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

(11) EP 3 462 108 A1

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

(43) Date of publication:
**03.04.2019 Bulletin 2019/14**

(21) Application number: **17837002.9**

(22) Date of filing: **02.08.2017**

(51) Int Cl.:
***F25B 1/00*** *(2006.01)* ***F25B 41/00*** *(2006.01)*
***F25B 43/00*** *(2006.01)*

(86) International application number:
**PCT/JP2017/028003**

(87) International publication number:
**WO 2018/025900 (08.02.2018 Gazette 2018/06)**

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

(30) Priority: **04.08.2016 JP 2016153753**

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

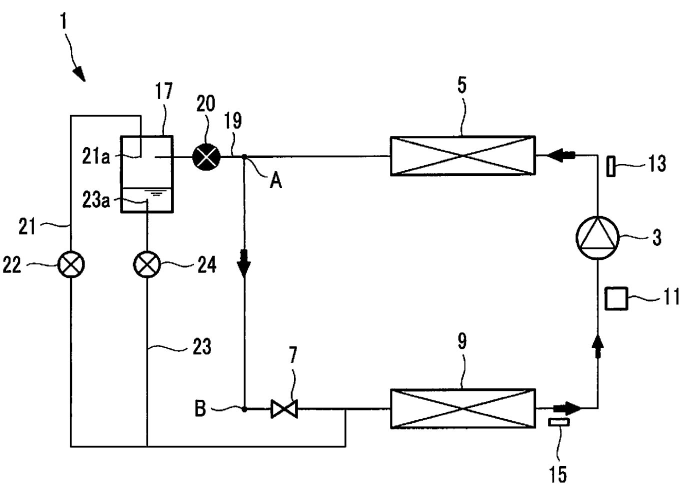
(72) Inventors:
- **MURAKAMI, Kenichi**
**Tokyo 108-8215 (JP)**
- **ENYA, Atsushi**
**Tokyo 108-8215 (JP)**

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

# (54) REFRIGERATION DEVICE AND CONTROL METHOD THEREFOR

(57) A refrigeration device is equipped with: an extraction pipe (19) that extracts a portion of a non-azeotropic refrigerant mixture from between a condenser (5) and an expansion valve (7); an extraction pipe on-off valve (20); a gas-liquid separator (17) that is connected to the extraction pipe (19), and that accumulates the non-azeotropic refrigerant mixture and separates the mixture into a gas and a liquid; a gas return pipe (21) connecting the gas-phase portion inside the gas-liquid separator (17) and a point between the expansion valve (7) and an evaporator (9); a gas return pipe on-off valve (22); a liquid return pipe (23) connecting the liquid-phase portion inside the gas-liquid separator (17) and a point between the expansion valve (7) and the evaporator (9); a liquid return pipe on-off valve (24); and a control unit that controls the extraction pipe on-off valve (20), the gas return pipe on-off valve (22), and the liquid return pipe on-off valve (24).

FIG. 1




EP 3 462 108 A1

## Description

### Technical Field

**[0001]** The present invention relates to a refrigeration device using a non-azeotropic refrigerant mixture and a control method therefor.

### Background Art

**[0002]** HFC refrigerants such as R410A are used as refrigerants used for an air conditioner. However, HFC refrigerants represented by R410A have a high global warming potential coefficient (GWP). Therefore, among HFC refrigerants, R32 with a lower GWP than R410A, and 1234yf and R1234ze(E) which are HFO refrigerants are cited as next candidate refrigerants for R410A. However, due to the refrigerant properties of a freon refrigerant and a natural refrigerant, there are advantages and disadvantages in the next candidate refrigerants. For example, R32 has a lower GWP and can obtain higher performance than R410A, but it has drawbacks that the discharge temperature is higher and the reliability in the low-temperature range is inferior, compared with R410A. R1234yf and R1234ze(E) have an advantage that the GWP is low (GWP is 10 or less), but they have only a volume capacity of about 50% because the density is lower compared with R410A, so they have a disadvantage of increasing the size of the equipment in order to ensure comparable performance.

**[0003]** In order to compensate for the advantages and disadvantages of refrigerants, use of a mixed refrigerant in which two or more types of refrigerants are mixed is considered. The following PTL 1 discloses changing the ratio of a mixed refrigerant in a refrigeration cycle by dissolving the mixed refrigerant in a refrigerating machine oil and utilizing the difference in the solubilities of refrigerants.

### Citation List

### Patent Literature

**[0004]** [PTL 1] Japanese Unexamined Patent Application Publication No. 7-98161

### Summary of Invention

### Technical Problem

**[0005]** As shown in Fig. 11, temperature sliding occurs in a non-azeotropic refrigerant mixture in which refrigerants having different boiling points are mixed, among mixed refrigerants. In other words, since the boiling points and the condensation points of mixed refrigerants are different, an isothermal line goes downward to the right on the p-h diagram if the pressure (p) is constant like a single refrigerant, in a wet steam (between a saturated liquid line and a saturated vapor line). That is, temperature sliding occurs in the non-azeotropic refrigerant mixture.

**[0006]** For example, the temperature difference in the temperature sliding varies depending on the ratio of each refrigerant in the non-azeotropic refrigerant mixture, as shown in Fig. 12. In Fig. 12, the horizontal axis is the mixing ratio [wt%] of R32 (low-boiling refrigerant) to R1234ze(E) (high-boiling refrigerant), and the vertical axis is the temperature difference [°C] of the temperature slidings on the high-pressure side (Fig. 12A: saturation temperature 40°C) and the low-pressure side (Fig. 12B: saturation temperature 10°C). As can be seen from Fig. 12, the temperature sliding is maximized when the mixing ratio of R32 to R1234ze(E) is around 20 wt%. In this case, since the saturation temperature is set to 10°C on the low-pressure side, the evaporator temperature may be 0°C or less on the low-pressure side, so there is a possibility of frosting of the evaporator. In the case of performing the heating operation, when the evaporator frosts, the heat exchange performance is lowered, and the heat absorption amount is decreased, so that the deterioration in the heating performance becomes conspicuous.

**[0007]** Fig. 13 shows the coefficient of performance (COP) at the time of cooling operation and heating operation in a case where the mixing ratio between R410A and R1234ze(E) is changed. In Fig. 13, the horizontal axis (lower axis) is the mixing ratio [wt%] of R32 to R1234ze(E), the horizontal axis (upper axis) is GWP at each mixing ratio, and the vertical axis is COP at the equal capacity ratio to R410A. As can be seen from Fig. 13, as the mixing ratio of R32 is decreased, the ratio of R1234ze(E) increases, so the GWP decreases, but the COP during the cooling operation and the heating operation decreases, especially the COP during the cooling operation largely decreases.

**[0008]** Therefore, it is desirable to make the mixing ratio of a non-azeotropic refrigerant mixture in a refrigeration cycle variable during an operation. In the above PTL 1, although it is possible to change the ratios of mixed refrigerants in the refrigeration cycle, since the solubility of refrigerant for refrigerating machine oil is used, it is necessary to control the temperature and oil storage amount of the refrigerating machine oil, there is a possibility that the system may be complicated.

**[0009]** The present invention has been made in view of such circumstances, and an object of the present invention is to provide a refrigeration device which can change a mixing ratio of a non-azeotropic refrigerant mixture in a refrigeration cycle with a simple configuration during an operation, and a control method therefor.

**[0010]** Another object is to provide a refrigeration device which can avoid frosting of the evaporator by temperature sliding of a non-azeotropic refrigerant mixture, and a control method therefor.

**[0011]** Still another object is to provide a refrigeration d evice using a non-azeotropic refrigerant mixture, capable of suppressing per formance deterioration during a cooling operation as much as possible, and a control method therefor.

Solution to Problem

**[0012]** In order to solve the above problems, a refrigeration device and a control method therefor of the present invention employs the following means.

**[0013]** In other words, a refrigeration device according to an aspect of the present invention includes a compressor that compresses a non-azeotropic refrigerant mixture in which a low-boiling refrigerant and a high-boiling refrigerant with boiling points different from each other are mixed; a condenser that condenses the non-azeotropic refrigerant mixture derived from the compressor; an expansion valve that expands the non-azeotropic refrigerant mixture derived from the condenser; an evaporator that evaporates the non-azeotropic refrigerant mixture derived from the expansion valve; an extraction pipe that extracts a part of the non-azeotropic refrigerant mixture from between the condenser and the expansion valve; an extraction pipe on-off valve provided in the extraction pipe; a gas-liquid separator that is connected to the extraction pipe, and that accumulates the non-azeotropic refrigerant mixture and separates the mixture into a gas and a liquid; a gas return pipe connecting the gas-phase portion inside the gas-liquid separator and a point between the expansion valve and an evaporator; a gas return pipe on-off valve provided in the gas return pipe; a liquid return pipe connecting the liquid-phase portion inside the gas-liquid separator and a point between the expansion valve and the evaporator; a liquid return pipe on-off valve provided in the liquid return pipe; and a control unit that controls the extraction pipe on-off valve, the gas return pipe on-off valve, and the liquid return pipe on-off valve.

**[0014]** By opening the extraction pipe on-off valve according to the command of the control unit, a part of the non-azeotropic refrigerant mixture is extracted through the extraction pipe from between the condenser and the expansion valve, and is temporarily stored in the gas-liquid separator. In the gas-liquid separator, gas and a liquid are separated according to the temperature and pressure inside the gas-liquid separator, and a liquid-phase portion and a gas-phase portion are formed.

**[0015]** When the gas return pipe on-off valve is opened according to the command of the control unit, a point between the expansion valve and the evaporator are communicated with the gas-phase portion in the gas-liquid separator through the gas return pipe, the pressure in the gas-phase portion becomes low and the low-boiling refrigerant is preferentially led to the evaporator. This makes it possible to increase the ratio of the low-boiling refrigerant in the non-azeotropic refrigerant mixture in the refrigeration cycle.

**[0016]** When the liquid return pipe on-off valve is opened according to the command of the control unit, a point between the expansion valve and the evaporator is communicated with the liquid-phase portion in the gas-liquid separator through the liquid return pipe, and the liquid refrigerant in the liquid-phase portion is led to the evaporator. Since the low-boiling refrigerant evaporates and is separated from the liquid-phase portion in the gas-liquid separator, there is a high-boiling refrigerant of a higher ratio in the liquid refrigerant than when a non-azeotropic refrigerant mixture is extracted from the extraction pipe. This makes it possible to increase the ratio of the high-boiling refrigerant in the non-azeotropic refrigerant mixture in the refrigeration cycle.

**[0017]** Thus, only by controlling each on-off valve of each pipe connected to the gas-liquid separator, a refrigerant which is separated into a gas and a liquid by the gas-liquid separator is returned during the refrigeration cycle from the gas-phase portion or the liquid-phase portion, so it is possible to arbitrarily change the mixing ratio of the low-boiling refrigerant and the high-boiling refrigerant with a simple configuration.

**[0018]** Examples of a low-boiling refrigerant include R32, and examples of a high-boiling refrigerant include R1234yf and R1234ze(E).

**[0019]** Further, in the refrigeration device according to an aspect of the present invention, during a heating operation, in a case where an outside air temperature is less than a predetermined value or a temperature of the evaporator is less than a predetermined value, the control unit performs a separation operation that opens the extraction pipe on-off valve, opens the gas return pipe on-off valve, and returns the gas refrigerant separated by the gas-liquid separator from the gas return pipe to the evaporator side.

**[0020]** During the heating operation, in general, the outside air temperature is low, so the temperature of the evaporator is low. When the temperature of the evaporator becomes lower than the predetermined value, for example, problems such as frosting of the evaporator occur. Therefore, in a case where the outside air temperature is less than the predetermined value or the temperature of the evaporator is less than the predetermined value, by opening the gas return pipe on-off valve, the gas refrigerant (mainly, a low-boiling refrigerant) separated by the gas-liquid separator is returned to the evaporator side through the gas return pipe, and the ratio of the low-boiling refrigerant in the refrigeration cycle is increased. In this case, by also opening the extraction pipe on-off valve, the non-azeotropic refrigerant mixture is led from the refrigeration cycle to the gas-liquid separator, and a low-boiling refrigerant is returned to the refrigeration cycle by the gas-liquid separator performing gas-liquid separation, so the ratio increase of the low-boiling refrigerant in the refrigeration cycle is further promoted.

**[0021]** By performing such a separation operation, by performing such a separation operation that separates a high-boiling refrigerant from the non-azeotropic refrigerant mixture in the refrigeration cycle to raise the ratio of a low-boiling refrigerant, temperature sliding is reduced, a saturation temperature at the evaporator can be increased, for example, frosting can be suppressed.

**[0022]** As the predetermined value of the outside air temperature or the predetermined value of the temperature of the evaporator, for example, a temperature at which the temperature of the evaporator falls and frost may occur is selected.

**[0023]** Further, in the refrigeration device according to an aspect of the present invention, after a predetermined period has elapsed since the separation operation is started, or after a degree of superheat of the non-azeotropic refrigerant mixture sucked in by the compressor is less than a predetermined value, the control unit closes the extraction pipe on-off valve.

**[0024]** Since the extraction pipe on-off valve is closed after a predetermined period has elapsed since the separation operation is started, or after a degree of superheat of the non-azeotropic refrigerant mixture sucked in by the compressor is less than a predetermined value, extraction of a part of the non-azeotropic refrigerant mixture in the refrigeration cycle to the gas-liquid separator is stopped. Thus, control to raise the ratio of the low-boiling refrigerant in the non-azeotropic refrigerant mixture in the refrigeration cycle is stopped, and operation can be continued with the composition of non-azeotropic refrigerant mixture after the separation operation.

**[0025]** As the "predetermined period" referred to in "after a predetermined period has elapsed since the separation operation is started", for example, a time until a desired mixing ratio is obtained by performing the separation operation is selected.

**[0026]** As the "predetermined value" referred to in "a degree of superheat of the refrigerant sucked in by the compressor is less than a predetermined value", for example, a value set for avoiding the liquid compression of the compressor is used.

**[0027]** Further, in the refrigeration device according to an aspect of the present invention, in a case where the outside air temperature is the predetermined value or more, or in a case where a temperature of a discharge gas discharged from the compressor is the predetermined value or more, the control unit opens the extraction pipe on-off valve, closes the gas return pipe on-off valve, and opens the liquid return pipe on-off valve.

**[0028]** When the outside air temperature is the predetermined value or more, there is no risk of problems such as frosting of the evaporator. Therefore, in a case where the outside air temperature is the predetermined value or more, the gas return pipe on-off valve is closed, and preferential returning of the low-boiling refrigerant to the refrigeration cycle is stopped. Then, by opening the liquid return pipe on-off valve, a large number of high-boiling refrigerants which are present in the liquid-phase portion are returned to the refrigeration cycle. In this case, by also opening the extraction pipe on-off valve, the non-azeotropic refrigerant mixture is led from the refrigeration cycle to the gas-liquid separator, and a high-boiling refrigerant of a liquid phase is preferentially returned to the refrigeration cycle by the gas-liquid separator performing gas-liquid separation, so the ratio increase of the high-boiling refrigerant in the refrigeration cycle is promoted.

**[0029]** As described above, by performing a mixing operation of mixing a high-boiling refrigerant in a non-azeotropic refrigerant mixture in the refrigeration cycle, it is possible to increase the ratio of the high-boiling refrigerant in the non-azeotropic refrigerant mixture, thereby returning the ratio to the mixing ratio at the time of filling the refrigerant.

**[0030]** In addition, when the discharge gas temperature discharged from the compressor becomes equal to or higher than the predetermined value, the discharge gas temperature can be lowered by returning the mixing ratio of refrigerant to the mixing ratio at the time of filling the refrigerant.

**[0031]** Further, in the refrigeration device according to an aspect of the present invention, during a cooling operation, the control unit opens the extraction pipe on-off valve and opens the gas return pipe on-off valve.

**[0032]** A low-boiling refrigerant such as R32 is higher in density than a high-boiling refrigerant such as R1234yf and R1234ze(E), so COP is higher. Therefore, during a cooling operation, by performing the separation operation that opens the extraction pipe on-off valve and the gas return pipe on-off valve, the ratio of a low-boiling refrigerant in the non-azeotropic refrigerant mixture in the refrigeration cycle increases. Thus, a highly efficient cooling operation can be realized.

**[0033]** Further, in the refrigeration device according to an aspect of the present invention, in a case where a temperature of a discharge gas discharged from the compressor is the predetermined value or more, the control unit opens the extraction pipe on-off valve, closes the gas return pipe on-off valve, and opens the liquid return pipe on-off valve.

**[0034]** When the ratio of a low-boiling refrigerant in the non-azeotropic refrigerant mixture in the refrigeration cycle increases, there is a possibility that the discharge gas temperature of the compressor becomes excessively high. Therefore, in a case where the discharge gas temperature is the predetermined value or more, by performing the mixing operation that opens the extraction pipe on-off valve, closes the gas return pipe on-off valve, and opens the liquid return pipe on-off valve, the ratio of a high-boiling refrigerant in the non-azeotropic refrigerant mixture is increased and the mixing ratio of refrigerant is returned to the mixing ratio at the time of filling the refrigerant. By doing this, it is possible to protect the equipment by avoiding the discharge gas temperature of the compressor from being excessively high.

**[0035]** A control method of a refrigeration device according to another aspect of the present invention, the refrigeration device including a compressor that compresses a non-azeotropic refrigerant mixture in which a low-boiling refrigerant and a high-boiling refrigerant with boiling points different from each other are mixed; a condenser that condenses the non-azeotropic refrigerant mixture derived from the compressor; an expansion valve that expands the non-azeotropic refrigerant mixture derived from the condenser; an evaporator that evaporates the non-azeotropic refrigerant mixture derived from the expansion valve; an extraction pipe that extracts a part of the non-azeotropic refrigerant mixture from between the condenser and the expansion valve; an extraction pipe on-off valve provided in the extraction pipe; a gas-liquid separator that is connected to the extraction pipe, and that accumulates the non-azeotropic refrigerant mixture and separates the mixture into a gas and a liquid; a gas return pipe connecting the gas-phase portion inside the gas-liquid separator and a point between the expansion valve and an evaporator; a gas return pipe on-off valve provided in the gas return pipe; a liquid return pipe connecting the liquid-phase portion inside the gas-liquid separator and a point between the expansion valve and the evaporator; a liquid return pipe on-off valve provided in the liquid return pipe; and a liquid return pipe on-off valve provided in the liquid return pipe, the method including controlling opening and closing of the extraction pipe on-off valve, the gas return pipe on-off valve, and the liquid return pipe on-off valve.

Advantageous Effects of Invention

**[0036]** Only by controlling each on-off valve of each pipe connected to the gas-liquid separator, a refrigerant which is separated into a gas and a liquid by the gas-liquid separator is returned during the refrigeration cycle from the gas-phase portion or the liquid-phase portion, so it is possible to arbitrarily change the mixing ratio of the non-azeotropic refrigerant mixture with a simple configuration.

**[0037]** By performing the separation operation that separates a high-boiling refrigerant from the non-azeotropic refrigerant mixture in the refrigeration cycle to raise the ratio of a low-boiling refrigerant, a saturation temperature at the evaporator is increased, and thus frosting of the evaporator can be suppressed.

**[0038]** During a cooling operation, by performing the separation operation that opens the extraction pipe on-off valve and the gas return pipe on-off valve, the ratio of a low-boiling refrigerant in the non-azeotropic refrigerant mixture in the refrigeration cycle increases, and thus highly efficient cooling operation can be realized.

Brief Description of Drawings

**[0039]**

Fig. 1 is a schematic configuration diagram showing a refrigerant circuit of a refrigeration device according to an embodiment of the present invention and showing a normal operation (inclusion composition) during a heating operation.

Fig. 2 is a schematic configuration diagram of a refrigerant circuit showing a separation operation during the heating operation.

Fig. 3 is a schematic configuration diagram of a refrigerant circuit showing a normal operation (separation composition) during the heating operation.

Fig. 4 is a schematic configuration diagram of a refrigerant circuit showing a mixing operation during the heating operation.

Fig. 5 is a flowchart showing control during the heating operation.

Fig. 6 is a schematic configuration diagram of a refrigerant circuit showing a normal operation (inclusion composition) during a cooling operation.

Fig. 7 is a schematic configuration diagram of a refrigerant circuit showing a separation operation during the cooling operation.

Fig. 8 is a schematic configuration diagram of a refrigerant circuit showing a normal operation (separation composition) during a cooling operation.

Fig. 9 is a schematic configuration diagram of a refrigerant circuit showing a mixing operation during the cooling operation.

Fig. 10 is a flowchart showing control during the cooling operation.

Fig. 11 is a pressure (p)-enthalpy (h) diagram showing temperature sliding of a non-azeotropic refrigerant mixture.

Fig. 12A is a graph showing temperature sliding corresponding to a mixing ratio of the non-azeotropic refrigerant mixture and showing temperature sliding at saturation temperature of 40°C.

Fig. 12B is a graph showing temperature sliding corresponding to a mixing ratio of the non-azeotropic refrigerant mixture and showing temperature sliding at saturation temperature of 10°C.

Fig. 13 is a graph showing a change in COP corresponding to a mixing ratio of the non-azeotropic refrigerant mixture.

Description of Embodiments

**[0040]** Hereinafter, an embodiment according to the present invention will be described with reference to the drawings.

**[0041]** Fig. 1 shows the configuration of a refrigerant circuit of a refrigeration device 1 of the present embodiment. The refrigeration device 1 is used as, for example, an air conditioner, and it is possible to perform a heating operation and a cooling operation by switching the four-way valve (not shown) provided on the discharge side of the compressor 3. Fig. 1 shows the configuration during a heating operation.

**[0042]** The refrigeration device 1 uses a non-azeotropic refrigerant mixture in which R32 and R1234ze(E) are mixed, as a refrigerant. R32 is considered to be a low-boiling refrigerant with a lower boiling point relative to R1234ze(E). R1234ze(E) is considered to be a high-boiling refrigerant with a higher boiling point relative to R32. Further, R1234yf may be used instead of R1234ze(E).

**[0043]** The refrigeration device 1 includes a compressor 3 that compresses a non-azeotropic refrigerant mixture (hereinafter sometimes simply referred to as "refrigerant"), a condenser 5, an expansion valve 7, and an evaporator 9. A refrigerant circuit which performs a refrigeration cycle is configured by connecting the compressor 3, the condenser 5, the expansion valve 7, and the evaporator 9 by refrigerant pipes.

**[0044]** The compressor 3 is provided inside an outdoor unit, is assumed to be, for example, a scroll compressor or a rotary compressor, and is driven by an electric motor (not shown). The electric motor has an inverter device, and the rotation speed is arbitrarily changed according to a command from a control unit (not shown).

**[0045]** A suction pressure sensor 11 that measures the suction pressure Ps of the refrigerant is provided on the suction side of the compressor 3, and a discharge temperature sensor 13 that measures the discharge temperature of the refrigerant is provided on the discharge side of the compressor 3. The outputs from the suction pressure sensor 11 and the discharge temperature sensor 13 are transmitted to the control unit.

**[0046]** The condenser 5 is an indoor heat exchanger and condenses the high-pressure gas refrigerant derived from the compressor 3 by heating and heat-exchanging the indoor air during a heating operation.

**[0047]** The expansion valve 7 expands the refrigerant condensed and liquefied in the condenser 5. The opening of the expansion valve 7 is controlled by the control unit.

**[0048]** The evaporator 9 is assumed to be an outdoor heat exchanger provided inside the outdoor unit, and evaporates the refrigerant expanded by the expansion valve 7 by exchanging heat with the outside air, as the outdoor heat exchanger, during a heating operation. An evaporator outlet temperature sensor 15 that measures the evaporating refrigerant temperature is provided in the refrigerant outlet of the evaporator 9. The output from the evaporator outlet temperature sensor 15 is transmitted to the control unit.

**[0049]** Apart from the main refrigerant circuit performing a refrigeration cycle by the compressor 3, the condenser 5, the expansion valve 7 and the evaporator 9, described above, a gas-liquid separator 17 is provided. The gas-liquid separator 17 is assumed to be a tank having a capacity capable of temporarily storing a refrigerant. The gas-liquid separator 17 is provided inside the outdoor unit accommodating the compressor 3 and the evaporator 9.

**[0050]** An extraction pipe 19 is provided between the upper part of the gas-liquid separator 17 and an extraction position A between the condenser 5 and the expansion valve 7. The extraction pipe 19 is provided with an extraction pipe on-off valve 20. The extraction pipe on-off valve 20 is, for example, an electromagnetic valve, and is opened and closed according to a command from the control unit.

**[0051]** A gas return pipe 21 is provided between the gas-liquid separator 17 and the joining position B between the expansion valve 7 and the evaporator 9. The upstream end 21a of the gas return pipe 21 is located in the upper part of the gas-liquid separator 17 and opens into the gas-phase portion of the refrigerant separated in the gas-liquid separator 17. The gas return pipe 21 is provided with a gas return pipe on-off valve 22. The gas return pipe on-off valve 22 is, for example, an electromagnetic valve, and is opened and closed according to a command from the control unit.

**[0052]** A liquid return pipe 23 is provided between the gas-liquid separator 17 and the joining position B between the expansion valve 7 and the evaporator 9. The upstream end 23a of the liquid return pipe 23 is located at the lower part (or bottom) of the gas-liquid separator 17 and opens into the liquid-phase portion of the refrigerant separated in the gas-liquid separator 17. The liquid return pipe 23 is provided with a liquid return pipe on-off valve 24. The liquid return pipe on-off valve 24 is, for example, an electromagnetic valve, and is opened and closed according to a command from the control unit.

**[0053]** The control unit includes, for example, a central processing unit (CPU), a random access memory (RAM), a read only memory (ROM), a computer-readable storage medium, and the like. A series of processes for realizing various functions are stored in a storage medium or the like in the form of a program as an example. The CPU reads the program to a RAM or the like and to process information and executes a calculation process, thereby realizing various functions. The program may be installed in advance in a ROM or other storage medium, may be provided in a state stored in a computer-readable storage medium, or may be distributed through wired or wireless communication means. The computer-readable storage medium is a magnetic disk, a magneto-optical disk, a CD-ROM, a DVD-ROM, a semiconductor memory, or the like.

<During Heating Operation>

**[0054]** Next, the operation mode during a heating operation of the refrigeration device 1 having the above configuration will be described.

[Normal Operation (inclusion composition): During Heating Operation]

**[0055]** Fig. 1 shows a normal operation (inclusion composition) during a heating operation. In a normal operation, the operation is performed with a composition with a mixing ratio (for example, a mixing ratio of R32:R1234ze(E) = 1: 1) equivalent to that when the refrigeration device 1 is filled with a non-azeotropic refrigerant mixture.

**[0056]** The extraction pipe on-off valve 20 is closed, the gas return pipe on-off valve 22 is opened, and the liquid return pipe on-off valve 24 is opened. In each drawing, the opening of the valve is indicated as hollow, and the closing of the valve is indicated as solid.

**[0057]** By closing the extraction pipe on-off valve 20, the refrigerant is not extracted from the refrigeration cycle, and the mixing ratio of the refrigerant in the refrigeration cycle is not changed. Further, by opening the liquid return pipe on-off valve 24, the liquid refrigerant is not stored in the gas-liquid separator 17, so the mixing ratio of the refrigerant in the refrigeration cycle is not changed.

**[0058]** By opening the gas return pipe on-off valve 22, the pressure of the refrigerant is made equal to the pressure of the refrigerant expanded by the expansion valve 7. This makes it possible to prevent the low-boiling refrigerant from remaining unevaporated during the normal operation, and to prevent a liquid-filled state in which the gas-liquid separator 17 is filled with the unevaporated refrigerant during stop of operation.

[Separation Operation (During Heating Operation)]

**[0059]** Fig. 2 shows a separation operation during a heating operation. The separation operation is performed after the above-described normal operation (inclusion composition), and is performed to separate R1234ze (high-boiling refrigerant) from the refrigerant in the refrigeration cycle and increase the mixing ratio of R32 (low-boiling refrigerant) in the refrigerant in the refrigeration cycle.

**[0060]** The extraction pipe on-off valve 20 is opened, the gas return pipe on-off valve 22 is opened, and the liquid return pipe on-off valve 24 is closed.

**[0061]** By opening the extraction pipe on-off valve 20, a part of the liquid refrigerant is introduced into the gas-liquid separator 17 from between the condenser 5 and the expansion valve 7. In the gas-liquid separator 17, the gas return pipe on-off valve 22 is opened and the pressure is low being equal to the pressure between the expansion valve 7 and the evaporator 9, so R32 which is a low-boiling refrigerant, derived into the gas-liquid separator 17 is preferentially evaporated over R1234ze(E) which is a high-boiling refrigerant. Then, R32 evaporated in the gas-liquid separator 17 passes through the gas return pipe 21, is returned from the joining position B to the evaporator 9, and is used as a refrigerant for a refrigeration cycle. This increases the mixing ratio of R32 in the refrigerant in the refrigeration cycle.

[Normal Operation (Separation Composition): During Heating Operation]

**[0062]** Fig. 3 shows a normal operation (separation composition) during a heating operation. The normal operation is performed after the separation operation described above and is performed in a state where R1234ze(E) in the refrigerant in the refrigeration cycle is separated and the separation composition is such that the mixing ratio of R32 is increased.

**[0063]** The extraction pipe on-off valve 20 is closed, the gas return pipe on-off valve 22 is opened, and the liquid return pipe on-off valve 24 is closed.

**[0064]** By closing the extraction pipe on-off valve 20, the refrigerant is not extracted from the refrigeration cycle, and the mixing ratio of the refrigerant in the refrigeration cycle is not changed. Further, by closing the liquid return pipe on-off valve 24, the liquid refrigerant in the gas-liquid separator 17 is not returned to the refrigeration cycle, and the mixing ratio of the refrigerant in the refrigeration cycle is not changed.

**[0065]** By opening the gas return pipe on-off valve 22, R32 separated in the gas-liquid separator 17 is led to the evaporator 9 through the gas return pipe 21.

[Mixing Operation: During Heating Operation]

**[0066]** Fig. 4 shows a mixing operation during a heating operation. The mixing operation is performed after the above-described normal operation (separation composition) and decreases the mixing ratio of R32 in the refrigerant by mixing R1234ze(E) in the refrigerant in the refrigeration cycle is made.

**[0067]** The extraction pipe on-off valve 20 is opened, the gas return pipe on-off valve 22 is closed, and the liquid return pipe on-off valve 24 is opened.

**[0068]** By opening the extraction pipe on-off valve 20, the liquid refrigerant is introduced into the gas-liquid separator 17 from between the condenser 5 and the expansion valve 7. Since the gas return pipe on-off valve 22 is closed in the gas-liquid separator 17, R32 evaporated in the gas-liquid separator 17 is not supplied from the joining position B to the refrigerant in the refrigeration cycle. On the other hand, since the liquid return pipe on-off valve 24 is opened, the liquid refrigerant stored in the gas-liquid separator 17 is led from the joining position B to the evaporator 9 through the liquid return pipe 23. Thus, the liquid refrigerant in the gas-liquid separator 17, in which R1234ze (E) is concentrated by the separation operation (see Fig. 2), is returned to the refrigerant flowing in the refrigeration cycle, so the mixing ratio of R1234ze(E) in the refrigerant in the refrigeration cycle is increased.

**[0069]** Next, with reference to Fig. 5, the control method of the refrigeration device 1 during a heating operation will be described. The following steps are performed according to a command from the control unit.

**[0070]** In a case where the operation is started, it is determined whether or not the outside air temperature is lower than a predetermined value (for example, 10°C) (step S1). For the outside air temperature, the measured value of the outside air temperature sensor (not shown) is used. In a case where the outside air temperature is lower than 10°C, a separation operation (see Fig. 2) is performed to increase the mixing ratio of R32 in the refrigerant in the refrigeration cycle. Thus, the temperature sliding in the evaporator 9 is reduced (see Fig. 12B), and the low pressure in the evaporator 9 rises to prevent frosting.

**[0071]** In a case where it is determined that the outside air temperature is 10°C or higher at step S1, the process proceeds to step S3, and the normal operation (inclusion composition) is performed (see Fig. 1). In the normal operation (inclusion composition), the mixing ratio in the refrigerant flowing in the refrigeration cycle is made equal to that at the time of refrigerant filling, and the mixing ratio of R32 is not excessively large, so the discharge gas temperature of the refrigerant gas discharged from the compressor 3 is maintained at a predetermined value or less in this operation.

**[0072]** In a case where the measured temperature Tho-R of the evaporator outlet temperature sensor 15 is the predetermined value (for example, -3°C) or higher while the normal operation (inclusion composition) is performed at step S3 (step S4), it is determined whether or not a unit stop command is present (step S5). In a case where a unit stop command is issued, the refrigeration device 1 is stopped and the process is terminated. In a case where the unit stop command has not been issued, the process returns to step S3 and the normal operation (inclusion composition) is continued.

**[0073]** In a case where the measured temperature Tho-R of the evaporator outlet temperature sensor 15 becomes lower than -3°C in step S4, the process proceeds to step S3 and the separation operation is performed. Due to the separation operation, the low pressure of the evaporator 9 rises to prevent frosting.

**[0074]** While the separation operation is performed in step S2, it is determined whether or not the suction superheat degree of the compressor 3 is lower than 2°C or whether or not a predetermined time (for example, one hour) has elapsed since the separation operation is started (step S6). The suction superheat degree is calculated from the difference between the saturation temperature of the pressure obtained by the suction pressure sensor 11 and the temperature obtained by the evaporator outlet temperature sensor 15.

**[0075]** In step S6, in a case where the suction superheat degree is not lower than 2°C and one hour has not elapsed since the separation operation, the process returns to step S2 and the separation operation is continued.

**[0076]** In step S6, in a case where the suction superheat degree is lower than 2°C or one hour or more has elapsed since the separation operation, the process proceeds to step S7 and the normal operation (separation composition) is performed (see Fig. 3). In the normal operation (separation composition), an operation is performed in which R1234ze(E) is separated from the refrigerant in the refrigeration cycle to increase the mixing ratio of R32. Thus, frosting of the evaporator 9 is suppressed, and the operation with high COP is performed as shown in Fig. 13.

**[0077]** During the normal operation (separation composition), it is determined whether or not the discharge temperature Tho-D measured by the discharge temperature sensor 13 exceeds a predetermined value (for example, 110°C) (step S8). In a case where the discharge temperature Tho-D exceeds 110°C, the process proceeds to step S9 to perform a mixing operation (see Fig. 4). In the mixing operation, R1234ze(E) is mixed in the refrigerant in the refrigeration cycle, and the mixing operation is performed so as to approach the mixing ratio at the time of filling. Thus, the mixing ratio of R32 in the refrigerant in the refrigeration cycle decreases, and the discharge temperature decreases. The mixing operation is terminated after a predetermined time (for example, 5 minutes) has elapsed, and the process proceeds to step S3 to perform the normal operation (inclusion composition).

**[0078]** In a case where the discharge temperature Tho-D does not exceed 110°C in step S8, the process proceeds to step S10, and it is determined whether or not a unit stop command is present. In a case where the unit stop command has not been issued, the process returns to step S7 and the normal operation (separation composition) is continued. In a case where the unit stop command is issued, the process proceeds to step S11, and after the mixing operation is performed for a predetermined time (for example, 5 minutes), the refrigeration device 1 is stopped and the process is terminated. By performing the mixing operation before stopping the refrigeration device 1, the mixing ratio in the refrigerant to be flown to the refrigeration cycle at the next startup is returned to that of the refrigerant at the time of filling.

<During Cooling Operation>

**[0079]** Next, the operation mode during a cooling operation of the refrigeration device 1 having the above configuration will be described. The heating operation is switched to the cooling operation by switching the four-way valve (not shown) provided on the discharge side of the compressor 3. Thus, the condenser during a heating operation is switched into the evaporator (indoor heat exchanger) during a cooling operation, and the evaporator during a heating operation is switched into the condenser (outdoor heat exchanger) during a cooling operation.

[Normal Operation (inclusion composition): During Cooling Operation]

**[0080]** Fig. 6 shows a normal operation (inclusion composition) during a cooling operation. In a normal operation, the operation is performed with a composition with a mixing ratio (for example, a mixing ratio of R32:R1234ze(E) = 1: 1) equivalent to that when the refrigeration device 1 is filled with a non-azeotropic refrigerant mixture.

**[0081]** The extraction pipe on-off valve 20 is closed, the gas return pipe on-off valve 22 is opened, and the liquid return pipe on-off valve 24 is closed.

**[0082]** By closing the extraction pipe on-off valve 20, the refrigerant is not extracted from the refrigeration cycle, and the mixing ratio of the refrigerant in the refrigeration cycle is not changed. Further, by opening the liquid return pipe on-off valve 24, the liquid refrigerant is not stored in the gas-liquid separator 17, so the mixing ratio of the refrigerant in the refrigeration cycle is not changed.

**[0083]** By opening the gas return pipe on-off valve 22, the pressure of the refrigerant is made equal to the pressure of the refrigerant expanded by the expansion valve 7. This makes it possible to prevent the low-boiling refrigerant from remaining unevaporated during the normal operation, and to prevent a liquid-filled state in which the gas-liquid separator is filled with the unevaporated refrigerant during stop of operation.

[Separation Operation (During Cooling Operation)]

**[0084]** Fig. 7 shows a separation operation during a cooling operation. The separation operation is performed after the above-described normal operation (inclusion composition) and is performed to separate R1234ze(E) (high-boiling refrigerant) from the refrigerant in the refrigeration cycle and increase the mixing ratio of R32 (low-boiling refrigerant) in the refrigerant in the refrigeration cycle.

**[0085]** The extraction pipe on-off valve 20 is opened, the gas return pipe on-off valve 22 is opened, and the liquid return pipe on-off valve 24 is closed.

**[0086]** By opening the extraction pipe on-off valve 20, the liquid refrigerant is introduced into the gas-liquid separator 17 from between the condenser 5 and the expansion valve 7. In the gas-liquid separator 17, the gas return pipe on-off valve 22 is opened and the pressure is low being equal to the pressure between the expansion valve 7 and the evaporator 9, so R32 which is a low-boiling refrigerant, derived into the gas-liquid separator 17 is preferentially evaporated over R1234ze(E) which is a high-boiling refrigerant. Then, R32 evaporated in the gas-liquid separator 17 passes through the gas return pipe 21, is returned from the joining position B to the evaporator 9, and is used as a refrigerant for a refrigeration cycle. This increases the mixing ratio of R32 in the refrigerant in the refrigeration cycle.

[Normal Operation (Separation Composition): During Cooling Operation]

**[0087]** Fig. 8 shows a normal operation (separation composition) during a cooling operation. The normal operation is performed after the separation operation described above, and is performed in a state where R1234ze(E) in the refrigerant in the refrigeration cycle is separated and the separation composition is such that the mixing ratio of R32 is increased.

**[0088]** The extraction pipe on-off valve 20 is closed, the gas return pipe on-off valve 22 is closed, and the liquid return pipe on-off valve 24 is closed.

**[0089]** By closing the extraction pipe on-off valve 20, the refrigerant is not extracted from the refrigeration cycle, and the mixing ratio of the refrigerant in the refrigeration cycle is not changed. Further, by closing the liquid return pipe on-off valve 24, the liquid refrigerant in the gas-liquid separator 17 is not returned to the refrigeration cycle, and the mixing ratio of the refrigerant in the refrigeration cycle is not changed.

**[0090]** The gas return pipe on-off valve 22 is closed, unlike the normal operation (separation composition) during the heating operation shown in Fig. 3. This is because the outside air temperature during the cooling operation is higher than in the heating operation, the environmental temperature inside the outdoor unit where the gas-liquid separator 17 is provided is high, and R1234ze(E) which is the high-boiling refrigerant also evaporates, it may join into a refrigerant flowing in a refrigeration cycle through the gas return pipe 21. In the case where the gas-liquid separator 17 is provided in an environment (for example, in a room) that is not affected by the outside air temperature rather than in the outdoor unit, similarly to the normal operation (separation composition) during the heating operation, the gas return pipe on-off valve 22 may be opened.

[Mixing operation: During Cooling Operation]

**[0091]** Fig. 9 shows a mixing operation during a cooling operation. The mixing operation is performed after the above-described normal operation (separation composition) and decreases the mixing ratio of R32 in the refrigerant by mixing R1234ze(E) in the refrigerant in the refrigeration cycle is made.

**[0092]** The extraction pipe on-off valve 20 is opened, the gas return pipe on-off valve 22 is closed, and the liquid return pipe on-off valve 24 is opened.

**[0093]** By opening the extraction pipe on-off valve 20, the liquid refrigerant is introduced into the gas-liquid separator 17 from between the condenser 5 and the expansion valve 7. Since the gas return pipe on-off valve 22 is closed in the gas-liquid separator 17, R32 evaporated in the gas-liquid separator 17 is not supplied from the joining position B to the refrigerant in the refrigeration cycle. On the other hand, since the liquid return pipe on-off valve 24 is opened, the liquid refrigerant stored in the gas-liquid separator 17 is led from the joining position B to the evaporator 9 through the liquid return pipe 23. Thus, the liquid refrigerant in the gas-liquid separator 17, in which R1234ze (E) is concentrated by the separation operation (see Fig. 7), is returned to the refrigerant flowing in the refrigeration cycle, so the mixing ratio of R1234ze(E) in the refrigeration cycle is increased.

**[0094]** Next, with reference to Fig. 10, the control method of the refrigeration device 1 during a cooling operation will be described. The following steps are performed according to a command from the control unit.

**[0095]** When the operation is started, the process proceeds to step S21, and the separation operation (see Fig. 7) is performed to increase the mixing ratio of R32 in the refrigerant in the refrigeration cycle. Thus, the cooling operation with an improved COP is performed (see Fig. 13).

**[0096]** While the separation operation is performed in step S21, it is determined whether or not the suction superheat degree of the compressor 3 is lower than 2°C or whether or not a predetermined time (for example, one hour) has elapsed since the separation operation is started (step S22) .

**[0097]** In step S22, in a case where the suction superheat degree is not lower than 2°C and one hour has not elapsed since the separation operation, the process returns to step S21 and the separation operation is continued.

**[0098]** In step S22, in a case where the suction superheat degree is lower than 2°C or one hour or more has elapsed since the separation operation, the process proceeds to step S23 and the normal operation (separation composition) is performed (see Fig. 8). In the normal operation (separation composition), an operation is performed in which R1234ze(E) is separated from the refrigerant in the refrigeration cycle to increase the mixing ratio of R32. Thus, the cooling operation with a high COP is continued.

**[0099]** While the normal operation (separation composition) is performed in step S23, it is determined whether or not the discharge temperature Tho-D measured by the discharge temperature sensor 13 exceeds a predetermined value (for example, 110°C) (step S24). In a case where the discharge temperature Tho-D exceeds 110°C, the process proceeds to step S25 to perform a mixing operation (see Fig. 9). In the mixing operation, R1234ze(E) is mixed in the refrigerant in the refrigeration cycle, and the mixing operation is performed so as to approach the mixing ratio at the time of filling. Thus, the mixing ratio of R32 in the refrigerant in the refrigeration cycle decreases, and the discharge temperature decreases. The mixing operation is terminated after a predetermined time (for example, 5 minutes) has elapsed, and the process proceeds to step S26 to perform the normal operation (inclusion composition) (see Fig. 6).

**[0100]** In the normal operation (inclusion composition), the mixing ratio in the refrigerant flowing in the refrigeration cycle is made equal to that at the time of filling of the refrigerant, and the mixing ratio of R32 is not large, so the discharge gas temperature of the refrigerant gas discharged from the compressor 3 is maintained at a predetermined value or less in this operation.

**[0101]** While the normal operation (inclusion composition) is performed at step S26, it is determined whether or not a unit stop command is present (step S27). In a case where a unit stop command is issued, the refrigeration device 1 is stopped and the process is terminated. In a case where the unit stop command has not been issued, the process returns to step S26 and the normal operation (inclusion composition) is continued.

**[0102]** In a case where the discharge temperature Tho-D does not exceed 110°C in step S24, the process proceeds to step S28, and it is determined whether or not a unit stop command is present. In a case where the unit stop command has not been issued, the process returns to step S23 and the normal operation (separation composition) is continued. In a case where the unit stop command is issued, the process proceeds to step S29, and after the mixing operation is performed for a predetermined time (for example, 5 minutes), the refrigeration device 1 is stopped and the process is terminated. By performing the mixing operation before stopping the refrigeration device 1, the mixing ratio in the refrigerant to be flown to the refrigeration cycle at the next startup is returned to that of the refrigerant at the time of filling.

**[0103]** As described above, according to the present embodiment, the following effects are achieved.

**[0104]** By connecting each of the pipes 19, 21, and 23 to the gas-liquid separator 17 and controlling each of the on-off valve 20, 22, and 24, a gas refrigerant or a liquid refrigerant obtained by the separation by the gas-liquid separator 17 can be returned to the refrigeration cycle, so it is possible to arbitrarily change the mixing ratio of the low-boiling refrigerant (R32) and the high-boiling refrigerant (R1234ze(E)) with a simple configuration.

**[0105]** During the heating operation, in general, the outside air temperature is low, so the temperature of the evaporator 9 is low. When the temperature of the evaporator 9 becomes the predetermined value or less, for example, problems such as frosting of the evaporator occur. Therefore, in a case where the outside air temperature is lower than a predetermined value (for example, 10°C) or the evaporator outlet temperature is lower than a predetermined value (for example, -3°C), by opening the gas return pipe on-off valve 22, the ratio of R32 (low-boiling refrigerant) in the refrigeration cycle increases. In this case, by also opening the extraction pipe on-off valve 20, the refrigerant is led from the refrigeration cycle to the gas-liquid separator 17, and R32 is returned to the refrigeration cycle by the gas-liquid separator 17 performing gas-liquid separation, so the ratio increase of R32 in the refrigeration cycle is further promoted. By performing the separation operation that separates R1234ze(E) (high-boiling refrigerant) from the refrigerant in the refrigeration cycle to increase the ratio of R32, temperature sliding is reduced, and a saturation temperature at the evaporator 9 is increased, so frosting can be suppressed.

**[0106]** Since the extraction pipe on-off valve 20 is closed after a predetermined period (for example, one hour) has elapsed since the separation operation (see Fig. 2) is started, or after a suction superheat degree is lower than a predetermined value (for example, 2°C), extraction of a part of the refrigerant in the refrigeration cycle to the gas-liquid separator 17 is stopped (see Fig. 3). Thus, control to increase the ratio of R32 in the refrigerant flowing in the refrigeration cycle is stopped, and the normal operation (separation composition) can be performed with the composition of the mixed refrigerant after the separation operation.

**[0107]** During the heating operation, when the outside air temperature is a predetermined value (for example, 10°C) or more, there is no risk of problems such as frosting of the evaporator 9. Therefore, in a case where the outside air temperature is the predetermined value or higher, the gas return pipe on-off valve 22 is closed, and preferential returning of R32 to the refrigeration cycle is stopped. Then, by opening the liquid return pipe on-off valve 24, a large number of R1234ze(E) which is present in the liquid refrigerant in the gas-liquid separator 17 is returned to the refrigeration cycle. In this case, by also opening the extraction pipe on-off valve 20, the refrigerant is led from the refrigeration cycle to the gas-liquid separator 17, and R1234ze(E) of a liquid phase is preferentially returned to the refrigeration cycle by the gas-liquid separator 17 performing gas-liquid separation, so the ratio increase of R1234ze(E) in the refrigeration cycle is promoted.

**[0108]** As described above, by performing the mixing operation of mixing R1234ze(E) in the refrigerant in the refrigeration cycle, it is possible to increase the ratio of R1234ze(E) in the refrigerant, thereby returning the ratio to the mixing ratio at the time of refrigerant filling.

**[0109]** In addition, in a case where the temperature of the discharge gas discharged from the compressor 3 becomes the predetermined value (for example, 110°C) or higher, the discharge gas temperature can be lowered by returning the mixing ratio of refrigerant to the mixing ratio at the time of filling by the mixing operation.

**[0110]** During a cooling operation, by performing the separation operation (see Fig. 7) that opens the extraction pipe on-off valve 20 and the gas return pipe on-off valve 22, the ratio of R32 in the refrigerant in the refrigeration cycle increases. Thus, a highly efficient cooling operation can be realized.

**[0111]** Even in the cooling operation, in a case where the discharge gas temperature becomes a predetermined value (for example, 110°C) or higher, the mixing operation (see Fig. 9) that opens the extraction pipe on-off valve 20, closes the gas return pipe on-off valve 22, and opens the liquid return pipe on-off valve 24 is performed to increase the ratio of R1234ze(E) in the refrigerant, thereby returning the mixing ratio to the mixing ratio at the time of refrigerant filling. By doing this, it is possible to protect the equipment by avoiding the discharge gas temperature of the compressor 3 from being excessively high.

**[0112]** Although the refrigeration device capable of switching between heating and cooling has been described in the above-described embodiment, the present invention is not limited to thereto, and the same also applies to the refrigeration device that performs only the heating operation or the cooling operation.

Reference Signs List

**[0113]**

1 REFRIGERATION DEVICE
3 COMPRESSOR
5 CONDENSER
7 EXPANSION VALVE
9 EVAPORATOR
11 SUCTION PRESSURE SENSOR
13 DISCHARGE TEMPERATURE SENSOR
15 EVAPORATOR OUTLET TEMPERATURE SENSOR
17 GAS-LIQUID SEPARATOR
19 EXTRACTION PIPE
20 EXTRACTION PIPE ON-OFF VALVE
21 GAS RETURN PIPE
22 GAS RETURN PIPE ON-OFF VALVE
23 LIQUID RETURN PIPE
24 LIQUID RETURN PIPE ON-OFF VALVE
A EXTRACTION POSITION
B JOINING POSITION

## Claims

**1.** A refrigeration device comprising:

a compressor that compresses a non-azeotropic refrigerant mixture in which a low-boiling refrigerant and a high-boiling refrigerant with boiling points different from each other are mixed;
a condenser that condenses the non-azeotropic refrigerant mixture derived from the compressor;
an expansion valve that expands the non-azeotropic refrigerant mixture derived from the condenser;
an evaporator that evaporates the non-azeotropic refrigerant mixture derived from the expansion valve;
an extraction pipe that extracts a part of the non-azeotropic refrigerant mixture from between the condenser and the expansion valve;
an extraction pipe on-off valve provided in the extraction pipe;
a gas-liquid separator that is connected to the extraction pipe, and that accumulates the non-azeotropic refrigerant mixture and separates the mixture into a gas and a liquid;
a gas return pipe connecting the gas-phase portion inside the gas-liquid separator and a point between the expansion valve and an evaporator;
a gas return pipe on-off valve provided in the gas return pipe;
a liquid return pipe connecting the liquid-phase portion inside the gas-liquid separator and a point between the expansion valve and the evaporator;
a liquid return pipe on-off valve provided in the liquid return pipe; and
a control unit that controls the extraction pipe on-off valve, the gas return pipe on-off valve, and the liquid return pipe on-off valve.

2. The refrigeration device according to claim 1, wherein during a heating operation, in a case where an outside air temperature is less than a predetermined value or a temperature of the evaporator is less than a predetermined value, the control unit performs a separation operation that opens the extraction pipe on-off valve, opens the gas return pipe on-off valve, and returns the gas refrigerant separated by the gas-liquid separator from the gas return pipe to the evaporator side.

3. The refrigeration device according to claim 2, wherein after a predetermined period has elapsed since the separation operation is started, or after a degree of superheat of the non-azeotropic refrigerant mixture sucked in by the compressor is less than a predetermined value, the control unit closes the extraction pipe on-off valve.

4. The refrigeration device according to claim 2 or 3, wherein in a case where the outside air temperature is the predetermined value or more or in a case where a temperature of a discharge gas discharged from the compressor is the predetermined value or more, the control unit opens the extraction pipe on-off valve, closes the gas return pipe on-off valve, and opens the liquid return pipe on-off valve.

5. The refrigeration device according to claim 1, wherein during a cooling operation, the control unit opens the extraction pipe on-off valve and opens the gas return pipe on-off valve.

6. The refrigeration device according to claim 4, wherein in a case where a temperature of a discharge gas discharged from the compressor is the predetermined value or more, the control unit opens the extraction pipe on-off valve, closes the gas return pipe on-off valve, and opens the liquid return pipe on-off valve.

7. A control method of a refrigeration device including

a compressor that compresses a non-azeotropic refrigerant mixture in which a low-boiling refrigerant and a high-boiling refrigerant with boiling points different from each other are mixed;
a condenser that condenses the non-azeotropic refrigerant mixture derived from the compressor;
an expansion valve that expands the non-azeotropic refrigerant mixture derived from the condenser;
an evaporator that evaporates the non-azeotropic refrigerant mixture derived from the expansion valve;
an extraction pipe that extracts a part of the non-azeotropic refrigerant mixture from between the condenser and the expansion valve;
an extraction pipe on-off valve provided in the extraction pipe;
a gas-liquid separator that is connected to the extraction pipe, and that accumulates the non-azeotropic refrigerant mixture and separates the mixture into a gas and a liquid;
a gas return pipe connecting the gas-phase portion inside the gas-liquid separator and a point between the expansion valve and an evaporator;
a gas return pipe on-off valve provided in the gas return pipe;
a liquid return pipe connecting the liquid-phase portion inside the gas-liquid separator and a point between the expansion valve and the evaporator; and
a liquid return pipe on-off valve provided in the liquid return pipe,

the method comprising:
controlling opening and closing of the extraction pipe on-off valve, the gas return pipe on-off valve, and the liquid return pipe on-off valve.

**Amended claims under Art. 19.1 PCT**

1. (Amended) A refrigeration device comprising:

a compressor that compresses a non-azeotropic refrigerant mixture in which a low-boiling refrigerant and a high-boiling refrigerant with boiling points different from each other are mixed;
a condenser that condenses the non-azeotropic refrigerant mixture derived from the compressor;
an expansion valve that expands the non-azeotropic refrigerant mixture derived from the condenser;
an evaporator that evaporates the non-azeotropic refrigerant mixture derived from the expansion valve;
an extraction pipe that extracts a part of the non-azeotropic refrigerant mixture from between the condenser and the expansion valve;
an extraction pipe on-off valve provided in the extraction pipe;
a gas-liquid separator that is connected to the extraction pipe, and that accumulates the non-azeotropic refrigerant mixture and separates the mixture into a gas and a liquid;
a gas return pipe that connects the gas-phase portion inside the gas-liquid separator and a point between the expansion valve and the evaporator and returns a gas phase of the non-azeotropic refrigerant mixture separated by the gas-liquid separator to a point between the ex-

pansion valve and the evaporator as a gas refrigerant;
a gas return pipe on-off valve provided in the gas return pipe;
a liquid return pipe connecting the liquid-phase portion inside the gas-liquid separator and a point between the expansion valve and the evaporator;
a liquid return pipe on-off valve provided in the liquid return pipe; and
a control unit that controls the extraction pipe on-off valve, the gas return pipe on-off valve, and the liquid return pipe on-off valve.

**2.** The refrigeration device according to claim 1, wherein during a heating operation, in a case where an outside air temperature is less than a predetermined value or a temperature of the evaporator is less than a predetermined value, the control unit performs a separation operation that opens the extraction pipe on-off valve, opens the gas return pipe on-off valve, and returns the gas refrigerant separated by the gas-liquid separator from the gas return pipe to the evaporator side.

**3.** The refrigeration device according to claim 2, wherein after a predetermined period has elapsed since the separation operation is started, or after a degree of superheat of the non-azeotropic refrigerant mixture sucked in by the compressor is less than a predetermined value, the control unit closes the extraction pipe on-off valve.

**4.** The refrigeration device according to claim 2 or 3, wherein in a case where the outside air temperature is the predetermined value or more or in a case where a temperature of a discharge gas discharged from the compressor is the predetermined value or more, the control unit opens the extraction pipe on-off valve, closes the gas return pipe on-off valve, and opens the liquid return pipe on-off valve.

**5.** The refrigeration device according to claim 1, wherein during a cooling operation, the control unit opens the extraction pipe on-off valve and opens the gas return pipe on-off valve.

**6.** The refrigeration device according to claim 4, wherein in a case where a temperature of a discharge gas discharged from the compressor is the predetermined value or more, the control unit opens the extraction pipe on-off valve, closes the gas return pipe on-off valve, and opens the liquid return pipe on-off valve.

**7.** (Amended) A control method of a refrigeration device including

a compressor that compresses a non-azeotropic refrigerant mixture in which a low-boiling refrigerant and a high-boiling refrigerant with boiling points different from each other are mixed;
a condenser that condenses the non-azeotropic refrigerant mixture derived from the compressor;
an expansion valve that expands the non-azeotropic refrigerant mixture derived from the condenser;
an evaporator that evaporates the non-azeotropic refrigerant mixture derived from the expansion valve;
an extraction pipe that extracts a part of the non-azeotropic refrigerant mixture from between the condenser and the expansion valve;
an extraction pipe on-off valve provided in the extraction pipe;
a gas-liquid separator that is connected to the extraction pipe, and that accumulates the non-azeotropic refrigerant mixture and separates the mixture into a gas and a liquid;
a gas return pipe that connects the gas-phase portion inside the gas-liquid separator and a point between the expansion valve and the evaporator and returns a gas phase of the non-azeotropic refrigerant mixture separated by the gas-liquid separator to a point between the expansion valve and the evaporator as a gas refrigerant;
a gas return pipe on-off valve provided in the gas return pipe;
a liquid return pipe connecting the liquid-phase portion inside the gas-liquid separator and a point between the expansion valve and the evaporator; and
a liquid return pipe on-off valve provided in the liquid return pipe,

the method comprising:
controlling opening and closing of the extraction pipe on-off valve, the gas return pipe on-off valve, and the liquid return pipe on-off valve.

FIG. 1

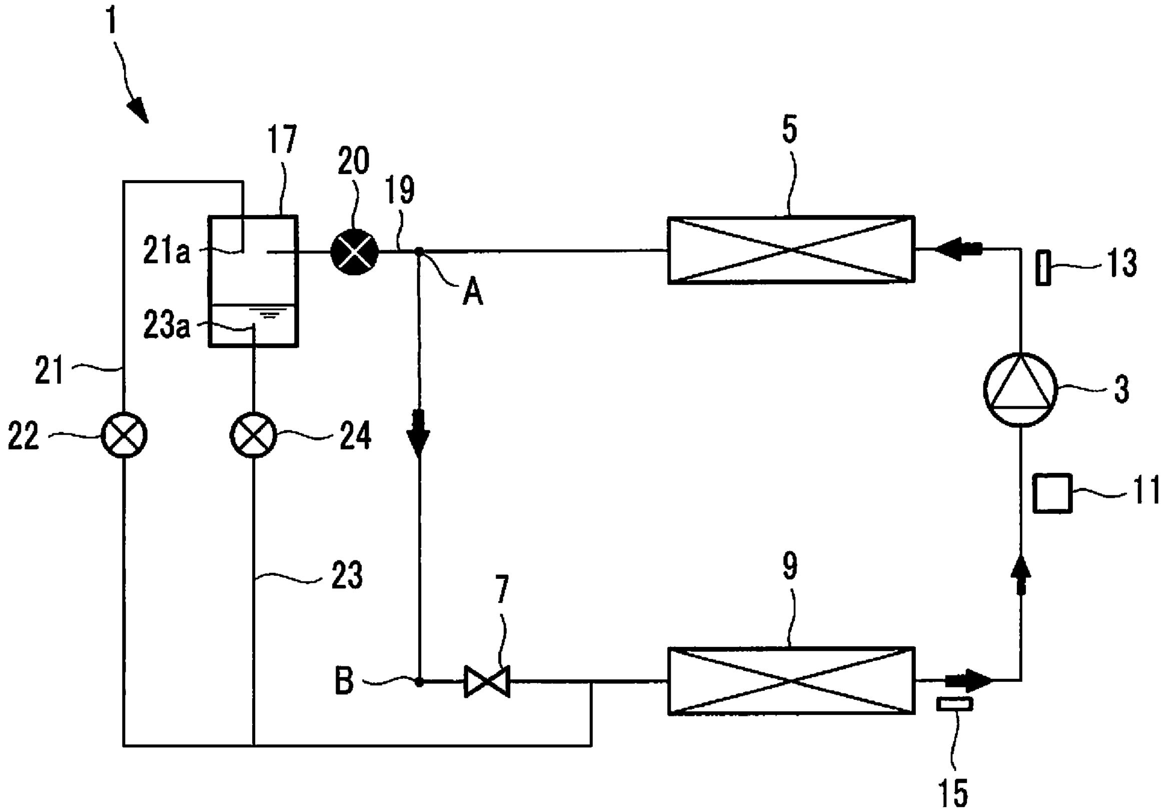

1
17
20
19
5
21a
A
13
23a
21
3
22
24
11
23
9
7
B
15

FIG. 2

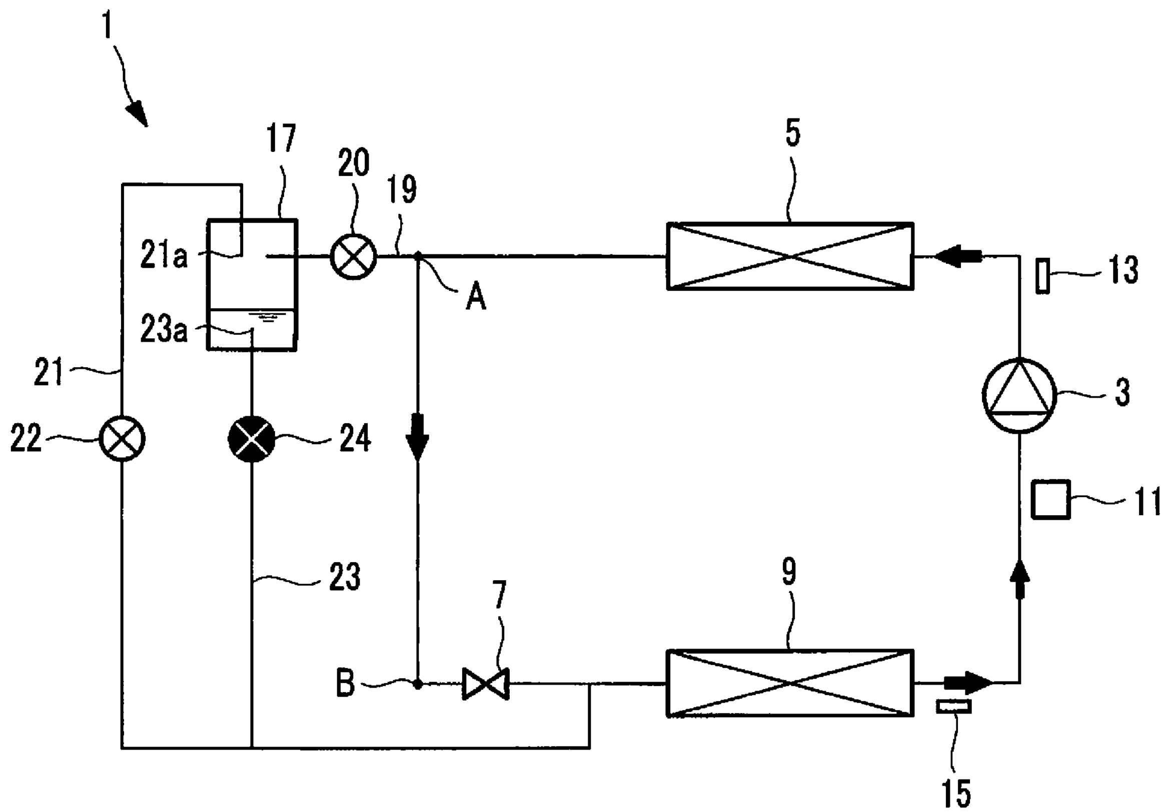

1
17
20
19
5
21a
A
13
23a
21
3
22
24
11
23
9
7
B
15

FIG. 3

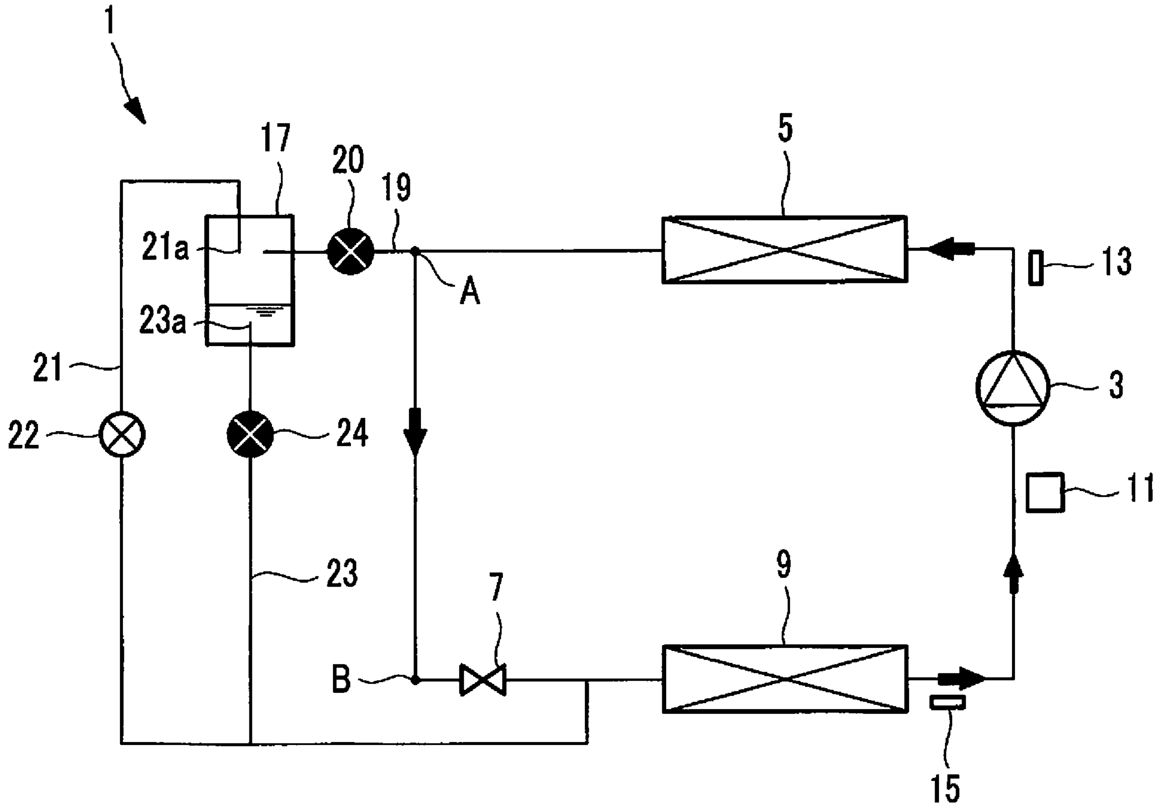

1
17
20
19
5
21a
A
13
23a
21
3
22
24
11
23
7
9
B
15

FIG. 4

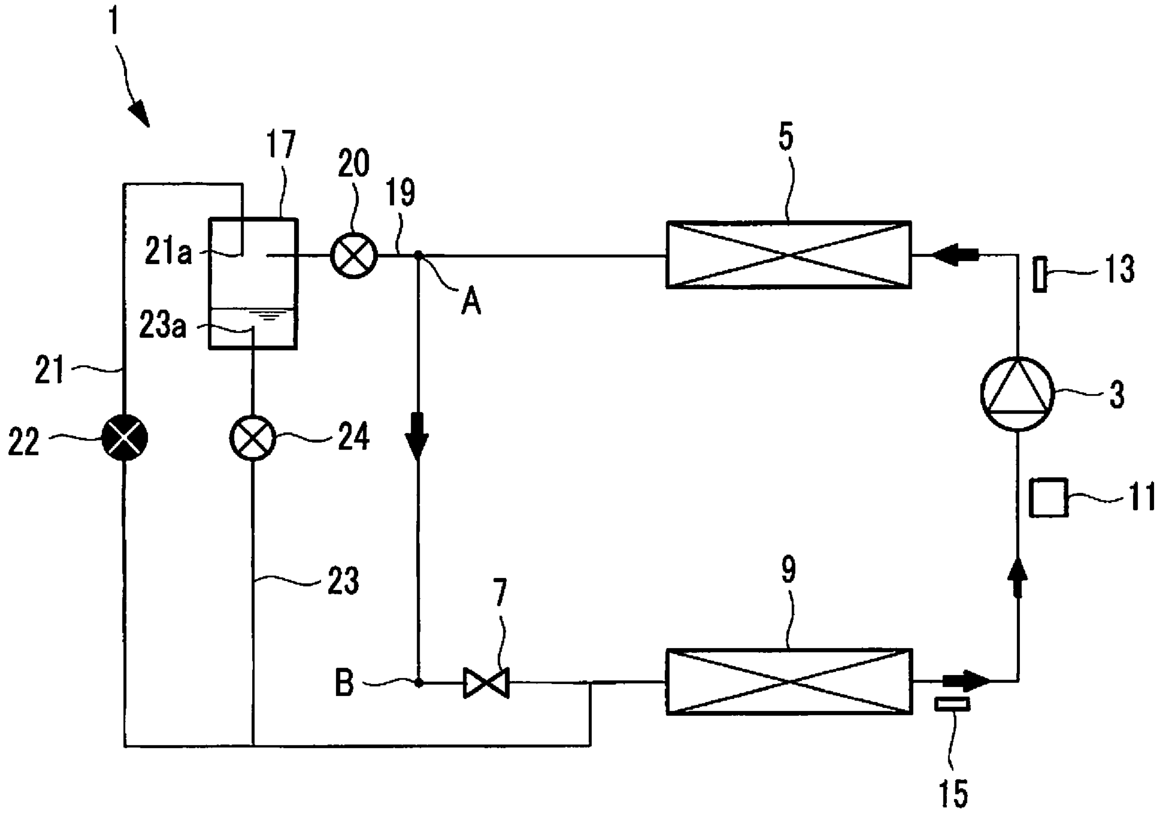
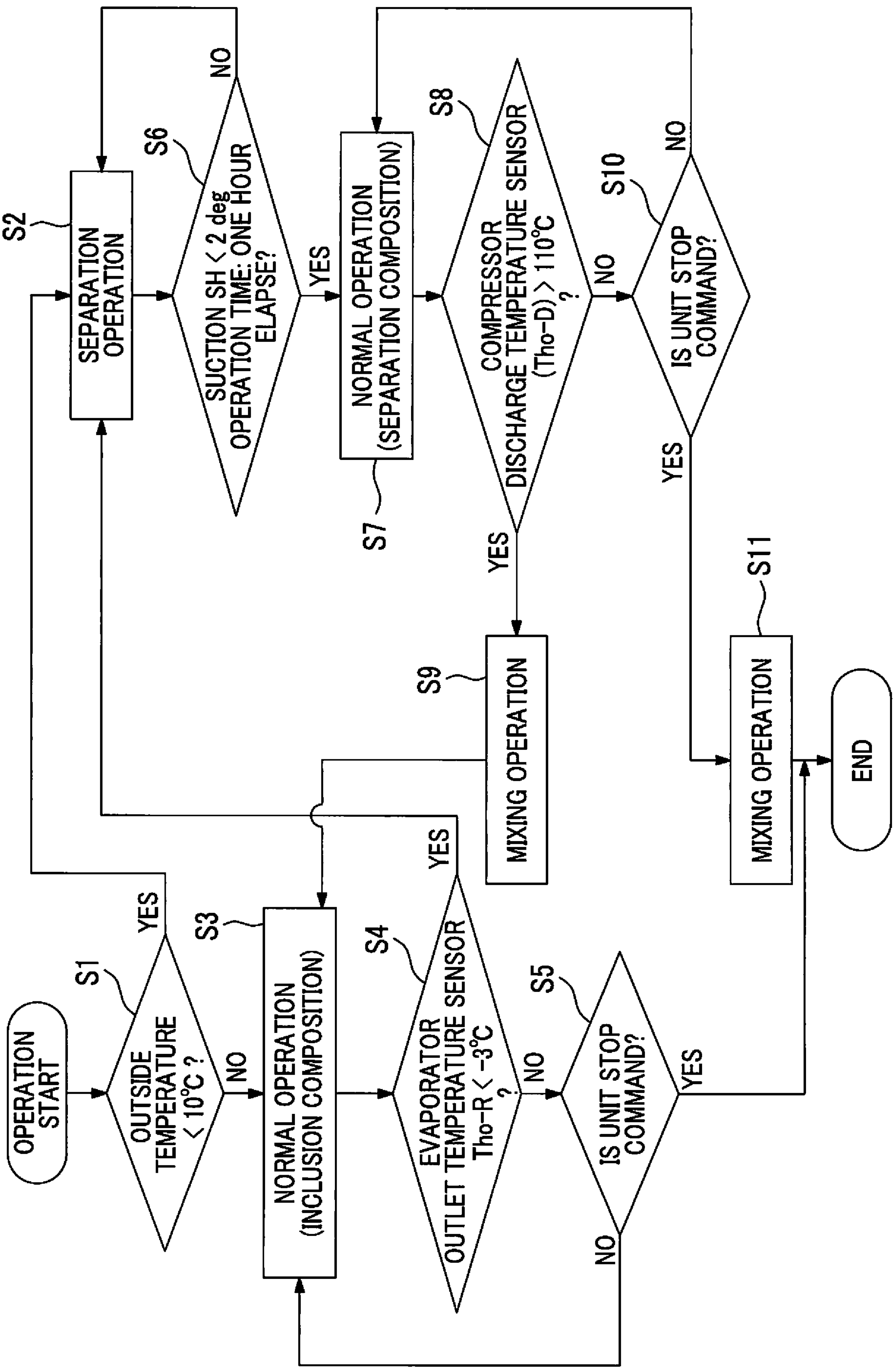

1
17
20
19
5
21a
A
13
23a
21
3
22
24
11
23
7
9
B
15

FIG. 5



OPERATION START
S1
OUTSIDE TEMPERATURE < 10°C ?
YES
NO
S2
SEPARATION OPERATION
S3
NORMAL OPERATION (INCLUSION COMPOSITION)
S4
EVAPORATOR OUTLET TEMPERATURE SENSOR Tho-R < -3°C ?
YES
NO
S5
IS UNIT STOP COMMAND?
YES
NO
S6
SUCTION SH < 2 deg OPERATION TIME: ONE HOUR ELAPSE?
YES
NO
S7
NORMAL OPERATION (SEPARATION COMPOSITION)
S8
COMPRESSOR DISCHARGE TEMPERATURE SENSOR (Tho-D) > 110°C ?
YES
NO
S9
MIXING OPERATION
S10
IS UNIT STOP COMMAND?
YES
NO
S11
MIXING OPERATION
END

FIG. 6

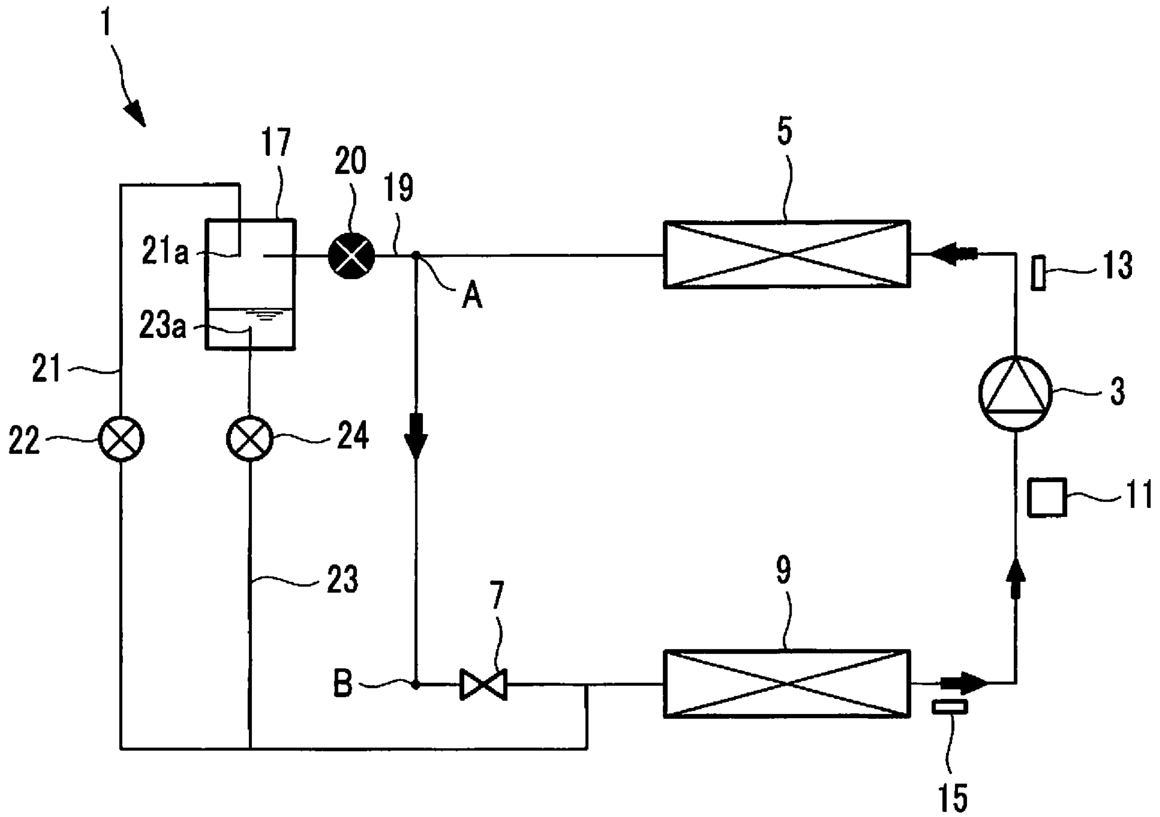

1
17
20
19
5
21a
A
13
23a
21
3
22
24
11
23
9
7
B
15

FIG. 7

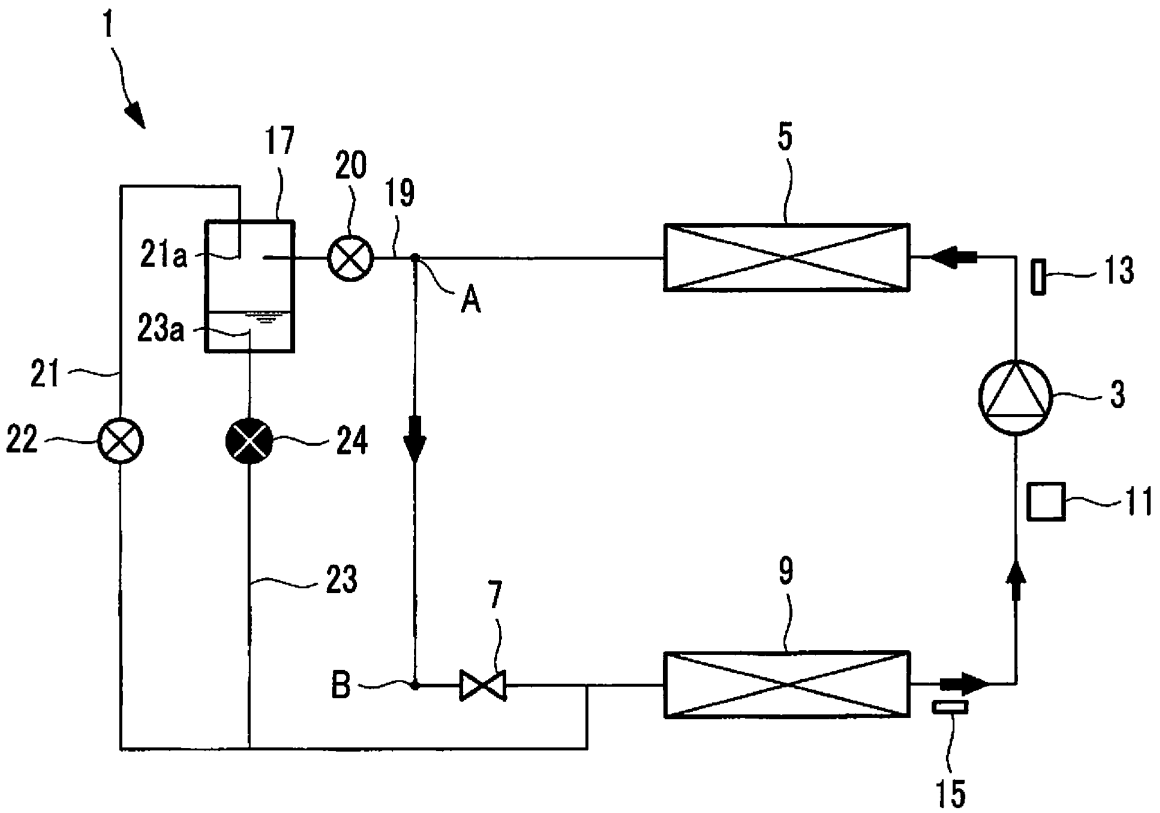

1
17
20
19
5
21a
A
13
23a
21
3
22
24
11
23
9
7
B
15

FIG. 8

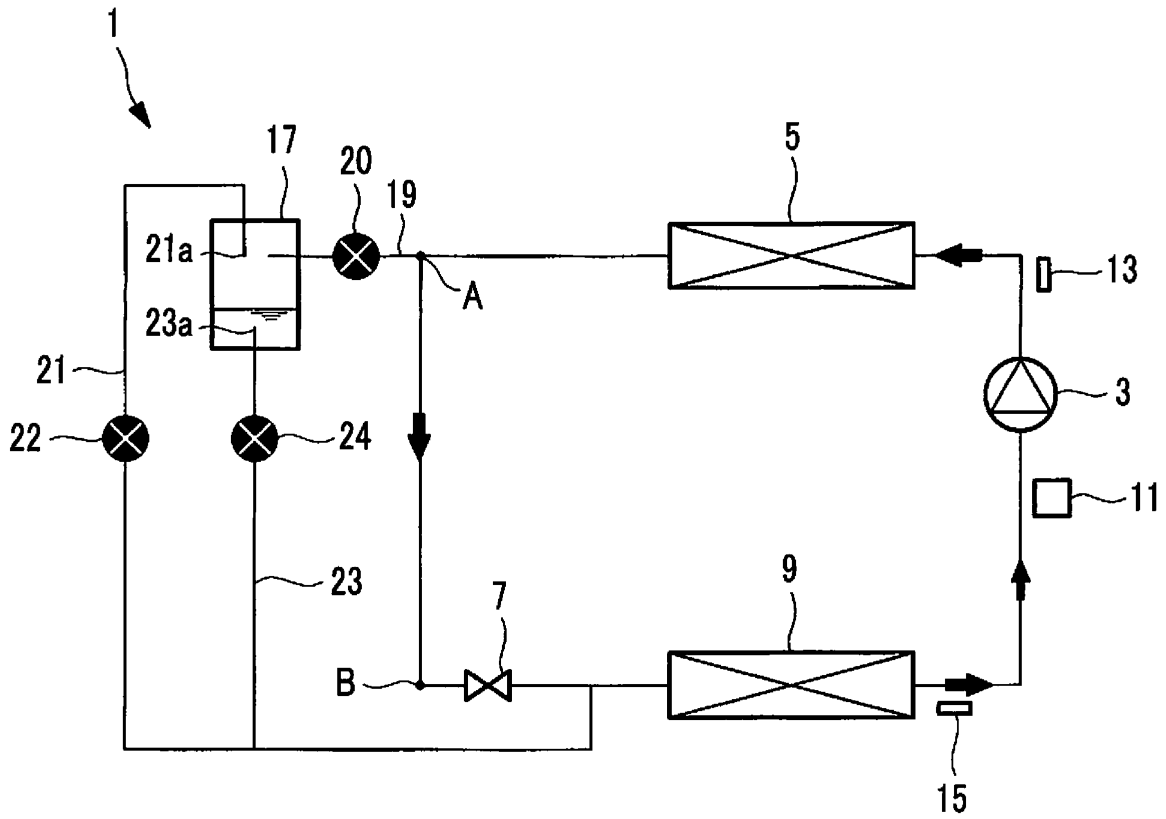

1
17
20
19
5
21a
13
A
23a
21
3
22
24
11
23
9
7
B
15

FIG. 9

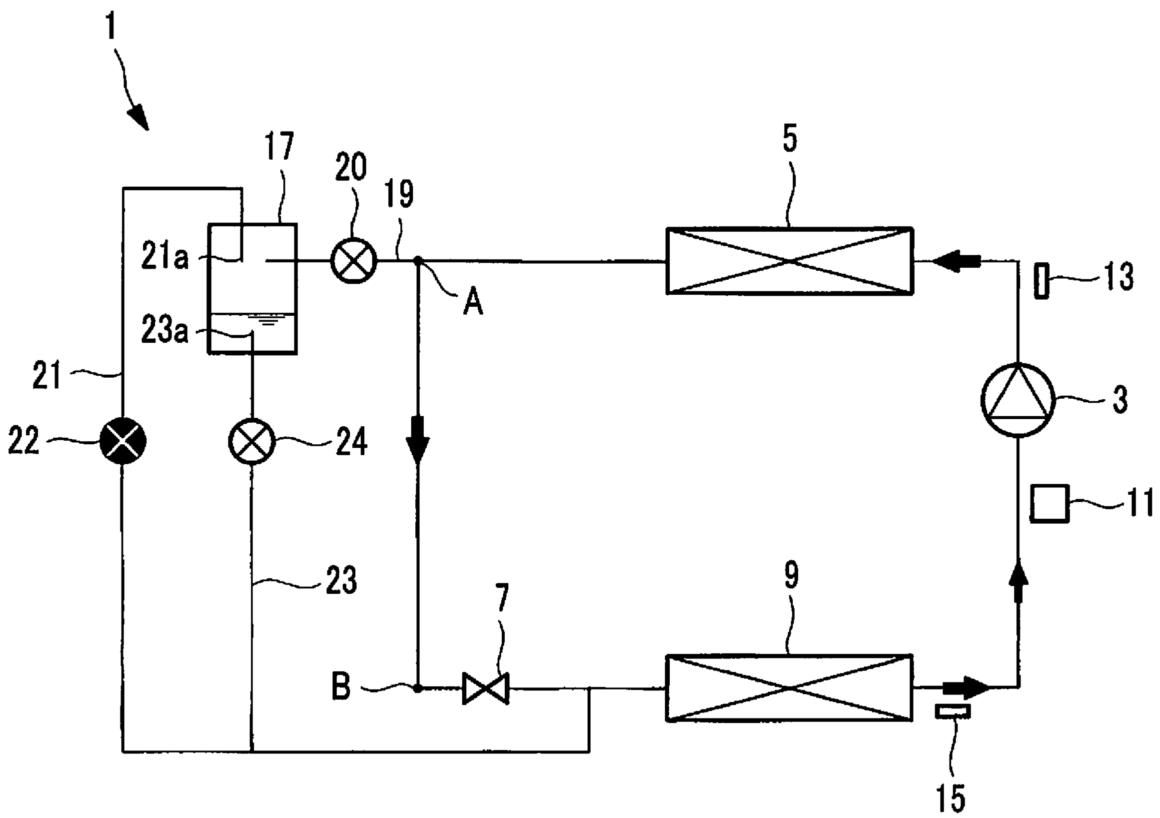

1
17
20
19
5
21a
13
A
23a
21
3
22
24
11
23
9
7
B
15

FIG. 10

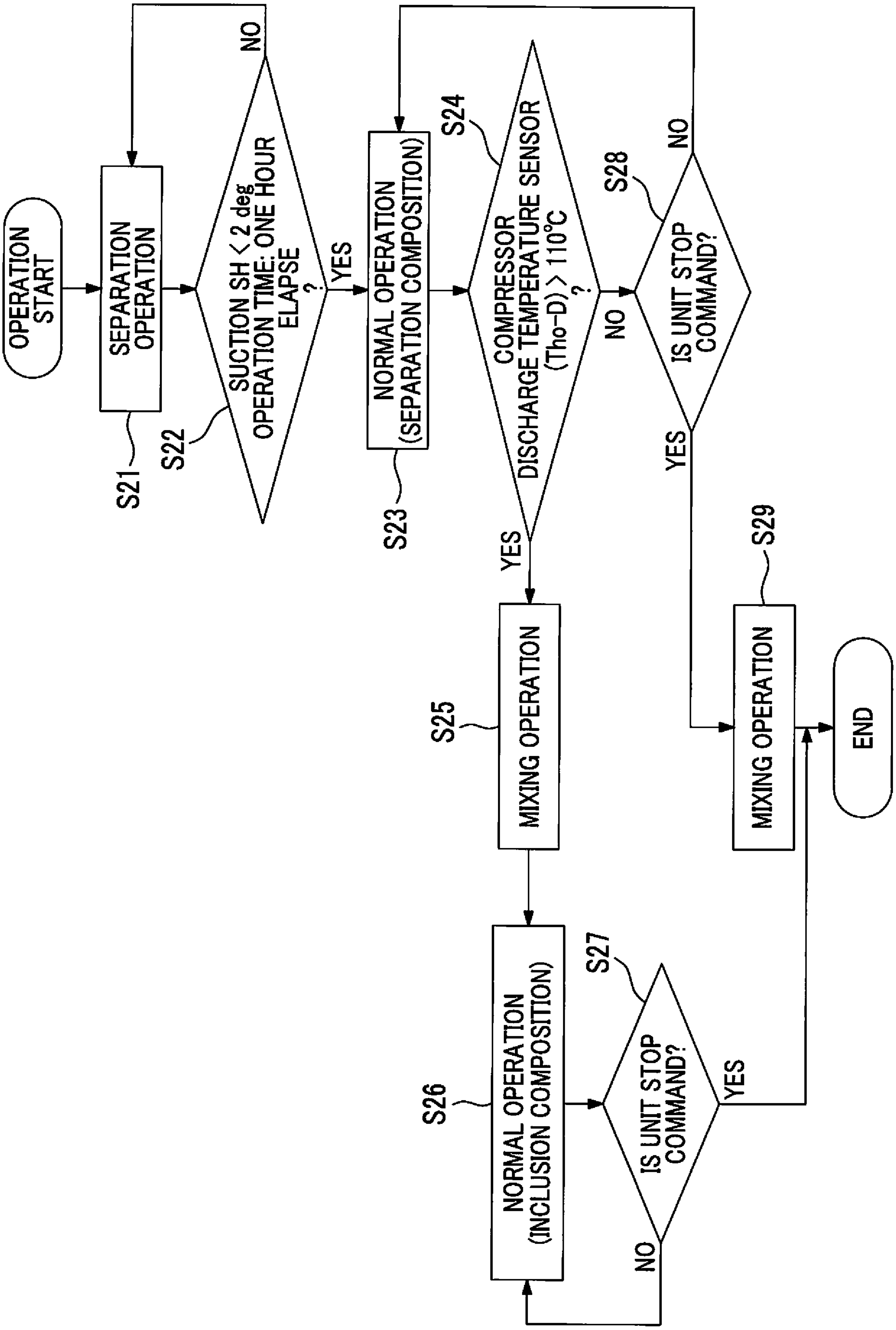

OPERATION START
SEPARATION OPERATION
S21
SUCTION SH < 2 deg
OPERATION TIME: ONE HOUR ELAPSE ?
S22
YES
NO
NORMAL OPERATION (SEPARATION COMPOSITION)
S23
COMPRESSOR DISCHARGE TEMPERATURE SENSOR (Tho-D) > 110°C ?
S24
YES
NO
IS UNIT STOP COMMAND?
S28
YES
NO
MIXING OPERATION
S25
NORMAL OPERATION (INCLUSION COMPOSITION)
S26
IS UNIT STOP COMMAND?
S27
YES
NO
MIXING OPERATION
S29
END

FIG. 11

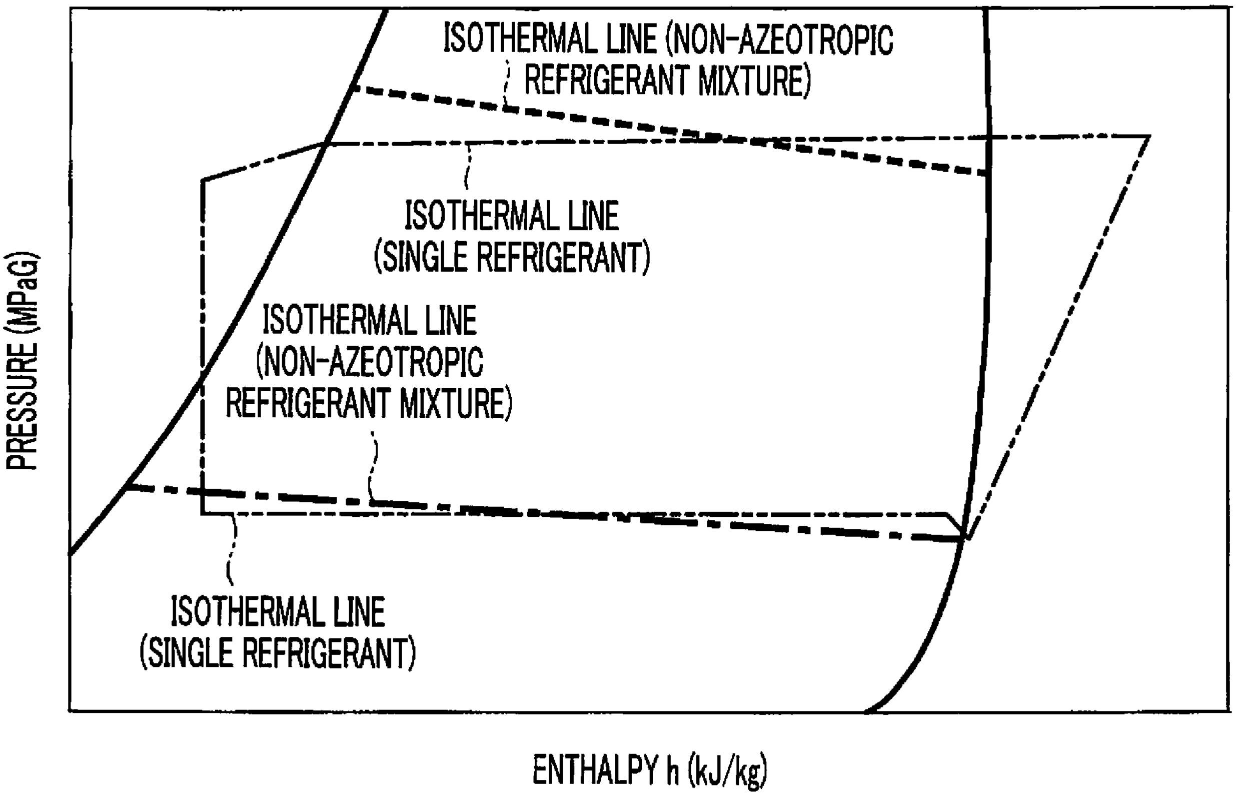

ISOTHERMAL LINE (NON-AZEOTROPIC REFRIGERANT MIXTURE)
ISOTHERMAL LINE (SINGLE REFRIGERANT)
ISOTHERMAL LINE (NON-AZEOTROPIC REFRIGERANT MIXTURE)
ISOTHERMAL LINE (SINGLE REFRIGERANT)
PRESSURE (MPaG)
ENTHALPY h (kJ/kg)

FIG. 12A

HIGH-PRESSURE SIDE: SATURATION TEMPERATURE 40°C

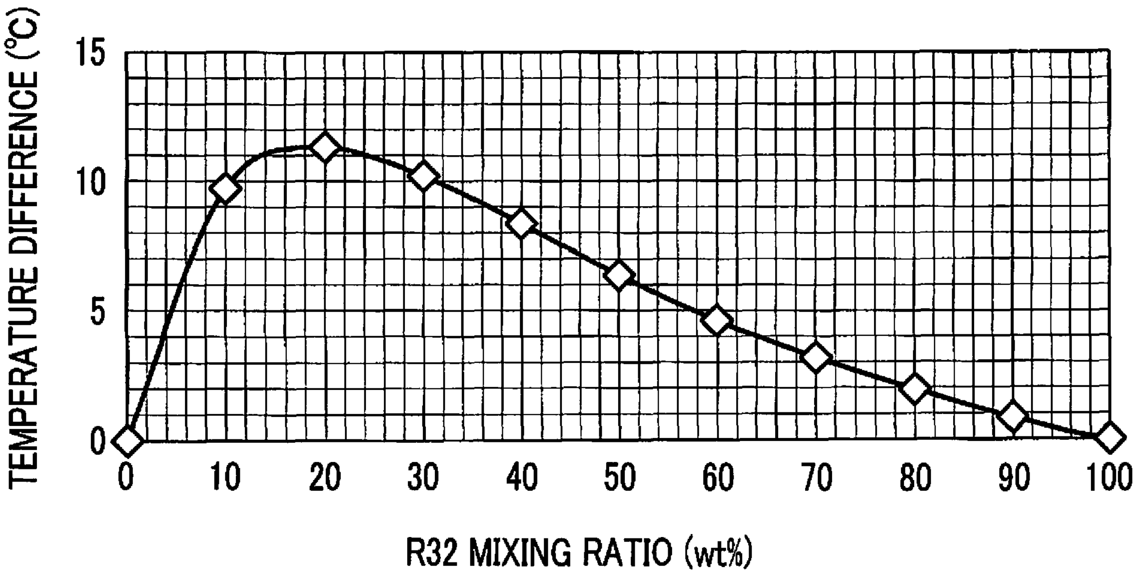



FIG. 12B

LOW-PRESSURE SIDE: SATURATION TEMPERATURE 10°C

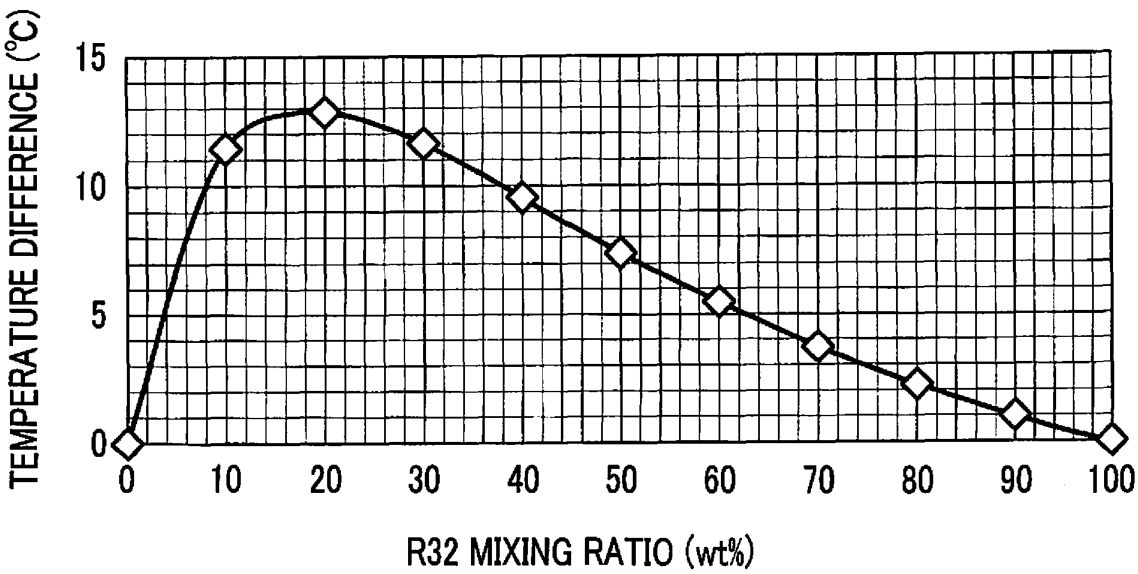
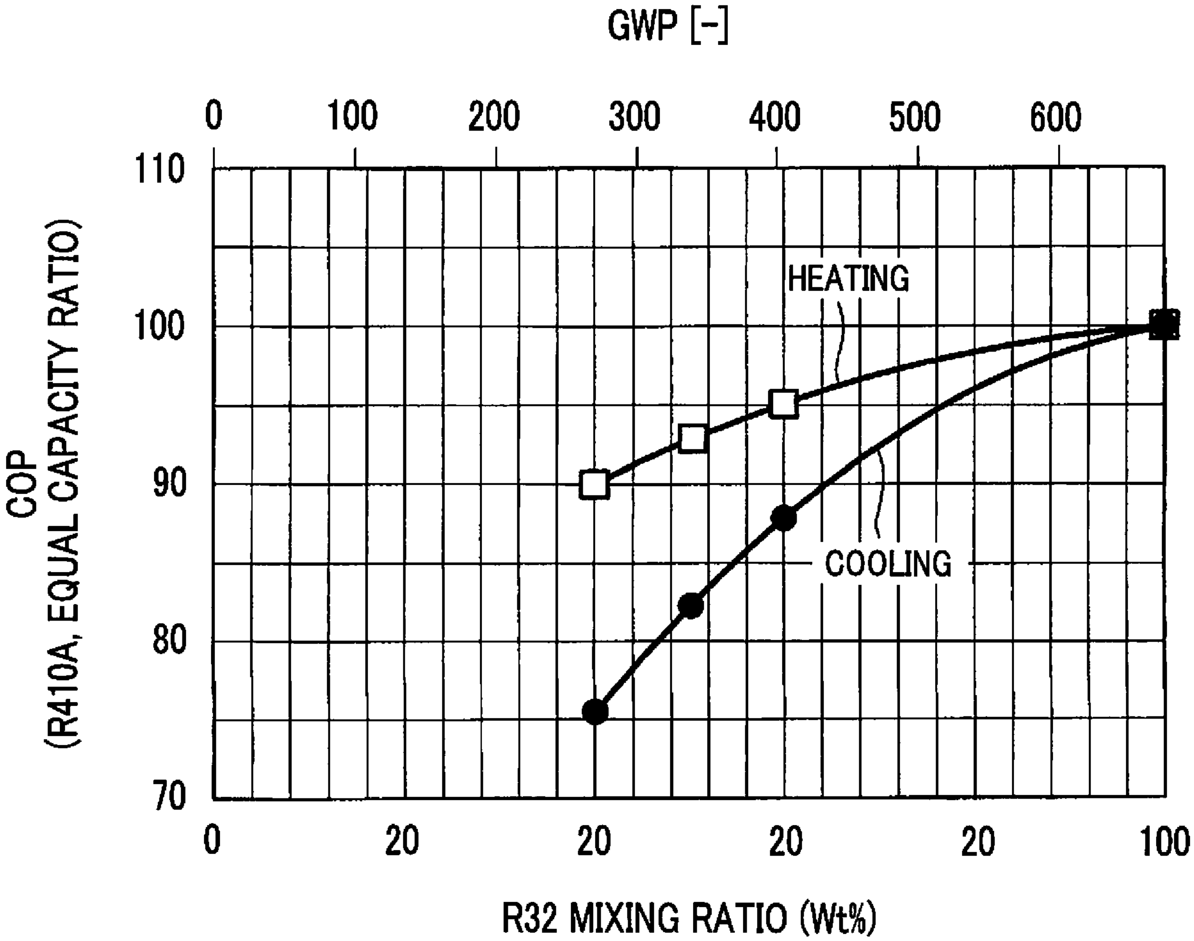


FIG. 13


GWP [-]
0
100
200
300
400
500
600
110
100
90
80
70
HEATING
COOLING
COP
(R410A, EQUAL CAPACITY RATIO)
0
20
20
20
20
100
R32 MIXING RATIO (Wt%)

**INTERNATIONAL SEARCH REPORT**

International application No. PCT/JP2017/028003

A. CLASSIFICATION OF SUBJECT MATTER
*F25B1/00*(2006.01)i, *F25B41/00*(2006.01)i, *F25B43/00*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B1/00, F25B41/00, F25B43/00

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

| | | | |
|---|---|---|---|
| Jitsuyo Shinan Koho | 1922-1996 | Jitsuyo Shinan Toroku Koho | 1996-2017 |
| Kokai Jitsuyo Shinan Koho | 1971-2017 | Toroku Jitsuyo Shinan Koho | 1994-2017 |

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. |
|---|---|---|
| X<br>A | JP 61-006567 A (Matsushita Electric Industrial Co., Ltd.), 13 January 1986 (13.01.1986), page 2, upper left column, line 13 to page 2, lower right column, line 15; drawings (Family: none) | 1,7<br>2-6 |
| A | JP 07-198215 A (Mitsubishi Heavy Industries, Ltd.), 01 August 1995 (01.08.1995), entire text; all drawings (Family: none) | 1-7 |
| A | JP 07-332814 A (Daikin Industries, Ltd.), 22 December 1995 (22.12.1995), entire text; all drawings (Family: none) | 1-7 |

☒ 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 |
|---|---|
| 23 October 2017 (23.10.17) | 31 October 2017 (31.10.17) |

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

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

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2017/028003

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | JP 63-129253 A (Mitsubishi Heavy Industries, Ltd.), 01 June 1988 (01.06.1988), entire text; all drawings (Family: none) | 1-7 |
| A | JP 56-087746 A (General Electric Co.), 16 July 1981 (16.07.1981), entire text; all drawings (Family: none) | 1-7 |
| A | JP 07-098161 A (Toshiba Corp.), 11 April 1995 (11.04.1995), entire text; all drawings (Family: none) | 1-7 |
| A | WO 2009/154149 A1 (Mitsubishi Electric Corp.), 23 December 2009 (23.12.2009), entire text; all drawings & US 2011/0079042 A1 & EP 2306121 A1 & EP 3081879 A2 & CN 102066852 A | 1-7 |
| A | JP 2013-204936 A (Fujitsu General Ltd.), 07 October 2013 (07.10.2013), entire text; all drawings (Family: none) | 1-7 |

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

## REFERENCES CITED IN THE DESCRIPTION



### Patent documents cited in the description

- JP 7098161 A **[0004]**