[0122] For example, the two gas vent valves may be disposed at identical height, and the body 41 of the gas-liquid separator 40 may be provided with a device 46 (such as a level sensor or a level switch depicted by broken lines in FIG. 2) configured to detect a water level in the body 41. Each of the two gas vent valves can operate at different timing in an exemplary case where one of the gas vent valves is configured as described in the above embodiment and the other one of the gas vent valves is an electromagnetic valve controlled by the controller 80 to open when the water level detected by the device 46 is lower than predetermined height. Also in such a configuration, only one of the gas vent valves can operate in the state where the volume of gas in the gas-liquid separator 40 is relatively small, and gas can be exhausted to outside the body 41 via the exhaust ports of the two gas vent valves when a relatively large amount of gas (gas refrigerant) flows into the body 41 of the gas-liquid separator 40.

(4-3) Modification example C

[0123] The refrigeration cycle apparatus 100 according to the above embodiment includes the two gas vent valves. The refrigeration cycle apparatus 100 may alternatively include three or more gas vent valves.

<Supplementary note>

[0124] The embodiment and the modification examples of the present disclosure have been described above. Various modifications to modes and details will be available without departing from the object and the scope of the present disclosure recited in the claims.

INDUSTRIAL APPLICABILITY

[0125] The present disclosure is applicable widely and usefully to a refrigeration cycle apparatus including a refrigerant circuit and a water circuit.

REFERENCE SIGNS LIST

[0126]

10: refrigerant circuit
12: compressor
20: first heat exchanger
30: water circuit
34: utilization facility
40: gas-liquid separator
42: inlet port
44: outlet port
52: first gas vent valve
52a: exhaust port
54: second gas vent valve
54a: exhaust port
56: pressure relief valve
58: first exhaust pipe
58a: exhaust end
59: second exhaust pipe
59a: exhaust end
90: casing
100: refrigeration cycle apparatus
D1: diameter of first gas vent valve
D2: diameter of second gas vent valve
J: connecting portion
P: pipe
V: first amount

CITATION LIST

PATENT LITERATURE

[0127] [Patent Literature 1] Japanese Unexamined Patent Publication No. 2016-95130

Claims

1. A refrigeration cycle apparatus (100) comprising:

a refrigerant circuit (10) connecting, via a pipe (P), a compressor (12) configured to compress a refrigerant and a first heat exchanger (20) configured to exchange heat between the refrigerant and water;
a water circuit (30) in which the water having exchanged heat with the refrigerant in the first heat exchanger (20) is configured to flow;
a gas-liquid separator (40) connected to the water circuit; and
a first gas vent valve (52) and a second gas vent valve (54) attached to the gas-liquid separator and configured to vent air from the gas-liquid separator.

2. The refrigeration cycle apparatus according to claim 1, wherein

the second gas vent valve operates, when gas in the gas-liquid separator exceeds first volume (V), to communicate inside of the gas-liquid separator and outside of the gas-liquid separator, and
the first gas vent valve operates, before the gas in the gas-liquid separator exceeds the first vol-

ume, to communicate inside of the gas-liquid separator and outside of the gas-liquid separator.

3. The refrigeration cycle apparatus according to claim 1 or 2, wherein
the second gas vent valve has a diameter (D2) larger than a diameter (D1) of the first gas vent valve.

4. The refrigeration cycle apparatus according to any one of claims 1 to 3, wherein
the second gas vent valve is disposed below the first gas vent valve.

5. The refrigeration cycle apparatus according to claim 4, wherein

the gas-liquid separator has an inlet port (42) allowing the water to flow thereinto from the water circuit, and an outlet port (44) allowing the water to flow out to the water circuit, and
a connecting portion (J) at which the second gas vent valve and the gas-liquid separator is connected is disposed below the inlet port.

6. The refrigeration cycle apparatus according to claim 5, wherein
the connecting portion at which the second gas vent valve and the gas-liquid separator is connected is disposed above the outlet port.

7. The refrigeration cycle apparatus according to any one of claims 1 to 6, wherein

the gas-liquid separator is disposed in a casing (90), and
the casing is disposed outdoors.

8. The refrigeration cycle apparatus according to any one of claims 1 to 7, further comprising

a first exhaust pipe (58) connected to an exhaust port (52a) of the first gas vent valve,
wherein
the first exhaust pipe has an exhaust end (58a) that allows exhaust of gas having passed through the first exhaust pipe, and
the exhaust end of the first exhaust pipe is disposed outdoors.

9. The refrigeration cycle apparatus according to any one of claims 1 to 8, further comprising

a second exhaust pipe (59) connected to an exhaust port (54a) of the second gas vent valve,
wherein
the second exhaust pipe has an exhaust end (59a) that allows exhaust of gas having passed through the second exhaust pipe, and
the exhaust end of the second exhaust pipe is disposed outdoors.

10. The refrigeration cycle apparatus according to any one of claims 1 to 9, further comprising

a utilization facility (34) connected to the water circuit and configured to utilize heat of the water, wherein
the gas-liquid separator is disposed downstream of the first heat exchanger and upstream of the utilization facility in a flow direction of the water in the water circuit.

11. The refrigeration cycle apparatus according to any one of claims 1 to 10, further comprising
a pressure relief valve (56) attached to the gas-liquid separator.

Amended claims in accordance with Rule 137(2) EPC.

1. A refrigeration cycle apparatus (100) comprising:

a refrigerant circuit (10) connecting, via a pipe (P), a compressor (12) configured to compress a refrigerant and a first heat exchanger (20) configured to exchange heat between the refrigerant and water;
a water circuit (30) in which the water having exchanged heat with the refrigerant in the first heat exchanger (20) is configured to flow;
a gas-liquid separator (40) connected to the water circuit; and
a first gas vent valve (52) attached to the gas-liquid separator and configured to vent air from the gas-liquid separator **characterized in that** the refrigeration cycle apparatus (100) further comprises a second gas vent valve (54) attached to the gas-liquid separator and configured to vent air from the gas-liquid separator.

2. The refrigeration cycle apparatus according to claim 1, wherein

the second gas vent valve operates, when gas in the gas-liquid separator exceeds first volume (V), to communicate inside of the gas-liquid separator and outside of the gas-liquid separator, and
the first gas vent valve operates, before the gas in the gas-liquid separator exceeds the first volume, to communicate inside of the gas-liquid separator and outside of the gas-liquid separator.

3. The refrigeration cycle apparatus according to claim 1 or 2, wherein
the second gas vent valve has a diameter (D2) larger than a diameter (D1) of the first gas vent valve.

4. The refrigeration cycle apparatus according to any one of claims 1 to 3, wherein
the second gas vent valve is disposed below the first gas vent valve.

5. The refrigeration cycle apparatus according to claim 4, wherein

the gas-liquid separator has an inlet port (42) allowing the water to flow thereinto from the water circuit, and an outlet port (44) allowing the water to flow out to the water circuit, and
a connecting portion (J) at which the second gas vent valve and the gas-liquid separator is connected is disposed below the inlet port.

6. The refrigeration cycle apparatus according to claim 5, wherein
the connecting portion at which the second gas vent valve and the gas-liquid separator is connected is disposed above the outlet port.

7. The refrigeration cycle apparatus according to any one of claims 1 to 6, wherein

the gas-liquid separator is disposed in a casing (90), and
the casing is disposed outdoors.

8. The refrigeration cycle apparatus according to any one of claims 1 to 7, further comprising

a first exhaust pipe (58) connected to an exhaust port (52a) of the first gas vent valve, wherein
the first exhaust pipe has an exhaust end (58a) that allows exhaust of gas having passed through the first exhaust pipe, and
the exhaust end of the first exhaust pipe is disposed outdoors.

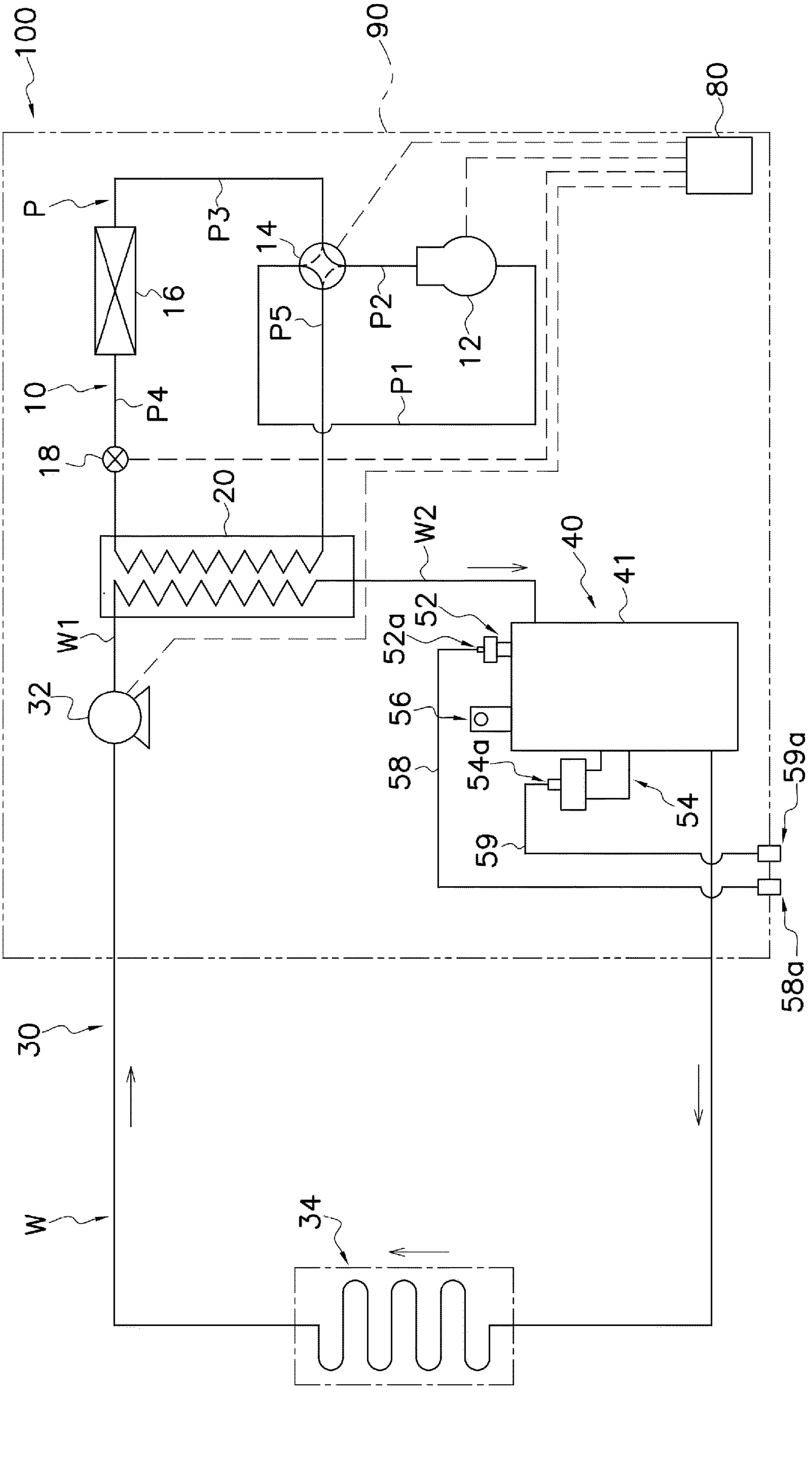
9. The refrigeration cycle apparatus according to any one of claims 1 to 8, further comprising

a second exhaust pipe (59) connected to an exhaust port (54a) of the second gas vent valve, wherein
the second exhaust pipe has an exhaust end (59a) that allows exhaust of gas having passed through the second exhaust pipe, and
the exhaust end of the second exhaust pipe is disposed outdoors.

10. The refrigeration cycle apparatus according to any one of claims 1 to 9, further comprising

a utilization facility (34) connected to the water circuit and configured to utilize heat of the water, wherein
the gas-liquid separator is disposed downstream of the first heat exchanger and upstream of the utilization facility in a flow direction of the water in the water circuit.

11. The refrigeration cycle apparatus according to any one of claims 1 to 10, further comprising
a pressure relief valve (56) attached to the gas-liquid separator.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P5
P2
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P1
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P4
18
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W2
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W1
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54a
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59a
58a
30
W
34

FIG. 1

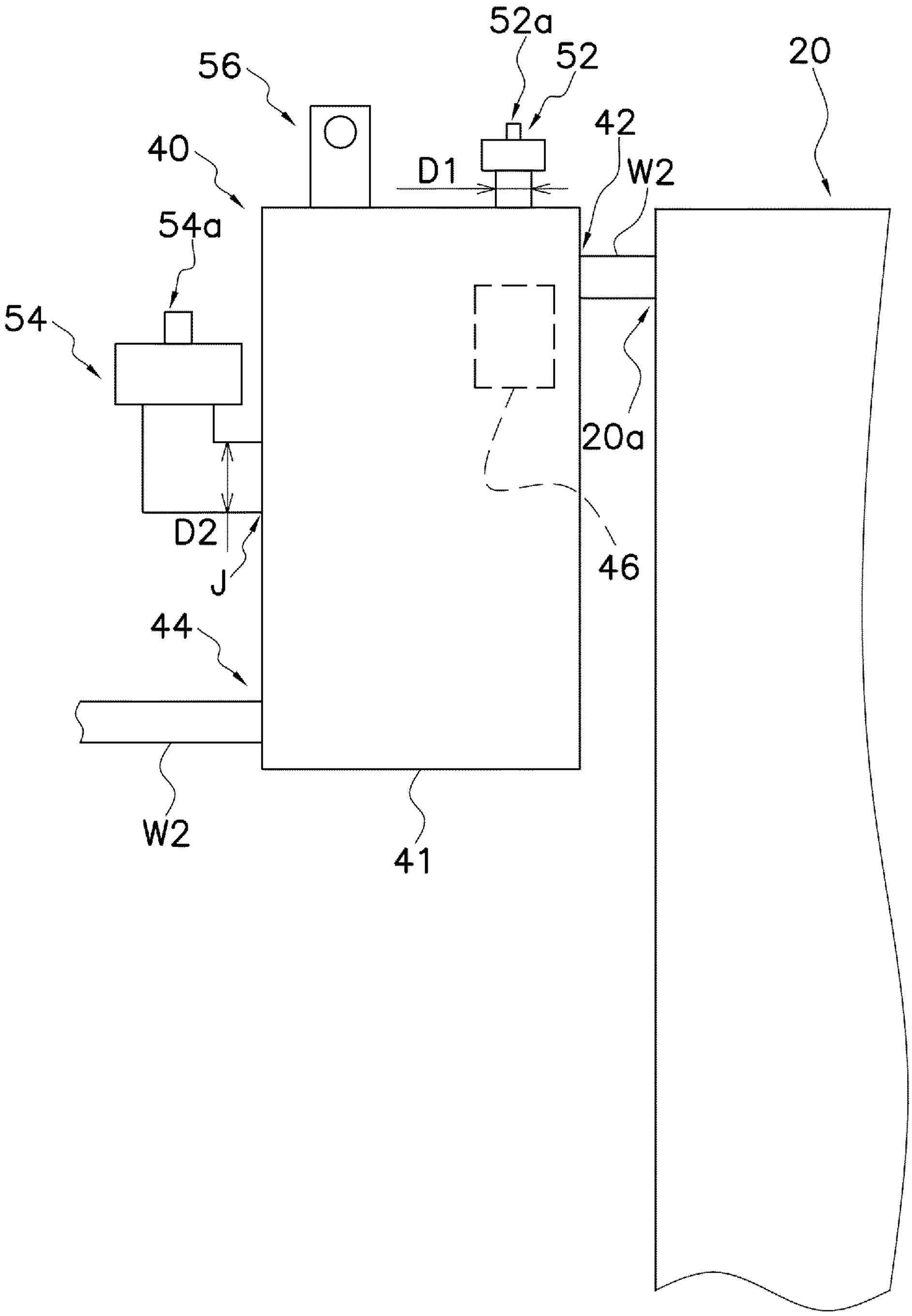

FIG. 2

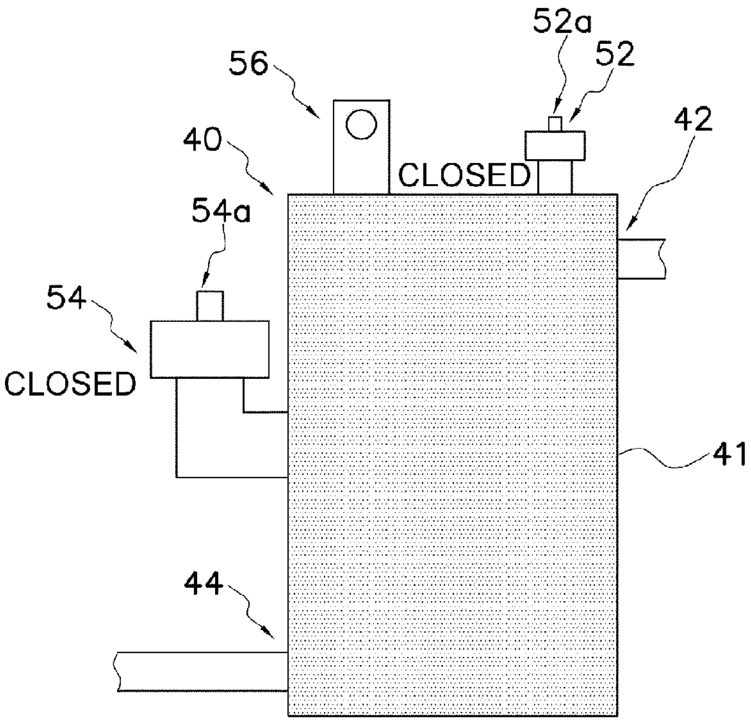
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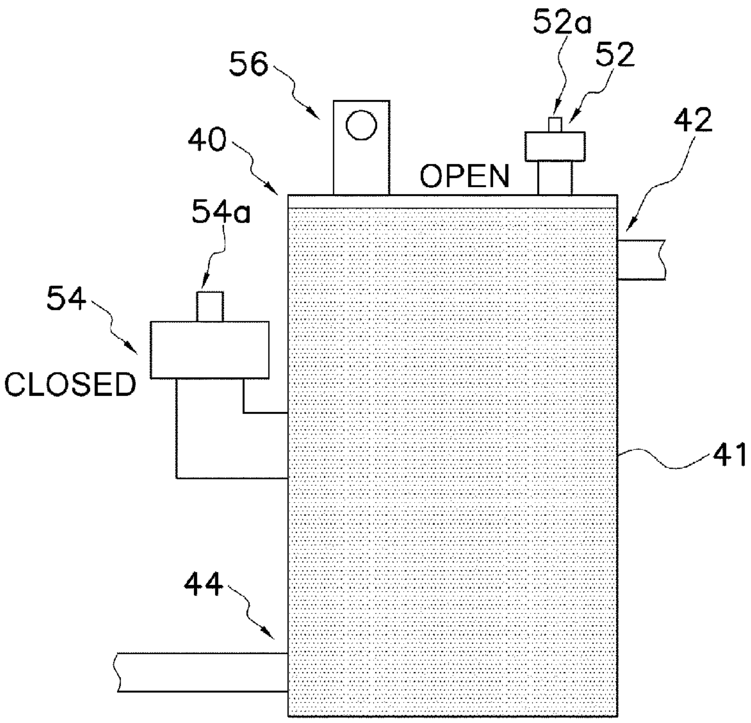
FIG. 3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41
44

FIG. 4

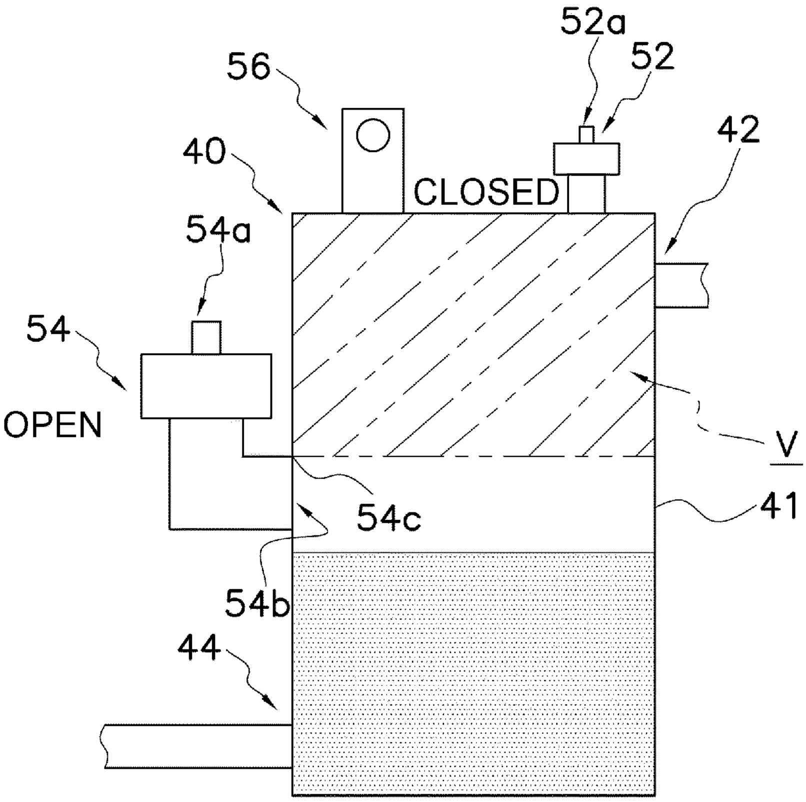

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 22 21 3769

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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			TECHNICAL FIELDS SEARCHED (IPC)
			F24D

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	22 May 2023	Arndt, Markus

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

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22-05-2023

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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