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(54) Title: REFRIGERATING CYCLE APPARATUS

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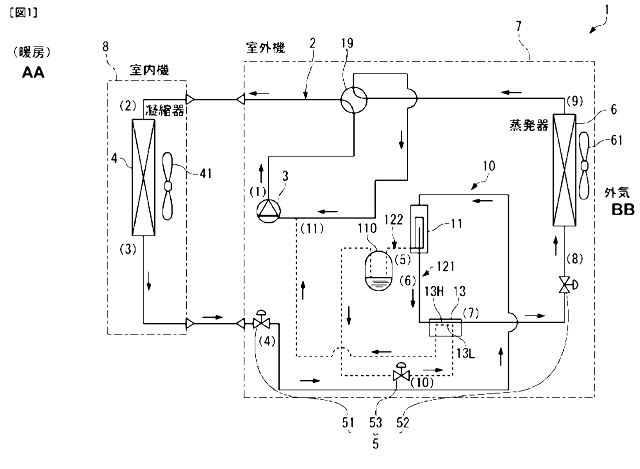


FIG. 1:
4 Condenser
6 Evaporator
7 Outdoor unit
8 Indoor unit
AA (Heating)
BB Outside air

(57) **Abstract**: Provided is an air conditioner 1 equipped with: a first depressurization unit 51 by which the pressure of non-azeotropic refrigerant mixture flowing out from a condenser **4** is reduced to a gas-liquid two-phase state; a gas-liquid separator 11 by which the non-azeotropic refrigerant mixture depressurized to a gas-liquid two-phase state is separated into a gas phase and a liquid phase; a first pathway 121 by which the gas-phase refrigerant in the gas-liquid separator 11 is supplied to an evaporator 6; a second pathway 122 by which the liquid-phase refrigerant in the gas-liquid separator 11 bypasses the evaporator 6; an intercooler 13 in which the refrigerant flowing through the first pathway 121 is condensed through heat exchange with the refrigerant flowing through the second pathway 122; a second depressurization unit 52 which reduces the pressure of the refrigerant flowing through the first pathway 121; and a third depressurization unit 53 which reduces the pressure of the refrigerant flowing through the second pathway 122.

(57) 要約: 空気調和機１は、凝縮器４から流れ出た非共沸混合冷媒の圧力を気液二相の状態にまで減少させる第１減圧部５１と、気液二相の状態にまで減圧された非共沸混合冷媒を気相および液相に分離する気液分離器１１と、気液分離器１１における気相の冷媒を、蒸発器６へと供給する第１経路１２１と、気液分離器１１における液相の冷媒を蒸発器６に対してバイパスする第２経路１２２と、第１経路１２１を流れる冷媒を、第２経路１２２を流れる冷媒との間で熱交換することで凝縮させるインタークーラー１３と、第１経路１２１を流れる冷媒の圧力を減少させる第２減圧部５２と、第２経路１２２を流れる冷媒の圧力を減少させる第３減圧部５３とを備える。

WO 2017/164333 A1

DESCRIPTION

Title of Invention

REFRIGERATING CYCLE APPARATUS

Technical Field

[0001]

The present invention relates to a refrigerating cycle apparatus which has a refrigerant circuit with a non-azeotropic refrigerant mixture sealed therein and can be used as an air conditioner capable of performing a heating operation or a water heater.

Background Art

[0002]

Currently, an HFC (hydrofluorocarbon) refrigerant which is typified by R410A is used in an apparatus using a refrigerating cycle, such as an air conditioner or a water heater. However, due to strengthened regulations for preventing global warming, development of a refrigerant having a low GWP (Global-warming potential) is underway. As refrigerant candidates with a lower GWP than R410A (GWP=2090), there are R32 (GWP=675), R1234yf (GWP=4), and R1234ze(E) (GWP=6), and in natural refrigerants, there are CO_2 (GWP=1) and the like.

[0003]

Here, R32 has good performance as a refrigerant but has a high GWP, compared to R1234yf or R1234ze(E). In the future, further reduction of the GWP is required.

Contrary to R32, R1234yf or R1234ze(E) is good in GWP but inferior in performance, compared to R32 or R410A.

[0004]

Although development of various refrigerants is underway from the viewpoint of the required GWP, performance, inflammability, or the like, it is difficult to satisfy these demands with a single refrigerant. For this reason, it has been proposed to mix and use two or more kinds of refrigerants at a predetermined ratio (for example, PTL 1).

In the air conditioner of PTL 1, R32 which is a first refrigerant and R134a (or R1234yf) which is a second refrigerant are used in a mixing ratio in which the first refrigerant is 80 wt% and the second refrigerant is 20 wt%.

[0005]

Here, in a case of mixing and using non-azeotropic refrigerants with different boiling points, such as R32 and R134a (or R1234yf), there is a temperature glide (a temperature gradient).

The temperature glide is the difference between a temperature at the start of condensation and a temperature at the end of condensation in terms of condensation.

Since the condensation start temperature and the condensation end temperature differ according to refrigerants, R134a having a high boiling point is liquefied first, and R32 having a low boiling point is liquefied thereafter, the temperature glide occurs. The temperature glide is, for example, about 6°C in the case of a two-kind refrigerant mixture, and extends to, for example, about 13°C in the case of a three-kind refrigerant mixture. It is difficult to establish an operation range of a refrigerating cycle in consideration of such a temperature glide.

[0006]

In PTL 1, the concentration of R32 sealed in a refrigerant circuit is high (80 wt%), and therefore, the temperature glide is small. In addition, a gas-liquid separator is connected to a position having a predetermined volume ratio, of a heat exchanger functioning as a condenser during a cooling operation, and an R134a-rich saturated vapor refrigerant separated from an R1234yf-rich liquid refrigerant is returned to the condenser and led to an evaporator via depressurization means, whereby the temperature glide is suppressed.

Citation List

Patent Literature

[0007]

[PTL 1] Japanese Unexamined Patent Application Publication No. 2012-236884

Any reference herein to a patent document or other matter which is given as prior art is not to be taken as an admission that that document or matter was known or that the information it contains was part of the common general knowledge as at the priority date of any of the claims.

Throughout the description and claims of the specification, the word "comprise" and variations of the word, such as "comprising" and "comprises", is not intended to exclude other additives, components, integers or steps.

Summary of Invention

Technical Problem

[0008]

R1234yf or R1234ze(E) with a low GWP has a greatly different boiling point from R32, and therefore, if the mixing ratio of R1234yf or R1234ze(E) is increased, the temperature glide becomes large.

If the temperature glide is large, frost formation occurs in an outdoor heat exchanger functioning as an evaporator during an operation for a heating use such as heating. The temperature of a refrigerant flowing through the evaporator does not become equal to or higher than the temperature of outside air, and therefore, for example, if the temperature of the outside air is 7°C and the temperature glide is 10°C, an evaporation start temperature becomes a temperature condition below a freezing point, and thus the frost formation on the evaporator inevitably occurs. For this reason, it is difficult to reduce the GWP in a refrigerating cycle apparatus for a heating use.

[0009]

The magnitude of the temperature glide varies according to the concentration of R32 in each of condensation and evaporation, as shown in Fig. 7. In the example shown in Fig. 7, the temperature glide is the largest when the concentration of R32 is about 20 wt% in both the condensation and the evaporation, and the temperature glide becomes smaller as the concentration of R32 increases therefrom.

In PTL 1, the refrigerant is branched in the middle of the condenser, so that gas-liquid separation is performed, and thereafter, the gas phase is returned to the condenser. However, the effect of suppressing the temperature glide by this manner is limited, and instead, an increase in the concentration of R32 sealed in the refrigerant circuit contributes to the suppression of the temperature glide. In PTL 1, the ratio of R134a or

R1234yf is merely in a range of 10 to 20%, and therefore, the GWP cannot be sufficiently lowered.

[0010]

Therefore, at least some embodiments of the present invention provide a refrigerating cycle apparatus in which it is possible to suppress a temperature glide to such an extent that the apparatus can be applied to a heating use while avoiding the occurrence of frost formation even if the mixing ratio of a refrigerant having a small GWP is increased in a non-azeotropic refrigerant mixture.

Solution to Problem

[0011]

According to the present invention, there is provided A refrigerating cycle apparatus having a refrigerant circuit in which a non-azeotropic refrigerant mixture is sealed and which is configured to include a compressor, a first heat exchanger, a depressurization unit, and a second heat exchanger, and capable of heating a heat load, the apparatus comprising: a first depressurization unit which reduces pressure of the non-azeotropic refrigerant mixture flowing out from a condenser which is one of the first heat exchanger and the second heat exchanger, to a gas-liquid two-phase state; a gas-liquid separator which separates the non-azeotropic refrigerant mixture depressurized to the gas-liquid two-phase state into a gas phase and a liquid phase; a first pathway for supplying a gas-phase refrigerant in the gas-liquid separator to an evaporator which is the other of the first heat exchanger and the second heat exchanger; a second pathway for making a liquid-phase refrigerant in the gas-liquid separator bypass the evaporator without being supplied to the evaporator; an intercooler which condensates the refrigerant flowing through the first pathway through heat exchange with the refrigerant flowing through the second pathway; a second depressurization unit which reduces pressure of the refrigerant flowing through the first pathway; and a third depressurization unit which reduces pressure of the refrigerant flowing through the second pathway, wherein the second pathway includes a liquid receiver which receives the liquid phase from the gas-liquid separator, and a valve capable of opening and closing a flow path between the gas-liquid separator and the liquid receiver or adjusting a flow rate of the refrigerant flowing through the flow path, the third depressurization unit is located at a downstream side of the liquid receiver, and a terminal end of the second pathway is configured to discharge to the refrigerant circuit, a refrigerant evaporated using the third depressurization unit in the second pathway, so that the evaporated refrigerant is suctioned into the compressor.

[0012]

In the refrigerating cycle apparatus according to the present invention, it is preferable that the second pathway is provided with a liquid receiver which receives the liquid phase from the gas-liquid separator, and a valve capable of opening and closing a flow path between the gas-liquid separator and the liquid receiver or adjusting a flow rate of the refrigerant flowing through the flow path.

[0013]

In the refrigerating cycle apparatus according to the present invention, it is preferable that the non-azeotropic refrigerant mixture includes R32 as a first refrigerant, and at least one of R1234yf and R1234ze(E) as a second refrigerant, and a concentration of the first refrigerant in the entirety of the non-azeotropic refrigerant mixture sealed in the refrigerant circuit is in a range of 30 to 70 wt% (30 wt% or more and 70 wt% or less).

[0014]

In the refrigerating cycle apparatus according to the present invention, it is preferable that the non-azeotropic refrigerant mixture includes CO_2 as a third refrigerant, and a concentration of the third refrigerant in the entirety of the non-azeotropic refrigerant mixture sealed in the refrigerant circuit is 5 wt% or less.

[0015]

In the refrigerating cycle apparatus according to the present invention, it is preferable that heating and cooling of the heat load are possible, the apparatus further includes a switching valve which switches a direction of a flow of the refrigerant in the refrigerant circuit, a bridge circuit which switches a direction of a flow of the refrigerant in the refrigerant circuit, and a merging pathway for merging the liquid phase in the gas-liquid separator with the gas phase in the gas-liquid separator, and the third depressurization unit is configured to include a pathway for merging the liquid phase in the gas-liquid separator with the refrigerant flowing out from the evaporator.

Advantageous Effects of Invention

[0016]

According to the present invention, by performing gas-liquid separation on the non-azeotropic refrigerant mixture and making the refrigerant which includes a lot of refrigerants (for example, R1234yf) having a high boiling point bypass the evaporator without being supplied to the evaporator, it is possible to greatly increase the mixing ratio of the refrigerant (for example, R32) having a low boiling point in the refrigerant mixture flowing through the refrigerant circuit, with respect to the composition of the refrigerant mixture sealed in the refrigerant circuit. Accordingly, the temperature glide can be sufficiently suppressed enough to avoid the frost formation.

According to the present invention, by increasing the mixing ratio of the refrigerant having a high boiling point and a low GWP in the refrigerant mixture sealed in the refrigerant circuit, it is possible to reduce the GWP.

Brief Description of Drawings

[0017]

Fig. 1 is a diagram showing a configuration of an air conditioner (a refrigerating cycle apparatus) according to a first embodiment.

Fig. 2 is a p-h line diagram of a refrigerating cycle according to the first embodiment.

Fig. 3 is a diagram showing a configuration of an air conditioner according to a modification example of the first embodiment.

Fig. 4 is a diagram showing a configuration of an air conditioner according to a second embodiment (a heating operation).

Fig. 5 is a diagram showing the configuration of the air conditioner according to the second embodiment (a cooling operation).

Fig. 6 is a diagram showing the configuration of the air conditioner according to the second embodiment (a cooling operation: during gas-liquid separation).

Fig. 7 is a view showing a temperature glide in condensation (an upper stage) and a temperature glide in evaporation (a lower stage).

Description of Embodiments

[0018]

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

[First Embodiment]

An air conditioner 1 of a first embodiment shown in Fig. 1 is a refrigerating cycle apparatus capable of performing heating of indoor air (a heat load), that is, heating, by using outside air as a heat source.

Hereinafter, the air conditioner 1 will be described. However, the configuration which is described below can also be likewise applied to a refrigerating cycle apparatus such as a water heater which heats water as a heat load.

[0019]

The air conditioner 1 has a refrigerant circuit 2 which includes a compressor 3, a first heat exchanger 4, a depressurization unit 5 (51 to 53), and a second heat exchanger 6. The respective elements which are included in the refrigerant circuit 2 are connected by piping.

A non-azeotropic refrigerant mixture is sealed in the refrigerant circuit 2.

The compressor 3, the depressurization unit 5, and the second heat exchanger 6 configure an outdoor unit 7. The second heat exchanger 6 performs heat exchange between outside air which is blown by a fan 61 and a refrigerant.

The first heat exchanger 4 configures an indoor unit 8. The first heat exchanger 4 performs heat exchange between indoor air which is blown by a fan 41 and the refrigerant.

The non-azeotropic refrigerant mixture is sealed in the refrigerant circuit 2. The non-azeotropic refrigerant mixture circulates through the refrigerant circuit 2 in the direction indicated by an arrow in Fig. 1.

[0020]

The air conditioner 1 of this embodiment is not used for cooling but is used for only heating, and therefore, a four-way valve 19 (a switching valve) for switching the direction of the flow of the refrigerant can be omitted. Regardless of necessity of switching the direction of the flow of the refrigerant, the refrigerant circuit 2 is configured to include the four-way valve 19 in order to allow the outdoor unit to be used in common.

The air conditioner 1 performs a heating operation, and therefore, in this embodiment, the first heat exchanger 4 is referred to as a condenser 4 and the second heat exchanger 6 is referred to as an evaporator 6.

[0021]

The non-azeotropic refrigerant mixture is a mixture of refrigerants having different boiling points, and the non-azeotropic refrigerant mixture of this embodiment includes R32 as a first refrigerant, R1234yf as a second refrigerant having a higher boiling point than R32, and CO_2 as a third refrigerant. R32 is an HFC (hydrofluorocarbon) refrigerant, and R1234yf is an HFO (Hydro Fluoro Olefin) refrigerant.

[0022]

The mixing ratio, that is, the concentration of R32 in the entirety of the non-azeotropic refrigerant mixture sealed in the refrigerant circuit 2 is in a range of 30 to 70 wt% in a concentration by percent by weight.

That is, by sufficiently increasing the mixing ratio of the second refrigerant (R1234yf) having a small GWP while adopting R32 which is excellent in condensation pressure, volume capacity, and refrigerating effect, the

GWP equal to or less than a predetermined value is secured. As the composition of the refrigerant mixture which is sealed in the refrigerant circuit 2, it is preferable that the mixing ratio of the second refrigerant is larger than the mixing ratio of the first refrigerant.

Further, the mixing ratio, that is, the concentration of CO_2 in the entirety of the non-azeotropic refrigerant mixture sealed in the refrigerant circuit 2 is 5 wt% or less in a concentration by percent by weight. By adding CO_2 which is excellent in volume capacity, it becomes possible to downsize the compressor 3.

[0023]

As the second refrigerant, R1234ze(E) can also be used instead of R1234yf. In that case, "R1234yf" in the following description may be replaced with "R1234ze(E)".

Further, as the second refrigerant, both of R1234yf and R1234ze(E) can also be used.

[0024]

While the air conditioner 1 is in the heating operation, the mixing ratio of R32 in the non-azeotropic refrigerant mixture (hereinafter referred to as a refrigerant mixture) flowing through the evaporator 6 is higher than the mixing ratio (for example, 40 wt%) of R32 in the entire refrigerant mixture sealed in the refrigerant circuit 2. The mixing ratio of R32 in the refrigerant mixture flowing through the evaporator 6 is approximately 50 wt% (weight concentration).

As described above, in order to realize a mixing ratio during an operation, which is different from the sealed mixing ratio, the air conditioner 1 is provided with the depressurization units 51 to 53, a gas-liquid separator 11, a first pathway 121 for supplying a gas phase refrigerant in the gas-liquid separator 11 to the evaporator 6, a second pathway 122 for making a liquid phase refrigerant in the gas-liquid separator 11 bypass the evaporator 6 without being supplied to the evaporator 6, and an intercooler 13 (an inter-refrigerant heat exchanger). Then, a gas-liquid two-phase refrigerant mixture flowing out from the condenser 4 and depressurized by the depressurization unit 51 (a first depressurization unit) is subjected to gas-liquid separation by the gas-liquid separator 11 and the gas phase separated from the liquid phase is condensed by heat exchange with the liquid phase by the intercooler 13 and then supplied to the evaporator 6, whereby a R32-rich refrigerant separated from a R1234yf-rich liquid refrigerant flows to the evaporator 6.

[0025]

That is, in the air conditioner 1 of this embodiment, the mixing ratio (apparent mixing ratio) of R32 in the refrigerant mixture flowing through the refrigerant circuit 2 during an operation is sufficiently increased by a circuit 10 which includes the gas-liquid separator 11 and the intercooler 13, while securing the GWP equal to or less than a predetermined value by decreasing the mixing ratio of R32 in the entirety of the refrigerant mixture sealed in the refrigerant circuit 2 to increase the mixing ratio of R1234yf.

As shown in Fig. 7 showing the relationship between a temperature glide and the mixing ratio (concentration) of R32, in an area exceeding 20 wt% which is a peak of the temperature glide, the higher the mixing ratio (concentration) of R32 is, the smaller the temperature glide is.

[0026]

In this embodiment, the temperature glide in evaporation is suppressed to a range of about 7.0°C to 7.5°C by sufficiently increasing the apparent mixing ratio of R32. Accordingly, the occurrence of frost formation on the evaporator 6 can be avoided. The mixing ratio during an operation of R32 which is excellent in condensation pressure, volume capacity, and refrigerating effect is high compared to R1234yf, whereby the performance of the air conditioner 1 is also improved, which contributes to downsizing as well.

[0027]

Hereinafter, the circuit 10 which includes the gas-liquid separator 11 and the intercooler 13 will be described with reference to Figs. 1 and 2. In Figs. 1 and 2, corresponding positions are denoted by the same numbers ((1), (2), and the like).

The refrigerant mixture which is used in this embodiment also includes a small amount of CO_2. However, basically, it does not affect the operation of the circuit 10 which is described below, and therefore, description regarding to CO_2 is omitted. CO_2 has a lower boiling point than R32 and R1234yf, and therefore, it is basically in a gas phase state during an operation which is described below.

The refrigerant mixture which is used in this embodiment may be composed of only R32 and R1234yf without including CO_2.

[0028]

The circuit 10 is configured to include the depressurization units 51 to 53 configuring the depressurization unit 5, the gas-liquid separator 11, a liquid receiver 110, and the intercooler 13.

The depressurization units 51 to 53, the gas-liquid separator 11, the liquid receiver 110, and the intercooler 13 configure the outdoor unit 7.

[0029]

All the depressurization units 51 to 53 throttle and expand the refrigerant mixture. The throttle amount in each of the depressurization units 51 to 53 is adjustable.

[0030]

The depressurization unit 51 is located between the condenser 4 and the gas-liquid separator 11. The depressurization unit 51 depressurizes the refrigerant flowing out from an outlet (3) of the condenser 4 to an intermediate pressure p1 (refer to Fig. 2) in which a gas-liquid two-phase state is maintained (4). The pressure (the intermediate pressure p1) of the refrigerant which is supplied to the gas-liquid separator 11 is controlled according to the throttle amount of the depressurization unit 51. The degree of dryness in the gas-liquid separator 11 is determined according to the intermediate pressure p1.

[0031]

The gas-liquid separator 11 separates the gas-liquid two-phase refrigerant having passed through the depressurization unit 51 into the gas phase and the liquid phase.

The refrigerant mixture depressurized to the intermediate pressure p1 of the gas-liquid two-phase by the depressurization unit 51 flows into the gas-liquid separator 11 in a state where R1234yf having a high boiling point is further liquefied than R32.

The refrigerant which flows into the gas-liquid separator 11 is subjected to gas-liquid separation according to the degree of dryness corresponding to the intermediate pressure p1 in the gas-liquid separator 11. The saturated liquid (5) which is stored in the gas-liquid separator 11 includes R1234yf more than R32. The liquid phase in the gas-liquid separator 11 is supplied to a low-temperature pathway 13L of the intercooler 13 through the liquid receiver 110.

In the gas-liquid separator 11, the liquid-phase refrigerant bypasses the evaporator 6 through the second pathway 122 (a bypass pathway). In Figs. 1 and 2, the second pathway 122 is indicated by a broken line.

[0032]

The liquid receiver 110 receives the liquid refrigerant from the gas-liquid separator 11 and stores the liquid refrigerant therein. The liquid refrigerant exceeding a predetermined liquid level in the liquid receiver 110 flows into the low-temperature pathway 13L of the intercooler 13. In order to store the R1234yf-rich liquid refrigerant and increase the mixing ratio of R32 in the refrigerant mixture flowing through the evaporator 6, it is preferable that the liquid receiver 110 is provided in the second pathway 122.

[0033]

The gas-liquid separation situation in the gas-liquid separator 11 is determined according to the degree of dryness corresponding to the intermediate pressure p1. In this embodiment, the mixing ratio of R32 in the refrigerant mixture flowing through the evaporator 6 is made higher than the actual mixing ratio (the mixing ratio of R32 in the entirety of the refrigerant mixture sealed in the refrigerant circuit 2) by making the R1234yf-rich liquid refrigerant bypass the evaporator 6 without being supplied to the evaporator 6, and making only the R32-rich refrigerant separated from the liquid phase flow into the evaporator 6.

Here, the mixing ratio of R1234yf in the entirety of the refrigerant mixture sealed in the refrigerant circuit 2 is high, and therefore, the mixing ratio of R32 in the refrigerant mixture flowing into the evaporator 6 is greatly increased by separating the liquid refrigerant which mainly includes R1234yf and making the liquid refrigerant bypass the evaporator 6, and the temperature glide can be reduced correspondingly.

In this embodiment, the intermediate pressure p1 which determines the degree of dryness of the gas-liquid separator 11 is appropriately controlled by the depressurization unit 51, whereby it is possible to increase the apparent mixing ratio of R32 and sufficiently reduce the temperature glide.

[0034]

As the gas-liquid separator 11, a known gas-liquid separator of an appropriate type can be used. For example, a gravity separation type in which a gas phase and a liquid phase are separated from each other due to a difference in specific gravity (a density difference) by setting a refrigerant to be in a stationary state in a tank, a type of centrifugally separating a gas phase and a liquid phase by giving a swirling flow to a refrigerant, a surface tension type of holding a liquid by a bellows portion provided in an inner peripheral portion of a flow path, or the like can be adopted.

From the viewpoint of downsizing the outdoor unit 7, the centrifugal separation type and the surface tension type are preferable.

[0035]

The gas phase (6) separated from the liquid phase by the gas-liquid separator 11 passes through a high-temperature pathway 13H of the intercooler 13 and is supplied to the evaporator 6.

The intercooler 13 is provided with the high-temperature pathway 13H through which the gas phase flows, and the low-temperature pathway 13L through which the liquid phase flows. The high-temperature pathway 13H corresponds to a part of the first pathway 121 for supplying the gas phase in the gas-liquid separator 11 to the evaporator 6. The low-temperature pathway 13L corresponds to a part of the second pathway 122 for making the liquid phase in the gas-liquid separator 11 bypass the evaporator 6 without being supplied to the evaporator 6.

The intercooler 13 performs heat exchange between the gas phase flowing through the high-temperature pathway 13H and the liquid phase flowing through the low-temperature pathway 13L. By the heat exchange, the heat of the gas phase in the high-temperature pathway 13H is dissipated to the liquid phase in the low-temperature pathway 13L, and thus the gas phase in the high-temperature pathway 13H is condensed. A refrigerating cycle in which energy change is obtained by latent heat only when the condensed refrigerant flows into the evaporator 6 and is gasified by heat exchange with the outside air can be established.

It is preferable that the gas phase flowing out from the gas-liquid separator 11 is condensed to a saturated liquid by the intercooler 13 (7).

[0036]

The depressurization unit 52 (a second

depressurization unit) is located between the high-temperature pathway 13H of the intercooler 13 and the evaporator 6 downstream thereof in the first pathway 121. The refrigerant flowing out from the high-temperature pathway 13H is depressurized to an evaporation pressure p2 which is the pressure at the time of the start of evaporation, according to the throttle amount of the depressurization unit 52 (8), and flows into the evaporator 6. The refrigerant which flows into the evaporator 6 is the R32-rich refrigerant mixture, as described above. The refrigerant mixture flowing through the evaporator 6 evaporates by absorbing heat from the outside air (9).

[0037]

On the other hand, the liquid phase flowing out from the low-temperature pathway 13L of the intercooler 13 is depressurized by the depressurization unit 53 (a third depressurization unit) located in the second pathway 122 (10) and then evaporates by the amount corresponding to the heat absorbed from the gas phase of the high-temperature pathway 13H. The second pathway 122 is connected to a pathway through which a low-pressure refrigerant flowing out from the outlet of the evaporator 6 flows (11). Under the influence of the low-pressure refrigerant, the refrigerant flows to the downstream side while evaporating further on the downstream side than the depressurization unit 53.

[0038]

Fig. 2 schematically shows a p-h line diagram of the air conditioner 1 as an example. The operation of the refrigerant circuit 2 will be described with reference to Fig. 2.

The high-temperature and high-pressure refrigerant (1) discharged from the compressor 3 flows into the condenser 4 (2). The refrigerant (3) condensed by radiating heat to the indoor air by the condenser 4 is depressurized to the intermediate pressure p1 by the depressurization unit 51 to enter the gas-liquid two-phase state (4), and is subjected to gas-liquid separation (5) and (6) by the gas-liquid separator 11.

The R32-rich gas phase (6) separated from the liquid phase (5) by the gas-liquid separator 11 is condensed by heat exchange with the liquid phase (5) by the intercooler 13 (7). Further, the R32-rich gas phase is depressurized to the evaporation pressure p2 by the depressurization unit section 52 (8) and then flows into the evaporator 6. Since the mixing ratio of R32 in the refrigerant mixture flowing through the evaporator 6 is high, the temperature glide between the evaporation start temperature and the evaporation end temperature is small. The gas refrigerant

(9) evaporated by the evaporator 6 is supplied to the compressor 3.

On the other hand, the liquid phase (5) passes through the liquid receiver 110 and is then depressurized by the depressurization unit 53 (10), and further, flows to the downstream side while evaporating toward the terminal end (11) of the second pathway 122 via the intercooler 13.

[0039]

According to this embodiment, by performing gas-liquid separation into the R1234yf-rich liquid refrigerant and the R32-rich gas refrigerant and making the R1234yf-rich refrigerant bypass the evaporator 6 without being supplied to the evaporator 6, it is possible to make the refrigerant flow into the evaporator 6 with the mixing ratio of R32 increased to such an extent that the mixing ratio is reversed from the composition of the refrigerant mixture sealed in the refrigerant circuit 2. In this way, the temperature glide is suppressed, and therefore, the frost formation on the evaporator 6 can be avoided.

Further, the composition of the refrigerant mixture flowing from the evaporator 6 into the condenser 4 via the compressor 3 is also R32-rich, and therefore, the temperature glide in condensation can also be suppressed.

By the above, it becomes possible to establish the operation range of the air conditioner 1 over a wide operation range.

[0040]

According to the air conditioner 1 of this embodiment, the mixing ratio of R1234yf having a low GWP is high in the non-azeotropic refrigerant mixture sealed in the refrigerant circuit 2, and therefore, it is possible to realize the GWP less than 300.

[0041]

The gas-liquid separation situation follows the degree of dryness of the gas-liquid separator 11 corresponding to the intermediate pressure p1, and therefore, the gas-liquid separation situation can be controlled by controlling the intermediate pressure p1 according to the throttle amount of the depressurization unit 51. It is preferable that the intermediate pressure p1 is controlled such that the degree of dryness falls within a range of 0.3 to 0.5, for example. In order to normally establish the refrigerating cycle, the lower limit of the degree of dryness can be set to 0.1, for example.

It is preferable to set the flow rates of the liquid phase (5) and the gas phase (6) branched by the gas-liquid separator 11 in consideration of energy balance. For example, in a case where the degree of dryness of the gas-liquid separator 11 is 0.5, it is preferable to adjust the throttle amount of each of the second depressurization unit 51 and the third depressurization unit 52 such that the flow rates of the liquid phase and the gas phase are equal to each other (1:1).

[0042]

[Modification Example of First Embodiment]

In the air conditioner 1 shown in Fig. 3, the liquid receiver 110 and a valve 14 for opening and closing a flow path 11A between the gas-liquid separator 11 and the liquid receiver 110 are provided in the second pathway 122.

As described in the first embodiment, if an operation is performed while making the gas phase of the gas-liquid separator 11 flow into the evaporator 6 and making the liquid phase of the gas-liquid separator 11 bypass the evaporator 6, the liquid level in the liquid receiver 110 increases.

[0043]

The control can be performed as described below by using the liquid receiver 110 and the valve 14, both of which are located in the second pathway 122.

At an appropriate timing when the liquid refrigerant is stored in the liquid receiver 110, the valve 14 is closed, and thus liquid reception from the gas-liquid separator 11 to the liquid receiver 110 is stopped. At this time, the depressurization unit 53 is opened (the degree of opening is full opening).

If the operation is continued as it is, the liquid refrigerant in the liquid receiver 110 flows to the downstream side while evaporating toward the terminal end (11) so as to be pulled due to the low pressure in the pathway to which the terminal end (11) of the second pathway 122 is connected. At this time, mainly, R32 having a low boiling point evaporates and is discharged from the terminal end (11) of the second pathway 122. The discharged R32-rich refrigerant is suctioned into the compressor 3 and circulates through the refrigerant circuit 2, whereby the mixing ratio of R32 during an operation can be increased.

In the second pathway 122, R1234yf is concentrated according to the discharge of the R32-rich refrigerant.

[0044]

According to the control described above, it is possible to further extract the R32-rich refrigerant from the R1234yf-rich liquid refrigerant separated from the R32-rich gas phase by the gas-liquid separator 11 and discharge it to the refrigerant circuit 2, and therefore, the mixing ratio of R32 during an operation can be further increased.

[0045]

The R32 discharge control described above can be repeated at a predetermined frequency. If the R32 discharge operation mode is ended, the valve 14 is opened, the throttle amount of the depressurization unit 53 is set, and a transition to the same normal operation mode as that described in the first embodiment can be performed.

Further, a configuration may be made such that if the liquid level in the liquid receiver 110 is detected and the refrigerant is stored at a liquid level equal to or more than a predetermined start liquid level, the R32 discharge operation mode is started, and if the liquid level in the liquid receiver 110 falls below a predetermined end liquid level, the R32 discharge operation mode is ended.

[0046]

The same control may also be performed by using a flow rate adjustment valve capable of changing the flow rate of the refrigerant flowing through the flow path 11A between the gas-liquid separator 11 and the liquid receiver 110, instead of the valve 14.

That is, the flow rate in the flow path 11A may be increased by the flow rate adjustment valve, instead of opening the valve 14, and the flow rate in the flow path 11A may be decreased by the flow rate adjustment valve, instead of closing the valve 14.

[0047]

[Second Embodiment]

Next, a second embodiment will be described with reference to Figs. 4 to 6.

An air conditioner 9 according to the second embodiment can perform heating and cooling of indoor air (a heat load) using outside air as a heat source. That is, the air conditioner 9 is used for both the use for cooling and the use for heating.

Figs. 4 to 6 show the configuration of the air conditioner 9.

In the air conditioner 9, by switching the direction of the flow of the refrigerant by the four-way valve 19, it is possible to perform a heating operation shown in Fig. 4 and a cooling operation shown in Figs. 5 and 6.

[0048]

During the heating operation (Fig. 4), the first heat exchanger 4 functions as a condenser, and the second heat exchanger 6 functions as an evaporator.

During the cooling operation (Figs. 5 and 6), the first heat exchanger 4 functions as an evaporator, and the second heat exchanger 6 functions as a condenser.

In Figs. 4 to 6, the pathway from a discharge port of the compressor 3 to an inlet of the evaporator is shown by a solid line, and the pathway from an outlet of the evaporator to a suction port of the compressor 3 is shown by a two-dot chain line.

[0049]

Hereinafter, the air conditioner 9 of the second embodiment will be described with a focus on the differences from the air conditioner 1 of the first embodiment.

As shown in Fig. 4, the air conditioner 9 is provided with a bypass section 15A (shown by a broken line) into which the liquid phase separated from the gas phase by the gas-liquid separator 11 is introduced, and an on-off valve 151 for opening and closing the bypass section 15A, instead of the depressurization unit 53 for throttle expansion in the first embodiment.

A terminal end of the bypass section 15A is connected to a pathway 15B flowing out from the evaporator 6 toward the compressor 3. The bypass section 15A corresponds to a third depressurization unit which reduces the pressure of the refrigerant.

The second pathway 122 which makes the liquid phase in the gas-liquid separator 11 bypass the evaporator 6 without being supplied to the evaporator 6 is configured by the bypass section 15A and the pathway 15B.

[0050]

Further, the air conditioner 9 performs processing in which not only during the heating operation but also during the cooling operation, as necessary, the refrigerant flowing out from the condenser (4, 6) is depressurized to the gas-liquid two-phase state and then subjected to gas-liquid separation and the R32-rich refrigerant is caused to flow into the evaporator (6, 4).

The air conditioner 9 is provided with a bridge circuit 16 such that the processing is established both during the heating operation and during the cooling operation.

The bridge circuit 16 is configured by four check valves 161 to 164 which determine the direction of the flow of the refrigerant to be one direction.

[0051]

(Heating Operation)

The heating operation will be described with reference to Fig. 4.

During the heating operation, the on-off valve 151 is opened and the bypass section 15A is opened.

Further, an on-off valve 171 of a merging pathway 17 prepared in the liquid receiver 110 for a time when gas-liquid separation is not performed in the cooling operation is closed. The merging pathway 17 connects the inside of the liquid receiver 110 and the first pathway 121 from which the gas phase in the gas-liquid separator

11 is extracted.

In Figs. 4 to 6, the closed valve is shown in black.

[0052]

The refrigerant flowing out from the condenser 4 is depressurized to the intermediate pressure of the gas-liquid two-phase by the depressurization unit 51 and flows into the gas-liquid separator 11 through the check valve 161 of the bridge circuit 16. The liquid phase in the gas-liquid separator 11 flows into the bypass section 15A via the liquid receiver 110, is depressurized by the influence of the low-pressure refrigerant flowing through the pathway 15B connected to the terminal end of the bypass section 15A, and merged with the refrigerant flowing through the pathway 15B. Then, the liquid phase flows toward the compressor 3 while evaporating through the pathway 15B. The pathway 15B includes the low-temperature pathway 13L of the intercooler 13.

[0053]

The gas phase separated from the liquid phase in the gas-liquid separator 11 flows through the high-temperature pathway 13H of the intercooler 13 and is condensed by heat exchange with the refrigerant flowing through the low-temperature pathway 13L. Then, the gas phase passes through the check valve 163 of the bridge circuit 16, is depressurized by the depressurization unit 52, and then flows into the evaporator 6.

[0054]

(Cooling Operation)

The cooling operation will be described with reference to Figs. 5 and 6.

In the cooling operation, the direction of the refrigerating cycle is opposite to that in the heating operation, and therefore, the first heat exchanger 4 is referred to as an evaporator 4 and the second heat exchanger 6 is referred to as a condenser 6.

Accordingly, the function of each of the depressurization unit 51 and the depressurization unit 52 is switched from that in the heating operation.

During the cooling operation, the depressurization unit 52 corresponds to a first depressurization unit that reduces the pressure of the refrigerant flowing out from the condenser 6 to the gas-liquid two-phase state, and the depressurization unit 51 corresponds to a second depressurization unit that reduces the pressure of the refrigerant which is subjected to gas-liquid separation from the liquid phase and flows through the first pathway 121 to the pressure at the inlet of the evaporator 4.

[0055]

During the cooling operation, in only a case where there is a possibility that the frost formation may occur in a relationship with the temperature glide due to a small temperature difference between the refrigerant flowing through the evaporator 4 and the heat load (the indoor air), the temperature glide is suppressed by performing the processing of increasing the apparent mixing ratio of R32.

Here, in a case where the temperature of the indoor air detected by a sensor 18 is lower than a predetermined value, the processing of suppressing the temperature glide is performed (Fig. 6), and in a case where the temperature of the indoor air is equal to or higher than the predetermined value, the processing is not performed (Fig. 5). Further, the temperature of the refrigerant flowing through the evaporator 4 is also detected, and whether or not to perform the processing of suppressing the temperature glide can also be determined based on the difference between the temperature and the detected temperature of the indoor air. In addition, appropriate criteria for determination can be used.

[0056]

First, a case where the processing of suppressing the temperature glide is not performed due to a sufficient large temperature difference between the refrigerant flowing through the evaporator 4 and the indoor air will be described with reference to Fig. 5.

In this case, the on-off valve 151 of the bypass section 15A is closed and the on-off valve 171 of the merging pathway 17 prepared in the liquid receiver 110 is opened.

The liquid phase in the gas-liquid separator 11 flows into the merging pathway 17 via the liquid receiver 110 and flows out from the merging pathway 17 to the first pathway 121. That is, the refrigerant flowing out from the gas-liquid separator 11 in the liquid phase state is merged with the refrigerant flowing out from the gas-liquid separator 11 in the gas phase state.

If a sufficient capacity is secured in the gas-liquid separator 11, the liquid receiver 110 is not always necessary.

[0057]

The refrigerant flowing out from the outlet of the condenser 6 and depressurized to the intermediate pressure by the first depressurization unit (here, the depressurization unit 52) passes through the check valve 164 of the bridge circuit 16 and flows into the gas-liquid separator 11. Although the refrigerant is temporarily separated into the liquid phase and the gas phase in the gas-liquid separator 11, the liquid phase and the gas phase are merged with each other thereafter (refer to 20 in Fig. 5). That is, it not necessary to make the

R1234yf-rich liquid phase in the gas-liquid separator 11 bypass, and therefore, the R1234yf-rich liquid phase is supplied to the evaporator 4 together with the gas phase. The merged refrigerant is subjected to heat exchange with the refrigerant in the low-temperature pathway 13L while passing through the high-temperature pathway 13H of the intercooler 13, passes through the check valve 162 of the bridge circuit 16, is further depressurized by the second depressurization unit (here, the depressurization unit 51), and then flows into the evaporator 4.

[0058]

Next, a case where the processing of suppressing the temperature glide is performed will be described with reference to Fig. 6.

In this case, similar to the heating operation (Fig. 4), the refrigerant depressurized to the intermediate pressure is separated into the gas phase and the liquid phase by opening the on-off valve 151 of the bypass section 15A and closing the on-off valve 171 of the merging pathway 17 prepared in the liquid receiver 110.

If the processing of suppressing the temperature glide is always performed even during the cooling operation, the on-off valve 151 is not necessary.

[0059]

The liquid phase flowing from the gas-liquid separator 11 into the bypass section 15A via the liquid receiver 110 is depressurized by the influence of the low-pressure refrigerant flowing through the pathway 15B, and flows toward the compressor 3 while evaporating through the pathway 15B.

The R32-rich gas phase separated from the liquid phase in the gas-liquid separator 11 is condensed by heat exchange with the refrigerant flowing into the low-temperature pathway 13L from the pathway 15B. Then, the R32-rich gas phase is depressurized by the second depressurization unit (the depressurization unit 51), then passes through the check valve 162 of the bridge circuit 16, and flows into the evaporator 4.

By the above, the apparent mixing ratio of R32 circulating through the refrigerant circuit 2 can be increased, and therefore, the temperature glide is suppressed, and thus even in a case where the temperature difference between the indoor air and the refrigerant temperature is large, it is possible to avoid the frost formation on the evaporator 4.

[0060]

Also in the heating operation (Fig. 4) and the cooling operation (Fig. 6) of the second embodiment, control to discharge the R32-rich refrigerant from the second pathway 122 to the refrigerant circuit 2 can be performed by using the liquid receiver 110 and the valve 14, in the same manner as the modification example (Fig. 3) of the first embodiment.

[0061]

In addition to the above, 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.

As the non-azeotropic refrigerant mixture in the present invention, appropriate refrigerants having different boiling points can be used. The GWP can be reduced by increasing the mixing ratio of the refrigerant having a high boiling point and a low GWP, in the refrigerant mixture sealed in the refrigerant circuit.

Reference Signs List

[0062]

1: air conditioner (refrigerating cycle apparatus)

2: refrigerant circuit

3: compressor

4: first heat exchanger

5: depressurization unit

51 to 53: depressurization unit

6: second heat exchanger

7: outdoor unit

8: indoor unit

9: air conditioner (refrigerating cycle apparatus)

10: circuit

11: gas-liquid separator

11A: flow path

110: liquid receiver

121: first pathway

122: second pathway

13: intercooler

13H: high-temperature pathway

13L: low-temperature pathway

14: valve

15A: bypass section (third depressurization unit, pathway)

15B: pathway

151: on-off valve

16: bridge circuit

161 to 164: check valve

17: merging pathway

171: on-off valve

18: sensor

19: four-way valve

p1: intermediate pressure

p2: evaporation pressure

Claims

[Claim 1]

A refrigerating cycle apparatus having a refrigerant circuit in which a non-azeotropic refrigerant mixture is sealed and which is configured to include a compressor, a first heat exchanger, a depressurization unit, and a second heat exchanger, and capable of heating a heat load, the apparatus comprising:

a first depressurization unit which reduces pressure of the non-azeotropic refrigerant mixture flowing out from a condenser which is one of the first heat exchanger and the second heat exchanger, to a gas-liquid two-phase state;

a gas-liquid separator which separates the non-azeotropic refrigerant mixture depressurized to the gas-liquid two-phase state into a gas phase and a liquid phase;

a first pathway for supplying a gas-phase refrigerant in the gas-liquid separator to an evaporator which is the other of the first heat exchanger and the second heat exchanger;

a second pathway for making a liquid-phase refrigerant in the gas-liquid separator bypass the evaporator without being supplied to the evaporator;

an intercooler which condensates the refrigerant flowing through the first pathway through heat exchange with the refrigerant flowing through the second pathway;

a second depressurization unit which reduces pressure of the refrigerant flowing through the first pathway; and

a third depressurization unit which reduces pressure of the refrigerant flowing through the second pathway,

wherein the second pathway includes

a liquid receiver which receives the liquid phase from the gas-liquid separator, and

a valve capable of opening and closing a flow path between the gas-liquid separator and the liquid receiver or adjusting a flow rate of the refrigerant flowing through the flow path,

the third depressurization unit is located at a downstream side of the liquid receiver, and a terminal end of the second pathway is configured to discharge to the refrigerant circuit, a refrigerant evaporated using the third depressurization unit in the second pathway, so that the evaporated refrigerant is suctioned into the compressor.

[Claim 2]

The refrigerating cycle apparatus according to claim 1, wherein the non-azeotropic refrigerant mixture includes

R32 as a first refrigerant, and

at least one of R1234yf and R1234ze(E) as a second refrigerant, and

a concentration of the first refrigerant in the entirety of the non-azeotropic refrigerant mixture sealed in the refrigerant circuit is in a range of 30 to 70 wt%.

[Claim 3]

The refrigerating cycle apparatus according to claim 2, wherein the non-azeotropic refrigerant mixture includes

CO_2 as a third refrigerant, and

a concentration of the third refrigerant in the entirety of the non-azeotropic refrigerant mixture sealed in the refrigerant circuit is 5 wt% or less.

[Claim 4]

The refrigerating cycle apparatus according to any one of claims 1 to 3, wherein heating and cooling of the heat load are capable of being performed,

the apparatus further includes

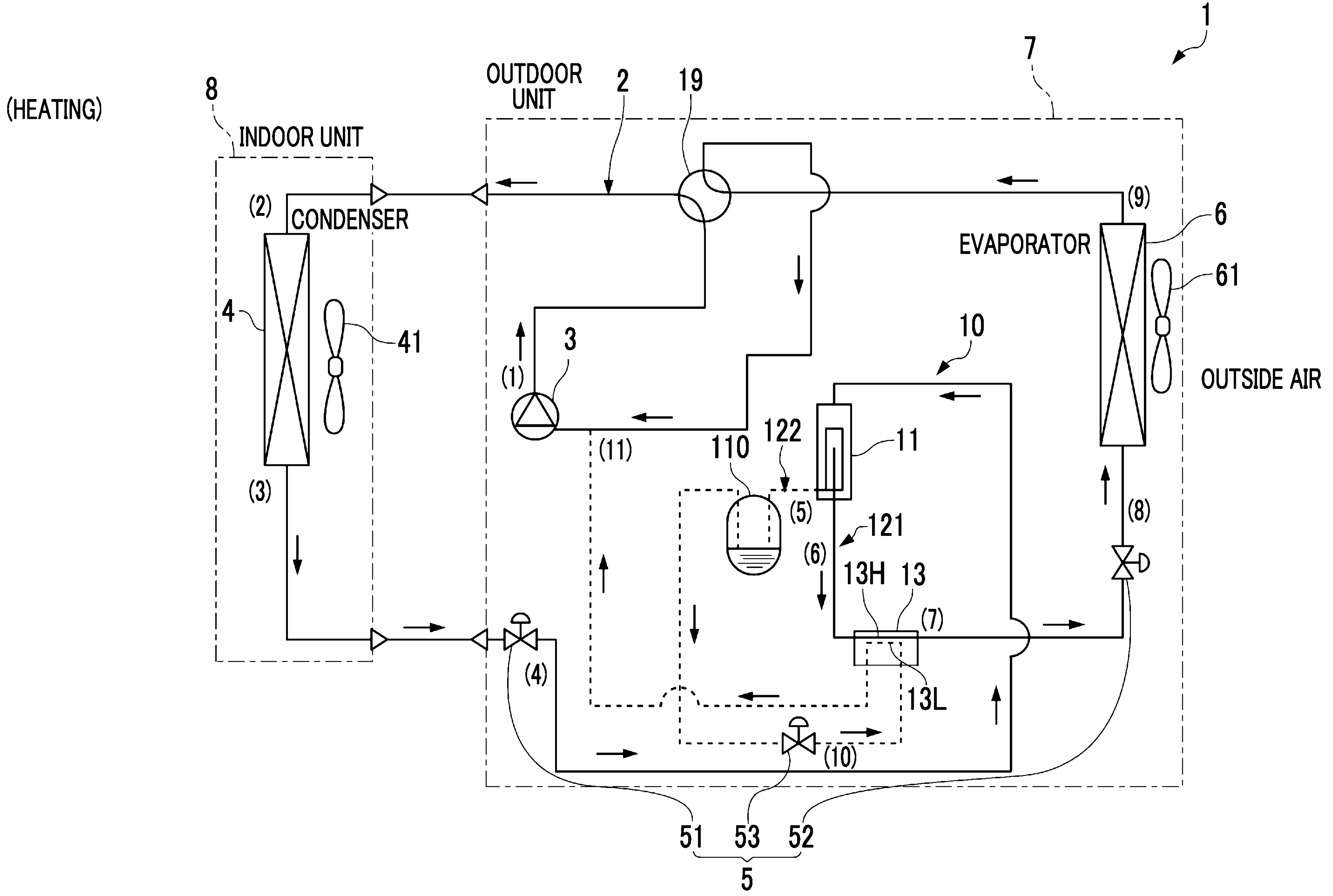
a switching valve which switches a direction of a flow of the refrigerant in the refrigerant circuit,

a bridge circuit which switches a direction of a flow of the refrigerant in the refrigerant circuit, and

a merging pathway for merging the liquid phase in the gas-liquid separator with the gas phase in the gas-liquid separator, and

the third depressurization unit is configured to include a pathway for merging the liquid phase in the gas-liquid separator with the refrigerant flowing out from the evaporator.

FIG. 1



1
7
8
(HEATING)
INDOOR UNIT
OUTDOOR UNIT
2
19
(2)
CONDENSER
(9)
6
EVAPORATOR
61
4
41
10
3
(1)
OUTSIDE AIR
(11)
110
122
11
(3)
(5)
121
(8)
(6)
13H
13
(7)
(4)
13L
(10)
51
53
52
5

FIG. 2

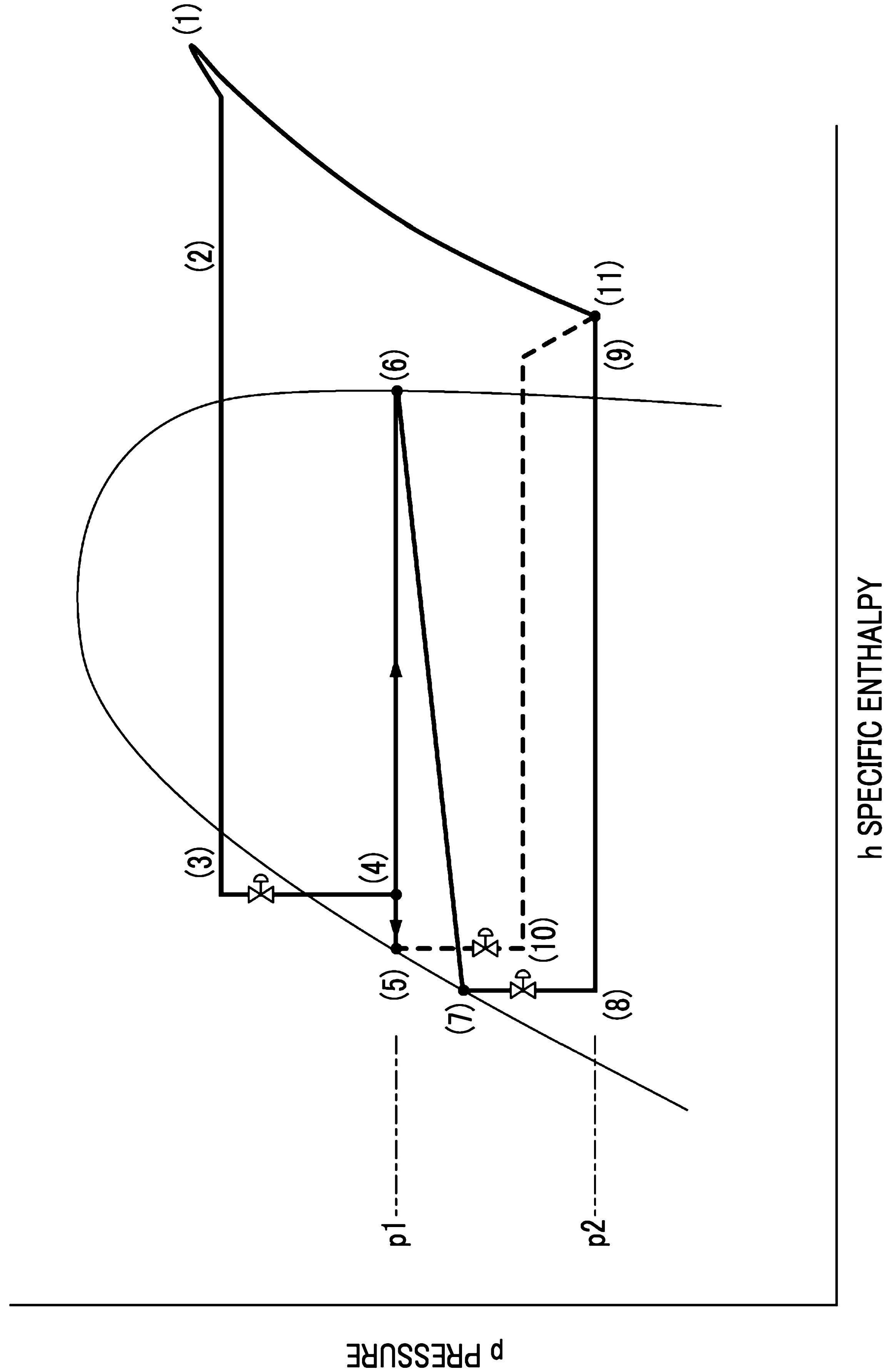
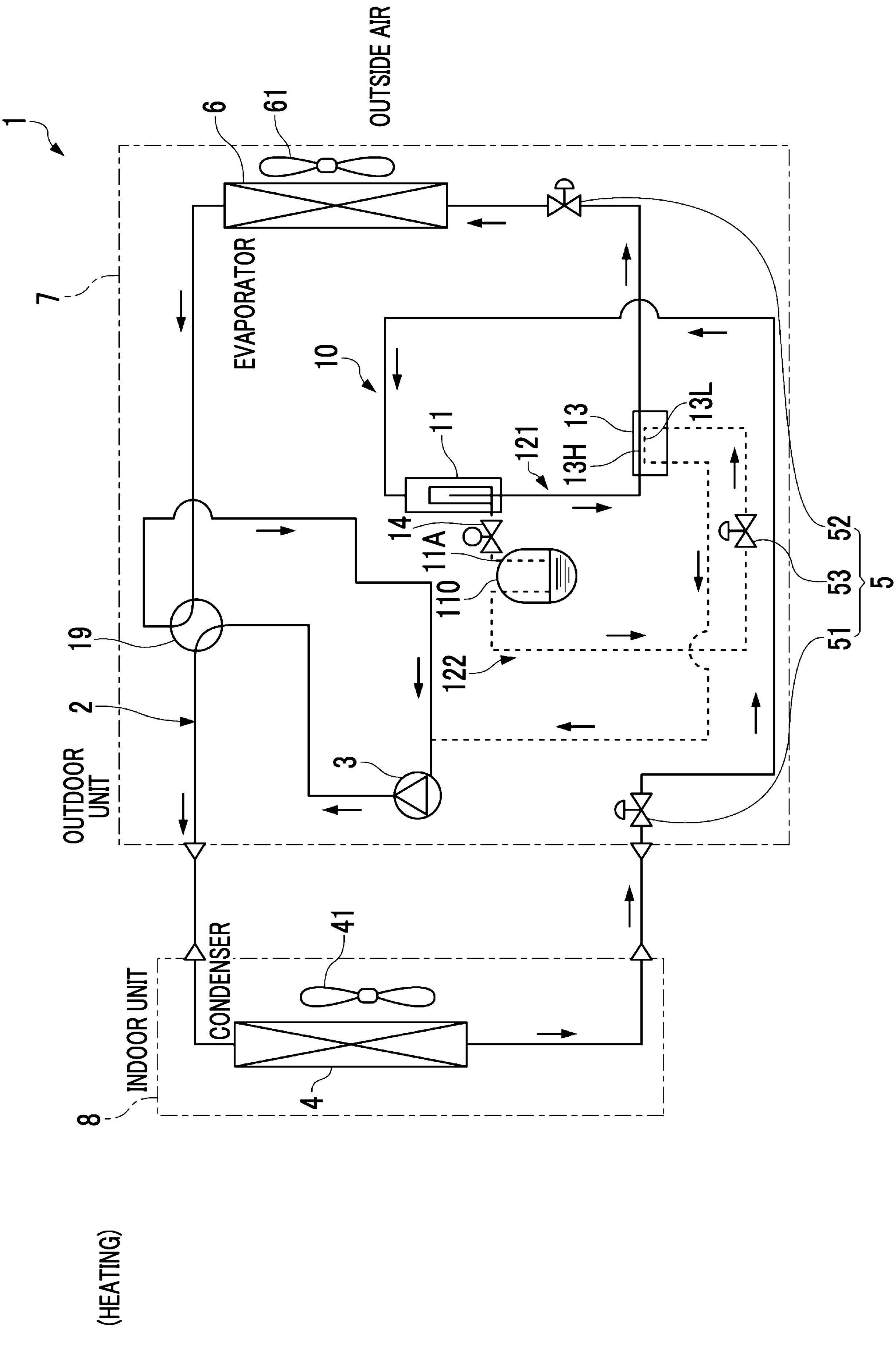


FIG. 3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EVAPORATOR
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11
121
13H
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13L
14
11A
110
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2
122
52
53
5
51
3
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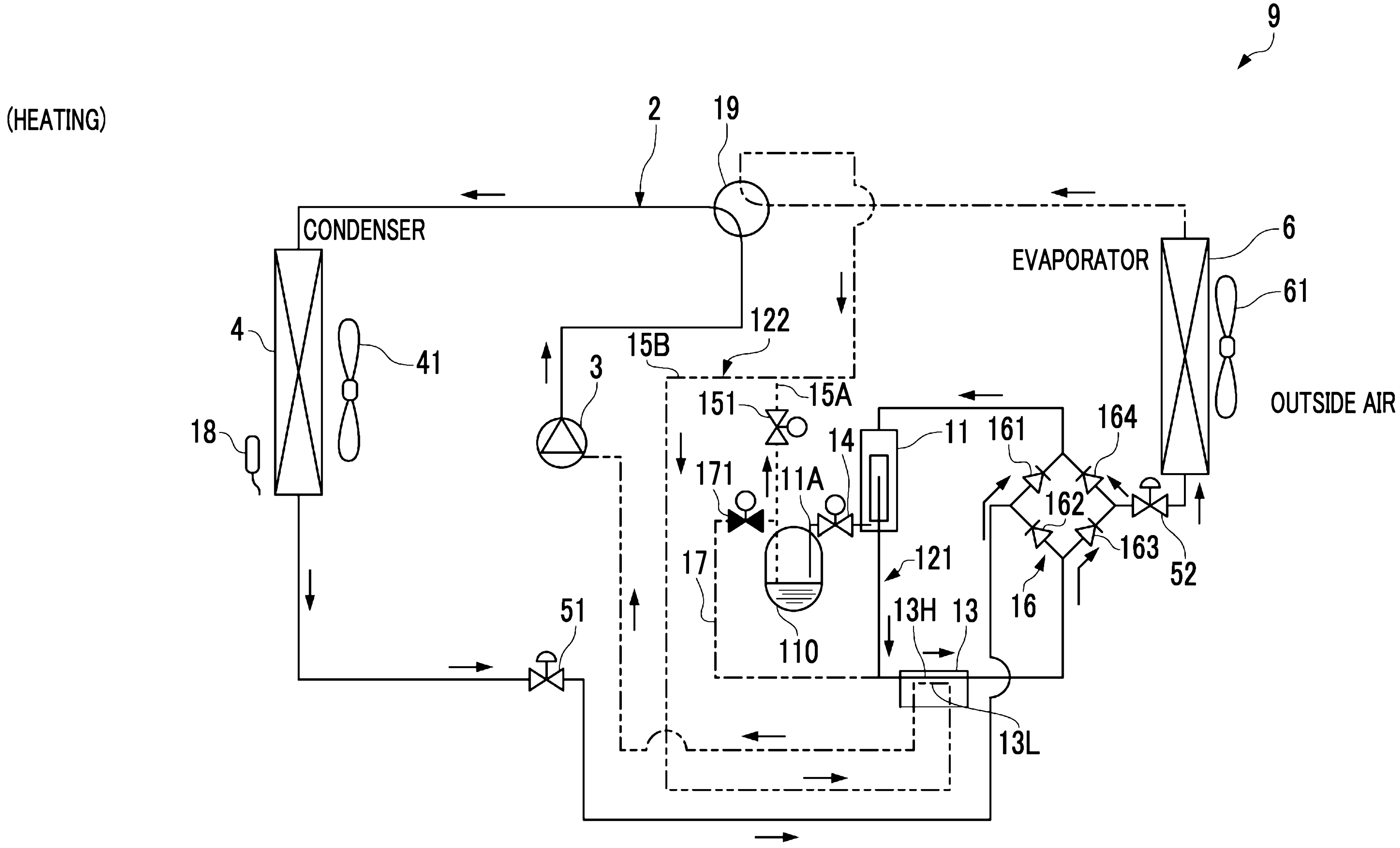
CONDENSER
41
INDOOR UNIT
4
8
(HEATING)

FIG. 4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CONDENSER
EVAPORATOR
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4
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3
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15B
15A
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171
11A
14
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163
52
OUTSIDE AIR
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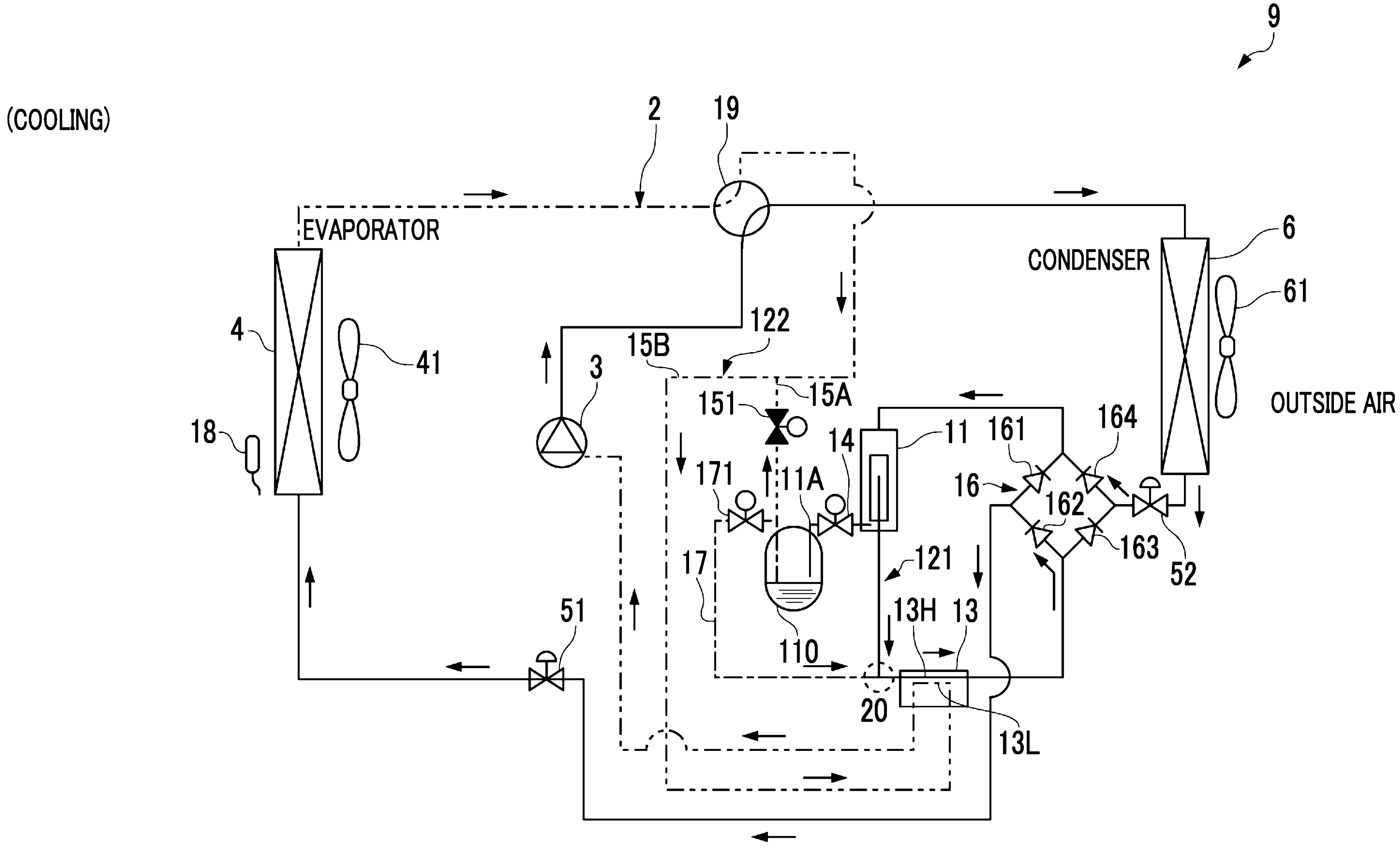
121
16
51
13H
13
13L

FIG. 5


(COOLING)
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EVAPORATOR
CONDENSER
6
61
4
41
3
122
15B
15A
151
18
OUTSIDE AIR
11
161
164
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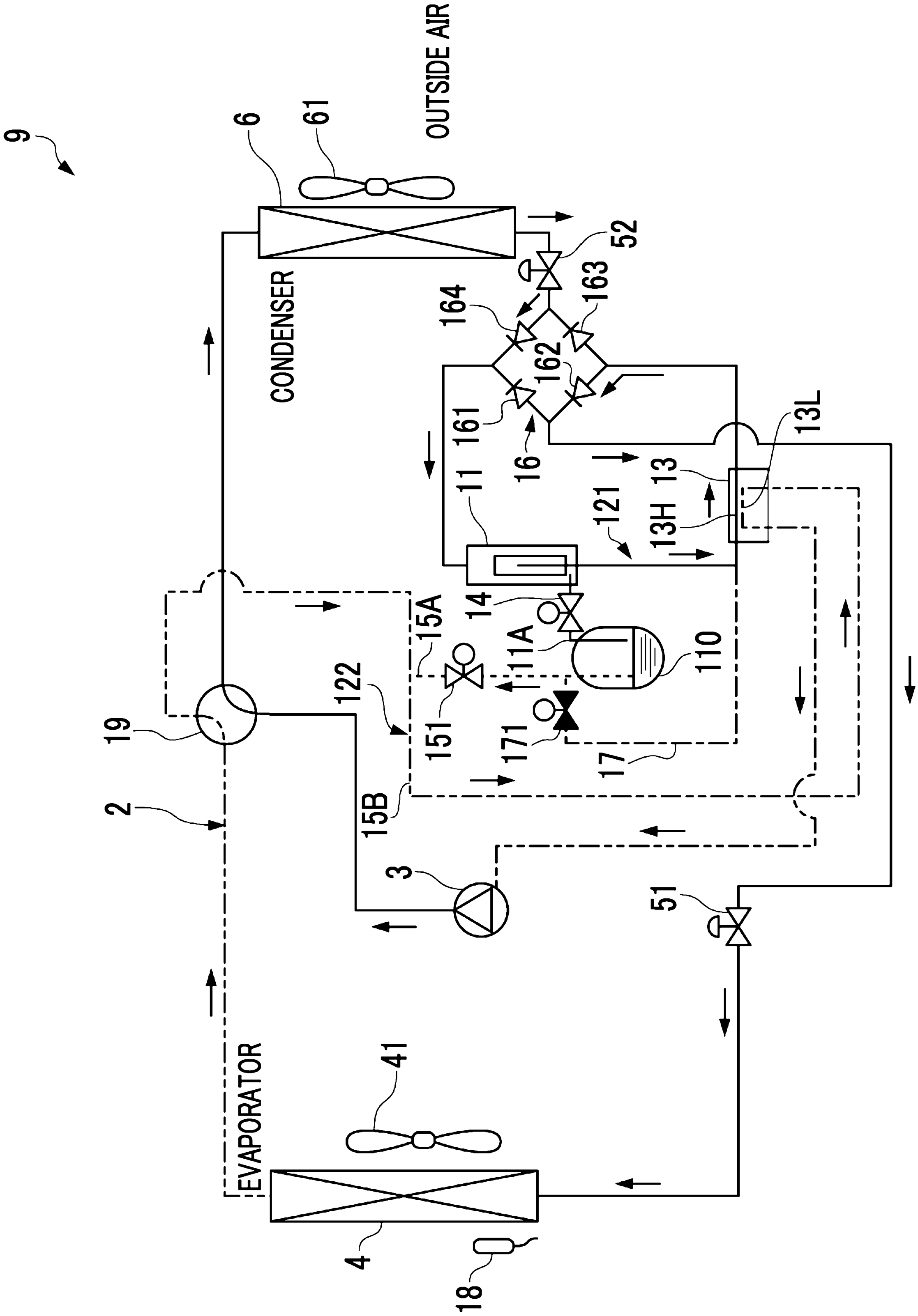
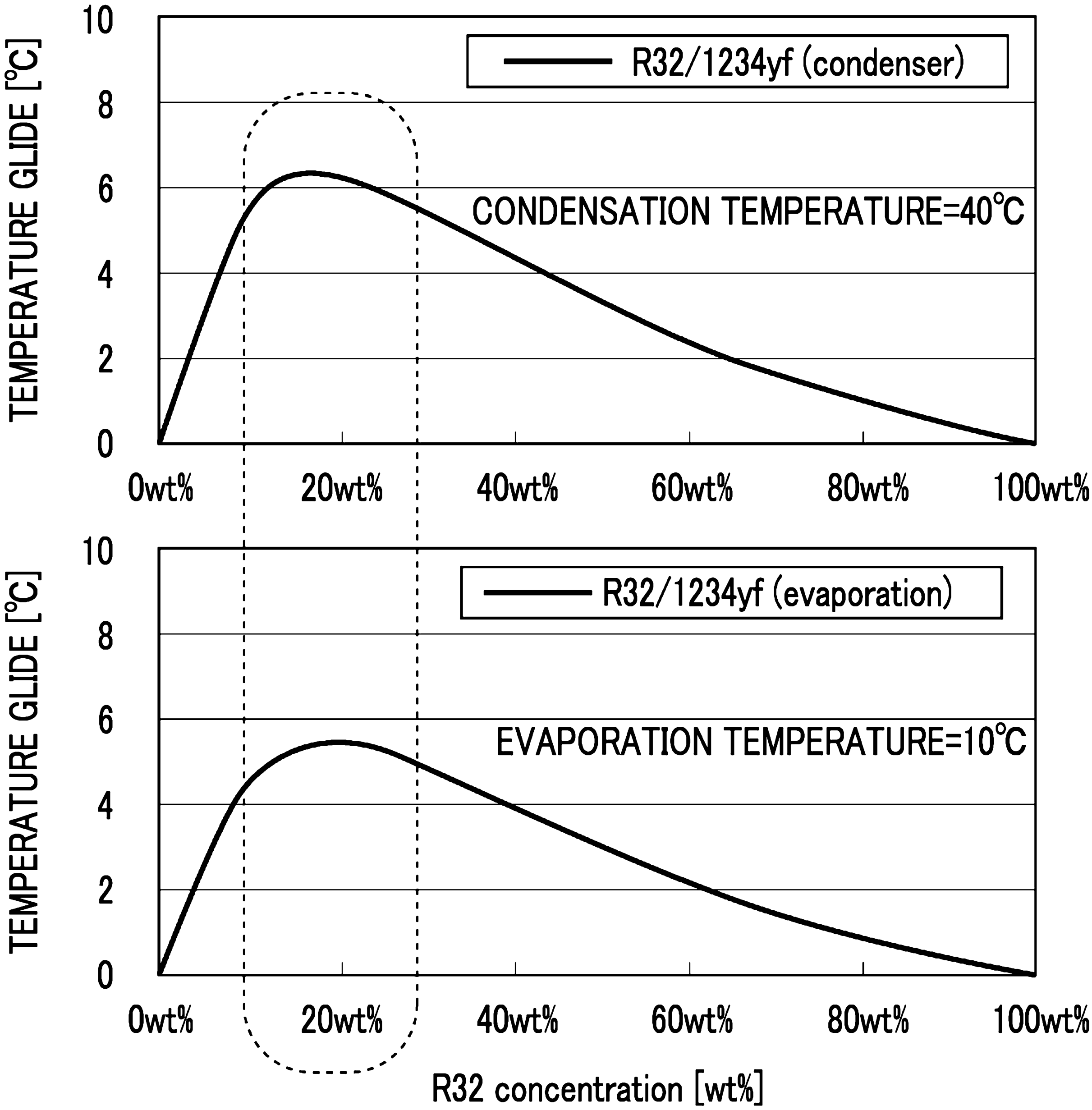
11A
16
162
163
52
17
121
51
13H
13
110
20
13L

FIG. 6



(COOLING)

FIG. 7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6
4
2
0
0wt%
20wt%
40wt%
60wt%
80wt%
100wt%
R32/1234yf (evaporation)
EVAPORATION TEMPERATURE=10℃
TEMPERATURE GLIDE [℃]
10
8
6
4
2
0
0wt%
20wt%
40wt%
60wt%
80wt%
100wt%
R32 concentration [wt%]