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(54) **AIR CONDITIONING DEVICE**

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• **SAIKUSA, Tetsuji**

Tokyo 100-8310 (JP)

• **KADOWAKI, Kimitaka**

Tokyo 100-8310 (JP)

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(74) Representative: **Pfenning, Meinig & Partner mbB**

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Theresienhöhe 11a

80339 München (DE)

(73) Proprietor: **Mitsubishi Electric Corporation**

Chiyoda-ku

Tokyo 100-8310 (JP)

(56) References cited:

EP-A1- 1 143 209

WO-A1-2013/038577

WO-A1-2014/132378

JP-A- 2002 115 939

JP-A- 2006 003 079

JP-A- 2007 163 071

JP-A- 2013 137 141

JP-A- 2013 167 398

JP-A- 2013 167 398

JP-A- H1 183 086

US-A1- 2011 302 941

(72) Inventors:

• **TSUJI, Yusuke**

Tokyo 100-8310 (JP)

• **OBAYASHI, Tomoyoshi**

Tokyo 100-8310 (JP)

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EP 3 587 947 B1

Description

Technical Field

[0001] The present invention relates to an air-conditioning apparatus including a refrigerant-heat medium heat exchanger that causes heat exchange to be performed between refrigerant and a heat medium.

Background Art

[0002] In known existing air-conditioning apparatuses, a refrigerant-heat medium heat exchanger causes heat exchange to be performed between refrigerant flowing in a refrigerant circuit and a heat medium flowing in a heat medium circuit. Patent Literature 1 discloses an air-conditioning apparatus which includes a primary circuit located on a heat source side and a secondary circuit located on an indoor side. According to Patent Literature 1, a main heat exchanger causes heat exchange to be performed between refrigerant flowing in the primary circuit and a heat medium flowing in the secondary circuit. In such a manner, in Patent Literature 1, refrigerant is not made to flow into the secondary circuit, to thereby reduce the inflow of the refrigerant to a pipe located on the indoor side.

[0003] JP 2013 167398 A discloses an outdoor unit that constitute a heat pump cycle device. A pressure relief valve and an air vent valve are installed in the outdoor unit outside, so usually, the refrigerant circuit side and the water circuit In the water heat exchanger which is separated from the side, the separation is broken, etc., and the flammable refrigerant from the refrigerant circuit to the water circuit side (R32, HFO, R290, R1270) When the refrigerant is mixed, the refrigerant can be discharged to the outside through the pressure relief valve and the air vent valve without flowing the refrigerant into the indoor side through the water circuit, and the refrigerant burns indoors.

[0004] EP 1143209 A1 discloses a bridge circuit having four check valves is provided upstream of a receiver, which is provided upstream of an expansion valve. A gas vent pipe for connecting the receiver and a pipe downstream of the expansion valve to each other is provided, and the gas vent pipe is provided with a gas vent valve.

[0005] JP 2002 115939 A discloses a heat pump system comprising a sensor for detecting the leakage of a refrigerant in a frame of an outdoor machine, a damper openable only at the outside of the frame to exhaust a leaking refrigerant, a reversible blower fan for an air heat exchanger and a controller for controlling them.

Citation List

Patent Literature

[0006] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2000-130877

Summary of Invention

Technical Problem

[0007] In the air-conditioning apparatus disclosed in Patent Literature 1, in the case where a main heat exchanger is provided in a heat source unit or the like that is provided outdoors, there is a risk that the main heat exchanger may freeze. If the main heat exchanger ruptures due to freezing, this can cause refrigerant to pass through the main heat exchanger, and flow into the secondary circuit and into a pipe located in an indoor side.

[0008] The present invention has been made to solve the above problem, and an object of the invention is to provide an air-conditioning apparatus that reduces, even if refrigerant enters a heat medium circuit, the inflow of the refrigerant to a heat medium pipe located on an indoor side.

Solution to Problem

[0009] The present invention is as defined in the appended set of claims. Embodiments 13 and 14 of the description described below are not part of the invention, but are only examples for further understanding the invention. An air-conditioning apparatus according to an embodiment of the present invention is defined in claim 1.

Advantageous Effects of Invention

[0010] According to an embodiment of the present invention, refrigerant and a heat medium are separated from each other by the separating unit disposed outside the space to be air-conditioned, and the refrigerant is discharged to the outside of the space to be air-conditioned by the discharge unit. Therefore, even if refrigerant enters the heat medium circuit, it is discharged to the outside of the space to be air-conditioned via the separating unit and the discharge unit. It is therefore possible to reduce the inflow of refrigerant to indoor part of the heat medium pipe that is located on an indoor side.

Brief Description of Drawings

[0011]

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

[Fig. 2] Fig. 2 is a schematic view illustrating a separating unit 4 in embodiment 1 of the present invention.

[Fig. 3] Fig. 3 is a graph illustrating a relationship between a bubble diameter and a bubble rising velocity in embodiment 1 of the present invention.

[Fig. 4] Fig. 4 is a graph illustrating a relationship between a water flow velocity and a discharge rate / an inflow rate in embodiment 1 of the present in-

vention.

[Fig. 5] Fig. 5 is a schematic view illustrating a separating unit 4a in a first modification of embodiment 1 of the present invention.

[Fig. 6] Fig. 6 is a schematic view illustrating a separating unit 4b in a second modification of embodiment 1 of the present invention.

[Fig. 7] Fig. 7 is a schematic view illustrating a separating unit 4c in a third modification of embodiment 1 of the present invention.

[Fig. 8] Fig. 8 is a schematic view illustrating a separating unit 4d in a fourth modification of embodiment 1 of the present invention.

[Fig. 9] Fig. 9 is a circuit diagram illustrating an air-conditioning apparatus 100 according to embodiment 2 of the present invention.

[Fig. 10] Fig. 10 is a circuit diagram illustrating an air-conditioning apparatus 100a according to a first modification of embodiment 2 of the present invention.

[Fig. 11] Fig. 11 is a circuit diagram illustrating an air-conditioning apparatus 100b according to a second modification of embodiment 2 of the present invention.

[Fig. 12] Fig. 12 is a circuit diagram illustrating an air-conditioning apparatus 200 according to embodiment 3 of the present invention.

[Fig. 13] Fig. 13 is a circuit diagram illustrating an air-conditioning apparatus 300 according to embodiment 4 of the present invention.

[Fig. 14] Fig. 14 is a circuit diagram illustrating an air-conditioning apparatus 400 according to embodiment 5 of the present invention.

[Fig. 15] Fig. 15 is a graph illustrating a relationship between the pressure of refrigerant and the saturation temperature of refrigerant in embodiment 5 of the present invention.

[Fig. 16] Fig. 16 is a circuit diagram illustrating an air-conditioning apparatus 600 according to embodiment 7 of the present invention.

[Fig. 17] Fig. 17 is a circuit diagram illustrating an air-conditioning apparatus 700 according to embodiment 8 of the present invention.

[Fig. 18] Fig. 18 is a circuit diagram illustrating an air-conditioning apparatus 800 according to embodiment 9 of the present invention.

[Fig. 19] Fig. 19 is a circuit diagram illustrating an air-conditioning apparatus 900 according to embodiment 10 of the present invention.

[Fig. 20] Fig. 20 is a circuit diagram illustrating an air-conditioning apparatus 1000 according to embodiment 11 of the present invention.

[Fig. 21] Fig. 21 is a circuit diagram illustrating an air-conditioning apparatus 1100 according to embodiment 12 of the present invention.

[Fig. 22] Fig. 22 is a circuit diagram illustrating an air-conditioning apparatus 1200 according to embodiment 13 of the present invention.

[Fig. 23] Fig. 23 is a schematic view illustrating a sub-separating unit 13 in embodiment 14 of the present invention.

[Fig. 24] Fig. 24 is a schematic view illustrating a sub-separating unit 13a in a modification of embodiment 14 of the present invention.

Description of embodiments

Embodiment 1

[0012] Embodiments of an air-conditioning apparatus according to the present invention will be described with reference to the drawings. Fig. 1 is a circuit diagram illustrating an air-conditioning apparatus 1 according to embodiment 1 of the present invention. The air-conditioning apparatus 1 will be described with reference to Fig. 1. As illustrated in Fig. 1, the air-conditioning apparatus 1 includes a refrigerant circuit 2, a heat medium circuit 3, a separating unit 4 and a discharge unit 5.

(Refrigerant Circuit 2)

[0013] In the refrigerant circuit 2, a compressor 22, a flow switching device 23, a heat-source-side heat exchanger 24, an expansion unit 25 and a refrigerant-heat medium heat exchanger 26 are connected by a refrigerant pipe 21, whereby refrigerant is circulated. The compressor 22, the flow switching device 23, the heat-source-side heat exchanger 24, the expansion unit 25 and the refrigerant-heat medium heat exchanger 26 are incorporated in a heat source unit 20. Refrigerant that flows in the refrigerant circuit 2 may be R410A or R407C, may be a slightly flammable refrigerant such as R1234yf, R1234ze, R32 or R290, or may be a natural refrigerant such as CO₂. Embodiment 1 will be described by referring to by way of example the case where the heat source unit 20 is an air-cooled device to be installed on an outdoor side. The air-cooled unit is a device in which the heat-source-side heat exchanger 24 causes heat exchange to be performed between refrigerant and outdoor air. The heat source unit 20 may be a water-cooled device to be installed on an indoor side. The water-cooled device is a device in which the heat-source-side heat exchanger 24 causes heat exchange to be performed between refrigerant and water.

(Compressor 22 and Flow Switching Device 23)

[0014] The compressor 22 is a device that sucks low-temperature, low-pressure refrigerant, compresses the sucked refrigerant into a high-temperature, high-pressure refrigerant, and discharges the high-temperature, high-pressure refrigerant. The compressor 22 is, for example, an inverter compressor whose capacity can be controlled. The flow switching device 23 changes the flow direction of refrigerant in the refrigerant circuit 2 in a switching manner. To be more specific, the flow switching

device 23 is, for example, a four-way valve. The flow switching device 23 changes the flow direction of the refrigerant discharged from the compressor 22 to cause the refrigerant to flow to the refrigerant-heat medium heat exchanger 26 (solid line in Fig. 1) or flow to the heat-source-side heat exchanger 24 (dashed line in Fig. 1). Thereby, both a heating operation and a cooling operation can be performed. In the case where only one of the heating operation and the cooling operation is performed, the flow switching device 23 may be omitted.

(Heat-Source-Side Heat Exchanger 24 and Expansion Unit 25)

[0015] The heat-source-side heat exchanger 24 is a device connected between the flow switching device 23 and the expansion unit 25 to cause heat exchange to be performed between, for example, outdoor air and refrigerant. The heat-source-side heat exchanger 24 operates as an evaporator in the heating operation, and operates as a condenser in the cooling operation. The heat source unit 20 may be provided with a heat-source-side fan that sends outdoor air to the heat-source-side heat exchanger 24. The expansion unit 25 is a pressure reducing valve or an expansion valve, which is connected between the heat-source-side heat exchanger 24 and the refrigerant-heat medium heat exchanger 26 to reduce the pressure of refrigerant, thereby expanding the refrigerant. The expansion unit 25 is, for example, an electronic expansion valve whose opening degree can be adjusted.

(Refrigerant-Heat Medium Heat Exchanger 26)

[0016] The refrigerant-heat medium heat exchanger 26 is connected between the expansion unit 25 and the flow switching device 23. The refrigerant-heat medium heat exchanger 26 causes heat exchange to be performed between the refrigerant flowing in the refrigerant circuit 2 and the heat medium flowing in the heat medium circuit 3. In the refrigerant-heat medium heat exchanger 26, the flow of the refrigerant and the flow of the heat medium are, for example, counter flows.

(Heat Medium Circuit 3)

[0017] In the heat medium circuit 3, a pump 32, the refrigerant-heat medium heat exchanger 26 and a load-side heat exchanger 33 are connected by a heat medium pipe 31, whereby a heat medium is circulated. As the heat medium to be circulated in the heat medium circuit 3, for example, water or brine can be used. The heat medium circuit 3 is provided with an air vent valve 34.

(Pump 32, Load-Side Heat Exchanger 33 and Air Vent Valve 34)

[0018] The pump 32 is a device provided on the outdoor side and upstream of the refrigerant-heat medium

heat exchanger 26 to transfer a heat medium. The load-side heat exchanger 33 is a device provided on the indoor side and downstream of the refrigerant-heat medium heat exchanger 26 to cause heat exchange to be performed between, for example, indoor air and the heat medium. The load-side heat exchanger 33 operates as a condenser in the heating operation, and operates as an evaporator in the cooling operation. The load-side heat exchanger 33 is incorporated in a cooling and heating device 30. A heating operation or cooling operation of the cooling and heating device 30 is carried out by heat exchange performed by the load-side heat exchanger 33. The air vent valve 34 is a valve provided downstream of the load-side heat exchanger 33 to vent air that has mixed into the heat medium flowing in the heat medium circuit 3. It should be noted that the indoor side means the living space of a house or the indoor space in a public place. In embodiment 1, the indoor space is space to be air-conditioned.

(Separating Unit 4)

[0019] The separating unit 4 is provided at part of the heat medium pipe 31 in which the heat medium having flowed out of the refrigerant-heat medium heat exchanger 26 flows before flowing into the load-side heat exchanger 33 and which is located outside the space to be air-conditioned. The separating unit 4 separates refrigerant and the heat medium from each other. In embodiment 1, the separating unit 4 is a component that is provided on the outdoor side, includes a connection port 41, a discharge port 42 and an outlet port 43, and separates gas and liquid from each other. The connection port 41 is an opening connected to a downstream side of the refrigerant-heat medium heat exchanger 26 in the heat medium circuit 3. The discharge port 42 is, for example, an opening that is provided in an upper portion of the separating unit 4 and allows gas in the separating unit 4 to be discharged through the opening. The outlet port 43 is an opening connected with an upstream side of the load-side heat exchanger 33 in the heat medium circuit 3 and allowing liquid to flow out through the opening. The separating unit 4 is a component that separates the fluid having flowed out of the refrigerant-heat medium heat exchanger 26 into gas and liquid, and causes the gas to be discharged through the discharge port 42, and also the liquid to flow out through the outlet port 43.

[0020] Fig. 2 is a schematic view illustrating the separating unit 4 in embodiment 1 of the present invention. As illustrated in Fig. 2, the separating unit 4 includes an extension portion 44, a discharge portion 45 and an outlet portion 46. The extension portion 44 is a pipe that extends upwards from the connection port 41 connected with the heat medium pipe 31, and then extends laterally from an upper end portion of the extension portion 44. The outlet portion 46 is a pipe extending downwards from the extension portion 44 and connected with the outlet port 43. The discharge portion 45 is a pipe located above the

outlet portion 46 and connected with the discharge port 42.

[0021] A fluid flowing in the heat medium pipe 31 flows through the connection port 41, and flows upwards through the extension portion 44. In this case, if the fluid contains gas mixed therein, small air bubbles of the gas combine into larger bubbles. The fluid flowing in the heat medium pipe 31 is temporarily held by the extension portion 44, thus preventing the fluid from directly flowing out of the separating unit 4. In such a manner, the fluid is separated into gas and liquid by the separating unit 4. As described above, the separating unit 4 of embodiment 1 includes a composite pipe that traps gas.

[0022] The separating unit 4 also has the following function. In the separating unit 4, the velocity of the fluid is decreased, whereby an upward force of buoyancy that causes the fluid to rise is made greater than a downward force of gravity that causes the fluid to sink, and as a result, gas collects in an upper region. Then, it is assumed that the refrigerant-heat medium heat exchanger 26 ruptures because of freezing or the like. If the refrigerant-heat medium heat exchanger 26 ruptures, there is a risk that refrigerant may enter a heat-medium passage in the refrigerant-heat medium heat exchanger 26 and then flow into the heat medium circuit 3. At this time, the refrigerant is gasified to some extent by the heat medium flowing in the heat medium circuit 3. This is because the boiling point of the refrigerant is generally lower than that of the heat medium.

[0023] The discharge portion 45 and the outlet portion 46 of the separating unit 4 each have a passage cross-sectional area larger than the passage cross-sectional area of the heat medium pipe 31. In embodiment 1, the heat medium pipe 31 and a flow switching unit are both circular pipes. As illustrated in Fig. 2, where d_1 is the pipe diameter of the heat medium pipe 31, d_2 is the pipe diameter of each of the discharge portion 45 and outlet portion 46 of the separating unit 4, and π is the circular constant, the passage cross-sectional area of the heat medium pipe 31 is set to satisfy $\pi(d_1/2)^2$, the passage cross-sectional area of each of the discharge portion 45 and the outlet portion 46 is set to satisfy $\pi(d_2/2)^2$, and the relationship $\pi(d_2/2)^2 > \pi(d_1/2)^2$ is satisfied. In such a manner, when the fluid flowing in the heat medium pipe 31 flows into the discharge portion 45 and the outlet portion 46 of the separating unit 4, which each have a larger passage cross-sectional area, the velocity of the fluid decreases.

[0024] Fig. 3 is a graph illustrating a relationship between a bubble diameter and a bubble rising velocity in embodiment 1 of the present invention. The relationship between the bubble diameter and bubble rising velocity will be described. In Fig. 3, the horizontal axis represents the bubble diameter [mm], and the vertical axis represents the bubble rising velocity in water [mm/s]. In Fig. 3, the solid line represents a bubble density of 1.25 kg/m^3 , the two-dot chain line represents a bubble density of 50.0 kg/m^3 , and the dashed line represents a bubble density

of 100.0 kg/m^3 . In this case, the lower the bubble density, the greater the degree of gasification; and the higher the bubble density, the greater the degree of liquefaction. The bubble density of gas is approximately 1.25 to 1.50 kg/m^3 , which corresponds to the solid line in Fig. 3. As illustrated in Fig. 3, regardless of the bubble density, the greater the bubble diameter, the higher the bubble rising velocity in water. Furthermore, the lower the bubble density, the higher the bubble rising velocity.

[0025] Generally, the flow rate and flow velocity of a fluid flowing in a pipe having a nominal diameter of 50 A (outside diameter: approximately 60.5 mm) are $16 \text{ m}^3/\text{h}$ and approximately 2000 mm/s , respectively. It should be noted that refrigerant which appears in the form of bubbles from a crack in the refrigerant-heat medium heat exchanger 26 is observed to have a diameter of approximately 1.5 mm or more. Therefore, in the case where the heat medium pipe 31 has a nominal diameter of 50 A, if a pipe having a nominal diameter greater than or equal to 80 A (outside diameter: 89.1 [mm]) is used as each of the discharge portion 45 and outlet portion 46 of the separating unit 4, the flow velocity of the fluid is less than or equal to 1000 mm/s . As illustrated in Fig. 3, when the flow velocity is 1000 mm/s , the bubble diameter is approximately 1.4 mm. That is, in the case of bubbles having a diameter greater than or equal to 1.4 mm, an upward force of buoyancy that causes the fluid to rise is greater than a downward force of gravity that causes the fluid to sink. Therefore, almost all of refrigerant existing in the form of bubbles within the separating unit 4 can be collected in the upper region. In embodiment 1, it is not indispensable that the separating unit 4 is set to have a larger passage cross-sectional area than the passage cross-sectional area of the heat medium pipe 31.

[0026] Fig. 4 is a graph illustrating a relationship between a water flow velocity and a discharge rate / an inflow rate in embodiment 1 of the present invention. The relationship between the flow velocity of water and a ratio obtained by dividing the Orate of discharge from the discharge unit 5 by the inflow rate will be described. In Fig. 4, the horizontal axis represents the water flow velocity [mm/s], and the vertical axis represents the discharge rate / the inflow rate [%]. As illustrated in Fig. 4, when the flow velocity of water is 1500 mm/s , the discharge rate / the inflow rate is approximately 75%, that is, the discharge rate is sufficient. In such a manner, in the case where the separating unit 4 has a passage cross-sectional area such that water flows in the separating unit 4 at a velocity less than or equal to 1500 mm/s , gas and liquid can be efficiently separated. Thereby, it is possible to efficiently discharge influent gas from the discharge unit 5.

(Discharge Unit 5)

[0027] As illustrated in Fig. 1, the discharge unit 5 has a discharge port 51, which is connected with the outlet port 43 of the separating unit 4 and allows refrigerant

separated by the separating unit 4 to be discharged to the outside of the space to be air-conditioned. The discharge unit 5 includes a gas vent valve, a gas escape valve or the like. In embodiment 1, the separating unit 4 and the discharge unit 5 are disposed outside the heat source unit 20. Thus, an existing heat source unit can be used as the heat source unit 20. Furthermore, the separating unit 4 and the discharge unit 5 can be each provided at a different position from the position of the heat source unit 20. Thus, the separating unit 4 and the discharge unit 5 can be each provided, for example, at the highest possible position. In this case, the discharge unit 5 can further effectively discharge gas.

(Operation Modes)

[0028] Next, operation modes of the air-conditioning apparatus 1 will be described. As the operation modes of the air-conditioning apparatus 1, a heating operation mode and a cooling operation mode are present. The heating operation mode and the cooling operation mode will be described with reference to Fig. 1.

(Heating Operation)

[0029] The heating operation will be described. In the heating operation, the flow switching device 23 causes the discharge side of the compressor 22 and the refrigerant-heat medium heat exchanger 26 to be connected to each other, and also the suction side of the compressor 22 to the heat-source-side heat exchanger 24 to be connected to each other (solid lines in Fig. 1). First, the flow of refrigerant in the refrigerant circuit 2 will be described. In the heating operation, refrigerant sucked into the compressor 22 is compressed by the compressor 22, and is discharged from the compressor 22 as high temperature, high pressure gas refrigerant. The high-temperature, high-pressure gas refrigerant discharged from the compressor 22 passes through the flow switching device 23, and flows into the refrigerant-heat medium heat exchanger 26 operating as a condenser. The refrigerant having flowed into the refrigerant-heat medium heat exchanger 26 exchanges heat with the heat medium and is thus condensed and liquefied. At this time, the heat medium is heated. The condensed and liquefied refrigerant is expanded and reduced in pressure by the expansion unit 25 to change into low-temperature, low-pressure two-phase gas-liquid refrigerant. The low-temperature, low-pressure two-phase gas-liquid refrigerant then flows into the heat-source-side heat exchanger 24 operating as an evaporator. In the heat-source-side heat exchanger 24, the low-temperature, low pressure two-phase gas-liquid refrigerant exchanges heat with, for example, outdoor air, and is thus evaporated and gasified. The evaporated and gasified low-temperature, low-pressure refrigerant passes through the flow switching device 23, and is sucked into the compressor 22.

[0030] Next, the flow of the heat medium in the heat

medium circuit 3 will be described. The heat medium transferred by the pump 32 flows into the refrigerant-heat medium heat exchanger 26. The heat medium having flowed into the refrigerant-heat medium heat exchanger 26 exchanges heat with refrigerant and is thus heated. The heated heat medium passes through the separating unit 4, and flows into the load-side heat exchanger 33, which is provided in the indoor side. In the load-side heat exchanger 33, the heat medium exchanges heat with, for example, indoor air and is thus cooled. At this time, the indoor air is heated, thus heating the indoor space. The cooled heat medium is then sucked into the pump 32.

(Cooling Operation)

[0031] Next, the cooling operation will be described. In the cooling operation, the flow switching device 23 causes the discharge side of the compressor 22 to be connected to the heat-source-side heat exchanger 24, and also the suction side of the compressor 22 to be connected to the refrigerant-heat medium heat exchanger 26 (dashed lines in Fig. 1). First, the flow of refrigerant in the refrigerant circuit 2 will be described. In the cooling operation, refrigerant sucked into the compressor 22 is compressed by the compressor 22, and is discharged from the compressor 22 as a high-temperature, high pressure gas refrigerant. The high-temperature, high-pressure gas refrigerant discharged from the compressor 22 passes through the flow switching device 23, and flows into the heat-source-side heat exchanger 24 operating as a condenser. The refrigerant having flowed into the heat-source-side heat exchanger 24 exchanges heat with, for example, outdoor air, and is thereby condensed and liquefied. The condensed and liquefied refrigerant is expanded and reduced in pressure by the expansion unit 25 to change into low-temperature, low-pressure two-phase gas-liquid refrigerant. The low-temperature, low-pressure two-phase gas-liquid refrigerant then flows into the refrigerant-heat medium heat exchanger 26 operating as an evaporator. In the refrigerant-heat medium heat exchanger 26, the refrigerant exchanges heat with, for example, the heat medium, and is thereby evaporated and gasified. At this time, the heat medium is cooled. The evaporated and gasified low-temperature, low-pressure refrigerant passes through the flow switching device 23, and sucked into the compressor 22.

[0032] Next, the flow of the heat medium in the heat medium circuit 3 will be described. The heat medium transferred by the pump 32 flows into the refrigerant-heat medium heat exchanger 26. The heat medium having flowed into the refrigerant-heat medium heat exchanger 26 exchanges heat with refrigerant, and is thereby cooled. The cooled heat medium passes through the separating unit 4 and flows into the load-side heat exchanger 33, which is provided on the indoor side. In the load-side heat exchanger 33, the heat medium exchanges heat with, for example, indoor air, and is thereby heated. At this time, the indoor air is cooled, thus cooling the indoor

space. The heated heat medium is then sucked into the pump 32.

(Operation upon Entrance of Refrigerant)

[0033] Next, it will be described what operation is performed in the case where refrigerant flows into the heat medium circuit 3. It is assumed that the refrigerant-heat medium heat exchanger 26 ruptures because of freezing or the like. If the refrigerant-heat medium heat exchanger 26 ruptures, there is a risk that refrigerant may enter a heat-medium passage in the refrigerant-heat medium heat exchanger 26 and then flow into the heat medium circuit 3.

[0034] The refrigerant having flowed into the heat medium circuit 3 flows from the refrigerant-heat medium heat exchanger 26 to the separating unit 4 through the heat medium pipe 31. The refrigerant enters the separating unit 4 through the connection port 41, and flows upwards through the extension portion 44. At this time, refrigerant sinking in a lower portion of the extension portion 44 is forcibly raised with the flow of the heat medium. In this case, all small bubbles of the refrigerant combine into larger bubbles. The flow of the refrigerant to flow in the heat medium pipe 31 is temporarily held by the extension portion 44. It is therefore possible to reduce the outflow of the refrigerant with the heat medium from the separating unit 4. After flowing upwards through the extension portion 44, the refrigerant flows into the discharge portion 45 and the outlet portion 46, whose passage cross-sectional areas are larger than that of the heat medium pipe 31. At this time, the flow velocity of the refrigerant decreases, whereby an upward force that causes the refrigerant to float toward the discharge portion 45 is made stronger than a downward force that causes the refrigerant to sink together with the heat medium toward the outlet portion 46, thus causing the refrigerant to rise toward the discharge portion 45.

[0035] In a portion having a larger passage cross-sectional area, the heat medium containing refrigerant stagnates. The refrigerant can be thus collected in stagnant part of the heat medium. As a result, small bubbles of the refrigerant combine into larger bubbles. Therefore, the refrigerant further rises upwards toward the discharge portion 45. After reaching the discharge portion 45, the refrigerant passes through the discharge port 42 and reaches the discharge unit 5. The refrigerant is then discharged from the discharge unit 5 to the outdoor side. It should be noted that a heat medium containing no refrigerant mixed therein flows downwards in the outlet portion 46, and then flows out through the outlet port 43 into the heat medium pipe 31. It is therefore possible to reduce the inflow of refrigerant to the indoor part of the heat medium pipe 31.

[0036] According to embodiment 1, the refrigerant and the heat medium are separated from each other by the separating unit 4, which is provided outside the space to be air-conditioned, and the refrigerant is then discharged

by the discharge unit 5 to the outside of the space to be air-conditioned. Thus, even if flowing into the heat medium circuit 3, the refrigerant is discharged to the outside of the space to be air-conditioned, via the separating unit 4 and the discharge unit 5. Because of this configuration, it is possible to reduce the inflow of refrigerant to the indoor part of the heat medium pipe 31.

[0037] The separating unit 4 has a larger passage cross-sectional area than that of the heat medium pipe 31. Therefore, the separating unit 4 can cause the flow velocity of the fluid to be reduced, whereby the upward force that causes the fluid to rise is made stronger than the downward force that causes the fluid to sink. Thus, refrigerant can be further discharged. Furthermore, the separating unit 4 includes the extension portion 44 extending upwards from the connection port 41, the discharge portion 45 extending upwards from the extension portion 44 to connect with the discharge port 42, and the outlet portion 46 located below the discharge portion 45 and extending downwards from the extension portion 44 to connect with the outlet port 43. As a result, refrigerant sinking in the lower portion of the extension portion 44 is forcibly raised with the flow of the heat medium. In this case, small bubbles of the refrigerant combine into larger bubbles. As described above, the flow of the refrigerant flowing in the heat medium pipe 31 is temporarily held by the extension portion 44. Therefore, it is possible to prevent the refrigerant from directly flowing out of the separating unit 4, and facilitate collection of the refrigerant. If the refrigerant is slightly flammable refrigerant or flammable refrigerant, the safety is further improved by reducing the inflow of the refrigerant to the indoor part of the heat medium pipe 31.

(First Modification)

[0038] Fig. 5 is a schematic view illustrating a separating unit 4a in a first modification of embodiment 1 of the present invention. The first modification is different from embodiment 1 in the structure of the separating unit 4a. As illustrated in Fig. 5, the separating unit 4a of the first modification includes a single pipe having a larger passage cross-sectional area than that of the heat medium pipe 31. Where d_1 is the pipe diameter of the heat medium pipe 31, d_3 is the pipe diameter of the separating unit 4a, and π is the circular constant, the passage cross-sectional area of the heat medium pipe 31 is set to satisfy $\pi(d_1/2)^2$, the passage cross-sectional area of each of the discharge portion 45 and the outlet portion 46 is set to satisfy $\pi(d_3/2)^2$, and the relationship $\pi(d_3/2)^2 > \pi(d_1/2)^2$ is satisfied. Thus, when the fluid flowing in the heat medium pipe 31 flows into the separating unit 4a having the larger passage cross-sectional area, the velocity of the fluid decreases as in embodiment 1. The connection port 41 of the separating unit 4a is located at a higher level than or the same level as that of the outlet port 43 in the height direction of the separating unit 4a. According to the first modification, the outlet port 43 is provided at the

bottom portion of the separating unit 4a.

[0039] According to the first modification, in the case where refrigerant enters the heat medium circuit 3, the refrigerant flows from the refrigerant-heat medium heat exchanger 26 to the separating unit 4a through the heat medium pipe 31. At this time, the refrigerant flows into the separating unit 4a having a larger passage cross-sectional area than that of the heat medium pipe 31. Therefore, the flow velocity of the refrigerant decreases, as a result of which an upward force that causes the refrigerant to rise toward the discharge portion 45 is made stronger than a downward force that causes the refrigerant to sink toward the outlet portion 46. The refrigerant thus rises toward the discharge port 42 located in an upper portion of the separating unit 4a. The rising refrigerant passes through the discharge port 42 and reaches the discharge unit 5. The refrigerant is then discharged from the discharge unit 5 to the outdoor side. It should be noted that a heat medium containing no refrigerant mixed therein passes through the separating unit 4a, and flows into the heat medium pipe 31 through the outlet port 43. It is therefore possible to reduce the inflow of refrigerant to the indoor part of the heat medium pipe 31.

[0040] The connection port 41 of the separating unit 4a is located at a higher level than or at the same level as that of the outlet port 43 in the height direction of the separating unit 4a. Because of this configuration, flow of the heat medium within the separating unit 4a is not hindered; that is, the heat medium can smoothly flow. The separating unit 4a may be a tubular container, not a pipe. Although pipes are more readily available than containers and require a lower cost than the containers, the separating unit 4a can be changed from the pipe to the tubular container as appropriate. Since the separating unit 4a can be made simply by connecting a component such as a pipe or a tubular container to the heat medium pipe 31, the separating unit 4a is easily made and readily available.

(Second Modification)

[0041] Fig. 6 is a schematic view illustrating a separating unit 4b in a second modification of embodiment 1 of the present invention. The second modification is different from embodiment 1 in the structure of the separating unit 4b. As illustrated in Fig. 6, in the second modification, the outlet port 43 is provided in a side surface of the separating unit 4b, and the connection port 41 and the outlet port 43 face each other. Therefore, flow of the heat medium within the separating unit 4b is not hindered, that is, the heat medium can smoothly flow. In the second modification, the separating unit 4b includes a single pipe having a larger passage cross-sectional area than that of the heat medium pipe 31 as in the first modification. Therefore, when the fluid flowing in the heat medium pipe 31 flows into the separating unit 4b having the larger passage cross-sectional area, the velocity of the fluid decreases as in the first modification.

(Third Modification)

[0042] Fig. 7 is a schematic view illustrating a separating unit 4c in a third modification of embodiment 1 of the present invention. The third modification is different from embodiment 1 in the structure of the separating unit 4c. As illustrated in Fig. 7, the pipe forming the separating unit 4c in the third modification extends further downwards than the separating unit 4c of the second modification. Thereby, scale generated from the heat medium flowing in the heat medium pipe 31 can be retained in a downwardly extended portion of the separating unit 4c. In the third modification, the separating unit 4c includes a single pipe having a larger passage cross-sectional area than that of the heat medium pipe 31 as in the first modification. Thereby, when the fluid flowing in the heat medium pipe 31 flows into the separating unit 4c having the larger passage cross-sectional area, the velocity of the fluid decreases as in the first modification.

(Fourth Modification)

[0043] Fig. 8 is a schematic view illustrating a separating unit 4d in a fourth modification of embodiment 1 of the present invention. The fourth modification is different from embodiment 1 in the structure of the separating unit 4d. As illustrated in Fig. 8, in the separating unit 4d in the fourth modification, a lower end 41a of the connection port 41 is located at a higher level than that of an upper end 43a of the outlet port 43 in the height direction of the separating unit 4d. Therefore, the heat medium entering the separating unit 4d from the connection port 41 flows downwards until it reaches the outlet port 43. Thus, the heat medium can further smoothly flow in the separating unit 4d. In the fourth modification, the separating unit 4d includes a single pipe having a larger passage cross-sectional area than that of the heat medium pipe 31 as in the first modification. Thereby, when the fluid flowing in the heat medium pipe 31 flows into the separating unit 4d having the larger passage cross-sectional area, the velocity of the fluid decreases as in the first modification.

Embodiment 2

[0044] Fig. 9 is a circuit diagram illustrating an air-conditioning apparatus 100 according to embodiment 2 of the present invention. In embodiment 2, an outlet-side valve 7 and an inlet-side valve 8 are provided. In this regard, embodiment 2 is different from embodiment 1. With respect to embodiment 2, components which are the same as those of embodiment 1 will be denoted by the same reference signs, and their descriptions will thus be omitted. Embodiment 2 will be described by referring mainly to the differences between embodiments 1 and 2.

[0045] As illustrated in Fig. 9, the outlet-side valve 7 and the inlet-side valve 8 are provided in the heat medium circuit 3. The outlet-side valve 7 is provided outside the space to be air-conditioned, and located downstream of

the separating unit 4, that is, it is located close to the outlet of the separating unit 4. At this position, the outlet-side valve 7 controls the flow rate of the heat medium. The outlet-side valve 7 may be a valve whose opening degree is adjustable or a valve whose opening degree is fixed. The inlet-side valve 8 is provided outside the space to be air-conditioned, and located upstream of the separating unit 4 and for example, downstream of the pump 32. At this position, the inlet-side valve 8 controls the flow rate of the heat medium. The inlet-side valve 8 may be a valve whose opening degree is adjustable or a valve whose opening degree is fixed, or may be a check valve that prevents back flow. It should be noted that only one of the outlet-side valve 7 and the inlet-side valve 8 may be provided. In this case, in the case where only the outlet-side valve 7 is provided, it is possible to more effectively reduce the inflow of refrigerant than in the case where only the inlet-side valve 8 is provided.

[0046] If refrigerant flows into the heat medium circuit 3, the outlet-side valve 7 and the inlet-side valve 8 are closed. To be more specific, if refrigerant enters the heat medium circuit 3, the refrigerant flows from the refrigerant-heat medium heat exchanger 26 to the separating unit 4 through the heat medium pipe 31. At this time, even if the refrigerant flows out of the separating unit 4 into the heat medium pipe 31, since the outlet-side valve 7 is in the closed state, the refrigerant thus does not flow past the outlet-side valve 7. It is therefore possible to reliably reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31. Furthermore, if the refrigerant enters the heat medium circuit 3, there is also a risk that the refrigerant may flow backwards from the refrigerant-heat medium heat exchanger 26. However, since the inlet-side valve 8 is in the closed state, the refrigerant does not flow past the inlet-side valve 8. It is therefore possible to further reliably reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31. As described above, in embodiment 2, if refrigerant flows into the heat medium circuit 3, the outlet-side valve 7 and the inlet-side valve 8 divides the heat medium circuit 3 into an area located on the indoor side and an area located on the outdoor side. It is therefore possible to reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31 through the heat medium circuit 3. It will be described with what configuration it is detected that refrigerant flows into the heat medium circuit 3 will be described later with reference to embodiment 4, etc.

(First Modification)

[0047] Fig. 10 is a circuit diagram illustrating an air-conditioning apparatus 100a according to a first modification of embodiment 2 of the present invention. The first modification is different from embodiment 2 in the location where the heat source unit 20 is installed. As illustrated in Fig. 10, the heat source unit 20 of the first modification of embodiment 2 is installed below the indoor space. For example, it is assumed that the heat source

unit 20 is provided in a downstairs space located below the indoor space. In this case, if flowing into the heat medium circuit 3, the refrigerant may rise because of buoyancy toward the indoor space located above the downstairs space. To be more specific, in the case where the refrigerant flows into the heat medium circuit 3, even if the pump 32 is in the stopped state, the refrigerant may rise toward the indoor space because of buoyancy. However, since the outlet-side valve 7 is in the closed state at this time, the refrigerant does not flow past the outlet-side valve 7. It is therefore possible to reliably reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31. Furthermore, even if refrigerant flows backwards from the refrigerant-heat medium heat exchanger 26, the inlet-side valve 8 is in the closed state, and thus the refrigerant does not flow past the inlet-side valve 8. It is therefore possible to further reliably reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31. As described above, because of provision of the outlet-side valve 7 or the inlet-side valve 8, also in the case where the heat source unit 20 is installed below the indoor space, it is possible to reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31.

(Second Modification)

[0048] Fig. 11 is a circuit diagram illustrating an air-conditioning apparatus 100b according to a second modification of embodiment 2 of the present invention. In the second modification, a plurality of cooling and heating devices 30 are connected. In this regard, the second modification is different from embodiment 2. As illustrated in Fig. 11, the plurality of cooling and heating devices 30 each include the load-side heat exchanger 33, and are connected in parallel with each other in the heat medium circuit 3. In this case, the outlet-side valve 7 and the inlet-side valve 8 are provided at positions that precede part of the heat medium pipe 31, from which heat medium pipes 31 connected to respective load-side heat exchangers 33 branch off. As described above, in the second modification, in the configuration in which the plurality of cooling and heating devices 30 are connected, it is possible to reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31 because of provision of the outlet-side valve 7 or the inlet-side valve 8.

Embodiment 3

[0049] Fig. 12 is a circuit diagram illustrating an air-conditioning apparatus 200 according to embodiment 3 of the present invention. Embodiment 3 is different from embodiment 2 in the location where the pump 32 is installed. With respect to embodiment 3, components which are the same as those of embodiment 1 or 2 will be denoted by the same reference signs, and their descriptions will thus be omitted. Embodiment 3 will be described by referring mainly to the differences between embodiment 3 and embodiments 1 and 2.

[0050] As illustrated in Fig. 12, the pump 32 is provided downstream of the refrigerant-heat medium heat exchanger 26. In embodiment 3, if entering the heat medium circuit 3, the refrigerant flows through the heat medium pipe 31 from the refrigerant-heat medium heat exchanger 26, and then immediately flows into the suction side of the pump 32 without passing through the indoor space. If the refrigerant stays on the suction side of the pump 32, it causes the pump 32 to run idle. If the pump 32 runs idle, the flow of the heat medium stops or becomes slower. Thus, the velocity of refrigerant contained in the heat medium also decreases. Further, the pressure of a fluid is reduced by the suction of the refrigerant by the pump 32, and as a result refrigerant being in a liquid state is easily gasified. Therefore, an upward force that causes the refrigerant to rise can be made stronger than a downward force that causes the refrigerant to sink. Thus, at the separating unit 4 and the discharge unit 5 into which the refrigerant flows after passing through the pump 32, the refrigerant can be discharged more effectively. In such a manner, in embodiment 3, since the pump 32 is provided downstream of the refrigerant-heat medium heat exchanger 26, it can be caused to run idle, thus stopping the flow of the heat medium. It is therefore possible to further reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31.

Embodiment 4

[0051] Fig. 13 is a circuit diagram illustrating an air-conditioning apparatus 300 according to embodiment 4 of the present invention. In embodiment 4, a refrigerant detection unit 6 is provided. In this regard, embodiment 4 is different from embodiment 2. With respect to embodiment 4, components which are the same as those of embodiments 1 to 3 will be denoted by the same reference signs, and their descriptions will thus be omitted. Embodiment 4 will be described by referring mainly to the differences between embodiment 4 and embodiments 1 to 3.

[0052] As illustrated in Fig. 13, the air-conditioning apparatus 300 includes the refrigerant detection unit 6 which detects that refrigerant flows into the heat medium circuit 3. The refrigerant detection unit 6 includes a discharged-refrigerant detection unit 6a that is provided at the discharge port 51 of the discharge unit 5 to detect refrigerant discharged from the discharge port 51. In embodiment 4, refrigerant discharged from the discharge port 51 is directly detected by the discharged-refrigerant detection unit 6a. It is therefore possible to immediately recognize that refrigerant flows into the heat medium circuit 3. It is explained in the description regarding embodiment 10 that will be made later, what control is performed in the case where the discharged-refrigerant detection unit 6a detects that refrigerant flows into the heat medium circuit 3.

Embodiment 5

[0053] Fig. 14 is a circuit diagram illustrating an air-conditioning apparatus 400 according to embodiment 5 of the present invention. In embodiment 5, a heating unit 9 is provided. In this regard, embodiment 5 is different from embodiment 4. With respect to embodiment 5, components which are the same as those of embodiments 1 to 4 will be denoted by the same reference signs, and their descriptions will thus be omitted. Embodiment 5 will be described by referring mainly to the differences between embodiment 5 and embodiments 1 to 4.

[0054] As illustrated in Fig. 14, the heating unit 9 is provided in the separating unit 4 to heat a liquid in the separating unit 4. The heating unit 9 is, for example, a heater. If refrigerant enters the heat medium circuit 3, there is a possibility that the refrigerant will circulate in a liquid state in the heat medium circuit 3 because of the pressure and temperature of the heat medium flowing in the heat medium circuit 3. At this time, the refrigerant having flowed into the separating unit 4 and being in a liquid state is heated by the heating unit 9. As a result, the refrigerant being in the liquid state is gasified, and discharged outdoors by the separating unit 4 and the discharge unit 5. Furthermore, in the case where the heat source unit 20 is in the stopped state and the temperature of the heat medium is reduced during maintenance such as a test run or routine inspection, when refrigerant enters the heat medium circuit 3, it stays in the liquid state in the heat medium circuit 3. In this case as well, the refrigerant which has flowed into the separating unit 4 and is in the liquid state is heated by the heating unit 9. As a result, the refrigerant being in the liquid state is gasified, and discharged outdoors by the separating unit 4 and the discharge unit 5.

[0055] Moreover, when refrigerant flows into the heat medium circuit 3, the heat source unit 20 becomes short of refrigerant, and may thus become unable to operate. In this case, it is not possible to heat the heat medium or the refrigerant by use of the heat source unit 20. Thus, the refrigerant is cooled and condensed by outside air or the like. The condensed refrigerant stays in the liquid state in the heat medium circuit 3. By contrast, in embodiment 5, the temperatures of the heat medium and refrigerant can be raised using the heater instead of the heat source unit 20. It is therefore possible to prevent condensation of refrigerant, and in addition gasify the refrigerant.

[0056] Fig. 15 is a graph illustrating a relationship between the pressure of the refrigerant and the saturation temperature of the refrigerant in embodiment 5 of the present invention. It will be described how each of different types of refrigerant easily gasify. In Fig. 15, the horizontal axis represents the pressure [MPa], and the vertical axis represents the saturation temperature [degrees C]. The solid line represents R32, the two-dot chain line represents R1234yf, and the dashed line represents R1234ze. In Fig. 14, the area located below these lines represents a liquid-state area, and the area located

above the lines represents a gas-state area. As illustrated in Fig. 14, R1234yf and R1234ze refrigerants do not easily gasify, as compared with R32. Thus, the configuration according to embodiment 5 obtains a remarkable advantage in the case where it is applied to the air-conditioning apparatus 400 using R1234yf and R1234ze refrigerants that do not easily gasify.

Embodiment 6

[0057] In embodiment 6, the separating unit 4 and the discharge unit 5 are incorporated in the heat source unit 20. In this regard, embodiment 6 is different from embodiments 1 to 5. With respect to embodiment 6, components which are the same as those of embodiments 1 to 5 will be denoted by the same reference signs, and their descriptions will thus be omitted. Embodiment 6 will be described by referring mainly to the differences between embodiment 6 and embodiments 1 to 5.

[0058] Since the separating unit 4 and the discharge unit 5 are incorporated in the heat source unit 20, the structure of the heat medium circuit 3 can be simplified. In the case where a heat source-side fan for use in heat rejection or heat exchange is provided in the heat source unit 20, the refrigerant in the separating unit 4 can be stirred with air blown from the heat-source-side heat exchanger 24. Thereby, the concentration of the refrigerant can be reduced, and the safety is thus improved.

Embodiment 7

[0059] Fig. 16 is a circuit diagram illustrating an air-conditioning apparatus 600 according to embodiment 7 of the present invention. In embodiment 7, a controller 10 and a pressure detection unit 6b are provided. In this regard, embodiment 7 is different from embodiment 5. With respect to embodiment 7, components which are the same as those of embodiments 1 to 6 will be denoted by the same reference signs, and their descriptions will thus be omitted. Embodiment 7 will be described by referring mainly to the difference between embodiment 7 and embodiments 1 to 6.

[0060] As illustrated in Fig. 16, the pressure detection unit 6b is provided downstream of the refrigerant-heat medium heat exchanger 26 to detect the pressure of the heat medium flowing in the heat medium circuit 3. In embodiment 7, the refrigerant detection unit 6 includes the discharged-refrigerant detection unit 6a and the pressure detection unit 6b. The pressure detection unit 6b may be provided upstream of the refrigerant-heat medium heat exchanger 26. The heat source unit 20 is provided with the controller 10. The controller 10 is, for example, a microcomputer that controls various devices.

[0061] The controller 10 closes the outlet-side valve 7 and the inlet-side valve 8 if the concentration of refrigerant that is detected by the refrigerant detection unit 6 exceeds a preset threshold. Alternatively, the controller 10 may stop the pump 32 if the concentration of refrigerant

detected by the refrigerant detection unit 6 exceeds the preset threshold. Specifically, in embodiment 7, the controller 10 closes the outlet-side valve 7 and the inlet-side valve 8 if the pressure of the heat medium detected by the pressure detection unit 6b exceeds a preset pressure threshold. For example, in the case where the heat medium is water, and the refrigerant is R32 that is a saturated liquid state when the pressure of water is 1.0 MPaA. In this case, as the refrigerant being in the liquid state gasifies, it expands such that its volume increases by approximately 37 times. Because of such expansion of the refrigerant in volume, the pressure of the heat medium abruptly rises. Therefore, it can be detected using the pressure detection unit 6a that refrigerant flows into the heat medium circuit 3.

[0062] If refrigerant enters the heat medium circuit 3, the refrigerant flows from the refrigerant-heat medium heat exchanger 26 to the separating unit 4 through the heat medium pipe 31. At this time, even if the refrigerant flows from the separating unit 4 into the heat medium pipe 31, since the controller 10 closes the outlet-side valve 7, the refrigerant does not flow past the outlet-side valve 7. It is therefore possible to reliably reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31. If the refrigerant enters the heat medium circuit 3, there is also a risk that the refrigerant will flow backwards from the refrigerant-heat medium heat exchanger 26. However, since the controller 10 closes the inlet-side valve 8, the refrigerant does not flow past the inlet-side valve 8. It is therefore possible to further reliably reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31. In such a manner, in embodiment 7, even if refrigerant flows into the heat medium circuit 3, since in the heat medium circuit 3, an area located on the indoor side and an area located on the outdoor side are isolated from each other by the outlet-side valve 7 and the inlet-side valve 8, it is possible to reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31 through the heat medium circuit 3. In the case where the controller 10 stops the pump 32, the heat medium does not flow, thus, nor does the refrigerant flow. It is therefore possible to reduce the inflow of the refrigerant to the indoor side.

Embodiment 8

[0063] Fig. 17 is a circuit diagram illustrating an air-conditioning apparatus 700 according to embodiment 8 of the present invention. In embodiment 8, the controller 10 and a temperature detection unit 6c are provided. In this regard, embodiment 8 is different from embodiment 5. In embodiment 8, components which are the same as those of embodiments 1 to 7 will be denoted by the same reference signs, and their descriptions will thus be omitted. Embodiment 8 will be described by referring mainly to the differences between embodiment 8 and embodiments 1 to 7.

[0064] As illustrated in Fig. 17, the temperature detec-

tion unit 6c is provided downstream of the refrigerant-heat medium heat exchanger 26 to detect the temperature of the heat medium flowing in the heat medium circuit 3. In embodiment 8, the refrigerant detection unit 6 includes the discharged-refrigerant detection unit 6a and the temperature detection unit 6c. The temperature detection unit 6c may be provided upstream of the refrigerant-heat medium heat exchanger 26. The heat source unit 20 is provided with the controller 10. The controller 10 is, for example, a microcomputer that controls various devices.

[0065] The controller 10 closes the outlet-side valve 7 and the inlet-side valve 8 if the concentration of refrigerant that is detected by the refrigerant detection unit 6 exceeds a preset threshold. Alternatively, the controller 10 may stop the pump 32 if the concentration of refrigerant detected by the refrigerant detection unit 6 exceeds the preset threshold. Specifically, in embodiment 8, the controller 10 closes the outlet-side valve 7 and the inlet-side valve 8 if the temperature of the heat medium that is detected by the temperature detection unit 6c at predetermined time intervals changes by more than a preset temperature-change threshold. For example, in the case where the heat medium is water, the refrigerant is R32 that is in a saturated liquid state when the pressure of water is 1.0 MPaA, and the ratio in flow rate between R32 and water is 1:4, the temperature of water drops by approximately 18 degrees C before the refrigerant being in the liquid state gasifies. In such a manner, as the refrigerant gasifies, the temperature of the heat medium changes abruptly. Therefore, it can be detected using the temperature detection unit 6c that the refrigerant flows into the heat medium circuit 3.

[0066] If refrigerant enters the heat medium circuit 3, it flows from the refrigerant-heat medium heat exchanger 26 to the separating unit 4 through the heat medium pipe 31. At this time, even if the refrigerant flows from the separating unit 4 into the heat medium pipe 31, the controller 10 closes the outlet-side valve 7. Thus, the refrigerant does not flow past the outlet-side valve 7. It is therefore possible to reliably reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31. Furthermore, if refrigerant enters the heat medium circuit 3, there is also a risk that the refrigerant will flow backwards from the refrigerant-heat medium heat exchanger 26. However, since the controller 10 closes the inlet-side valve 8, the refrigerant does not flow past the inlet-side valve 8. It is therefore possible to further reliably reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31. In such a manner, in embodiment 8, if the refrigerant flows into the heat medium circuit 3, the area located on the indoor side and the area located on the outdoor area in the heat medium circuit 3 are isolated from each other by the outlet-side valve 7 and the inlet-side valve 8. It is therefore possible to reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31 through the heat medium circuit 3. It should be noted that in the case where the controller 10 stops the

pump 32, the heat medium does not flow, thus nor does the refrigerant flow. It is therefore possible to reduce the inflow of the refrigerant to the indoor space.

5 Embodiment 9

[0067] Fig. 18 is a circuit diagram illustrating an air-conditioning apparatus 800 according to embodiment 9 of the present invention. In embodiment 9, the controller 10 and a current detection unit 6d are provided, and the pump 32 is located downstream of the heat-source-side heat exchanger 24. In this regard, embodiment 9 is different from embodiment 5. In embodiment 9, components which are the same as those of embodiments 1 to 8 will be denoted by the same reference signs, and their descriptions will thus be omitted. Embodiment 9 will be described by referring mainly to the differences between embodiment 9 and embodiments 1 to 8.

[0068] As illustrated in Fig. 18, the current detection unit 6d detects the operating current of the pump 32. In embodiment 9, the refrigerant detection unit 6 includes the discharged-refrigerant detection unit 6a and the current detection unit 6d. The heat source unit 20 is provided with the controller 10. The controller 10 is, for example, a microcomputer that controls various devices.

[0069] The controller 10 closes the outlet-side valve 7 and the inlet-side valve 8 if the concentration of refrigerant that is detected by the refrigerant detection unit 6 exceeds a preset threshold. Alternatively, the controller 10 may stop the pump 32 if the concentration of refrigerant detected by the refrigerant detection unit 6 exceeds the preset threshold. Specifically, in embodiment 9, the controller 10 closes the outlet-side valve 7 and the inlet-side valve 8 if the current in the pump 32 that is detected by the current detection unit 6d at predetermined intervals of time changes by more than a preset current-change threshold.

[0070] For example, in the case where refrigerant flows into the heat medium circuit 3, the operating current of the pump 32 varies if the refrigerant stays on the suction side of the pump 32 and the pump 32 thus runs idle, or if the heat medium circuit 3 freezes due to the refrigerant flowing into the heat medium circuit 3, thus cutting off water supply. In such a manner, if the refrigerant flows into the heat medium circuit 3, the operating current of the pump 32 varies. Thereby, it can be indirectly detected using the current detection unit 6d that the refrigerant flows into the heat medium circuit 3. The pump 32 may be provided upstream of the refrigerant-heat medium heat exchanger 26. In this case also, it can be detected using the current detection unit 6d that the refrigerant flows into the heat medium circuit.

[0071] If refrigerant enters the heat medium circuit 3, it flows from the refrigerant-heat medium heat exchanger 26 to the separating unit 4 through the heat medium pipe 31. At this time, even if the refrigerant flows from the separating unit 4 into the heat medium pipe 31, the controller 10 closes the outlet-side valve 7, and thus the re-

refrigerant does not flow past the outlet-side valve 7. It is therefore possible to reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31. Furthermore, if refrigerant enters the heat medium circuit 3, there is also a risk that the refrigerant will flow backwards from the refrigerant-heat medium heat exchanger 26. However, since the controller 10 closes the inlet-side valve 8, the refrigerant does not flow past the inlet-side valve 8. It is therefore possible to further reliably reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31.

[0072] As described above, in embodiment 9, in the case where the refrigerant flows into the heat medium circuit 3, in the heat medium circuit 3, the area located on the indoor side and the area located on the outdoor side are isolated from each other by the outlet-side valve 7 and the inlet-side valve 8. It is therefore possible to reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31 through the heat medium circuit 3. In the case where the controller 10 stops the pump 32, the heat medium does not flow, thus, nor does the refrigerant flow. It is therefore possible to reduce the inflow of the refrigerant to the indoor space.

Embodiment 10

[0073] Fig. 19 is a circuit diagram illustrating an air-conditioning apparatus 900 according to embodiment 10 of the present invention. In embodiment 10, the current detection unit 6d is omitted. In this regard, embodiment 10 is different from embodiment 9. With respect to embodiment 10, components which are the same as those of embodiments 1 to 9 will be denoted by the same reference signs, and their descriptions will thus be omitted. Embodiment 10 will be described by referring mainly to the differences between embodiment 10 and embodiments 1 to 9.

[0074] As illustrated in Fig. 19, the refrigerant detection unit 6 includes only the discharged-refrigerant detection unit 6a. The heat source unit 20 is provided with the controller 10. The controller 10 is, for example, a microcomputer that controls various devices.

[0075] The controller 10 closes the outlet-side valve 7 and the inlet-side valve 8 if the concentration of refrigerant that is detected by the refrigerant detection unit 6 exceeds a preset threshold. Alternatively, the controller 10 may stop the pump 32 if the concentration of refrigerant detected by the refrigerant detection unit 6 exceeds the preset threshold. Specifically, in embodiment 10, the controller 10 closes the outlet-side valve 7 and the inlet-side valve 8 if the concentration of refrigerant detected by the discharged-refrigerant detection unit 6a exceeds the preset refrigerant threshold. In embodiment 10, refrigerant can thus be directly detected. It is therefore possible to improve the accuracy of detection of refrigerant.

[0076] If refrigerant enters the heat medium circuit 3, it flows from the refrigerant-heat medium heat exchanger 26 to the separating unit 4 through the heat medium pipe

31. At this time, even if the refrigerant flows from the separating unit 4 into the heat medium pipe 31, the controller 10 closes the outlet-side valve 7, and thus the refrigerant does not flow past the outlet-side valve 7. It is therefore possible to reliably reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31. Furthermore, if refrigerant enters the heat medium circuit 3, there is also a risk that the refrigerant will flow backwards from the refrigerant-heat medium heat exchanger 26. However, since the controller 10 closes the inlet-side valve 8, the refrigerant does not flow past the inlet-side valve 8. It is therefore possible to further reliably reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31.

[0077] As described above, in embodiment 10, if the refrigerant flows into the heat medium circuit 3, the area located on the indoor side and the area located on the outdoor side in the heat medium circuit 3 are isolated from each other by the outlet-side valve 7 and the inlet-side valve 8. It is therefore possible to reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31 through the heat medium circuit 3. It should be noted that in the case where the controller 10 stops the pump 32, the heat medium does not flow, and thus nor does the refrigerant flow. It is therefore possible to reduce the inflow of the refrigerant to the indoor space.

Embodiment 11

[0078] Fig. 20 is a circuit diagram illustrating an air-conditioning apparatus 1000 according to embodiment 11 of the present invention. In embodiment 11, the pressure detection unit 6b, the temperature detection unit 6c and an escape valve 35 are provided. In this regard, embodiment 11 is different from embodiment 9. With respect to embodiment 11, components which are the same as those of embodiments 1 to 10 will be denoted by the same reference signs, and their descriptions will thus be omitted. Embodiment 11 will be described by referring mainly to the differences between embodiment 11 and embodiments 1 to 10.

[0079] As illustrated in Fig. 20, in the heat medium circuit 3, the escape valve 35 is provided downstream of the refrigerant-heat medium heat exchanger 26. The escape valve 35 is a valve that allows the heat medium flowing in the heat medium circuit 3 to escape. In embodiment 11, the refrigerant detection unit 6 includes the discharged-refrigerant detection unit 6a, the pressure detection unit 6b, the temperature detection unit 6c and the current detection unit 6d. The heat source unit 20 is provided with the controller 10. The controller 10 is, for example, a microcomputer that controls various devices.

[0080] The controller 10 activates the heating unit 9 by causing electric current to be supplied to the heating unit 9, if the concentration of refrigerant that is detected by the refrigerant detection unit 6 exceeds a preset threshold. The controller 10 also opens the escape valve 35 if the concentration of refrigerant detected by the refrigerant

ant detection unit 6 exceeds the preset threshold. It should be noted that refrigerant detection may be performed using any of the discharged-refrigerant detection unit 6a, the pressure detection unit 6b, the temperature detection unit 6c and the current detection unit 6d.

[0081] If refrigerant enters the heat medium circuit 3, there is a possibility that the refrigerant may circulate in a liquid state in the heat medium circuit 3 because of the pressure and temperature of the heat medium flowing in the heat medium circuit 3. At this time, the refrigerant being in the liquid state and having flowed into the separating unit 4 is heated by the heating unit 9. As a result, the refrigerant being in the liquid state is gasified, and discharged to the outdoor side by the separating unit 4 and the discharge unit 5. Furthermore, if the refrigerant enters the heat medium circuit 3, the escape valve 35 is opened, thereby causing the heat medium and the refrigerant flowing in the heat medium circuit 3 to be reduced in pressure. As a result, the saturation temperature of the refrigerant decreases, and heat exchange is performed between the refrigerant and the heat medium flowing together with the refrigerant. Thereby, the refrigerant being in the liquid state is gasified, and discharged to the outdoor side by the separating unit 4 and the discharge unit 5.

Embodiment 12

[0082] Fig. 21 is a circuit diagram illustrating an air-conditioning apparatus 1100 according to embodiment 12 of the present invention. In embodiment 12, a bypass circuit 11 and a bypass flow switching unit 12 are provided, and the outlet-side valve 7 and the inlet-side valve 8 are omitted. In this regard, embodiment 12 is different from embodiment 11. With respect to embodiment 12, components which are the same as those of embodiments 1 to 11 will be denoted by the same reference signs, and their descriptions will be omitted. Embodiment 12 will be described by referring mainly to the differences between embodiment 12 and embodiments 1 to 11.

[0083] As illustrated in Fig. 21, the bypass circuit 11 is a circuit that is provided outside the space to be air-conditioned, and connects the outlet port 43 of the separating unit 4 with the upstream side of the refrigerant-heat medium heat exchanger 26. The bypass flow switching unit 12 is a component that connects the outlet port 43 of the separating unit 4, the bypass circuit 11 and the upstream side of the load-side heat exchanger 33. The bypass flow switching unit 12 switches connection of the outlet port 43 between connection of the outlet port 43 of the separating unit 4 with the bypass circuit 11 and connection of the outlet port 43 of the separating unit 4 with the upstream side of the load-side heat exchanger 33. As the bypass flow switching unit 12, for example, a three-way valve is used; however, two two-way valves may be used.

[0084] Under normal conditions, the controller 10 controls the above switching of the bypass flow switching unit 12 to cause the liquid having flowed out through the

outlet port 43 to flow toward the load-side heat exchanger 33. Furthermore, if the concentration of refrigerant that is detected by the refrigerant detection unit 6 exceeds a preset threshold, the controller 10 controls the switching connection of the bypass flow switching unit 12 to cause the liquid having flowed out through the outlet port 43 to flow into the bypass circuit 11. It should be noted that refrigerant detection may be performed using any of the discharged-refrigerant detection unit 6a, the pressure detection unit 6b, the temperature detection unit 6c and the current detection unit 6d.

[0085] If refrigerant enters the heat medium circuit 3, the switching of the bypass flow switching unit 12 is controlled by the controller 10 to cause the liquid having flowed out through the outlet port 43 to flow into the bypass circuit 11. Thereby, the refrigerant flows together with the heat medium from the refrigerant-heat medium heat exchanger 26, passes through the pump 32 and flows into the separating unit 4, and thereafter flows into the bypass circuit 11. After flowing into the bypass circuit 11, the refrigerant and the heat medium re-flow into the refrigerant-heat medium heat exchanger 26 without passing through the indoor space. It is therefore possible to reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31. Furthermore, it should be noted that the refrigerant and the heat medium are circulated through the refrigerant-heat medium heat exchanger 26, the pump 32, the separating unit 4 and the bypass circuit 11 in this order, and thus pass through the separating unit 4 the same number of times as the refrigerant and the heat medium are circulated through the above components. Therefore, the larger the number of times the refrigerant is circulated, the larger the amount of refrigerant discharged by the separating unit 4 and the discharge unit 5. It is therefore possible to further reliably reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31.

Embodiment 13

[0086] Fig. 22 is a circuit diagram illustrating an air-conditioning apparatus 1200 according to embodiment 13 of the present invention. In embodiment 13, the separating unit 4 and the discharge unit 5 are omitted. In this regard, embodiment 13 is different from embodiment 12. With respect to embodiment 13, components which are the same as those of embodiments 1 to 12 will be denoted by the same reference signs, and their descriptions will thus be omitted. Embodiment 13 will be described by referring mainly to the differences between embodiment 13 and embodiments 1 to 12.

[0087] As illustrated in Fig. 22, the bypass circuit 11 is a circuit that is provided outside the space to be air-conditioned, and connects the downstream side of the refrigerant-heat medium heat exchanger 26 with the upstream side of the refrigerant-heat medium heat exchanger 26. In embodiment 13, the pump 32 is provided downstream of the refrigerant-heat medium heat ex-

changer 26, and the bypass circuit 11 thus connects the downstream side of the pump 32 with the upstream side of the refrigerant-heat medium heat exchanger 26. It should be noted that in the case where the pump 32 is provided downstream of the refrigerant-heat medium heat exchanger 26, the bypass circuit 11 connects the downstream side of the refrigerant-heat medium heat exchanger 26 with the upstream side of the pump 32. The bypass flow switching unit 12 is a component which connects the downstream side of the pump 32, the bypass circuit 11 and the upstream side of the load-side heat exchanger 33. The bypass flow switching unit 12 switches the connection of the outlet port 43 of the separating unit 4 between the connection of the outlet port 43 of the separating unit 4 with the bypass circuit 11 and the connection of the outlet port 43 of the separating unit 4 with the upstream side of the load-side heat exchanger 33. As the bypass flow switching unit 12, for example, a three-way valve is used; however, two two-way valves may be used.

[0088] Under normal conditions, the controller 10 controls the above switching of the bypass flow switching unit 12 to cause the heat medium transferred from the pump 32 to flow toward the load-side heat exchanger 33. If the concentration of refrigerant that is detected by the refrigerant detection unit 6 exceeds a preset threshold, the controller 10 controls the switching of the bypass flow switching unit 12 to cause the heat medium transferred from the pump 32 and refrigerant to flow into the bypass circuit 11. It should be noted that refrigerant detection may be performed using any of the pressure detection unit 6b, the temperature detection unit 6c and the current detection unit 6d.

[0089] If refrigerant enters the heat medium circuit 3, the switching of the bypass flow switching unit 12 is controlled by the controller 10 to cause the refrigerant and the heat medium transferred from the pump 32 to flow into the bypass circuit 11. Therefore, the refrigerant flows together with the heat medium from the refrigerant-heat medium heat exchanger 26, flows through the pump 32 and then flows into the bypass circuit 11. After flowing into the bypass circuit 11, the refrigerant and the heat medium re-flow into the refrigerant-heat medium heat exchanger 26 without passing through the indoor space. It is therefore possible to reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31. As described above, because of provision of the bypass circuit 11, it is possible to reduce the inflow of the refrigerant to the indoor part of the heat medium pipe 31 without providing the separating unit 4 or the discharge unit 5.

Embodiment 14

[0090] Fig. 23 is a schematic view illustrating a sub-separating unit 13 in embodiment 14 of the present invention. In embodiment 14, the sub-separating unit 13 is provided. In this regard, embodiment 14 is different from embodiment 4. In embodiment 14, components which

are the same as those of embodiments 1 to 13 will be denoted by the same reference signs, and their descriptions will thus be omitted. Embodiment 14 will be described by referring mainly to the differences between embodiment 14 and embodiments 1 to 13.

[0091] As illustrated in Fig. 23, the sub-separating unit 13 is a component that is provided at the discharge port 51 of the discharge unit 5 to separate gas and liquid. The sub-separating unit 13 is connected with a discharge pipe, which is connected with the discharge port 51 of the discharge unit 5 and extends upwards. The sub-separating unit 13 is a tubular component that extends downwards from the discharge pipe, connects with a liquid drain pipe at the bottom portion, and then extends upwards from the bottom portion. At an upper end of the sub-separating unit 13, a gas discharge port 13b is provided. In such a manner, the sub-separating unit 13 includes a composite pipe that traps gas. At the distal end of the sub-separating unit 13, the discharged-refrigerant detection unit 6a is provided. The liquid drain pipe is provided with a liquid drain valve 14.

[0092] When refrigerant having flowed into the heat medium circuit 3 is discharged from the discharge unit 5, a small amount of heat medium being in a liquid state may also spout out together with the refrigerant. At this time, there is a possibility that the heat medium having spouted out will splash on the discharged-refrigerant detection unit 6a. In embodiment 14, the sub-separating unit 13 causes the liquid heat medium discharged from the discharge unit 5 to accumulate at the bottom portion of the sub-separating unit 13, and then drop into the liquid drain pipe from the bottom portion. Then, the liquid drain valve 14 is opened to cause the heat medium to be discharged through the liquid drain valve 14. Therefore, when refrigerant is discharged from the gas discharge port 13b after passing through the sub-separating unit 13, the heat medium does not spout out. Thus, since the liquid heat medium is not splashed on the discharged-refrigerant detection unit 6a, it is possible to maintain the accuracy of detection by the discharged-refrigerant detection unit 6a.

(Modification)

[0093] Fig. 24 a schematic view illustrating a sub-separating unit 13a in a modification of embodiment 14 of the present invention. This modification is different from embodiment 14 in the structure of the sub-separating unit 13a. As illustrated in Fig. 24, the sub-separating unit 13a in this modification is a container. The sub-separating unit 13a is connected with a discharge pipe, which is connected with the discharge port 51 of the discharge unit 5 and extends upwards. The sub-separating unit 13a is connected with a liquid drain pipe at the bottom portion, and has the gas discharge port 13b provided in an upper portion. The discharged-refrigerant detection unit 6a is located at the distal end of the sub-separating unit 13a. The liquid drain pipe is provided with the liquid drain valve

14.

[0094] When refrigerant having flowed into the heat medium circuit 3 is discharged from the discharge unit 5, a small amount of heat medium being in a liquid state may also spout out together with the refrigerant. At this time, there is a possibility that the liquid heat medium having spouted out may splash on the discharged-refrigerant detection unit 6a. In this modification, the sub-separating unit 13a causes the liquid heat medium discharged from the discharge unit 5 to accumulate at the bottom portion of the sub-separating unit 13a, and then drop into the liquid drain pipe from the bottom portion. Then, the liquid drain valve 14 is opened to cause the liquid heat medium to be discharged through the liquid drain valve 14. Therefore, when refrigerant is discharged from the gas discharge port 13b after passing through the sub-separating unit 13a, the heat medium does not spout out. Thus, since the liquid heat medium is not splashed on the discharged-refrigerant detection unit 6a, it is possible to maintain the accuracy of detection by the discharged-refrigerant detection unit 6a, as in embodiment 14.

Reference Signs List

[0095] 1 air-conditioning apparatus 2 refrigerant circuit 3 heat medium circuit 4, 4a, 4b, 4c, 4d separating unit 5 discharge unit 6 refrigerant detection unit 6a discharged-refrigerant detection unit 6b pressure detection unit 6c temperature detection unit 6d current detection unit 7 outlet-side valve 8 inlet-side valve 9 heating unit 10 controller 11 bypass circuit 12 bypass flow switching unit 13, 13a sub-separating unit 13b gas discharge port 14 liquid drain valve 20 heat source unit 21 refrigerant pipe 22 compressor 23 flow switching device 24 heat-source-side heat exchanger 25 expansion unit 26 refrigerant-heat medium heat exchanger 30 cooling and heating device 31 heat medium pipe 32 pump 33 load-side heat exchanger 34 air vent valve 35 escape valve 41 connection port 41a lower end 42 discharge port 43 outlet port 43a upper end 44 extension portion 45 discharge portion 46 outlet portion 51 discharge port 100, 100a, 100b air-conditioning apparatus 200 air-conditioning apparatus 300 air-conditioning apparatus 400 air-conditioning apparatus 600 air-conditioning apparatus 700 air-conditioning apparatus 800 air-conditioning apparatus 900 air-conditioning apparatus 1000 air-conditioning apparatus 1100 air-conditioning apparatus 1200 air-conditioning apparatus

Claims

1. An air-conditioning apparatus comprising:

a refrigerant circuit in which a compressor (22), a heat-source-side heat exchanger (24), an expansion unit (25) and a refrigerant-heat medium heat exchanger (26) are connected by a refrigerant pipe (21), and refrigerant is circulated;

a heat medium circuit (3) in which a pump (32), the refrigerant-heat medium heat exchanger (26) and a load-side heat exchanger (33) are connected by a heat medium pipe (31), and a heat medium is circulated, the load-side heat exchanger (33) being configured to exchange heat with air in space to be air-conditioned; a separating unit (4) configured to separate the refrigerant and the heat medium from each other, the separating unit (4) being located at part of the heat medium pipe (31) in which the heat medium flows after flowing out of the refrigerant-heat medium heat exchanger (26) and before flowing into the load-side heat exchanger (33), and which is located outside the space to be air-conditioned; and

a discharge unit (5) connected to the separating unit (4) to discharge the refrigerant separated from the heat medium by the separating unit (4) to an outside of the space to be air-conditioned;

characterized in that

the separating unit (4) includes a connection port (41) connected with part of the heat medium circuit (3) which is located downstream of the refrigerant-heat medium heat exchanger (26),

a discharge port (42) connected with the discharge unit (5) to allow the refrigerant to be discharged to the discharge unit (5), and

an outlet port (43) connected with part of the heat medium circuit (3) which is located upstream of the load-side heat exchanger (33), and allowing the heat medium to be discharged;

wherein the connection port (41) is located at a higher level than or the same level as the outlet port (43) in a height direction of the separating unit (4).

2. The air-conditioning apparatus of claim 1, wherein the separating unit (4) has a passage cross-sectional area larger than a passage cross-sectional area of the heat medium pipe (31).

3. The air-conditioning apparatus of any one of claims 1 to 2, further comprising at least one of an outlet-side valve (7) provided outside the space to be air-conditioned and downstream of the separating unit (4), and configured to adjust a flow rate of the heat medium, an inlet-side valve (8) provided outside the space to be air-conditioned and upstream of the separating unit (4), and configured to adjust a flow rate of the heat medium, a heating unit (9) provided in the separating unit (4) and configured to heat a liquid in the separating unit (4), and an escape valve (35) provided at part of the heat medium circuit (3) which is located outside the space to be air-conditioned, and configured to allow the

heat medium flowing in the heat medium circuit (3) to escape.

4. The air-conditioning apparatus of any one of claims 1 to 3,
wherein the pump (32) is provided downstream of the refrigerant-heat medium heat exchanger (26). 5
5. The air-conditioning apparatus of any one of claims 1 to 4, further comprising
a sub-separating unit (13) provided at the discharge unit (5) and configured to separate gas and liquid from each other. 10
6. The air-conditioning apparatus of any one of claims 1 to 5, further comprising
a bypass circuit (11) provided outside the space to be air-conditioned, and connecting the outlet port (43) of the separating unit (4) with an upstream side of the refrigerant-heat medium heat exchanger (26). 15 20
7. The air-conditioning apparatus of any one of claims 1 to 6, further comprising
a refrigerant detection unit (6) configured to detect that the refrigerant flows into the heat medium circuit (3). 25
8. The air-conditioning apparatus of claim 7 as dependent on claim 5, further comprising
a controller (10) configured to perform at least one of a control to close the outlet-side valve (7) when a concentration of the refrigerant detected by the refrigerant detection unit (6) exceeds a preset threshold, a control to close the inlet-side valve (8) when a concentration of the refrigerant detected by the refrigerant detection unit (6) exceeds a preset threshold, a control to cause the heating unit (9) to operate, when a concentration of the refrigerant detected by the refrigerant detection unit (6) exceeds a preset threshold, and a control to open the escape valve (35) when a concentration of the refrigerant detected by the refrigerant detection unit (6) exceeds a preset threshold. 30 35 40
9. The air-conditioning apparatus of claim 7 or 8, wherein the refrigerant detection unit (6) includes at least one of a discharged-refrigerant detection unit (6a) provided at the discharge unit (5) and configured to detect the refrigerant discharged from the discharge unit (5), a pressure detection unit (6b) configured to detect a pressure of the heat medium flowing in the heat medium circuit (3), a temperature detection unit (6c) configured to detect a temperature of the heat medium flowing in the heat medium circuit (3), and a current detection unit (6d) configured to detect an operating current of the pump (32). 45 50 55
10. The air-conditioning apparatus of any one of claims

1 to 9,
wherein the separating unit (4) has a passage cross-sectional area which is set to cause a fluid in the separating unit (4) to flow at a velocity less than or equal to 1500 mm/s.

11. The air-conditioning apparatus of any one of claims 1 to 10,
wherein the heat medium separated from the refrigerant by the separating unit (4) flows to the load-side heat exchanger (33).

Patentansprüche

1. Klimaanlage, umfassend:

einen Kältemittelkreislauf, in dem ein Verdichter (22), ein wärmequellenseitiger Wärmetauscher (24), eine Expansioneinheit (25) und ein Kältemittel-Wärmemedium-Wärmetauscher (26) durch eine Kältemittelleitung (21) verbunden sind, und in dem Kältemittel zirkuliert wird;
einen Wärmemediumkreislauf (3), in dem eine Pumpe (32), der Kältemittel-Wärmemedium-Wärmetauscher (26) und ein lastseitiger Wärmetauscher (33) durch eine Wärmemediumleitung (31) verbunden sind, und ein Wärmemedium zirkuliert wird, wobei der lastseitige Wärmetauscher (33) eingerichtet ist, Wärme mit Luft in einem zu klimatisierenden Raum auszutauschen;
eine Trenneinheit (4), die eingerichtet ist, das Kältemittel und das Wärmemedium voneinander zu trennen, wobei die Trenneinheit (4) an einem Teil der Wärmemediumleitung (31) angeordnet ist, in der das Wärmemedium nach dem Ausströmen aus dem Kältemittel-Wärmemedium-Wärmetauscher (26) und vor dem Einströmen in den lastseitigen Wärmetauscher (33) strömt, und die sich außerhalb des zu klimatisierenden Raums befindet; und
eine Abgabeeinheit (5), die mit der Trenneinheit (4) verbunden ist, um das durch die Trenneinheit (4) vom Wärmemedium abgetrennte Kältemittel nach außerhalb des zu klimatisierenden Raums abzugeben;

dadurch gekennzeichnet, dass
die Trenneinheit (4) aufweist:

eine Verbindungsöffnung (41), die mit einem Teil des Wärmemediumkreislaufs (3) verbunden ist, der sich stromabwärts des Kältemittel-Wärmemedium-Wärmetauschers (26) befindet,
eine Abgabeöffnung (42), die mit der Abgabeeinheit (5) verbunden ist, um zu ermöglichen, dass das Kältemittel an die Abgabe-

- einheit (5) abgegeben werden kann, und eine Auslassöffnung (43), die mit einem Teil des Wärmedienumkreislaufs (3) verbunden ist, der sich stromaufwärts des lastseitigen Wärmetauschers (33) befindet und ermöglicht, dass das Wärmedienum abgegeben werden kann; wobei die Verbindungsöffnung (41) in einer Höhenrichtung der Trenneinheit (4) auf einem höheren Niveau als oder auf einem gleichen Niveau wie die Auslassöffnung (43) angeordnet ist.
2. Klimaanlage nach Anspruch 1, wobei die Trenneinheit (4) eine Durchlassquerschnittsfläche aufweist, die größer ist als eine Durchlassquerschnittsfläche der Wärmedienumleitung (31).
 3. Klimaanlage nach einem der Ansprüche 1 bis 2, ferner umfassend: mindestens ein auslassseitiges Ventil (7), das außerhalb des zu klimatisierenden Raums und stromabwärts der Trenneinheit (4) vorgesehen und eingerichtet ist, eine Strömungsrate des Wärmedienums anzupassen, ein einlassseitiges Ventil (8), das außerhalb des zu klimatisierenden Raums und stromaufwärts der Trenneinheit (4) vorgesehen und eingerichtet ist, eine Strömungsrate des Wärmedienums anzupassen, eine Erwärmungseinheit (9), die in der Trenneinheit (4) vorgesehen und eingerichtet ist, eine Flüssigkeit in der Trenneinheit (4) zu erwärmen, und ein Auslassventil (35), das an einem Teil des Wärmedienumkreislaufs (3) vorgesehen ist, der sich außerhalb des zu klimatisierenden Raums befindet, und eingerichtet ist, zu ermöglichen, dass das im Wärmedienumkreislauf (3) strömende Wärmedienum entweichen kann.
 4. Klimaanlage nach einem der Ansprüche 1 bis 3, wobei die Pumpe (32) stromabwärts des Kältemittel-Wärmedienum-Wärmetauschers (26) vorgesehen ist.
 5. Klimaanlage nach einem der Ansprüche 1 bis 4, ferner umfassend: eine Teil-Trenneinheit (13), die an der Abgabeeinheit (5) vorgesehen und eingerichtet ist, Gas und Flüssigkeit voneinander zu trennen.
 6. Klimaanlage nach einem der Ansprüche 1 bis 5, ferner umfassend: einen Umgehungsreislauf (11), der außerhalb des zu klimatisierenden Raums vorgesehen ist und die Auslassöffnung (43) der Trenneinheit (4) mit einer stromaufwärts gelegenen Seite des Kältemittel-Wärmetauschers (26) verbindet.
 7. Klimaanlage nach einem der Ansprüche 1 bis 6, ferner umfassend: eine Kältemittel-Erfassungseinheit (6), die eingerichtet ist, zu erfassen, dass das Kältemittel in den Wärmedienumkreislauf (3) strömt.
 8. Klimaanlage nach Anspruch 7 in Abhängigkeit von Anspruch 5, ferner umfassend: eine Steuerungseinheit (10), die eingerichtet ist, zumindest eine Steuerung durchzuführen, um das auslassseitige Ventil (7) zu schließen, wenn eine von der Kältemittel-Erfassungseinheit (6) erfasste Konzentration des Kältemittels einen voreingestellten Schwellenwert überschreitet, einer Steuerung, um das einlassseitige Ventil (8) zu schließen, wenn eine von der Kältemittel-Erfassungseinheit (6) erfasste Konzentration des Kältemittels einen voreingestellten Schwellenwert überschreitet, eine Steuerung, um die Erwärmungseinheit (9) zu veranlassen, zu arbeiten, wenn eine von der Kältemittel-Erfassungseinheit (6) erfasste Konzentration des Kältemittels einen voreingestellten Schwellenwert überschreitet, und eine Steuerung, um das Auslassventil (35) zu öffnen, wenn eine von der Kältemittel-Erfassungseinheit (6) erfasste Konzentration des Kältemittels einen voreingestellten Schwellenwert überschreitet.
 9. Klimaanlage nach Anspruch 7 oder 8, wobei die Kältemittel-Erfassungseinheit (6) mindestens eine Abgegebenes-Kältemittel-Erfassungseinheit (6a), die an der Abgabeeinheit (5) vorgesehen und eingerichtet ist, das von der Abgabeeinheit (5) abgegebene Kältemittel zu erfassen, eine Druckerfassungseinheit (6b), die eingerichtet ist, einen Druck des in dem Wärmedienumkreislauf (3) strömenden Wärmedienums zu erfassen, eine Temperatur-Erfassungseinheit (6c), die eingerichtet ist, eine Temperatur des in dem Wärmedienumkreislauf (3) strömenden Wärmedienums zu erfassen, und eine Strom-Erfassungseinheit (6d), die eingerichtet ist, einen Betriebsstrom der Pumpe (32) zu erfassen, umfasst.
 10. Klimaanlage nach einem der Ansprüche 1 bis 9, wobei die Trenneinheit (4) eine Durchlassquerschnittsfläche aufweist, die so eingestellt ist, dass bewirkt wird, dass ein Fluid in der Trenneinheit (4) mit einer Geschwindigkeit von weniger als oder gleich 1500 mm/s strömt.
 11. Klimaanlage nach einem der Ansprüche 1 bis 10, wobei das durch die Trenneinheit (4) vom Kältemittel getrennte Wärmedienum zum lastseitigen Wärmetauscher (33) strömt.

Revendications

1. Appareil de climatisation comprenant :

un circuit de fluide frigorigène dans lequel un compresseur (22), un échangeur de chaleur côté source de chaleur (24), une unité d'expansion (25), et un échangeur de chaleur fluide frigorigène-agent caloporteur (26) sont connectés par un tuyau de fluide frigorigène (21) et un fluide frigorigène est mis en circulation ;
 un circuit d'agent caloporteur (3) dans lequel une pompe (32), l'échangeur de chaleur fluide frigorigène-agent caloporteur (26) et un échangeur de chaleur côté charge (33) sont connectés par un tuyau d'agent caloporteur (31), et un agent caloporteur est mis en circulation, l'échangeur de chaleur côté charge (33) étant configuré pour échanger de la chaleur avec l'air dans l'espace à climatiser ;
 une unité de séparation (4) configurée pour séparer le fluide frigorigène et l'agent caloporteur l'un de l'autre, l'unité de séparation (4) étant située sur une partie du tuyau d'agent caloporteur (31) dans lequel l'agent caloporteur s'écoule après être sorti de l'échangeur de chaleur fluide frigorigène-agent caloporteur (26) et avant de s'écouler dans l'échangeur de chaleur côté charge (33), et qui est située à l'extérieur de l'espace à climatiser ; et
 une unité d'évacuation (5) reliée à l'unité de séparation (4) pour évacuer le fluide frigorigène séparé de l'agent caloporteur par l'unité de séparation (4) vers l'extérieur de l'espace à climatiser ;
caractérisé en ce que
 l'unité de séparation (4) comprend
 un orifice de connexion (41) connecté à une partie du circuit d'agent caloporteur (3) qui est située en aval de l'échangeur de chaleur fluide frigorigène-agent caloporteur (26),
 un orifice d'évacuation (42) connecté à l'unité d'évacuation (5) pour permettre au fluide frigorigène d'être évacué dans l'unité d'évacuation (5), et
 un orifice de sortie (43) connecté à une partie du circuit d'agent caloporteur (3) qui est située en amont de l'échangeur de chaleur côté charge (33) et permettant d'évacuer le fluide caloporteur ;
 dans lequel l'orifice de connexion (41) est situé à un niveau supérieur à ou au même niveau que l'orifice de sortie (43) dans le sens de la hauteur de l'unité de séparation (4).

2. Appareil de climatisation selon la revendication 1, dans lequel l'unité de séparation (4) a une section de passage plus grande qu'une section de passage

du tuyau d'agent caloporteur (31).

3. Appareil de climatisation selon l'une quelconque des revendications 1 et 2, comprenant en outre au moins l'une d'une vanne côté sortie (7) disposée à l'extérieur de l'espace à climatiser et en aval de l'unité de séparation (4), et configurée pour régler un débit de l'agent caloporteur, d'une vanne côté entrée (8) disposée à l'extérieur de l'espace à climatiser et en amont de l'unité de séparation (4), et configurée pour régler un débit de l'agent caloporteur, d'une unité de chauffage (9) disposée dans l'unité de séparation (4) et configurée pour chauffer un liquide dans l'unité de séparation (4), et d'une vanne d'échappement (35) disposée au niveau d'une partie du circuit d'agent caloporteur (3) qui est située à l'extérieur de l'espace à climatiser, et configurée pour permettre à l'agent caloporteur circulant dans le circuit d'agent caloporteur (3) de s'échapper.
4. Appareil de climatisation selon l'une quelconque des revendications 1 à 3, dans lequel la pompe (32) est disposée en aval de l'échangeur de chaleur fluide frigorigène-agent caloporteur (26).
5. Appareil de climatisation selon l'une quelconque des revendications 1 et 4, comprenant en outre une unité de sous-séparation (13) disposée au niveau de l'unité d'évacuation (5) et configurée pour séparer le gaz et le liquide l'un de l'autre.
6. Appareil de climatisation selon l'une quelconque des revendications 1 à 5, comprenant en outre un circuit de dérivation (11) disposé à l'extérieur de l'espace à climatiser, et connectant l'orifice de sortie (43) de l'unité de séparation (4) à un côté amont de l'échangeur de chaleur fluide frigorigène-agent caloporteur (26).
7. Appareil de climatisation selon l'une quelconque des revendications 1 et 6, comprenant en outre une unité de détection de fluide frigorigène (6) configurée pour détecter que le fluide frigorigène s'écoule dans le circuit d'agent caloporteur (3).
8. Appareil de climatisation selon la revendication 7, dépendante de la revendication 5, comprenant en outre un dispositif de commande (10) configuré pour effectuer au moins l'une d'une commande de fermeture de la vanne côté sortie (7) lorsqu'une concentration du fluide frigorigène détectée par l'unité de détection de fluide frigorigène (6) dépasse un seuil prédéfini, d'une commande de fermeture de la vanne côté entrée (8) lorsqu'une concentration du fluide frigorigène détectée par l'unité de détection de fluide frigorigène (6) dépasse un seuil prédéfini, d'une

commande pour faire fonctionner l'unité de chauffage (9) lorsqu'une concentration du fluide frigorigène détectée par l'unité de détection de fluide frigorigène (6) dépasse un seuil prédéfini, et d'une commande d'ouverture de la vanne d'échappement (35) lorsqu'une concentration du fluide frigorigène détectée par l'unité de détection de fluide frigorigène (6) dépasse un seuil prédéfini.

9. Appareil de climatisation selon la revendication 7 ou 8, 10
 dans lequel l'unité de détection de fluide frigorigène (6) comprend au moins une unité de détection de fluide frigorigène évacué (6a) disposée au niveau de l'unité d'évacuation (5) et configurée pour détecter le fluide frigorigène évacué de l'unité d'évacuation (5), une unité de détection de la pression (6b) configurée pour détecter une pression de l'agent caloporteur circulant dans le circuit d'agent caloporteur (3), une unité de détection de la température (6c) configurée pour détecter une température de l'agent caloporteur circulant dans le circuit d'agent caloporteur (3), et une unité de détection du courant (6d) configurée pour détecter un courant de fonctionnement de la pompe (32). 15 20 25
10. Appareil de climatisation selon l'une quelconque des revendications 1 à 9, 30
 dans lequel l'unité de séparation (4) a une section de passage qui est réglée pour amener un fluide dans l'unité de séparation (4) à s'écouler à une vitesse inférieure ou égale à 1500 mm/s.
11. Appareil de climatisation selon l'une quelconque des revendications 1 à 10, 35
 dans lequel l'agent caloporteur séparé du fluide frigorigène par l'unité de séparation (4) s'écoule vers l'échangeur de chaleur côté charge (33). 40 45 50 55

FIG. 1

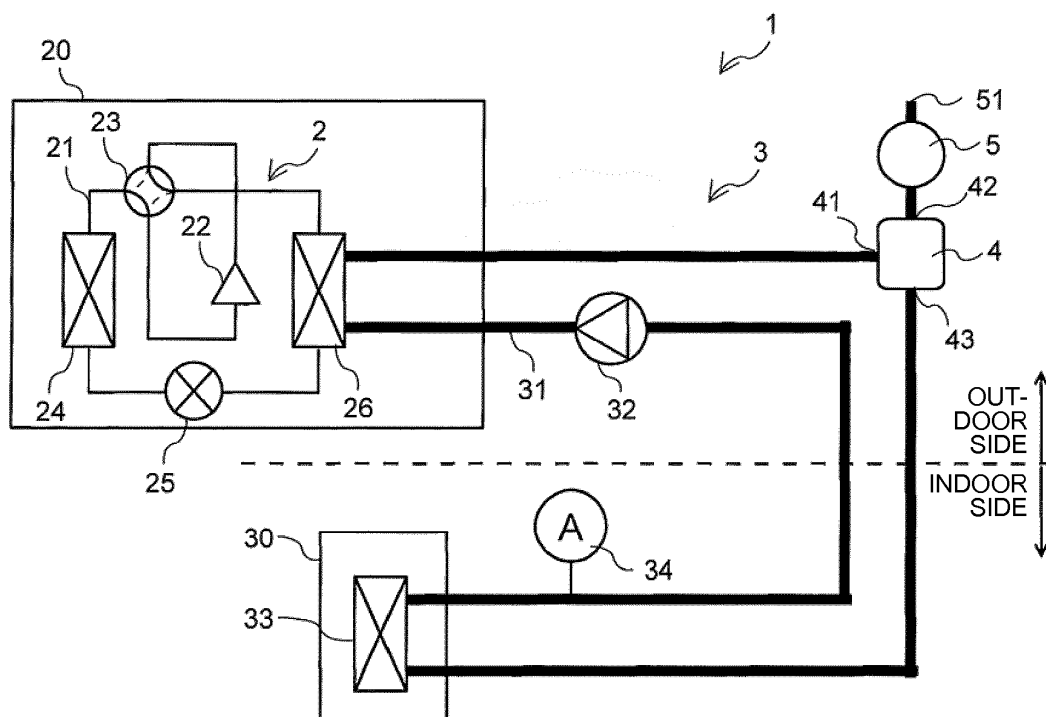


FIG. 2

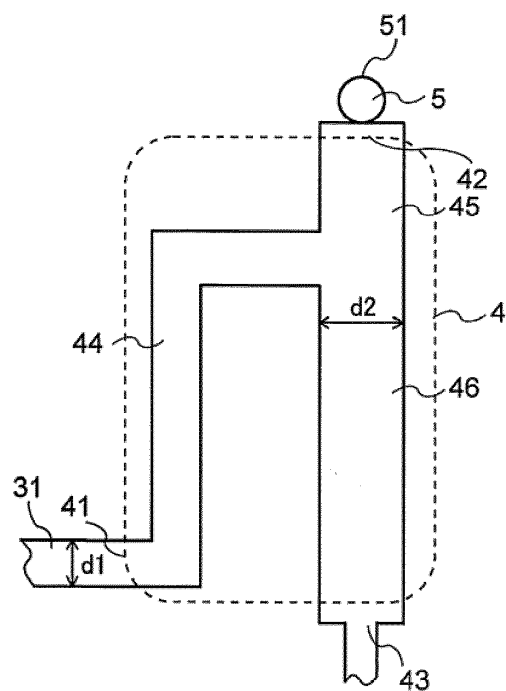


FIG. 3

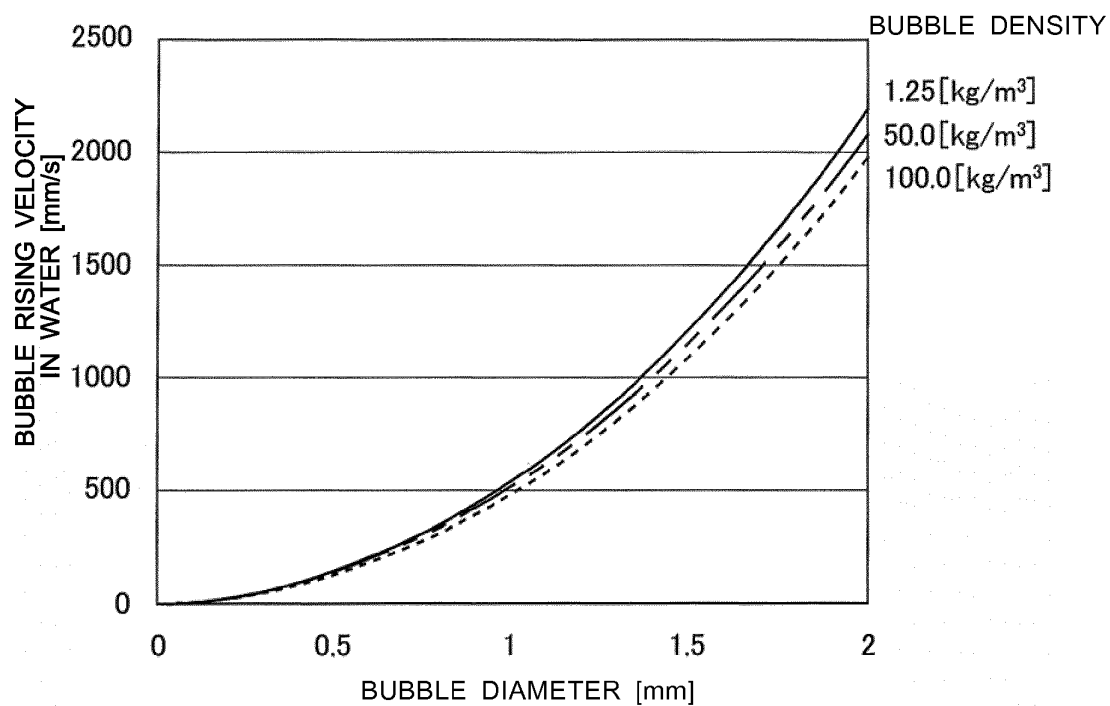


FIG. 4

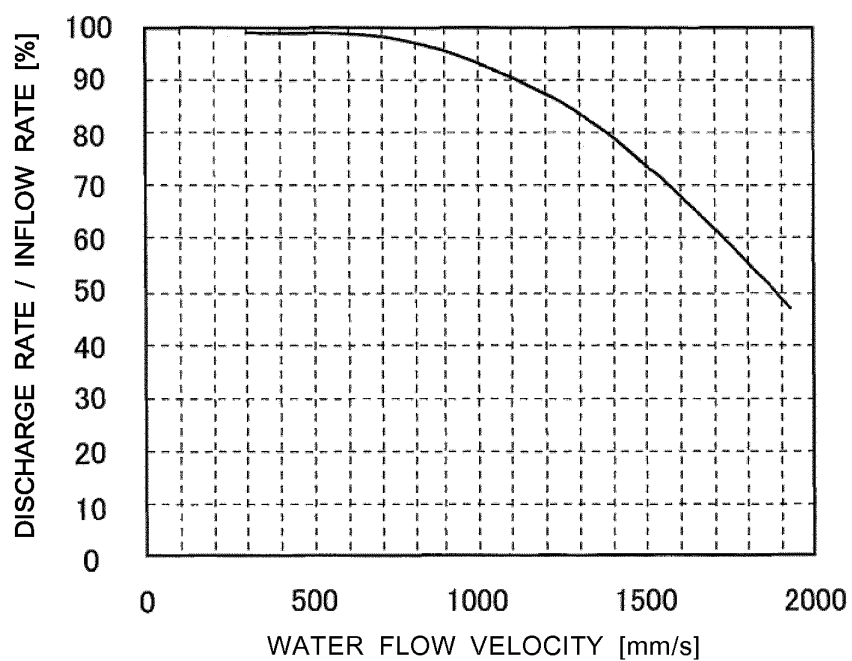


FIG. 5

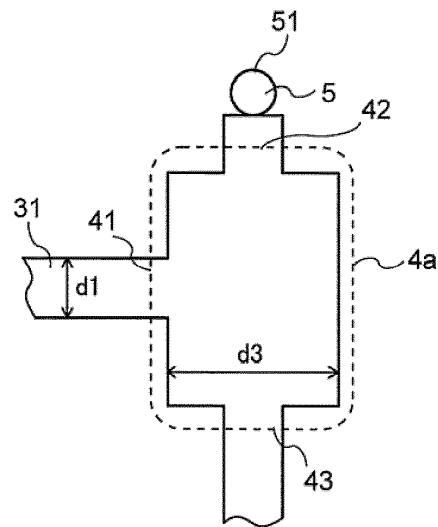


FIG. 6

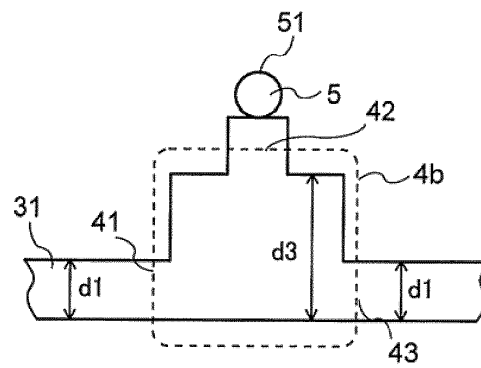


FIG. 7

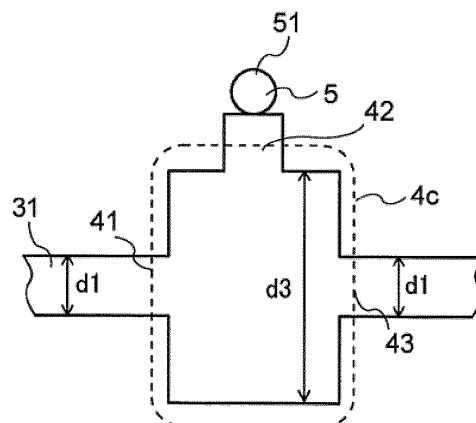


FIG. 8

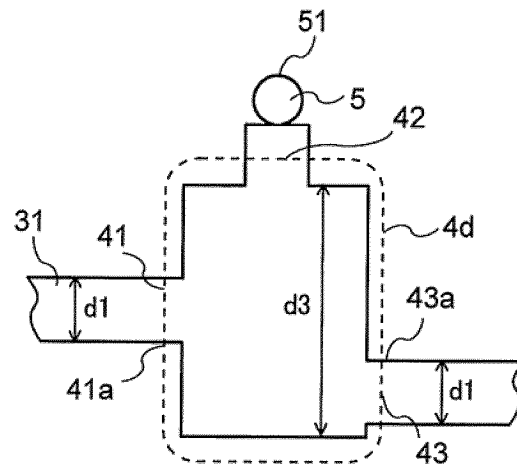


FIG. 9

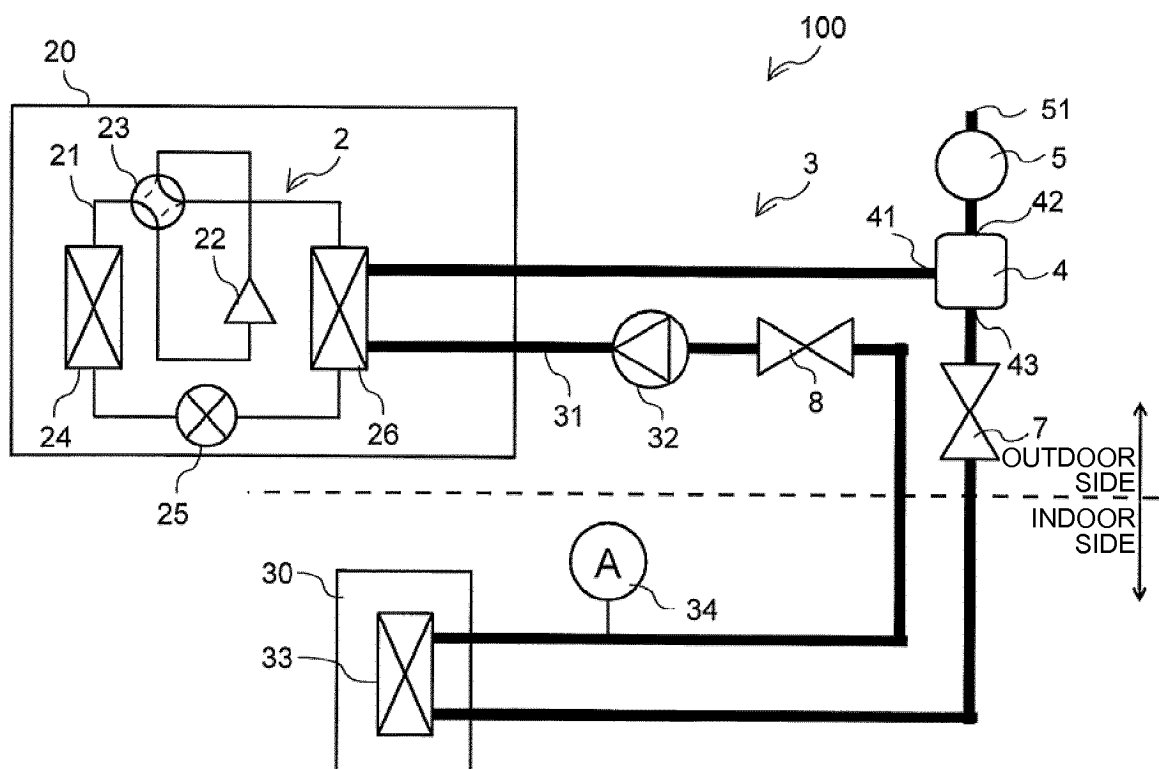
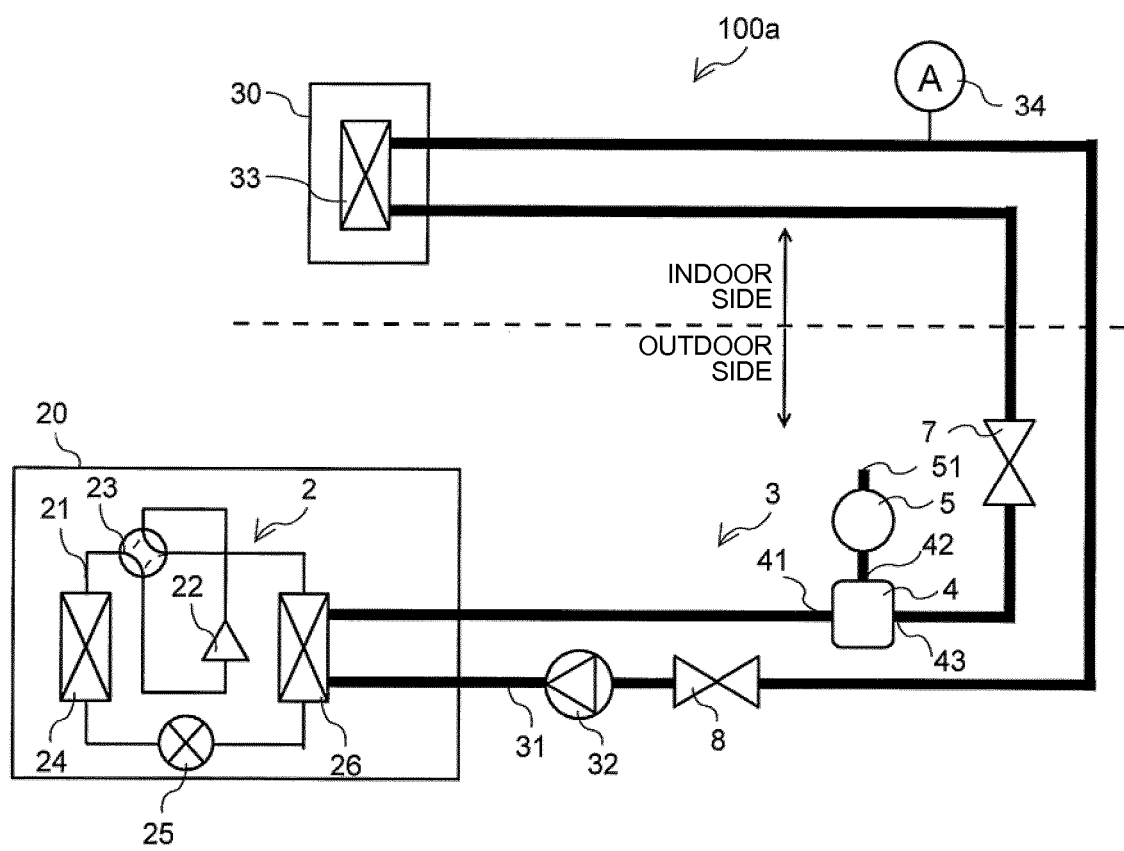


FIG. 10



681941 KPO 2210

FIG. 11

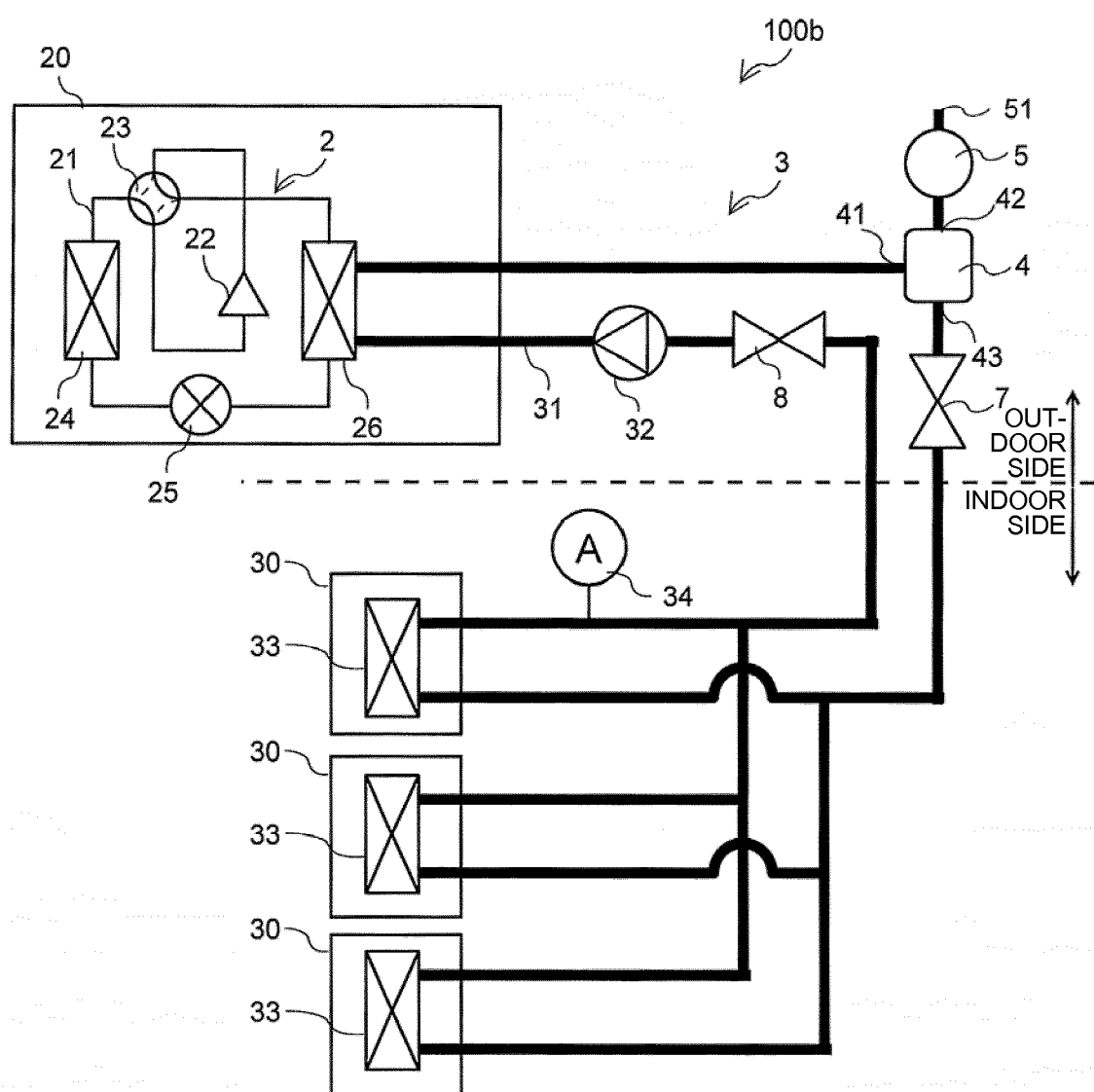


FIG. 12

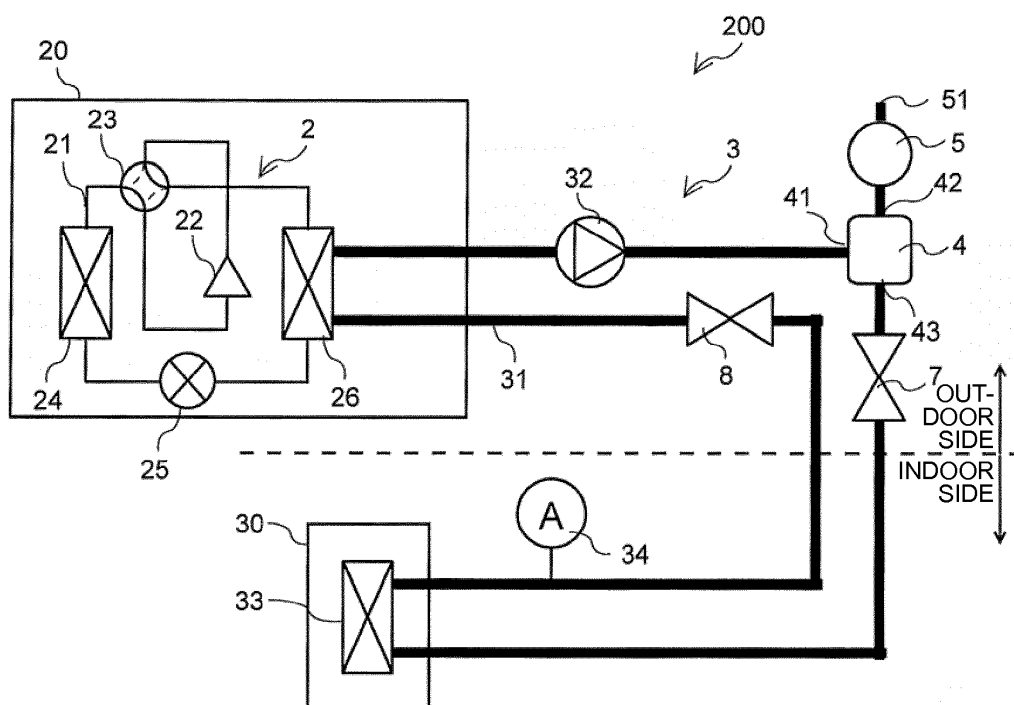


FIG. 13

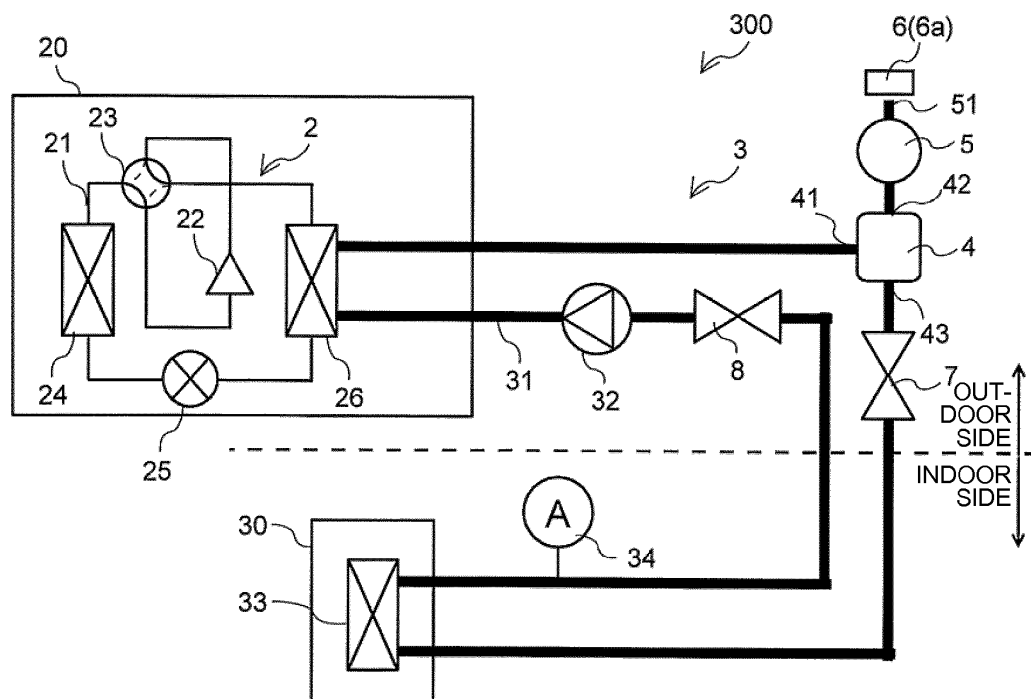


FIG. 14

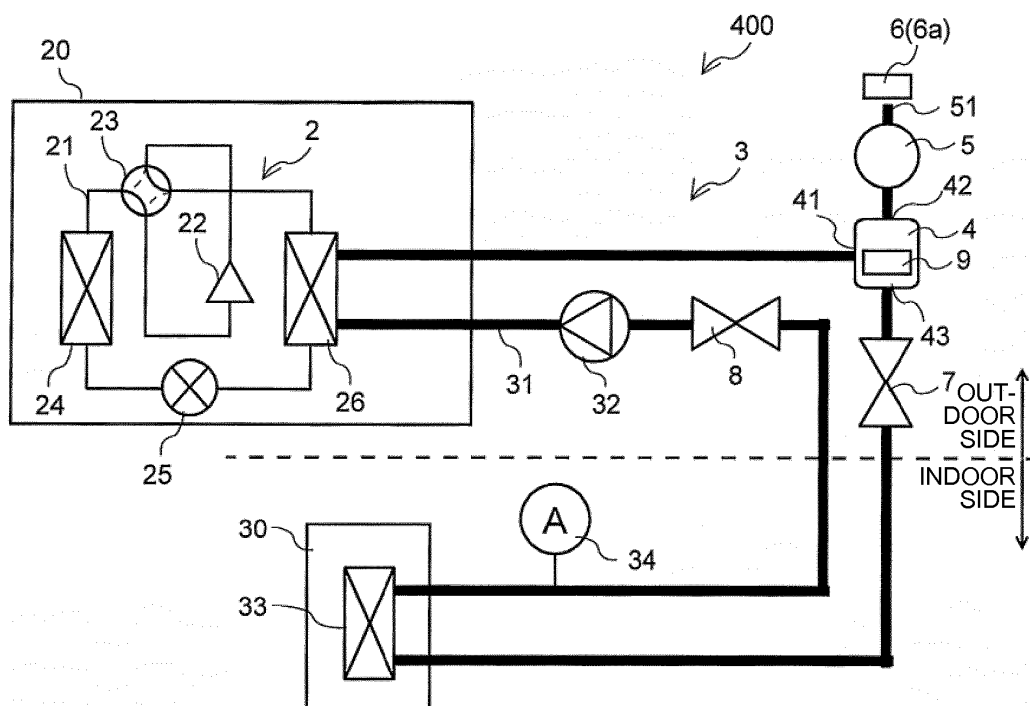


FIG. 15

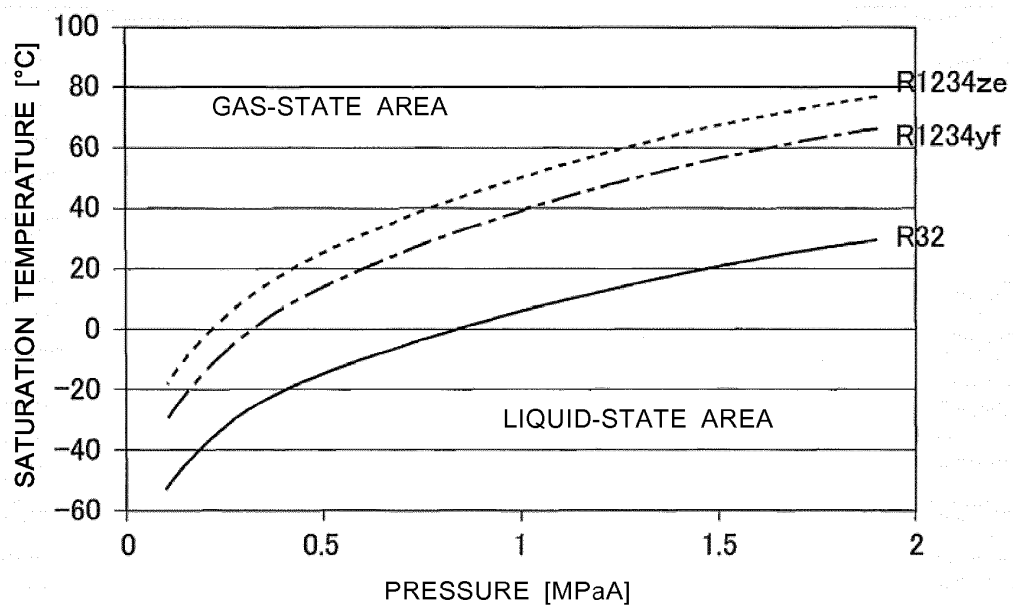


FIG. 16

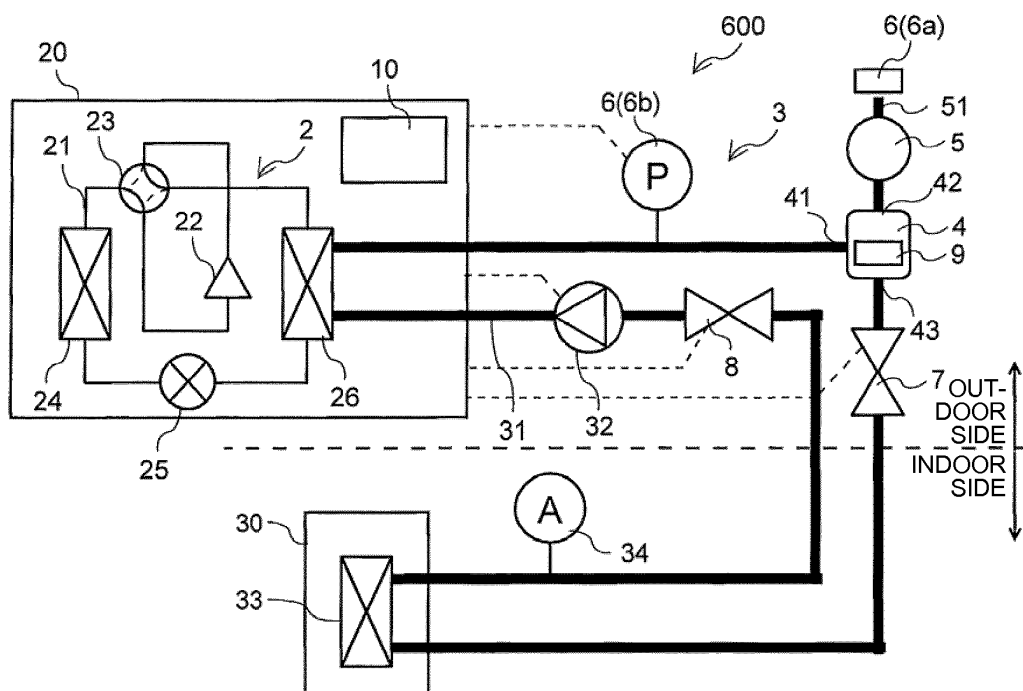


FIG. 17

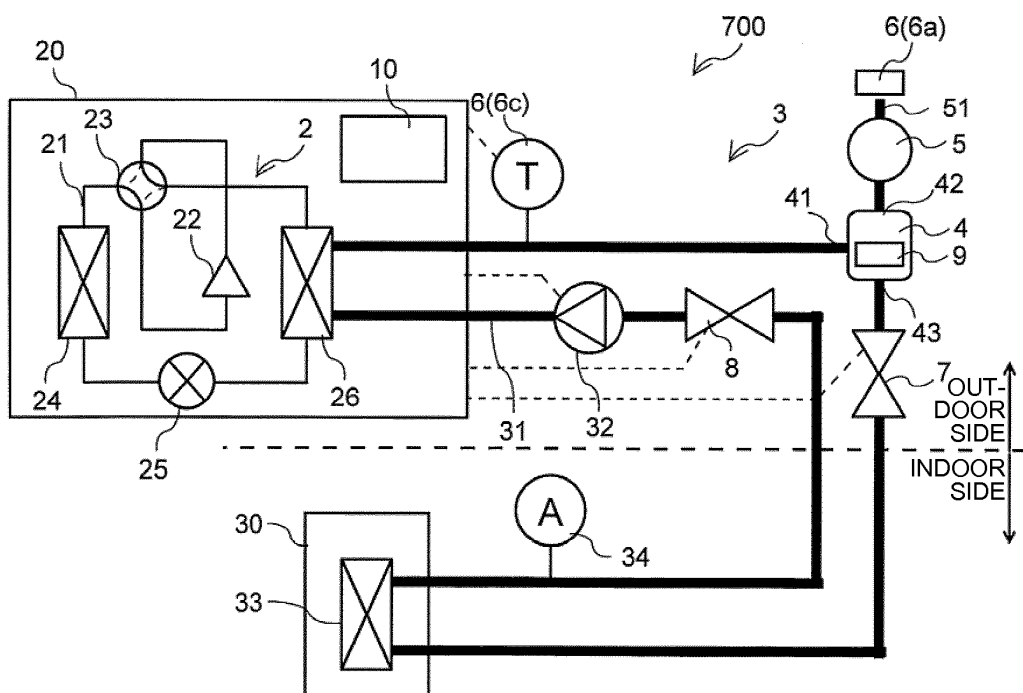


FIG. 18

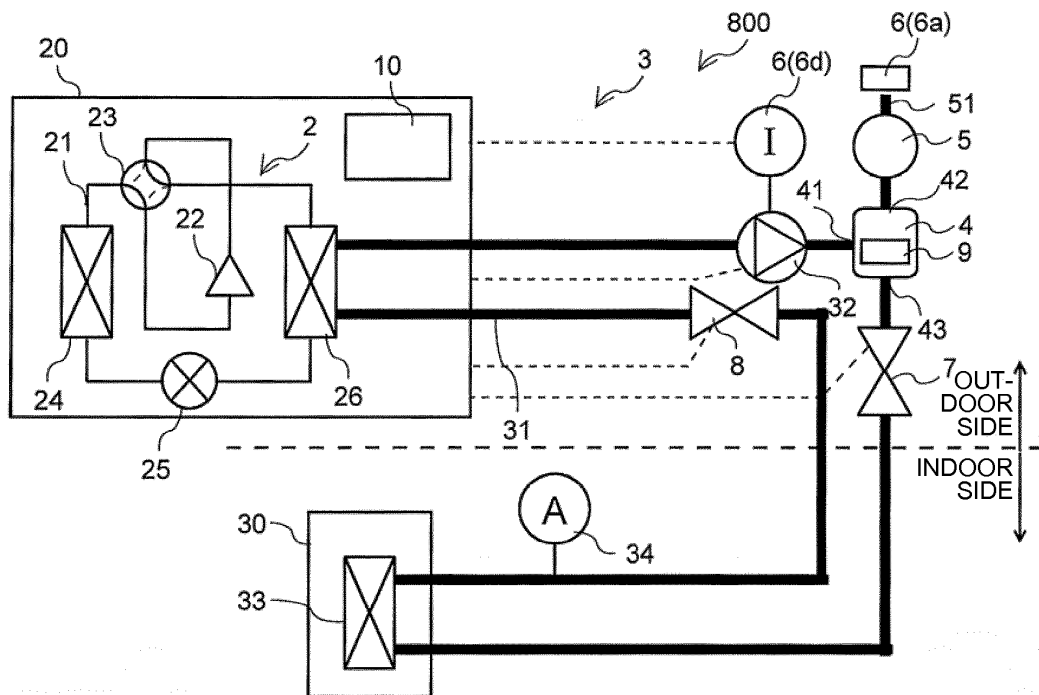


FIG. 19

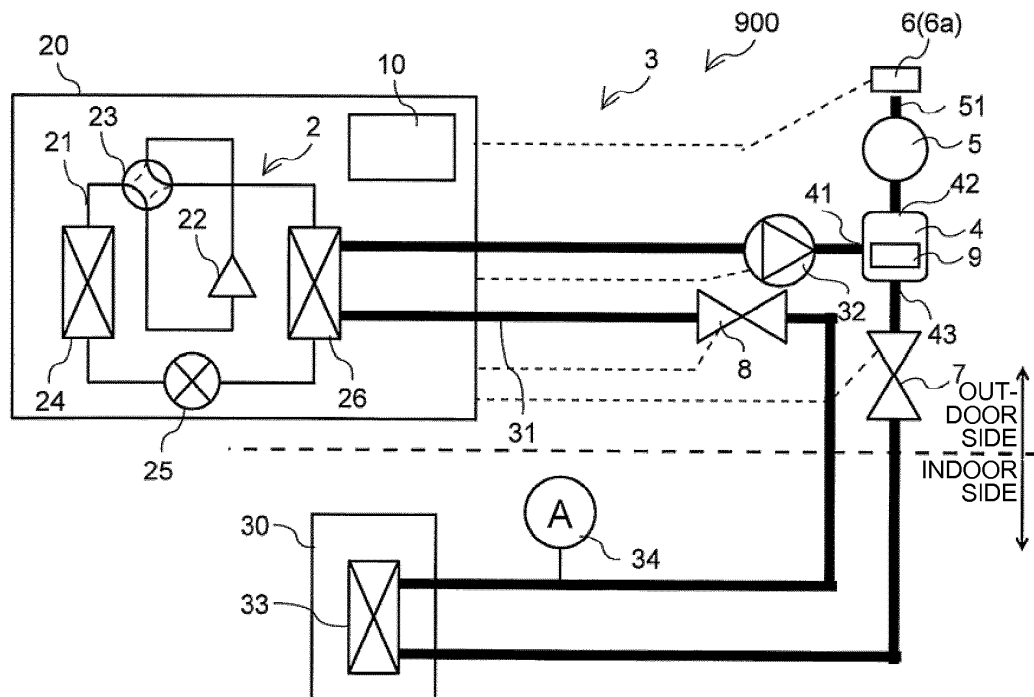


FIG. 20

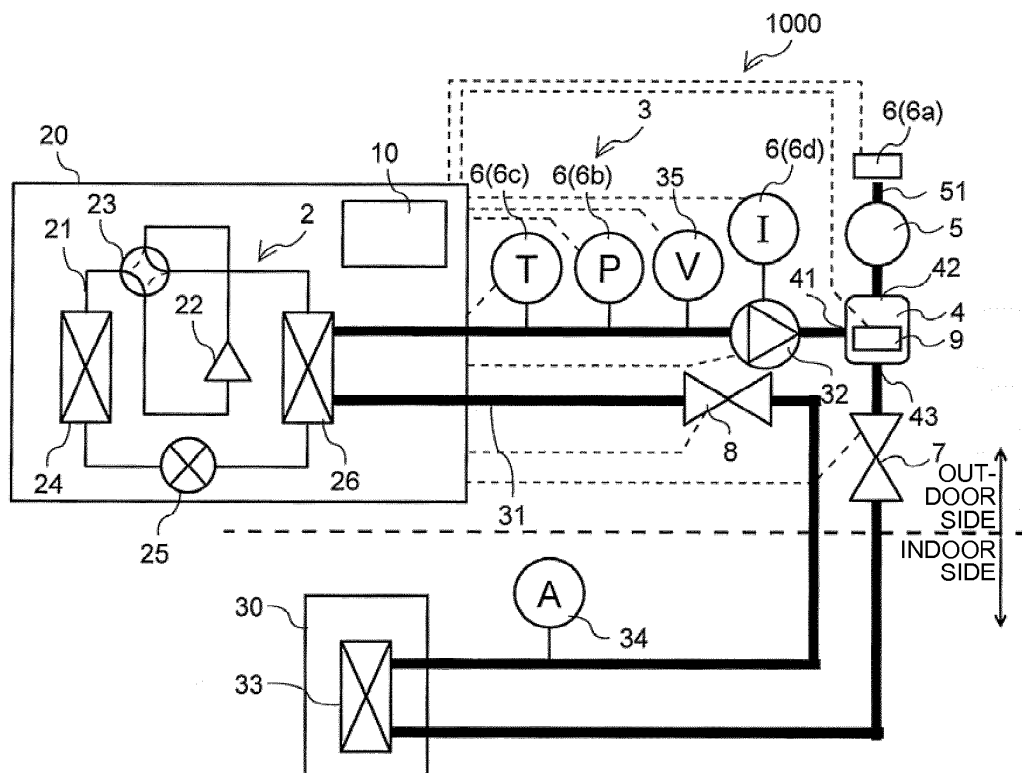


FIG. 21

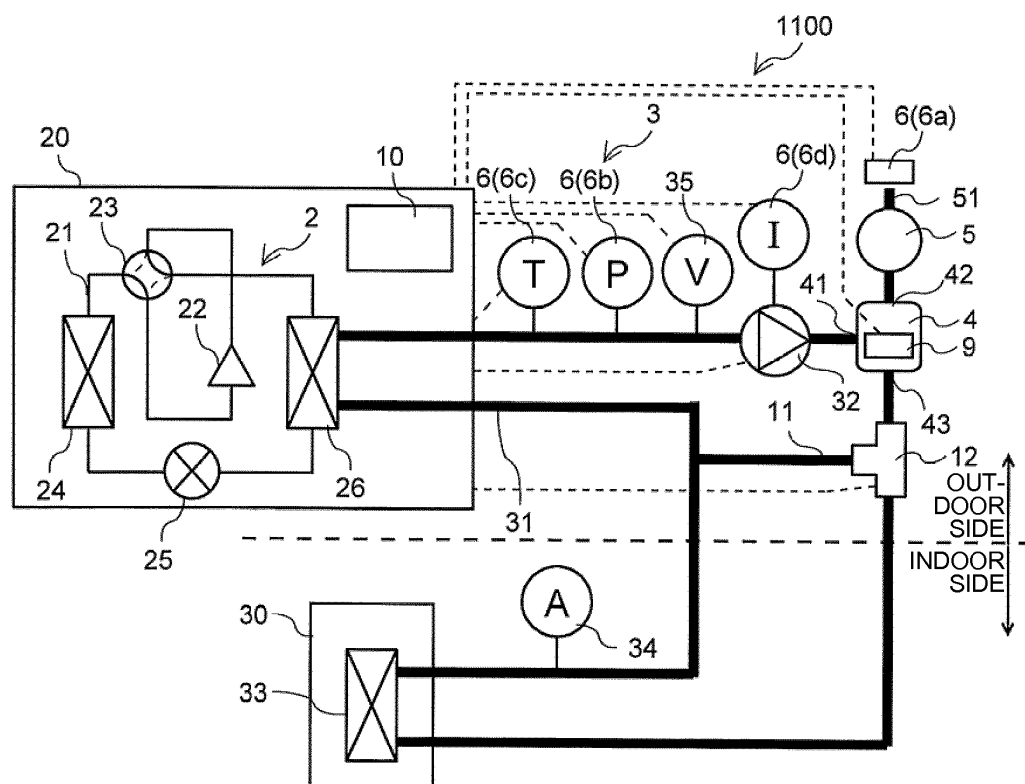


FIG. 22

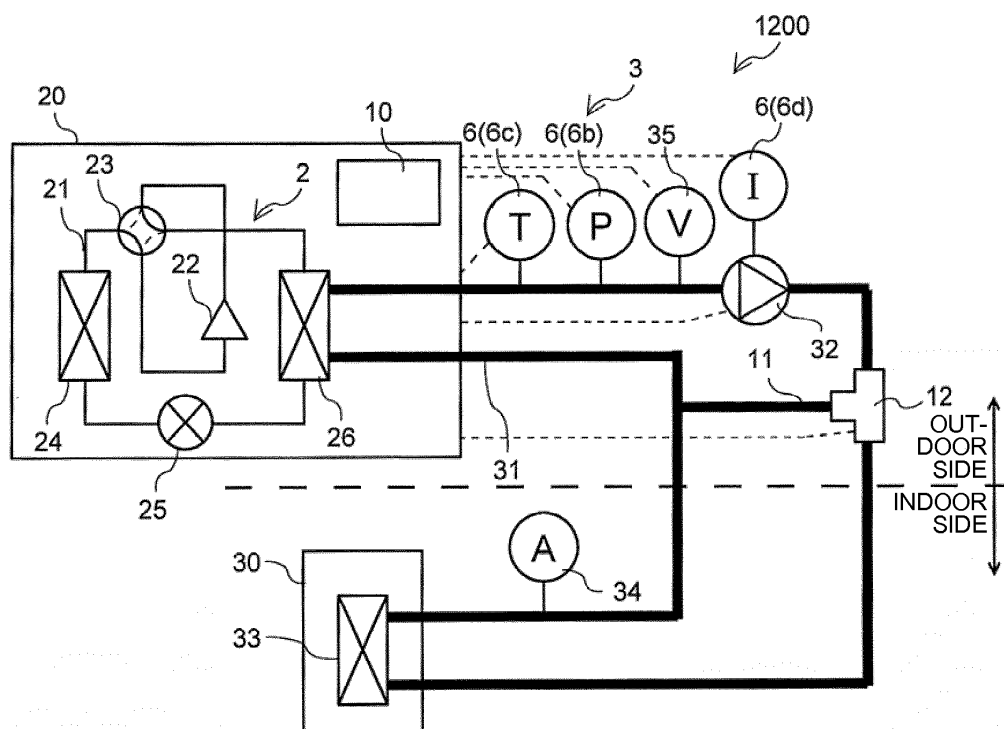


FIG. 23

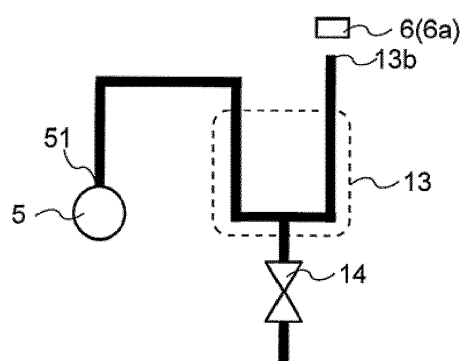
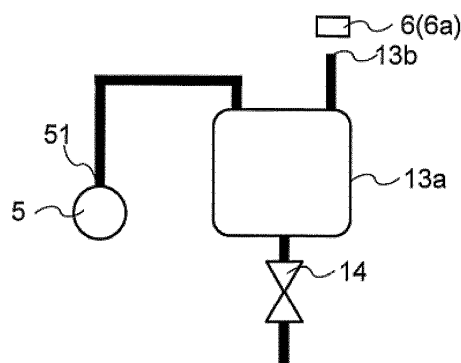


FIG. 24



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2013167398 A [0003]
- EP 1143209 A1 [0004]
- JP 2002115939 A [0005]
- JP 2000130877 A [0006]