(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 502 587 A1

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

(43) Date of publication:
26.06.2019 Bulletin 2019/26

(21) Application number: **18757015.5**

(22) Date of filing: **19.01.2018**

(51) Int Cl.:
F25B 1/00 *(2006.01)* ***F25B 13/00*** *(2006.01)*
F25B 39/02 *(2006.01)* ***F25B 39/04*** *(2006.01)*
F28C 3/06 *(2006.01)*

(86) International application number:
PCT/JP2018/001539

(87) International publication number:
WO 2018/155028 (30.08.2018 Gazette 2018/35)

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

(30) Priority: **21.02.2017 JP 2017029854**

(71) Applicant: **Mitsubishi Heavy Industries Thermal Systems, Ltd.**
Tokyo 108-8215 (JP)

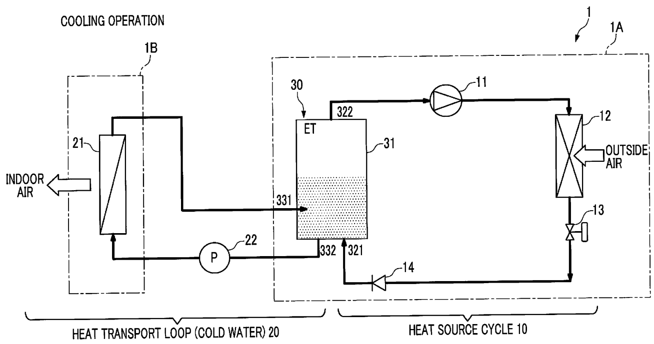
(72) Inventors:
- **ENYA, Atsushi**
  Tokyo 108-8215 (JP)
- **MURAKAMI, Kenichi**
  Tokyo 108-8215 (JP)

(74) Representative: **Cabinet Beau de Loménie**
158, rue de l'Université
75340 Paris Cedex 07 (FR)

(54) REFRIGERANT SYSTEM PROVIDED WITH DIRECT CONTACT HEAT EXCHANGER, AND CONTROL METHOD OF REFRIGERANT SYSTEM

(57) In this system, while heat exchange is efficiently carried out through direct contact of multiple types of refrigerant, the refrigeration cycle function is made to function adequately without the problem of contamination of the refrigeration cycle refrigerant by a dissimilar refrigerant. This refrigerant system (1) is provided with: a heat source cycle (10) comprising a compressor (11), a heat exchanger (12) and a decompression unit (13); a heat transport loop (20) which circulates a liquid-phase transport refrigerant that transports heat towards a heat load; and a direct contact heat exchanger (30) which allows direct contact between the transport refrigerant and a heat source refrigerant sealed in the heat source cycle (10). As a heat source refrigerant, a second refrigerant is sealed in the heat source cycle (10) in addition to the first refrigerant. Of the first refrigerant and the second refrigerant, which has a higher boiling point than that of the first refrigerant, at least the first refrigerant boils in the direct contact heat exchanger (30), into which the heat source refrigerant passing through the decompression unit (13) flows, and the density of the liquid phase of the second refrigerant is lower than the density of the transport refrigerant.

FIG. 1



EP 3 502 587 A1

Description

Technical Field

[0001] The present invention relates to a refrigerant system provided with a direct contact heat exchanger allowing direct contact between two refrigerants and a refrigerant system control method.

Background Art

[0002] At present, a hydrofluorocarbon (HFC) refrigerant represented by R410A is used in equipment using a refrigeration cycle such as air conditioners and chillers. As regulations for global warming prevention are strengthened, development of refrigerants low in global-warming potential (GWP) is in progress.

[0003] In addition, development of various types of refrigerants is in progress in view of cycle efficiency (performance) and safety such as incombustibility as well as global warming.

[0004] The inventor of the present invention proposes a refrigerant system provided with a heat source cycle (refrigeration cycle) in which an HFO refrigerant, an HFC refrigerant, or the like circulates, a heat transport loop transporting a water refrigerant to a heat load, and a direct contact heat exchanger allowing direct contact between a heat source cycle refrigerant and the water refrigerant in a tank (PTL 1). The heat source cycle refrigerant and the water refrigerant are mixed in the direct contact heat exchanger. The density difference between the heat source cycle refrigerant and the water refrigerant under a pressure condition of the direct contact heat exchanger functioning as a condenser is smaller during a heating operation than during a cooling operation. Accordingly, in PTL 1, the heat source cycle refrigerant that has passed through the direct contact heat exchanger is separated from the water refrigerant by the density difference after decompression during the heating operation.

Citation List

Patent Literature

[0005] [PTL 1] Japanese Unexamined Patent Application Publication No. 2015-87051

Summary of Invention

Technical Problem

[0006] Insofar as the heat source cycle refrigerant and the water refrigerant are brought into direct contact with each other by the direct contact heat exchanger, the heat source cycle refrigerant and the water refrigerant are inevitably mixed. Regardless of the cooling operation and the heating operation, it is rather difficult to completely separate the water refrigerant from the heat source cycle refrigerant. Accordingly, a refrigeration cycle may not be fully functional or may not be established.

[0007] Component malfunction, lubricant degradation, and so on may arise once the heat source cycle refrigerant is contaminated with water. The heating operation entails a high risk of malfunction attributable to freezing.

[0008] An object of the present invention is to provide a refrigerant system and a refrigerant system control method allowing, while heat exchange is efficiently carried out through direct contact of multiple types of refrigerant, the refrigeration cycle function to be made to function adequately without the problem of contamination of the refrigeration cycle refrigerant by a dissimilar refrigerant.

Solution to Problem

[0009] A first refrigerant system according to the present invention includes a heat source cycle having a compressor, a heat exchanger, and a decompression unit, a heat transport loop circulating a liquid-phase transport refrigerant transporting heat toward a heat load, and a direct contact heat exchanger allowing direct contact between the transport refrigerant and a heat source refrigerant sealed in the heat source cycle.

[0010] According to the present invention, a second refrigerant is sealed in the heat source cycle in addition to a first refrigerant as the heat source refrigerant. In the direct contact heat exchanger, into which the heat source refrigerant passing through the decompression unit flows, of the first refrigerant and the second refrigerant which has a higher boiling point than that of the first refrigerant, at least the first refrigerant boils. A density of a liquid phase of the second refrigerant is lower than a density of the transport refrigerant.

[0011] The present invention can be developed for heating applications as well.

[0012] A second refrigerant system according to the present invention includes a heat source cycle having a compressor, a heat exchanger, and a decompression unit, a heat transport loop circulating a liquid-phase transport refrigerant transporting heat toward a heat load, and a direct contact heat exchanger allowing direct contact between the transport refrigerant and a heat source refrigerant sealed in the heat source cycle.

[0013] A second refrigerant is sealed in the heat source cycle in addition to a first refrigerant as the heat source refrigerant and the heat source cycle includes a heat exchanger condensing a gas phase of the heat source refrigerant taken out from the direct contact heat exchanger. In the direct contact heat exchanger, into which the first refrigerant discharged from the compressor flows, of the first refrigerant and the second refrigerant which has a higher boiling point than that of the first refrigerant, the second refrigerant condenses. A density of a liquid phase of the second refrigerant is lower than a density of the transport refrigerant.

[0014] The present invention can be developed in a heating-cum-cooling refrigerant system as well.

[0015] A third refrigerant system according to the present invention includes a heat source cycle having a compressor, a heat exchanger, and a decompression unit, a heat transport loop circulating a liquid-phase transport refrigerant transporting heat toward a heat load, a direct contact heat exchanger allowing direct contact between the transport refrigerant and a heat source refrigerant sealed in the heat source cycle, and a direction switching unit switching a direction in which the heat source refrigerant flows through the heat source cycle.

[0016] A second refrigerant is sealed in the heat source cycle in addition to a first refrigerant as the heat source refrigerant and the heat source cycle includes a heat exchanger condensing a gas phase of the heat source refrigerant taken out from the direct contact heat exchanger. In the direct contact heat exchanger, into which the heat source refrigerant passing through the decompression unit flows, of the first refrigerant and the second refrigerant which has a higher boiling point than that of the first refrigerant, the first refrigerant boils. A density of a liquid phase of the second refrigerant is lower than a density of the transport refrigerant. In the direct contact heat exchanger, into which the first refrigerant discharged from the compressor flows, of the first refrigerant and the second refrigerant which has a higher boiling point than that of the first refrigerant, at least the second refrigerant condenses. The density of the liquid phase of the second refrigerant is lower than the density of the transport refrigerant.

[0017] In each of the refrigerant systems described above, the transport refrigerant is preferably water and the second refrigerant is preferably a hydrocarbon-based (HC-based) refrigerant.

[0018] The present invention can be further developed for a refrigerant system control method as well.

[0019] A first control method is a method for controlling a refrigerant system including a heat source cycle having a compressor, a heat exchanger, and a decompression unit, a heat transport loop circulating a liquid-phase transport refrigerant transporting heat toward a heat load, and a direct contact heat exchanger allowing direct contact between the transport refrigerant and a heat source refrigerant sealed in the heat source cycle. The method includes using a second refrigerant having a liquid density lower than a density of the transport refrigerant in addition to a first refrigerant as the heat source refrigerant sealed in the heat source cycle and in the direct contact heat exchanger, into which the heat source refrigerant passing through the decompression unit flows, controlling an internal temperature of the direct contact heat exchanger to an evaporation temperature higher than a boiling point of the first refrigerant and a boiling point of the second refrigerant such that of the first refrigerant and the second refrigerant which has a higher boiling point than that of the first refrigerant, at least the first refrigerant boils.

[0020] A second control method is a method for controlling a refrigerant system including a heat source cycle having a compressor, a heat exchanger, and a decompression unit, a heat transport loop circulating a liquid-phase transport refrigerant transporting heat toward a heat load, and a direct contact heat exchanger allowing direct contact between the transport refrigerant and a heat source refrigerant sealed in the heat source cycle. The method includes using a second refrigerant having a liquid density lower than a density of the transport refrigerant in addition to a first refrigerant as the heat source refrigerant sealed in the heat source cycle and in the direct contact heat exchanger, into which the first refrigerant discharged from the compressor flows, controlling an internal temperature of the direct contact heat exchanger to a condensation temperature between a boiling point of the first refrigerant and a boiling point of the second refrigerant such that of the first refrigerant and the second refrigerant which has a higher boiling point than that of the first refrigerant, the second refrigerant condenses.

Advantageous Effects of Invention

[0021] According to the present invention, it is possible to reliably prevent the transport refrigerant from contaminating the heat source refrigerant circulating through the heat source cycle owing to the presence of the liquid phase of the second refrigerant in the direct contact heat exchanger while the heat source refrigerant and the transport refrigerant are in direct contact with each other in the direct contact heat exchanger. Accordingly, a refrigeration cycle function can be made to function adequately.

Brief Description of Drawings

[0022]

Fig. 1 is a diagram schematically illustrating a refrigerant system for cooling according to a first embodiment.

Fig. 2 is a graph illustrating the relationship between a pressure and the respective saturation temperatures of a first refrigerant, a second refrigerant, and a transport refrigerant.

Fig. 3 is a graph illustrating the relationship between a temperature and the respective liquid densities of the first refrigerant, the second refrigerant, and the transport refrigerant.

Fig. 4 is a diagram schematically illustrating a refrigerant system for heating according to a second embodiment.

Fig. 5 is a diagram schematically illustrating a cooling-cum-heating refrigerant system according to a third embodiment (during a cooling operation).

Fig. 6 is a diagram schematically illustrating the cooling-cum-heating refrigerant system according to the third embodiment (during a heating operation).

Description of Embodiments

[0023] Hereinafter, embodiments of the present invention will be described with reference to accompanying drawings.

[First Embodiment]

[0024] In a first embodiment, a refrigerant system 1 having a cooling function will be described.

[0025] The refrigerant system 1 illustrated in Fig. 1 is provided with a heat source cycle 10 (refrigeration cycle) in which a heat source cycle refrigerant is circulated, a heat transport loop 20 in which a liquid-phase transport refrigerant is circulated, a direct contact heat exchanger 30, and a control device (not illustrated).

[0026] The entire refrigerant system 1 is regarded as a closed cycle sealed with respect to the atmosphere.

[0027] The refrigerant system 1 is configured as an air conditioner that undergoes a cooling operation (cooling) so as to cool indoor air as a heat load with outside air as a heat source and is provided with an outdoor unit 1A, an indoor unit 1B, and a pipe provided in the outdoor unit 1A and the indoor unit 1B to constitute a refrigerant circuit.

[0028] The outdoor unit 1A is provided with a compressor 11, an outdoor heat exchanger 12, a decompression unit 13, a check valve 14, the direct contact heat exchanger 30, and a unit (not illustrated) that accommodates the compressor 11, the outdoor heat exchanger 12, the decompression unit 13, the check valve 14, and the direct contact heat exchanger 30.

[0029] The indoor unit 1B is provided with an indoor heat exchanger 21 and a unit (not illustrated) that accommodates the indoor heat exchanger 21.

[0030] The equipment configurations of the outdoor unit 1A and the indoor unit 1B are not limited to the present embodiment. Depending on unit installation spaces and the like, the components of the heat source cycle 10 and the heat transport loop 20 and the like can be appropriately disposed in the outdoor unit 1A and the indoor unit 1B, respectively.

[0031] The heat source cycle 10 is configured to include the compressor 11, the outdoor heat exchanger 12 that is disposed outdoors and functions as a condenser, the decompression unit 13, and the direct contact heat exchanger 30 that functions as an evaporator.

[0032] In the heat source cycle 10, a first refrigerant and a second refrigerant are sealed at a predetermined sealing ratio as heat source cycle (HSC) refrigerants (hereinafter, referred to as heat source refrigerants). The ratio of the first refrigerant sealed in the heat source cycle 10 is, for example, 50 Wt% to 90 Wt% and exceeds the ratio of the second refrigerant sealed in the same heat source cycle 10.

[0033] An HFC refrigerant, an HFO refrigerant, or the like can be used as the first refrigerant.

[0034] R32 is an example of the hydro fluoro carbon (HFC) refrigerant.

[0035] Examples of the hydro fluoro olefin (HFO) refrigerant include R1234ze and R1234yf. From the viewpoint of global warming potential (GWP) reduction, it is preferable to use an HFO-based refrigerant.

[0036] Hydrocarbon-based (HC-based) refrigerants such as propane and isobutane can be used as the second refrigerant. The HC-based refrigerants are lower in GWP than R1234ze and R1234yf.

[0037] The heat source refrigerants may be divided into three or more types of refrigerants including the first refrigerant, the second refrigerant, and another refrigerant.

[0038] The refrigerant used for the first refrigerant and the refrigerant used for the second refrigerant can be appropriately selected in view of cycle efficiency, GWP, and the like.

[0039] In the present embodiment, R32 is used as the first refrigerant and propane, which is an HC-based refrigerant, is used as the second refrigerant. Both isobutane and propane may be used as the second refrigerant.

[0040] The first and second refrigerants will be referred to as the heat source refrigerants when the first and second refrigerants do not have to be distinguished from each other.

[0041] The compressor 11 compresses the heat source refrigerant suctioned into a housing by means of a scroll compression mechanism, a rotary compression mechanism, or the like and discharges the heat source refrigerant. From the viewpoint of environmental load and the like, it is preferable to adopt an oil-free compressor using no chiller oil (lubricant).

[0042] The outdoor heat exchanger 12 indirectly performs heat exchange between the heat source refrigerant and outside air via, for example, a tube through which the heat source refrigerant flows. In order to promote the heat exchange, it is preferable to blow outside air toward the outdoor heat exchanger 12 with a fan.

[0043] The decompression unit 13 decompresses the heat source refrigerant. An expansion valve, a capillary tube, or the like can be used as the decompression unit 13.

[0044] The check valve 14 is provided between the decompression unit 13 and the direct contact heat exchanger 30. The check valve 14 regulates the direction in which the heat source refrigerant flows in one direction from the decompression unit 13 to the direct contact heat exchanger 30.

[0045] The heat transport loop 20 is configured to include the direct contact heat exchanger 30, the indoor heat exchanger 21 disposed indoors, and a pump 22.

[0046] The liquid-phase transport refrigerant is sealed in the heat transport loop 20. Water is adopted as the transport refrigerant of the present embodiment.

[0047] The transport refrigerant is in a liquid phase over the temperature change range in the refrigerant system 1 and undergoes no phase transition. Hereinafter, the transport refrigerant will be referred to as a water refrigerant. The water refrigerant has a GWP of 0. The water refrigerant has no combustibility.

[0048] The indoor heat exchanger 21 indirectly performs heat exchange between water and indoor air. In order to promote the heat exchange, it is preferable to blow suctioned indoor air toward the indoor heat exchanger 21 with a fan. The indoor heat exchanger 21 and the fan can be configured as, for example, a fan coil unit.

[0049] The pump 22 circulates the water refrigerant between the direct contact heat exchanger 30 and the indoor heat exchanger 21 by pumping the water refrigerant from the direct contact heat exchanger 30 toward the indoor heat exchanger 21. The pump 22 is connected to the pipe of the heat transport loop 20 through which water flows.

[0050] Any type of pump can be used as the pump 22. Examples of the pump 22 include volumetric and non-volumetric pumps.

[0051] The direct contact heat exchanger 30 causes the heat source refrigerant and the water refrigerant to exchange heat with each other by bringing the refrigerants into direct contact with each other. The direct contact heat exchanger 30 is provided with a tank 31, a heat source refrigerant inlet 321, a heat source refrigerant outlet 322, a water inlet 331, and a water outlet 332. The heat source refrigerant inlet 321 is positioned in the bottom portion of the tank 31 and the heat source refrigerant outlet 322 is positioned in the upper portion of the tank 31.

[0052] The water refrigerant stored in the tank 31 and the heat source refrigerant that has flowed into the tank 31 from the heat source refrigerant inlet 321 come into direct contact with each other. As a result, the water refrigerant and the heat source refrigerant exchange heat. The liquid phase of the heat source refrigerant as well as the water refrigerant may be stored in the tank 31.

[0053] It is possible to reduce the combustibility of the entire refrigerant system 1, even if the heat source refrigerant has combustibility, because of the water refrigerant that is present in the tank 31 and the pipe of the heat transport loop 20.

[0054] In the direct contact heat exchanger 30 of the refrigerant system 1 of the present embodiment that is under a predetermined low-pressure condition and a temperature condition corresponding thereto, mainly the first refrigerant as the heat source refrigerant rather than the second refrigerant as the heat source refrigerant is boiled and the water refrigerant is cooled with the latent heat of the first refrigerant.

[0055] In the direct contact heat exchanger 30, those exchanging heat are in direct contact with each other. Accordingly, a high level of heat exchange efficiency can be obtained as compared with typical heat exchangers in which a sufficient temperature difference is required as those exchanging heat are in indirect contact via a tube or the like. In addition, the direct contact heat exchanger 30 is configured to be capable of reliably preventing water-based contamination of the heat source refrigerant circulating through the heat source cycle 10 based on the physical properties of the heat source refrigerant and the water refrigerant as described below with the heat source refrigerant and the water refrigerant in direct contact with each other.

[0056] In the present embodiment, the boiling point difference and the liquid density difference between the refrigerants used in the refrigerant system 1 are used so that the heat exchange by the direct contact heat exchanger 30 is established and water-based contamination of the heat source refrigerant circulating through the heat source cycle 10 is prevented.

[0057] As described above, the refrigerant system 1 of the present embodiment uses three types of refrigerants, that is, the first refrigerant as the heat source refrigerant, the second refrigerant as the heat source refrigerant, and the water refrigerant as the transport refrigerant.

[0058] From the respective physical properties of the three types of refrigerants, the following relationship is established inside the tank 31 of the direct contact heat exchanger 30.

[0059] First, the boiling point of the second refrigerant is higher than the boiling point of the first refrigerant. It is preferable that the boiling point difference between the first refrigerant and the second refrigerant is at least 10°C to 30°C or more.

[0060] In addition to the boiling point difference described above, the density of the liquid phase of the second refrigerant is lower than the density of water (liquid phase). It is preferable that the liquid density of the second refrigerant is, for example, approximately 600 to 700 kg/m3.

[0061] In Fig. 2, the saturation temperature of R32 is indicated by a solid line and the saturation temperature of propane is indicated by a dashed line. Referring to these saturation temperatures, the propane as the second refrigerant is higher than R32 as the first refrigerant in boiling point, which is the temperature at which the vapor pressure becomes equal to the external pressure. This is the same for both a low pressure pl and a high pressure ph defined in the refrigerant system 1.

[0062] In a case where the low pressure pl has a reference value of 0.5 MPa on the basis of the atmospheric pressure, the temperature of the gas phase of R32 in a saturated state is -9.1°C. This temperature is almost equivalent to the boiling point of R32.

[0063] Likewise, in a case where the low pressure pl is 0.5 MPa on the basis of the atmospheric pressure, the temperature of the gas phase of the propane in a saturated state is 8.0°C. This temperature is almost equivalent to the boiling point of the propane.

[0064] The boiling point of R32 is different from the boiling point of the propane as described above. Accordingly, by the control device (not illustrated) controlling the internal temperature of the tank 31 to an appropriate temperature, R32, which constitutes the heat source refrigerant that has flowed into the direct contact heat exchanger 30 at the low pressure pl with the propane and is lower in boiling point than the propane, can be boiled before the propane and a part of the propane can be kept in the tank 31 as a liquid phase.

[0065] Specifically, it is possible to control the temperature of the liquid phase portion inside the tank 31 by controlling the capacity of the heat source cycle 10 by using a detected temperature while detecting the temperature of the liquid phase portion in the tank 31. It is also possible to control the temperature of the liquid phase portion in the tank 31 to a predetermined temperature by using a device such as a chiller transporting water with a constant temperature. An evaporation temperature ET is set equal to or lower than the temperature of the cold water that is taken out from the tank 31. In the tank 31, R32 with the lower boiling point boils first and the liquid-phase propane stays.

[0066] Next, as illustrated in Fig. 3, the liquid density of the propane, which is the second refrigerant, is lower than the liquid density of the water refrigerant.

[0067] The liquid density of the propane in the tank 31 is approximately 518 kg/m3 when the internal temperature of the tank 31 is controlled to 10°C, which is slightly higher than the boiling point of the propane, with the internal pressure of the tank 31 having a reference value of 0.5 MPa on the basis of the atmospheric pressure. The liquid density of water is approximately 1,000 kg/m3 in the temperature range illustrated in Fig. 3, and thus the liquid density of the propane is lower than the liquid density of water.

[0068] As illustrated in Fig. 3, the liquid density of R32 is close to the liquid density of water.

[0069] The liquid phase of the propane floats above the water that is stored in the tank 31 owing to the liquid density difference between the water and the propane.

[0070] The action of the cooling operation (cooling) that is performed by the refrigerant system 1 will be described below.

[0071] The refrigerant system 1 circulates the heat source refrigerant with the heat source cycle 10 by operating the compressor 11 and circulates the water refrigerant to the heat transport loop 20 by operating the pump 22.

[0072] The heat source refrigerant is compressed by the compressor 11 of the heat source cycle 10, and the heat source refrigerant is condensed by heat exchange with outside air by the outdoor heat exchanger 12 under a high-pressure condition based on the high pressure ph and decompressed by the decompression unit 13. Then, the low-temperature and low-pressure heat source refrigerant flows into the direct contact heat exchanger 30. The temperature of the heat source refrigerant flowing into the tank 31 from the heat source refrigerant inlet 321 of the direct contact heat exchanger 30 is sufficiently lower than the temperature of the water refrigerant stored in the tank 31 of the direct contact heat exchanger 30.

[0073] In the tank 31, cold water obtained from direct contact between the low-temperature and low-pressure heat source refrigerant and the water refrigerant is supplied indoors by the heat transport loop 20. As a result, indoor air is cooled.

[0074] The control device (not illustrated) provided in the refrigerant system 1 controls the internal temperature of the outdoor heat exchanger 12 to a predetermined condensation temperature and controls the internal temperature of the tank 31 of the direct contact heat exchanger 30 to the predetermined evaporation temperature ET.

[0075] The control device puts the inside of the tank 31 under a low-pressure condition based on the low pressure pl. The evaporation temperature ET is set to a temperature (such as 10°C) slightly higher than the boiling point of the propane corresponding to the internal pressure of the tank 31.

[0076] R32, which constitutes the heat source refrigerant that has flowed into the tank 31 from the heat source refrigerant inlet 321 with the propane, has a boiling point of -9.1°C, and is lower in boiling point than the propane, immediately boils and gasifies under the atmosphere inside the tank 31, is turned into bubbles, and floats in the water. By latent heat being generated with the liquid-to-gas phase transition of R32 and R32 sufficiently coming into contact with the water refrigerant during the bubble generation and floating, the heat transfer between R32 and the water refrigerant is promoted and the water refrigerant is cooled.

[0077] It is also possible to dispose a member hit by the flow of the heat source refrigerant that has flowed in from the heat source refrigerant inlet 321 inside the tank 31 so that R32 and the water refrigerant more sufficiently come into contact with each other. The heat source refrigerant inlet 321 can be provided at an appropriate position, such as a side wall of the tank 31, not limited to the bottom portion of the tank 31.

[0078] After the gasification, R32 flows to the outside of the tank 31 through the heat source refrigerant outlet 322 from the space above the liquid surface inside the tank 31. Then, R32 is suctioned to the compressor 11.

[0079] The propane that has flowed into the tank 31 with R32 shows a behavior different from that of R32 in the tank 31 based on the physical properties of the propane.

[0080] In the tank 31, the propane, which has a boiling point of 8.0°C and is higher in boiling point than R32, boils after the boiling of R32, which is lower in boiling point than the propane. In addition, the propane slowly gasifies and a part of the propane remains in the tank 31 as a liquid phase.

[0081] When the propane partially remains in the tank 31 in the liquid phase, the ratio of the propane in the circulation amount of the heat source refrigerant decreases as compared with the sealing ratio in the heat source cycle 10, and the ratio of R32 in the circulation amount of the heat source refrigerant rises to the same extent. The performance of the refrigerant system 1 is improved as the refrigerant system 1 is operated in a state where R32, which is higher in cycle efficiency than propane, has a high ratio.

[0082] The gas phase of the propane sufficiently comes into contact with the water refrigerant while the latent heat is generated during the phase transition and the bubble generation and floating occur. Accordingly, the gas phase contributes to the cooling of the water refrigerant.

[0083] Likewise, the liquid phase of the propane is mixed with the liquid-phase water refrigerant and sufficiently comes into contact with the water refrigerant. As a result, the liquid phase contributes to the cooling of the water refrigerant.

[0084] Along with the gas phase of R32, the gas phase of the propane flows out from the inner upper portion of the tank 31 to the heat source cycle 10 through the heat source refrigerant outlet 322.

[0085] The water refrigerant cooled as a result of heat exchange with R32 and the propane flows to the outside of the tank 31 through the water outlet 332 and is pumped to the pipe of the heat transport loop 20 by the pump 22. The cold water that has flowed into the indoor heat exchanger 21 exchanges heat with the air suctioned to the indoor heat exchanger 21. The air cooled as a result is blown indoors.

[0086] As described above, the propane, which remains in the tank 31 as a liquid phase since the boiling point of the propane is higher than the boiling point of R32, is lower in liquid density than water. Accordingly, the propane floats above the water refrigerant stored in the tank 31. Since the liquid phase of the propane is present on the liquid surface, the water refrigerant is covered with the liquid phase of the propane. Accordingly, even if the liquid phase of the propane is lifted in the flow of the gas of R32 and the gas of the propane flowing out from the heat source refrigerant outlet 322, it is possible to prevent the water refrigerant from being lifted and flowing out to the heat source cycle 10.

[0087] If R32 alone is used as the heat source refrigerant, the water refrigerant in the tank 31 may be lifted by the gas flow and the heat source refrigerant circulating through the heat source cycle 10 may be contaminated with water exceeding an allowance in amount. In the present embodiment, propane as well as R32 is used as the heat source refrigerant, and thus it is possible to suppress lifting of the water refrigerant and prevent water-based contamination of the heat source refrigerant circulating through the heat source cycle 10. The direct contact heat exchanger 30 of the present embodiment has a function to prevent water refrigerant-based heat source refrigerant contamination with R32 and the water refrigerant sufficiently separated from each other by the liquid phase of propane interposed between the gas phase of R32 and the water refrigerant. Accordingly, there is no need to take a measure such as taking out the gas of the heat source refrigerant from the inside of the tank 31 and transferring the gas to a tank performing decompression to a pressure suitable for separation between the gas of the heat source refrigerant and the water refrigerant in the gas.

[0088] According to the present embodiment, the heat source refrigerant circulating through the heat source cycle 10 owing to the presence of the liquid phase of the propane in the tank 31 while the heat source refrigerant and the water refrigerant are in direct contact with each other in the tank 31 is not limited and contains no water.

[0089] The refrigerant system 1 of the present embodiment provided with the direct contact heat exchanger 30 cooling the water refrigerant uses the first refrigerant (such as R32) and the second refrigerant (such as the propane) as the heat source refrigerants circulating through the heat source cycle 10. The first refrigerant involves latent heat and plays a central role in cooling the water refrigerant. The second refrigerant is higher in boiling point than the first refrigerant and lower in liquid density than the water refrigerant. By using the two types of refrigerants, it is possible to achieve GWP reduction while ensuring cycle efficiency more easily than in a case where one type of refrigerant (such as R32) is used alone. In addition, it is possible to obtain a high heat exchange performance unique to direct contact heat exchange from behaviors respectively based on the physical properties of the first and second refrigerants and it is possible to suppress water-based contamination of the heat source refrigerant circulating through the heat source cycle 10 as much as possible. Accordingly, it is possible to allow the heat source cycle 10, eventually the entire refrigerant system 1, to sufficiently function by avoiding problems attributable to water-based contamination such as component malfunction and lubricant degradation.

[0090] The evaporation temperature ET is appropriately determined in view of, for example, the efficiency of heat exchange by the direct contact heat exchanger 30 and the amount of the liquid phase of propane required for preventing the heat source cycle 10 from being contaminated with water. As a result, it is possible to adjust the amount of the liquid-phase propane that remains in the tank 31.

[0091] For example, only R32 boils and the propane does not boil in the tank 31 when the evaporation temperature ET is set to a temperature (such as 5°C) between the boiling point of R32 and the boiling point of the propane. In this case, most of the propane remains in the tank 31 except for the liquid phase of the propane lifted by the gas of R32 and flowing out. Accordingly, it is possible to more sufficiently prevent lifting of the water refrigerant with the thick liquid film of the propane. Also, since most of the propane remains in the tank 31, only R32 mainly circulates through the heat source cycle 10, and thus the cycle efficiency can be improved.

[0092] Depending on operation situations of the refrigerant system 1, it is also possible to variably control the evaporation temperature ET within a predetermined temperature range with the control device.

[Second Embodiment]

[0093] Next, a second embodiment of the present invention will be described with reference to Fig. 4. The same reference numerals are given to the same configurations as in the first embodiment.

[0094] As in the case of the refrigerant system 1 described above, a refrigerant system 2 of the second embodiment illustrated in Fig. 4 is provided with the heat source cycle 10 in which the heat source cycle refrigerant is circulated, the heat transport loop 20 in which the liquid-phase transport refrigerant is circulated, the direct contact heat exchanger 30, and the control device (not illustrated).

[0095] In the heat source cycle 10, the first refrigerant and the second refrigerant are sealed at a predetermined sealing ratio as the heat source refrigerants.

[0096] The following description focuses on differences between the first and second embodiments.

[0097] The refrigerant system 2 of the second embodiment has a heating function whereas the refrigerant system 1 of the first embodiment has a cooling function. In the second embodiment, the heat source refrigerant flows through the heat source cycle 10 in the direction that is opposite to the direction according to the first embodiment. In other words, the heat source refrigerant discharged from the compressor 11 flows into the tank 31 of the direct contact heat exchanger 30. The water refrigerant as the transport refrigerant is stored in the tank 31.

[0098] In the direct contact heat exchanger 30 of the refrigerant system 2 of the second embodiment that is under a predetermined high-pressure condition and a temperature condition corresponding thereto, the heat source refrigerant and the water refrigerant are in direct contact with each other, heat is transferred to the water refrigerant via the liquid-phase second refrigerant mainly from the gas-phase first refrigerant rather than the second refrigerant with the first refrigerant and the second refrigerant constituting the heat source refrigerants, and the water refrigerant is heated as a result. Most of the second refrigerant remains in the tank 31 in a liquid-phase state, and mainly the gas phase of the first refrigerant circulates through the heat source cycle 10.

[0099] A check valve 15 is provided between the compressor 11 and the direct contact heat exchanger 30. The check valve 15 regulates the direction in which the heat source refrigerant flows in one direction from the compressor 11 to the direct contact heat exchanger 30.

[0100] The heat source cycle 10 is provided with a heat exchanger 16 in addition to the compressor 11, the outdoor heat exchanger 12, the decompression unit 13, and the direct contact heat exchanger 30. The heat exchanger 16 condenses the gas phase of the heat source refrigerant taken out from the tank 31 of the direct contact heat exchanger 30 by means of heat exchange with outside air. The heat exchanger 16 brings the gas phase of the heat source refrigerant and the outside air into indirect contact with each other via a tube or the like.

[0101] Check valves 17 and 18 are provided between the tank 31 and the heat exchanger 16 and between the heat exchanger 16 and the decompression unit 13. The check valves 17 and 18 regulate the direction in which the heat source refrigerant flows in one direction from the tank 31 to the decompression unit 13 through the heat exchanger 16.

[0102] The gas phase of the heat source refrigerant flows into the tank 31 from a heat source refrigerant inlet 341 positioned in the upper portion of the tank 31. The heat source refrigerant flows out toward the heat exchanger 16 from a heat source refrigerant outlet 342 separated from the heat source refrigerant inlet 341.

[0103] A pipe may be provided from the upper portion of the tank 31 to the vicinity of the liquid surface and the gas phase of the heat source refrigerant may flow in from the tip of the pipe.

[0104] The heat source refrigerant inlet 341 may be disposed at a position other than the upper portion of the tank 31. Examples of the position include the bottom portion of the tank 31.

[0105] The heat exchanger 16 can be incorporated in the unit of the outdoor unit 1A with the outdoor heat exchanger 12. In that case, it is preferable that the heat exchanger 16 is disposed on the inner peripheral side of the outdoor heat exchanger 12 disposed so as to surround a fan in the unit. Then, air suctioned to the heat exchanger 16 by the fan and raised in temperature by passing through the heat exchanger 16 flows into the outdoor heat exchanger 12, and thus it is possible to prevent a tube or a fin of the outdoor heat exchanger 12 from undergoing frost formation.

[0106] From the respective physical properties of the three types of refrigerants used in the refrigerant system 2 of the second embodiment, the following relationship is established inside the tank 31 of the direct contact heat exchanger 30 as in the case of the first embodiment.

[0107] The boiling point of the second refrigerant is higher than the boiling point of the first refrigerant. The density of the liquid phase of the second refrigerant is lower than the density of water (liquid phase).

[0108] Also in the second embodiment, R32 is used as the first refrigerant and propane, which is an HC-based refrigerant, is used as the second embodiment.

[0109] Referring to Fig. 2, in a case where the high pressure ph has a reference value of 2.0 MPa on the basis of the atmospheric pressure, the temperature of the gas phase of R32 in a saturated state is 33.4°C. This temperature is almost equivalent to the boiling point of R32.

[0110] Likewise, in a case where the high pressure ph is 2.0 MPa on the basis of the atmospheric pressure, the temperature of the gas phase of the propane in a saturated state is 59.6°C. This temperature is almost equivalent to the boiling point of the propane.

[0111] Referring to Fig. 3, the liquid density of the propane in the tank 31 is approximately 429 kg/m3 when the internal temperature of the tank 31 is controlled to 45°C, which is a temperature between the boiling point of the propane and the boiling point of R32, with the internal pressure of the tank 31 having a reference value of 2.0 MPa on the basis of the atmospheric pressure.

The liquid density of the propane is lower than the liquid density of water.

[0112] The action of the heating operation (heating) that is performed by the refrigerant system 2 will be described below.

[0113] The control device (not illustrated) controls the internal temperature of the outdoor heat exchanger 12 to a predetermined evaporation temperature and controls the internal temperature of the tank 31 of the direct contact heat exchanger 30 to a predetermined condensation temperature CT. It is preferable that the control device controls the internal temperature of the heat exchanger 16 to a predetermined condensation temperature as well.

[0114] As in the case of the cooling operation, in the temperature control during the heating operation, it is possible to control the temperature of the liquid phase portion inside the tank 31 to a predetermined temperature by controlling the capacity of the heat source cycle 10 by using the detected temperature of the liquid phase portion in the tank 31. The condensation temperature CT is set equal to or higher than the temperature of the hot water that is taken out from the tank 31, the propane condenses in the tank 31, and R32 with the lower boiling point dominates the gas phase.

[0115] The refrigerant system 2 circulates the heat source refrigerant with the heat source cycle 10 by operating the compressor 11 and circulates the water refrigerant to the heat transport loop 20 by operating the pump 22.

[0116] The heat source refrigerant discharged from the compressor 11 of the heat source cycle 10 flows into the tank 31 of the direct contact heat exchanger 30 that is under a high-pressure condition based on the high pressure ph.

[0117] The control device puts the inside of the tank 31 under a high-pressure condition based on the high pressure ph. The condensation temperature CT is set to a temperature (such as 45°C) higher than the boiling point of R32 corresponding to the internal pressure of the tank 31 and lower than the boiling point of the propane corresponding to the same internal pressure of the tank 31.

[0118] The heat source refrigerant discharged from the compressor 11 is pushed into the tank 31 through the check valve 14. In the tank 31, the boiling point of the propane (59.6°C) is higher than the condensation temperature CT, and thus the propane is condensed on a gas-liquid interface. The propane accumulates in the tank 31 as a supercooled liquid. R32 does not condense in tank 31. The gas phase of the heat source refrigerant that is present above the liquid surface is taken out from the heat source refrigerant outlet 342 to the outside of the tank 31 and flows into the heat exchanger 16 through the check valve 17. R32, which did not condense in the tank 31, is also liquefied by the heat exchanger 16, and R32 flows into the outdoor heat exchanger 12 via the decompression unit 13. During the heating operation, the outdoor heat exchanger 12 functions as an evaporator. When the heat exchanger 16 is disposed on the inner peripheral side of the outdoor heat exchanger 12 as described above, outside air absorbs the heat of the heat source refrigerant in the heat exchanger 16. Accordingly, an effect as if the outside air temperature rose is obtained, and frost formation on the outdoor heat exchanger 12 can be suppressed.

[0119] In the direct contact heat exchanger 30, the liquid density of the propane is lower than the liquid density of water, and thus the liquid phase of the propane is present on the liquid surface in the tank 31. In the second embodiment, the heat of the gas phase of the first refrigerant (R32) that is present above the liquid surface is transmitted to the liquid phase of the second refrigerant (propane), and the water refrigerant is heated by the heat being transmitted to the water refrigerant via the second refrigerant while the water surface is covered with the second refrigerant that is present on the liquid surface. As a result, lifting of the water refrigerant is prevented. Even if the liquid phase of the propane is lifted in the flow of the gas above the liquid surface flowing out from the heat source refrigerant outlet 342, it is possible to prevent the water refrigerant from being lifted and flowing out to the heat source cycle 10.

[0120] The propane that has flowed into the tank 31 from the heat source refrigerant inlet 341 and condensed exchanges heat with the water in the tank 31 while being mixed with the water.

[0121] With the second embodiment, it is possible to contribute to heat transfer promotion by means of the latent heat that results from propane condensation and the sufficient water-propane contact during the water-propane mixing.

[0122] It is possible to heat indoor air by supplying indoors the hot water obtained in the tank 31 by means of the heat transport loop 20.

[0123] As described above, the direct contact heat exchanger 30 of the second embodiment has a function to prevent water refrigerant-based heat source refrigerant contamination by condensing only propane, allowing the liquid phase of the propane to be interposed between the gas phase of R32 and the water refrigerant, and sufficiently separating R32 and the water refrigerant from each other. Accordingly, the heat source refrigerant circulating through the heat source cycle 10 owing to the presence of the liquid phase of the propane in the tank 31 is not limited and contains no water.

[Third Embodiment]

[0124] Next, a third embodiment of the present invention will be briefly described with reference to Figs. 5 and 6. The same reference numerals are given to the same configurations as in the first embodiment.

[0125] A refrigerant system 3 of the third embodiment has both a cooling function and a heating function and is a heating-cum-cooling air conditioner.

[0126] The refrigerant system 3 of the third embodiment is provided with the heat source cycle 10 in which the heat source cycle refrigerant is circulated, the heat transport loop 20 in which the liquid-phase transport refrigerant is circulated, the direct contact heat exchanger 30, the heat exchanger 16, a direction switching unit 19 switching the direction in which the heat source refrigerant flows through the heat source cycle 10, and the check valves 14, 17, and 18. The direction switching unit 19 is, for example, a four-way valve.

[0127] As illustrated in Fig. 5, during the cooling operation (cooling), the direction switching unit 19 causes the heat source refrigerant to flow through the heat source cycle 10 in the direction in which the heat source refrigerant that has passed through the decompression unit 13 flows into the direct contact heat exchanger 30. At this time, in the heat source cycle 10, the heat source refrigerant flows through the solid-line passage in Fig. 5 in the direction indicated by the arrow in Fig. 5. During the cooling operation, the heat source refrigerant does not flow through the dashed-line passage in Fig. 5 owing to the relationship between a pressure gradient and the directions of the check valves 17 and 18.

[0128] The solid-line passage of the heat source cycle 10 in Fig. 5 is the same as the heat source cycle 10 of the refrigerant system 1 of the first embodiment illustrated in Fig. 1. Accordingly, during the cooling operation, the refrigerant system 3 functions in the same manner as the refrigerant system 1 of the first embodiment.

[0129] As illustrated in Fig. 6, during the heating operation (heating), the direction switching unit 19 causes the heat source refrigerant to flow through the heat source cycle 10 in the direction in which the heat source refrigerant discharged from the compressor 11 flows into the direct contact heat exchanger 30. At this time, in the heat source cycle 10, the heat source refrigerant flows through the solid-line passage in Fig. 6 in the direction indicated by the arrow in Fig. 6. During the cooling operation, the heat source refrigerant does not flow through the dashed-line passage in Fig. 6 owing to the relationship between the direction of the check valve 14 and the pressure gradients in front thereof and therebehind.

[0130] The solid-line passage of the heat source cycle 10 in Fig. 6 is the same as the heat source cycle 10 of the refrigerant system 2 of the second embodiment illustrated in Fig. 4. Accordingly, during the heating operation, the refrigerant system 3 functions in the same manner as the refrigerant system 2 of the second embodiment.

[0131] The configurations described in the above embodiments can be selected or appropriately changed to other configurations without departing from the gist of the present invention.

Reference Signs List

[0132]

1, 2, 3	Refrigerant system
1A	Outdoor unit
1B	Indoor unit
10	Heat source cycle
11	Compressor
12	Outdoor heat exchanger
13	Decompression unit
14, 17, 18	Check valve
16	Heat exchanger
19	Direction switching unit
20	Heat transport loop
21	Indoor heat exchanger
22	Pump
30	Direct contact heat exchanger
31	Tank
321	Heat source refrigerant inlet
322	Heat source refrigerant outlet
331	Water inlet
332	Water outlet
341	Heat source refrigerant inlet
342	Heat source refrigerant outlet
ph	High pressure
pl	Low pressure

Claims

1. A refrigerant system comprising:

a heat source cycle having a compressor, a heat exchanger, and a decompression unit;
a heat transport loop circulating a liquid-phase transport refrigerant transporting heat toward a heat load; and
a direct contact heat exchanger allowing direct contact between the transport refrigerant and a heat source refrigerant sealed in the heat source cycle,
wherein a second refrigerant is sealed in the heat source cycle in addition to a first refrigerant as the heat source refrigerant, and
in the direct contact heat exchanger, into which the heat source refrigerant passing through the decompression unit flows,
of the first refrigerant and the second refrigerant which has a higher boiling point than that of the first refrigerant, at least the first refrigerant boils and a density of a liquid phase of the second refrigerant is lower than a density of the transport refrigerant.

2. A refrigerant system comprising:

a heat source cycle having a compressor, a heat exchanger, and a decompression unit;
a heat transport loop circulating a liquid-phase transport refrigerant transporting heat toward a heat load; and
a direct contact heat exchanger allowing direct contact between the transport refrigerant and a

heat source refrigerant sealed in the heat source cycle,
wherein a second refrigerant is sealed in the heat source cycle in addition to a first refrigerant as the heat source refrigerant and the heat source cycle includes a heat exchanger condensing a gas phase of the heat source refrigerant taken out from the direct contact heat exchanger, and
in the direct contact heat exchanger, into which the first refrigerant discharged from the compressor flows,
of the first refrigerant and the second refrigerant which has a higher boiling point than that of the first refrigerant, the second refrigerant condenses and a density of a liquid phase of the second refrigerant is lower than a density of the transport refrigerant.

3. A refrigerant system comprising:

a heat source cycle having a compressor, a heat exchanger, and a decompression unit;
a heat transport loop circulating a liquid-phase transport refrigerant transporting heat toward a heat load;
a direct contact heat exchanger allowing direct contact between the transport refrigerant and a heat source refrigerant sealed in the heat source cycle; and
a direction switching unit switching a direction in which the heat source refrigerant flows through the heat source cycle,
wherein a second refrigerant is sealed in the heat source cycle in addition to a first refrigerant as the heat source refrigerant and the heat source cycle includes a heat exchanger condensing a gas phase of the heat source refrigerant taken out from the direct contact heat exchanger,
in the direct contact heat exchanger, into which the heat source refrigerant passing through the decompression unit flows,
of the first refrigerant and the second refrigerant which has a higher boiling point than that of the first refrigerant, the first refrigerant boils and a density of a liquid phase of the second refrigerant is lower than a density of the transport refrigerant, and
in the direct contact heat exchanger, into which the first refrigerant discharged from the compressor flows,
of the first refrigerant and the second refrigerant which has a higher boiling point than that of the first refrigerant, at least the second refrigerant condenses and the density of the liquid phase of the second refrigerant is lower than the density of the transport refrigerant.

4. The refrigerant system according to any one of Claims 1 to 3,
wherein the transport refrigerant is water, and
the second refrigerant is a hydrocarbon-based refrigerant.

5. A refrigerant system control method for controlling a refrigerant system including a heat source cycle having a compressor, a heat exchanger, and a decompression unit, a heat transport loop circulating a liquid-phase transport refrigerant transporting heat toward a heat load, and a direct contact heat exchanger allowing direct contact between the transport refrigerant and a heat source refrigerant sealed in the heat source cycle, the method comprising:

using a second refrigerant having a liquid density lower than a density of the transport refrigerant in addition to a first refrigerant as the heat source refrigerant sealed in the heat source cycle; and
in the direct contact heat exchanger, into which the heat source refrigerant passing through the decompression unit flows,
controlling an internal temperature of the direct contact heat exchanger to an evaporation temperature higher than a boiling point of the first refrigerant and a boiling point of the second refrigerant such that of the first refrigerant and the second refrigerant which has a higher boiling point than that of the first refrigerant, at least the first refrigerant boils.

6. A refrigerant system control method for controlling a refrigerant system including a heat source cycle having a compressor, a heat exchanger, and a decompression unit, a heat transport loop circulating a liquid-phase transport refrigerant transporting heat toward a heat load, and a direct contact heat exchanger allowing direct contact between the transport refrigerant and a heat source refrigerant sealed in the heat source cycle, the method comprising:

using a second refrigerant having a liquid density lower than a density of the transport refrigerant in addition to a first refrigerant as the heat source refrigerant sealed in the heat source cycle; and
in the direct contact heat exchanger, into which the first refrigerant discharged from the compressor flows,
controlling an internal temperature of the direct contact heat exchanger to a condensation temperature between a boiling point of the first refrigerant and a boiling point of the second refrigerant such that of the first refrigerant and the second refrigerant which has a higher boiling point than that of the first refrigerant, the second

refrigerant condenses.

FIG. 1

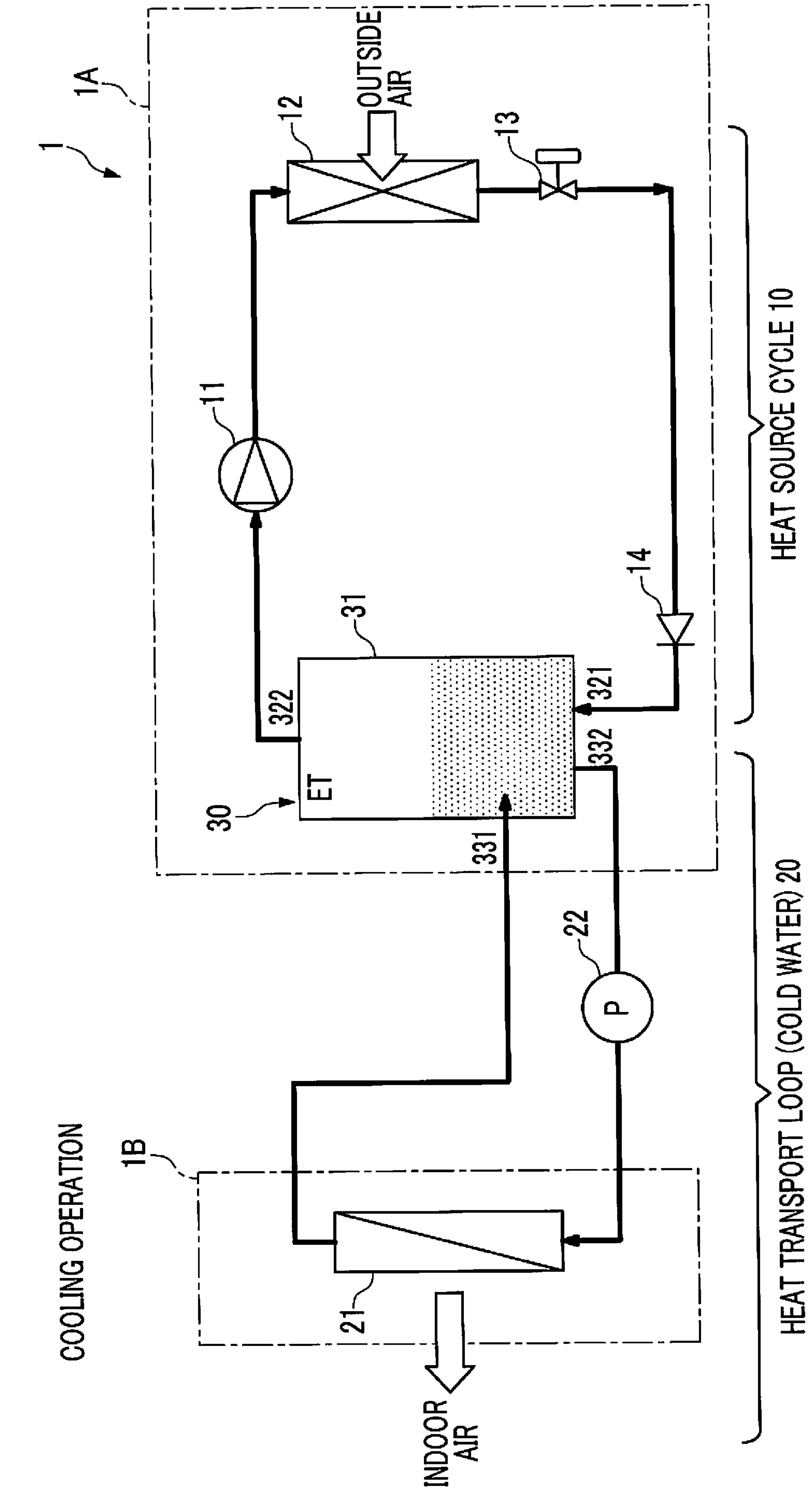

1
1A
12
OUTSIDE AIR
13
11
14
31
322
321
332
ET
30
331
22
P
HEAT SOURCE CYCLE 10
HEAT TRANSPORT LOOP (COLD WATER) 20
COOLING OPERATION
1B
21
INDOOR AIR

FIG. 2

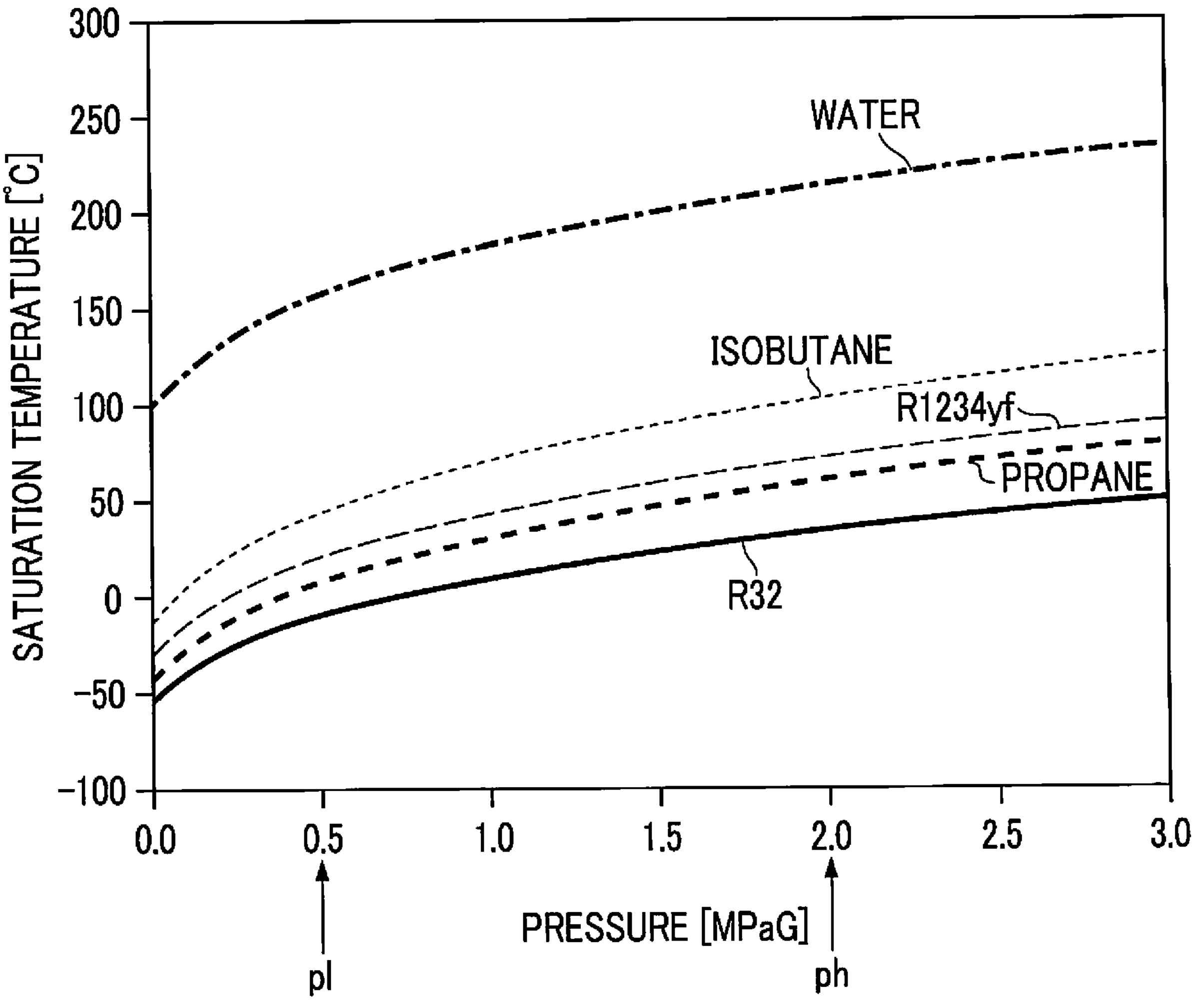

300
250
200
150
100
50
0
-50
-100
SATURATION TEMPERATURE [°C]
WATER
ISOBUTANE
R1234yf
PROPANE
R32
0.0
0.5
1.0
1.5
2.0
2.5
3.0
PRESSURE [MPaG]
pl
ph

FIG. 3

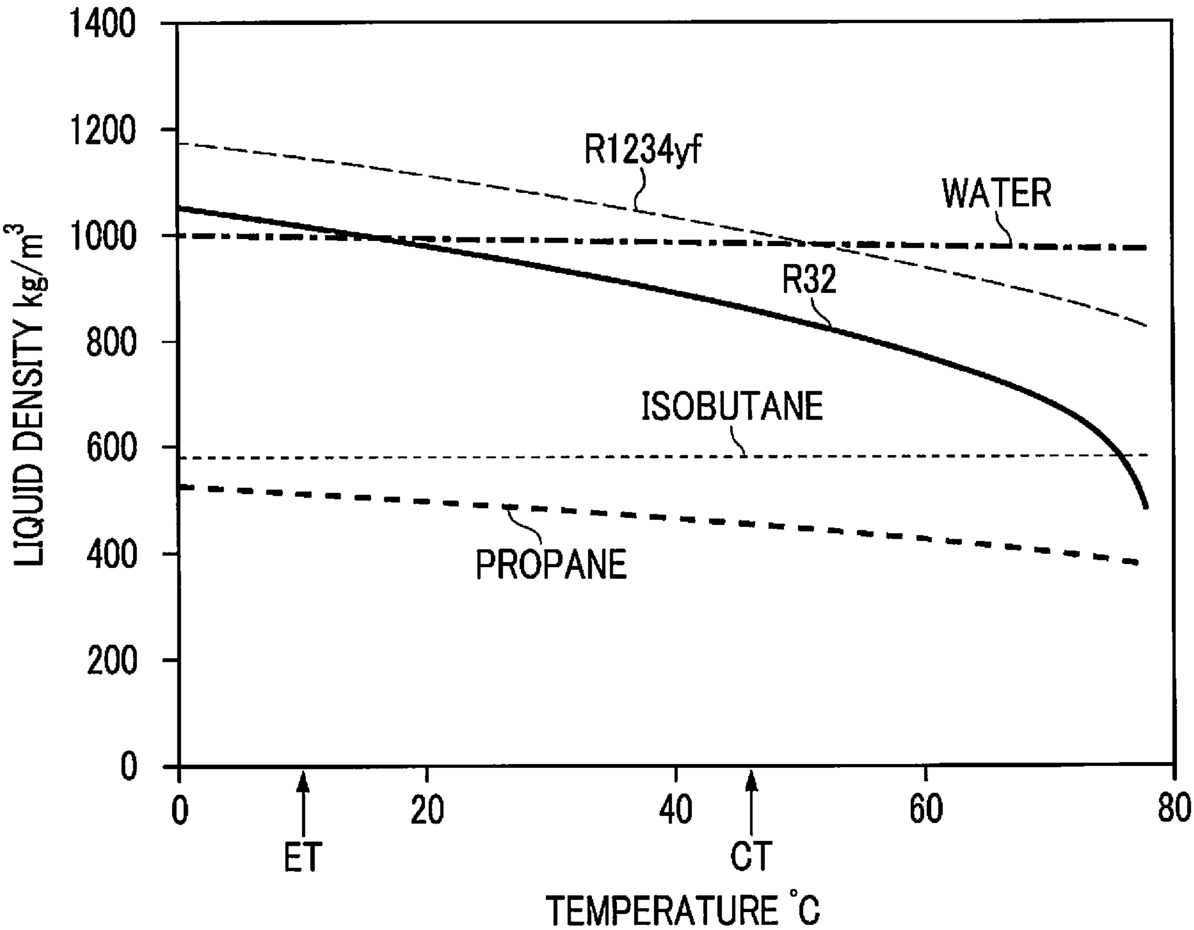

1400
1200
1000
800
600
400
200
0
LIQUID DENSITY kg/m3
R1234yf
WATER
R32
ISOBUTANE
PROPANE
0
20
40
60
80
ET
CT
TEMPERATURE °C

FIG. 4

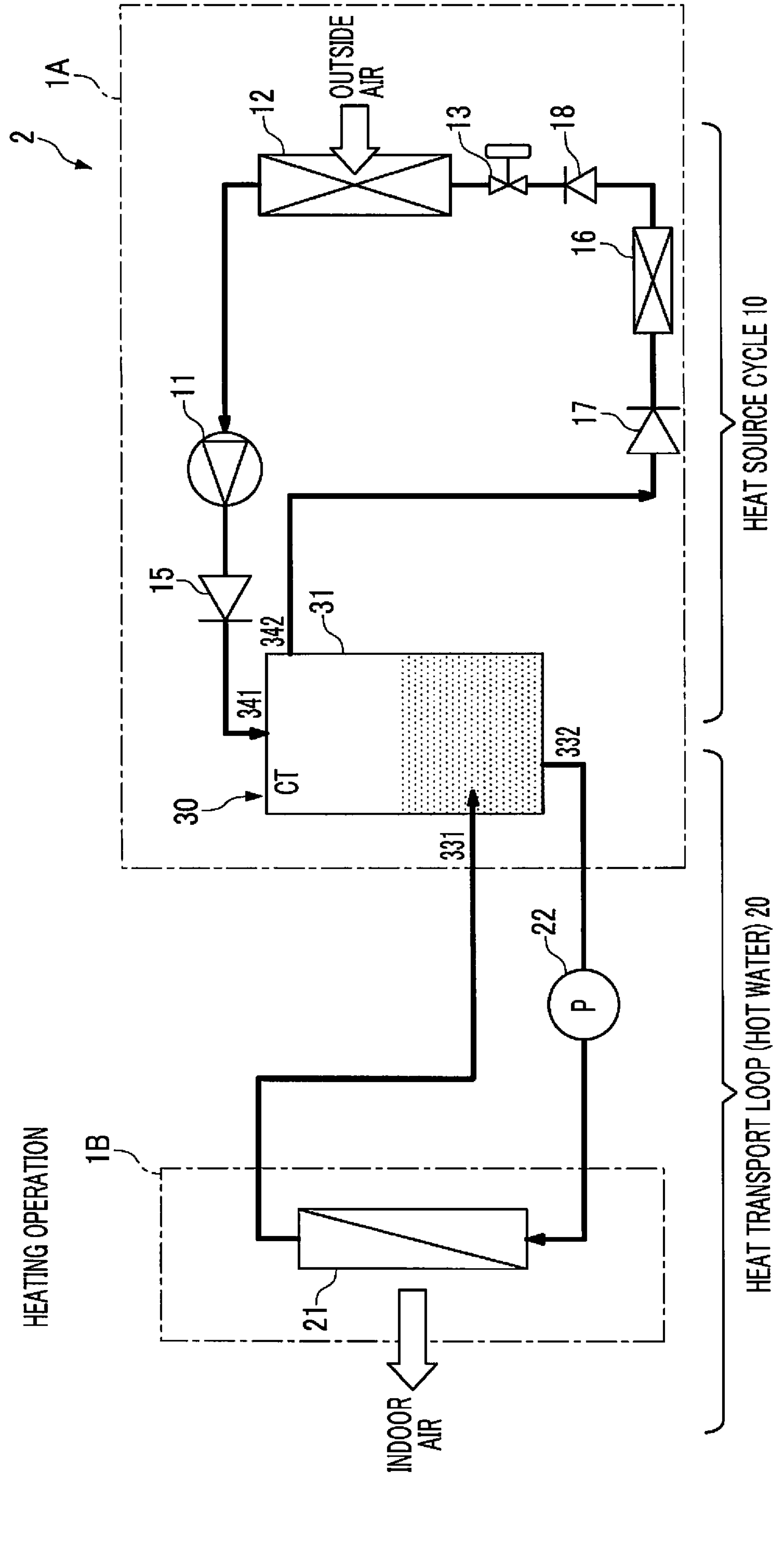

2
1A
12
OUTSIDE AIR
13
18
16
11
15
17
31
342
341
30
CT
332
331
22
P
HEAT SOURCE CYCLE 10
HEAT TRANSPORT LOOP (HOT WATER) 20
HEATING OPERATION
1B
21
INDOOR AIR

FIG. 5

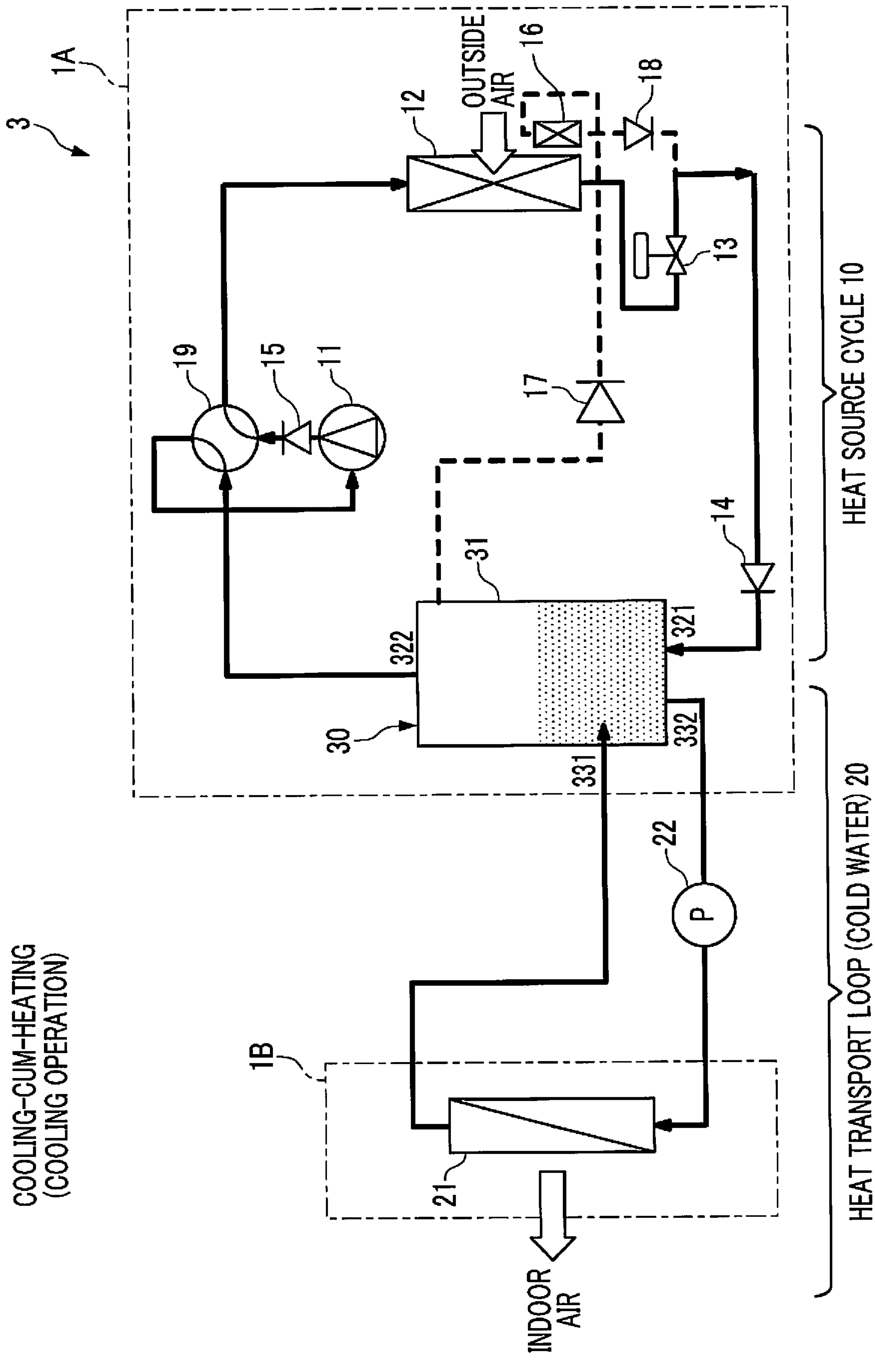
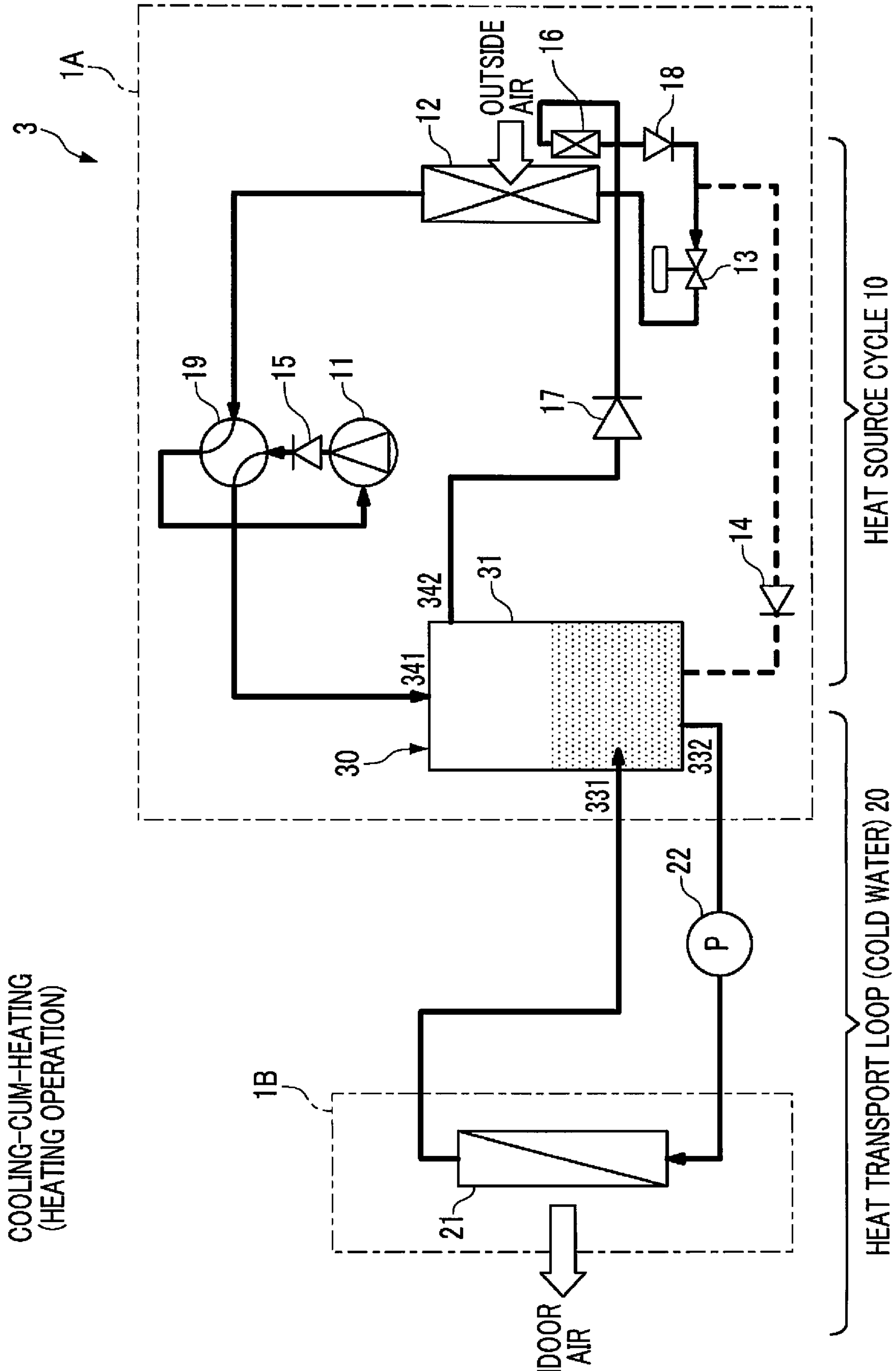

COOLING-CUM-HEATING
(COOLING OPERATION)
3
1A
1B
OUTSIDE AIR
INDOOR AIR
11
12
13
14
15
16
17
18
19
21
22
P
30
31
321
322
331
332
HEAT SOURCE CYCLE 10
HEAT TRANSPORT LOOP (COLD WATER) 20

FIG. 6


COOLING-CUM-HEATING
(HEATING OPERATION)
3
1A
1B
OUTSIDE
AIR
INDOOR
AIR
11
12
13
14
15
16
17
18
19
21
22
P
30
31
331
332
341
342
HEAT SOURCE CYCLE 10
HEAT TRANSPORT LOOP (COLD WATER) 20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/001539

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F25B1/00(2006.01)i, F25B13/00(2006.01)i, F25B39/02(2006.01)i, F25B39/04(2006.01)i, F28C3/06(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl. F25B1/00, F25B13/00, F25B39/02, F25B39/04, F28C3/06

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2018
Registered utility model specifications of Japan	1996-2018
Published registered utility model applications of Japan	1994-2018

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2001-263836 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 26 September 2001, paragraphs [0040], [0045], fig. 1-2, 5-6 (Family: none)	1-6
A	JP 2012-72929 A (PANASONIC CORP.) 12 April 2012, paragraph [0066], fig. 3 & WO 2012/042694 A1 & EP 2623913 A1, paragraph [0080], fig. 3 & CN 103124890 A & KR 10-2014-0005881 A	1-6
A	JP 2004-101034 A (DAIDO STEEL CO., LTD.) 02 April 2004, paragraph [0019], fig. 1 (Family: none)	1-6

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 March 2018 (26.03.2018)	03 April 2018 (03.04.2018)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2015087051 A **[0005]**