



(11)

EP 3 633 290 A1

(12)

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

(43) Date of publication:
08.04.2020 Bulletin 2020/15

(21) Application number: **18809576.4**

(22) Date of filing: **31.05.2018**

(51) Int Cl.:
F25B 29/00 ^(2006.01) **F24F 11/86** ^(2018.01)
F25B 6/02 ^(2006.01) **F24F 140/20** ^(2018.01)

(86) International application number:
PCT/JP2018/020954

(87) International publication number:
WO 2018/221652 (06.12.2018 Gazette 2018/49)

(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:
KH MA MD TN

(30) Priority: **31.05.2017 JP 2017107916**
09.08.2017 JP 2017154405
27.10.2017 JP 2017208330

(71) Applicant: **Daikin Industries, Ltd.**
Osaka-shi, Osaka 530-8323 (JP)

(72) Inventors:
• **UENO, Akitoshi**
Osaka-shi
Osaka 530-8323 (JP)
• **KOMANO, Hiroshi**
Osaka-shi
Osaka 530-8323 (JP)
• **TAKEUCHI, Ryuuji**
Osaka-shi
Osaka 530-8323 (JP)
• **MABUCHI, Shougo**
Osaka-shi
Osaka 530-8323 (JP)

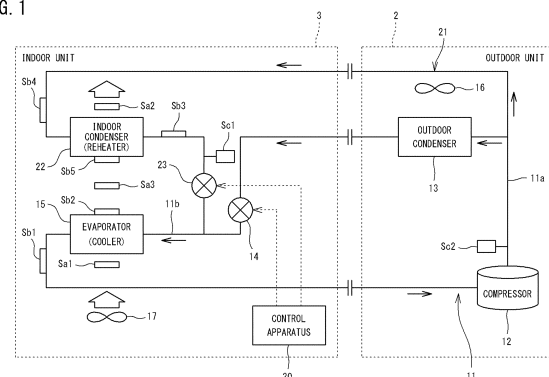
(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(54) **AIR CONDITIONING APPARATUS**

(57) Provided is an air conditioner capable of suitably controlling, through control of the opening degree of a cooling expansion valve, the degree of superheating of refrigerant that has passed through an evaporator. An air conditioner includes: a compressor (12); an outdoor condenser (13); a cooling expansion valve (14); an evaporator (15); a cooling circuit (11) connecting the compressor (12), the outdoor condenser (13), the cooling expansion valve (14), and the evaporator (15) in that order; a reheat path (21); an indoor condenser (22); a reheat expansion valve (23); and a control apparatus (30). The control apparatus (30) includes: a cooling control unit (31) that adjusts the degree of superheating of refrigerant that has passed through the evaporator (15) by adjusting a circulation amount of the refrigerant in the evaporator (15) through control of the opening degree of the cooling expansion valve (14); and a reheat control unit (32) that adjusts a room temperature by adjusting a circulation amount of the refrigerant in the indoor condenser (22) through control of the opening degree of the reheat expansion valve (23). An upper limit of the opening degree of the reheat expansion valve (23) controlled by the re-

heat control unit (32) is set based on a ratio between a cooling capacity of the evaporator (15) and a reheat capacity of the indoor condenser (22), the ratio enabling the cooling expansion valve (14) to adjust the degree of superheating.

FIG. 1



Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to an air conditioner capable of a reheat dehumidification operation.

BACKGROUND ART

10 **[0002]** There has conventionally been known an air conditioner capable of a reheat dehumidification operation with which a room is dehumidified while a temperature drop in the room is suppressed (see, for example, Patent Literature 1 and Patent Literature 2). In this air conditioner, a compressor, an outdoor condenser, a cooling expansion valve, and an evaporator (cooler) are connected in that order by a refrigerant pipe. Refrigerant discharged from the compressor is condensed by the outdoor condenser, decompressed by the cooling expansion valve, and then evaporated by exchanging heat with indoor air in the evaporator to cool and dehumidify the indoor air.

15 **[0003]** The air conditioner also includes a reheat path that bypasses the outdoor condenser and the cooling expansion valve. The reheat path is provided with an indoor condenser (reheater) and a reheat expansion valve. The refrigerant discharged from the compressor not only flows into the outdoor condenser but also branches off into the indoor condenser, and is condensed by exchanging heat, in the indoor condenser, with indoor air that has passed through the evaporator. The refrigerant is then decompressed by the reheat expansion valve, merges with refrigerant flowing from the cooling expansion valve, and flows into the evaporator. The indoor condenser maintains the interior of a room at a predetermined temperature by heating the indoor air that has been cooled and dehumidified in the evaporator.

CITATION LIST

25 [PATENT LITERATURE]

[0004]

Patent Literature 1: Japanese Unexamined Patent Publication No. 2011-133171

30 Patent Literature 2: Japanese Unexamined Patent Publication No. 1-222137

SUMMARY OF INVENTION

TECHNICAL PROBLEM

35 **[0005]** The air conditioner as described above is usually configured such that a predetermined degree of superheating is applied to the refrigerant that has passed through the evaporator and the compressor does not suck the liquid refrigerant. The degree of superheating is adjusted to a predetermined value through adjustment of the flow rate of the refrigerant flowing through the evaporator, the flow rate being adjusted through control of the opening degree of the cooling expansion valve. Meanwhile, the indoor temperature is adjusted to a target temperature through adjustment of the flow rate of the refrigerant flowing through the indoor condenser, the flow rate being adjusted through control of the opening degree of the reheat expansion valve.

40 **[0006]** However, if the opening degree of the reheat expansion valve is increased in order to increase a reheat capacity, the flow rate of the refrigerant flowing into the evaporator through the indoor condenser increases relative to the flow rate of the refrigerant flowing into the evaporator through the outdoor condenser. This makes it difficult to adjust the degree of superheating by controlling the opening degree of the cooling expansion valve.

45 **[0007]** The present invention has been made in view of such circumstances, and an object of the present invention is to provide an air conditioner capable of suitably controlling, through control of the opening degree of a cooling expansion valve, the degree of superheating of refrigerant that has passed through an evaporator.

SOLUTION TO PROBLEM

[0008]

55 (1) An air conditioner of the present invention includes:

a compressor;

an outdoor condenser that condenses refrigerant compressed by the compressor;

a cooling expansion valve that decompresses the refrigerant condensed by the outdoor condenser;
 an evaporator that evaporates the refrigerant decompressed by the cooling expansion valve by exchanging heat with indoor air, and cools and dehumidifies the indoor air;
 a cooling circuit connecting the compressor, the outdoor condenser, the cooling expansion valve, and the evaporator in that order;
 a reheat path that branches from a path connecting the compressor and the outdoor condenser in the cooling circuit, and is connected to a path connecting the cooling expansion valve and the evaporator;
 an indoor condenser that condenses, in the reheat path, the refrigerant compressed by the compressor by exchanging heat with the indoor air cooled and dehumidified by the evaporator, and heats the indoor air;
 a reheat expansion valve that decompresses, in the reheat path, the refrigerant condensed by the indoor condenser; and
 a control apparatus that controls opening degrees of the cooling expansion valve and the reheat expansion valve, wherein the control apparatus includes:

a cooling control unit that adjusts a degree of superheating of the refrigerant that has passed through the evaporator by adjusting a circulation amount of the refrigerant in the evaporator through control of the opening degree of the cooling expansion valve; and
 a reheat control unit that adjusts a room temperature by adjusting a circulation amount of the refrigerant in the indoor condenser through control of the opening degree of the reheat expansion valve, and
 an upper limit of the opening degree of the reheat expansion valve controlled by the reheat control unit is set based on a ratio between a cooling capacity of the evaporator and a reheat capacity of the indoor condenser, the ratio enabling the cooling expansion valve to adjust the degree of superheating.

Note that the upper limit of the opening degree does not include the opening degree in a case of the reheat expansion valve being fully opened, but means the opening degree between that of the fully closed valve and that of the fully opened valve.

In the air conditioner having the above configuration, the upper limit of the opening degree of the reheat expansion valve is set based on the ratio between the cooling capacity of the evaporator and the reheat capacity of the indoor condenser, the ratio enabling the cooling expansion valve to adjust the degree of superheating. Therefore, the circulation amount of the refrigerant in the indoor condenser can be limited in order to prevent an excessive increase in the ratio of the circulation amount of the refrigerant in the indoor condenser to the circulation amount of the refrigerant in the evaporator, and it is possible to appropriately adjust the degree of superheating of the evaporator by controlling the opening degree of the cooling expansion valve.

(2) The control apparatus preferably further includes an upper limit adjustment unit that adjusts the upper limit of the opening degree of the reheat expansion valve in accordance with a change in the cooling capacity of the evaporator during operation.

According to this configuration, for example, in a case where the cooling capacity of the evaporator is lowered in accordance with a decrease in external heat load during operation, the upper limit of the opening degree of the reheat expansion valve can be adjusted to be low and the reheat capacity of the indoor condenser can also be lowered. Even if the cooling capacity of the evaporator changes, therefore, the ratio of the circulation amount of the refrigerant in the indoor condenser to the circulation amount of the refrigerant in the evaporator does not increase excessively, making it possible to appropriately adjust the degree of superheating by controlling the opening degree of the cooling expansion valve.

(3) The upper limit of the opening degree of the reheat expansion valve is preferably adjusted based on a ratio between a circulation amount of the refrigerant flowing through the cooling expansion valve and a circulation amount of the refrigerant flowing through the reheat expansion valve.

According to this configuration, the circulation amount of the refrigerant flowing through the cooling expansion valve is correlated with the cooling capacity of the evaporator, and the circulation amount of the refrigerant flowing through the reheat expansion valve is correlated with the reheat capacity of the indoor condenser. This makes it possible to adjust the upper limit of the opening degree of the reheat expansion valve based on the ratio between the circulation amount of the refrigerant flowing through the cooling expansion valve and the circulation amount of the refrigerant flowing through the reheat expansion valve.

(4) The upper limit of the opening degree of the reheat expansion valve is preferably adjusted based on a ratio between an air temperature difference before and after air passes through the evaporator and an air temperature difference before and after the air passes through the indoor condenser.

According to this configuration, the air temperature difference before and after the air passes through the evaporator is correlated with the cooling capacity of the evaporator, and the air temperature difference before and after the air

passes through the indoor condenser is correlated with the reheat capacity of the indoor condenser. This makes it possible to adjust the upper limit of the opening degree of the reheat expansion valve based on the ratio between the temperature differences. Since each temperature difference can be easily measured using an air temperature sensor, it is easy to adjust the upper limit of the opening degree of the reheat expansion valve.

(5) The reheat control unit preferably corrects an amount of controlling the opening degree of the reheat expansion valve in accordance with a degree of subcooling of the refrigerant at an outlet of the indoor condenser, and adjusts the degree of subcooling.

In a case where the degree of subcooling at the outlet of the indoor condenser cannot be secured sufficiently, gas-liquid two-phase refrigerant flows into the reheat expansion valve and the circulation amount of the refrigerant in the indoor condenser suddenly decreases, making superheating control difficult.

In view of such inconvenience, the reheat control unit of the air conditioner having the above configuration corrects the amount of controlling the opening degree of the reheat expansion valve in accordance with the degree of subcooling of the refrigerant at the outlet of the indoor condenser, and adjusts the degree of subcooling to a predetermined value. This makes it possible to suitably secure the degree of subcooling.

(6) The control apparatus is preferably configured to further control an operation in a reheat dehumidification mode in which the air cooled and dehumidified by the evaporator is heated by the indoor condenser, control an operation in a cooling mode in which the air cooled and dehumidified by the evaporator just passes through the indoor condenser, perform the operation in the reheat dehumidification mode when a temperature of air sucked into the evaporator is within a range of a target temperature and a relative humidity of the sucked air is equal to or higher than a target humidity, and perform the operation in the cooling mode when the temperature of the air sucked into the evaporator is higher than the target temperature, or when the temperature of the sucked air is within the range of the target temperature and the relative humidity of the sucked air is lower than the target humidity.

According to this configuration, when the temperature of the air sucked into the evaporator is within the range of the target temperature and the relative humidity of the sucked air is equal to or higher than the target humidity, the humidity is relatively high with respect to the indoor temperature. Therefore, the operation in the reheat dehumidification mode is performed in order to lower the humidity without lowering the temperature. On the other hand, when the temperature of the air sucked into the evaporator is higher than the target temperature, or when the temperature of the sucked air is within the range of the target temperature and the relative humidity of the sucked air is lower than the target humidity, the operation in the cooling mode is performed in order to lower the temperature in preference to the humidity. The reheat dehumidification mode or the cooling mode is selected in accordance with the state of the sucked air as described above, and the humidity and temperature of the indoor space are controlled to appropriate values.

(7) Preferably, a first reheat on-off valve is connected to a reheat refrigerant pipe on a refrigerant inflow side of the indoor condenser during the operation in the reheat dehumidification mode, and the reheat expansion valve is connected to a refrigerant outflow side of the indoor condenser, and a reheat bypass pipe that bypasses the first reheat on-off valve is connected to the reheat refrigerant pipe, and a second reheat on-off valve having a smaller diameter than the first reheat on-off valve is connected to the reheat bypass pipe.

(8) When starting the operation in the reheat dehumidification mode, the control apparatus is preferably configured to perform a liquid refrigerant removal operation in which the control apparatus opens the reheat expansion valve with the first reheat on-off valve closed, then opens the second reheat on-off valve after a predetermined time, and then opens the first reheat on-off valve after a predetermined time.

According to this configuration, when the operation in the reheat dehumidification mode is started, the second reheat on-off valve having a smaller diameter than the first reheat on-off valve is opened first. During the cooling operation, therefore, the liquid refrigerant accumulated in the reheat refrigerant pipe does not rush through the reheat expansion valve, thus preventing vibration and noise of the pipe.

(9) When ending the operation in the reheat dehumidification mode, the control apparatus is preferably configured to close the first reheat on-off valve and the second reheat on-off valve, and then close the reheat expansion valve a predetermined time.

[0009] According to this configuration, when the operation in the reheat dehumidification mode ends, the first reheat on-off valve and the second reheat on-off valve are closed, and then the reheat expansion valve is closed after a predetermined time. In the meantime, the liquid refrigerant in the indoor condenser can be discharged from the indoor condenser. The liquid refrigerant discharged from the indoor condenser can be returned to the compressor after being evaporated by the evaporator of the cooling circuit.

ADVANTAGEOUS EFFECTS OF INVENTION

[0010] The present invention makes it possible to suitably control, through control of the opening degree of a cooling expansion valve, the degree of superheating of refrigerant that has passed through an evaporator.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

[FIG. 1] FIG. 1 is a schematic configuration diagram of an air conditioner according to a first embodiment of the present invention.

[FIG. 2] FIG. 2 is a configuration diagram of functions of a control apparatus.

[FIG. 3] FIG. 3 is a flowchart illustrating a procedure of basic control of the air conditioner.

[FIG. 4] FIG. 4 is an explanatory diagram illustrating the relationship between a cooling capacity and a reheat capacity associated with a change in external load.

[FIG. 5] FIG. 5 is a flowchart illustrating a procedure of Applied Control 1 of the air conditioner.

[FIG. 6] FIG. 6 is a flowchart illustrating a procedure of Applied Control 2 of the air conditioner.

[FIG. 7] FIG. 7 is a flowchart illustrating a procedure of Applied Control 2 of the air conditioner.

[FIG. 8] FIG. 8 is a diagram illustrating a refrigeration cycle on a Mollier diagram.

[FIG. 9] FIG. 9 is a schematic configuration diagram of an air conditioner according to a second embodiment of the present invention.

[FIG. 10] FIG. 10 is an explanatory diagram illustrating how to switch operating modes in accordance with an interior (indoor) temperature.

[FIG. 11] FIG. 11 is a flowchart illustrating operating mode switching control.

[FIG. 12] FIG. 12 is a table illustrating how refrigerant circuit components are set in each operating mode.

[FIG. 13] FIG. 13 is a time chart illustrating opening and closing timings of a first reheat on-off valve and a second reheat on-off valve.

DESCRIPTION OF EMBODIMENTS

[0012] Embodiments of the present invention will be described below with reference to the drawings.

[First embodiment]

<Overall configuration of air conditioner>

[0013] FIG. 1 is a schematic configuration diagram of an air conditioner according to an embodiment of the present invention.

[0014] An air conditioner 1 of the present embodiment is used in an environment such as a meat factory in which a target to be cooled, such as meat containing a lot of moisture, is frequently brought into and out of a room. The air conditioner 1 is capable of a reheat dehumidification operation with which to dehumidify the room while keeping the room temperature constant. For example, the air conditioner 1 is a refrigeration apparatus used to cool a space to be cooled, such as a meat storage in a meat processing factory.

[0015] The air conditioner 1 includes an outdoor unit (heat source unit) 2 and an indoor unit (utilization unit) 3. The outdoor unit 2 and the indoor unit 3 are connected by a connection pipe. The air conditioner 1 also includes a control apparatus 30 that controls the operations of the outdoor unit 2 and the indoor unit 3.

[0016] The outdoor unit 2 is installed outdoors, for example, and includes a compressor 12, an outdoor condenser 13, an outdoor fan 16, a refrigerant pressure sensor Sc2, and the like.

[0017] The indoor unit 3 is disposed indoors, for example, inside a factory, and includes a first expansion valve 14, an evaporator (cooler) 15, an indoor condenser (reheater) 22, a second expansion valve 23, an indoor fan 17, air temperature sensors Sa1, Sa2, and Sa3, refrigerant temperature sensors Sb1, Sb2, Sb3, Sb4, and Sb5, a refrigerant pressure sensor Sc1, and the like.

[0018] The compressor 12, the outdoor condenser 13, the first expansion valve 14, and the evaporator 15 are connected in that order by a refrigerant pipe to form a cooling circuit 11. The cooling circuit 11 functions exclusively to lower the temperature and humidity of indoor air.

[0019] The air conditioner 1 of the present embodiment further includes a reheat path 21. In the cooling circuit 11, the reheat path 21 branches from a path 11a connecting the compressor 12 and the outdoor condenser 13, and is connected to a path 11b connecting the first expansion valve 14 and the evaporator 15. The reheat path 21 bypasses the outdoor

condenser 13 and the first expansion valve 14 in the cooling circuit 11. The reheat path 21 is provided with the indoor condenser 22 and the second expansion valve 23. Therefore, the indoor condenser 22 and the second expansion valve 23 are provided in parallel with the outdoor condenser 13 and the first expansion valve 14. The reheat path 21 functions to raise the temperature of the indoor air that has been cooled by the cooling circuit 11.

[0020] As the compressor 12, for example, a variable-capacity compressor is used, which is driven by a motor with an operation frequency (operation speed) adjustable through inverter control or the like. The compressor 12 compresses low-temperature, low-pressure gas refrigerant, sent from the evaporator 15, into high-temperature, high-pressure gas refrigerant. Alternatively, the compressor 12 may be a fixed-capacity compressor.

[0021] As the outdoor condenser 13, for example, a cross-fin type fin-and-tube heat exchanger, or a microchannel heat exchanger is used. The outdoor condenser 13 condenses the gas refrigerant discharged from the compressor 12 by exchanging heat with outdoor air to turn the refrigerant into liquid refrigerant. The outdoor air is supplied to the outdoor condenser 13 by the outdoor fan 16 being driven.

[0022] The first expansion valve 14 is, for example, an electronic expansion valve that is driven by a pulse motor, and has an adjustable opening degree. The opening degree of the first expansion valve 14 is controlled by the control apparatus 30. The first expansion valve 14 decompresses the liquid refrigerant that has been condensed by the outdoor condenser 13 to turn the refrigerant into low-temperature, low-pressure gas-liquid two-phase refrigerant. The first expansion valve 14 adjusts, through control of the opening degree thereof, the flow rate of the refrigerant flowing through the evaporator 15, and adjusts the degree of superheating of the refrigerant that has passed through the evaporator 15. In the following description, the first expansion valve 14 is also referred to as a "cooling expansion valve".

[0023] For example, a cross-fin type fin-and-tube heat exchanger, or a microchannel heat exchanger is used as the evaporator 15, like the outdoor condenser 13. The evaporator 15 evaporates the low-temperature, low-pressure gas-liquid two-phase refrigerant that has passed through the cooling expansion valve 14 by exchanging heat with the indoor air to turn the refrigerant into gas refrigerant. The evaporator 15 also functions as a cooler that cools and dehumidifies the indoor air by exchanging heat with the refrigerant. The indoor air is supplied to the evaporator 15 by the indoor fan 17 being driven.

[0024] For example, a cross-fin type fin-and-tube heat exchanger, or a microchannel heat exchanger is used as the indoor condenser 22, like the outdoor condenser 13. The indoor air that has been cooled and dehumidified by the evaporator 15 through driving of the indoor fan 17 is supplied to the indoor condenser 22. The gas refrigerant discharged from the compressor 12 flows into the indoor condenser 22 after branching from the path 11a that guides the refrigerant to the outdoor condenser 13. The indoor condenser 22 condenses the gas refrigerant by exchanging heat with the indoor air. As a result, the indoor air that has been cooled and dehumidified by the evaporator 15 is heated with the humidity kept low, and blown into the room. Therefore, the indoor condenser 22 functions as a reheater that reheats the indoor air that has been cooled by the evaporator 15.

[0025] Like the cooling expansion valve 14, the second expansion valve 23 is, for example, an electronic expansion valve that is driven by a pulse motor, and has an adjustable opening degree. The opening degree of the second expansion valve 23 is controlled by the control apparatus 30. The second expansion valve 23 decompresses the liquid refrigerant that has been condensed by the indoor condenser 22 to turn the refrigerant into low-temperature, low-pressure gas-liquid two-phase refrigerant. The second expansion valve 23 adjusts, through control of the opening degree thereof, the flow rate of the refrigerant flowing through the indoor condenser 22, and adjusts how much the indoor air is to be heated (reheated). Hereinafter, the second expansion valve 23 is also referred to as a "reheat expansion valve".

[0026] The air temperature sensors Sa1, Sa2, and Sa3 function as follows. The first air temperature sensor Sa1 detects the temperature of air sucked into the indoor unit 3. The second air temperature sensor Sa2 detects the temperature of air blown from the indoor unit 3. The third air temperature sensor Sa3 detects the temperature of air that has passed through the evaporator 15 but has not yet been supplied to the indoor condenser 22.

[0027] The refrigerant temperature sensors Sb1, Sb2, Sb3, Sb4, and Sb5 function as follows. The first refrigerant temperature sensor Sb1 detects the temperature of refrigerant at an outlet of the evaporator 15. The second refrigerant temperature sensor Sb2 detects the temperature of refrigerant flowing through the evaporator 15. The third refrigerant temperature sensor Sb3 detects the temperature of refrigerant at an outlet of the indoor condenser 22 (before reaching the reheat expansion valve 23). The fourth refrigerant temperature sensor Sb4 detects the temperature of refrigerant at an inlet of the indoor condenser 22. The fifth refrigerant temperature sensor Sb5 detects the temperature of refrigerant flowing through the indoor condenser 22.

[0028] The refrigerant pressure sensors Sc1 and Sc2 function as follows. The first pressure sensor Sc1 detects the refrigerant pressure at the outlet of the indoor condenser 22 (before reaching the reheat expansion valve 23). The second pressure sensor Sc2 detects the discharge pressure of the compressor 12.

[0029] Detection signals from the above sensors are input to and used by the control apparatus 30 for controlling various devices. Note that the air conditioner 1 does not need to include all the sensors described above, but just needs to include at least sensors used for exemplary control described later.

[0030] The control apparatus 30 includes, for example, an indoor control unit (not illustrated) provided in the indoor

unit 3, and an outdoor control unit (not illustrated) provided in the outdoor unit 2. The control apparatus 30 includes a microcomputer, a memory, a communication interface and the like. Signals from the various sensors provided in the indoor unit 3 and the outdoor unit 2 are input to the control apparatus 30. The control apparatus 30 controls the operations of, for example, the compressor 12, the expansion valves 14 and 23, and the fans 16 and 17. The control apparatus 30 can receive, through a remote controller or the like connected to the indoor unit 3, an input of a target value (set temperature) of a suction temperature or a blow-out temperature at the indoor unit 3.

[0031] FIG. 2 is a configuration diagram of functions of the control apparatus 30.

[0032] The control apparatus 30 has functions as a cooling control unit 31, a reheat control unit 32, and an upper limit adjustment unit 33.

[0033] The cooling control unit 31 is a functional unit that adjusts the circulation amount of refrigerant in the evaporator 15 by controlling the opening degree of the cooling expansion valve 14, cools and dehumidifies the indoor air as desired based on the cooling capacity of the evaporator 15, and adjusts the degree of superheating of the refrigerant that has passed through the evaporator 15.

[0034] The reheat control unit 32 is a functional unit that adjusts the circulation amount of refrigerant in the indoor condenser 22 by controlling the opening degree of the reheat expansion valve 23, and adjusts the indoor temperature as desired based on the reheat capacity of the indoor condenser 22. The reheat control unit 32 adjusts the opening degree of the reheat expansion valve 23 with a predetermined opening degree set as an upper limit. The upper limit of the opening degree is larger than the opening degree at which the reheat expansion valve 23 is fully closed and smaller than the opening degree at which the reheat expansion valve 23 is fully opened.

[0035] The upper limit adjustment unit 33 is a functional unit that adjusts the upper limit of the opening degree of the reheat expansion valve 23, the opening degree being controlled by the reheat control unit 32. The upper limit adjustment unit 33 is the functional unit used exclusively in Applied Control 1 of exemplary control described below.

[0036] In general, a cooling capacity ϕ_C can be expressed by the following formula (1), and a reheat capacity ϕ_R can be expressed by the following formula (2). [Formula 1]

$$\phi_C = \underbrace{\frac{CV_C \sqrt{\Delta P_C}}{\sqrt{G_C}} h_C \cdot G_C}_{\text{Cooling system circulation amount}} + \underbrace{\frac{CV_R \sqrt{\Delta P_R}}{\sqrt{G_R}} h_C \cdot G_R}_{\text{Reheat system circulation amount}} \quad \cdot \cdot \cdot (1)$$

[Formula 2]

$$\phi_R = \underbrace{\frac{CV_R \sqrt{\Delta P_R}}{\sqrt{G_R}} h_R \cdot G_R}_{\text{Reheat system circulation amount}} \quad \cdot \cdot \cdot (2)$$

where CV_C and CV_R represent flow rate coefficients with respect to the opening degrees of the cooling expansion valve 14 and the reheat expansion valve 23, respectively,

ΔP_C represents a differential pressure between the outdoor condenser 13 and the evaporator 15,

ΔP_R represents a differential pressure between the indoor condenser 22 and the evaporator 15,

h_C represents a low pressure-side enthalpy difference between the inlet and the outlet of the evaporator 15 (see FIG. 8),

h_R represents a high pressure-side enthalpy difference between the inlet and the outlet of the indoor condenser 22 (see FIG. 8), and

G_C and G_R each represent a specific gravity ratio (water basis) of the refrigerant on the high pressure side. A cooling system circulation amount indicates the circulation amount of refrigerant passing through the cooling expansion valve 14, and a reheat system circulation amount indicates the circulation amount of refrigerant passing through the reheat expansion valve 23. Therefore, the cooling capacity ϕ_C is determined based on the circulation amount

of refrigerant that passes through both the cooling expansion valve 14 and the reheat expansion valve 23 and flows into the evaporator 15. Meanwhile, the reheat capacity φ_R is determined based on the circulation amount of refrigerant that passes through the indoor condenser 22 and the reheat expansion valve 23.

5 [Exemplary control of air conditioner]

[0037] As described above, the air conditioner 1 adjusts the circulation amount of refrigerant in the evaporator 15 by controlling the opening degree of the cooling expansion valve 14, and adjusts the degree of superheating of the refrigerant that has passed through the evaporator 15 to a predetermined value. As a result, liquid refrigerant does not flow into
10 the compressor 12, and thus the compressor 12 is protected.

[0038] Meanwhile, not only the refrigerant that has passed through the cooling expansion valve 14 but also the refrigerant flowing from the reheat path 21 flows into the evaporator 15. The cooling expansion valve 14 cannot control the circulation amount of the refrigerant flowing from the reheat path 21. Therefore, if the circulation amount of the refrigerant flowing from the reheat path 21 becomes relatively large, it becomes difficult for the cooling expansion valve 14 to adjust
15 the degree of superheating.

[0039] In the air conditioner 1 of the present embodiment, therefore, an "upper limit" is set for the opening degree of the reheat expansion valve 23 in order to limit the amount of refrigerant flowing from the reheat path 21 into the evaporator 15 and to enable the cooling expansion valve 14 to adjust the degree of superheating. In other words, the upper limit of the opening degree of the reheat expansion valve 23 is set to a predetermined value within a range in which the cooling
20 expansion valve 14 can adjust the degree of superheating.

[0040] Hereinafter, exemplary control of the cooling expansion valve 14 and the reheat expansion valve 23, performed by the control apparatus 30, will be described. Specifically, the most basic control (basic control) and its applied control (Applied Control 1, 2) will be described in that order.

25 <Basic control>

[0041] FIG. 3 is a flowchart illustrating a procedure of basic control of the air conditioner. This basic control is an example of control in a case where the upper limit of the opening degree of the reheat expansion valve 23 is fixed.

[0042] First, in step S1, the first refrigerant temperature sensor Sb1 detects a refrigerant temperature T_{co} at the outlet of the evaporator 15. In step S2, the second refrigerant temperature sensor Sb2 detects a temperature T_{cm} of the refrigerant flowing through the evaporator 15. The refrigerant temperature T_{cm} corresponds to the evaporation temperature at the evaporator 15.
30

[0043] Next, in step S3, the control apparatus 30 calculates a degree of superheating SH of the refrigerant that has passed through the evaporator 15. Specifically, the degree of superheating SH is calculated by the following formula (3).
35

$$SH = T_{co} - T_{cm} \dots (3)$$

[0044] Next, in step S4, the control apparatus 30 calculates an opening degree C_{Pls} of the cooling expansion valve 14 for adjusting the degree of superheating SH to a predetermined target value. Specifically, first, the control apparatus 30 calculates a difference ΔSH between the current degree of superheating SH and a target degree of superheating SHm by the following formula (4).
40

$$\Delta SH = SH - SHm \dots (4)$$

[0045] Next, the control apparatus 30 calculates an operation amount ΔC_{Pls} of the opening degree of the cooling expansion valve 14 using the difference ΔSH in the degree of superheating. In the present embodiment, as indicated in the following formula (5), the operation amount ΔC_{Pls} of the opening degree of the cooling expansion valve is calculated based on the difference ΔSH in the degree of superheating through feedback control such as PID control.
50

$$\Delta C_{Pls} = PID(\Delta SH) \dots (5)$$

[0046] Then, the opening degree C_{Pls} of the cooling expansion valve 14 is calculated by the following formula (6).
55

$$C_{Pls} = C_{Pls}(\text{current value}) + \Delta C_{Pls} \dots \quad (6)$$

[0047] In step S5, the control apparatus 30 operates the cooling expansion valve 14 such that the cooling expansion valve 14 has the opening degree C_{Pls} calculated by the formula (6).

[0048] Next, in step S6, the first air temperature sensor Sa1 detects a suction temperature T_a of the indoor air sucked into the indoor unit 3.

[0049] In step S7, the control apparatus 30 calculates an opening degree R_{Pls} of the reheat expansion valve 23 for adjusting the suction temperature T_a to a predetermined target value. Specifically, first, the control apparatus 30 calculates a difference ΔT_a between the current suction temperature T_a and a target suction temperature T_{am} by the following formula (7).

$$\Delta T_a = T_a - T_{am} \dots \quad (7)$$

[0050] Then, an operation amount ΔR_{Pls} of the opening degree of the reheat expansion valve 23 is calculated using the difference ΔT_a in the suction temperature. In the present embodiment, as indicated in the following formula (8), the operation amount ΔR_{Pls} of the opening degree of the reheat expansion valve 23 is calculated based on the difference ΔT_a in the suction temperature through feedback control such as PID control.

$$\Delta R_{Pls} = \text{PID}(\Delta T_a) \dots \quad (8)$$

[0051] Next, the opening degree R_{Pls} of the reheat expansion valve 23 is calculated by the following formula (9).

$$R_{Pls} = R_{Pls}(\text{current value}) - \Delta R_{Pls} \dots \quad (9)$$

[0052] In step S8, the control apparatus 30 compares the opening degree R_{Pls} of the reheat expansion valve 23 calculated in step S7 with a predetermined upper limit value R_{Max} , and determines the smaller value as the opening degree R_{Pls} of the reheat expansion valve 23 to be actually used.

[0053] This predetermined upper limit value R_{Max} is set based on a ratio between the cooling capacity φ_C of the evaporator 15 (see the above formula (1)) and the reheat capacity φ_R of the indoor condenser 22 (see the above formula (2)), the ratio enabling the cooling expansion valve 14 to adjust the degree of superheating. That is, the upper limit value R_{Max} is set such that the following formula (10) is satisfied, where ξ represents the ratio.

$$\xi \cdot \varphi_C = \varphi_R \dots \quad (10)$$

[0054] The ratio ξ is appropriately determined based on, for example, the environment in which the air conditioner 1 is installed and operating conditions of the air conditioner 1. The ratio ξ is a fixed value set in advance for the air conditioner 1, and falls within a range of, for example, $0 < \xi \leq 1$.

[0055] In step S9, the control apparatus 30 controls the opening degree of the reheat expansion valve 23 based on the determined opening degree R_{Pls} .

[0056] The above control of the cooling expansion valve 14 and the reheat expansion valve 23 prevents an excessive increase in the ratio of the circulation amount of refrigerant in the indoor condenser 22 to the circulation amount of refrigerant in the evaporator 15, and enables the cooling expansion valve 14 to control the degree of superheating of the refrigerant that has passed through the evaporator 15.

[0057] In step S7, the operation amount ΔR_{Pls} of the opening degree of the reheat expansion valve 23 is calculated based on the difference ΔT_a between the suction temperature T_a and the target value T_{am} of the suction temperature. Alternatively, the operation amount ΔR_{Pls} may be calculated, through PID control or the like, based on a difference between the refrigerant temperature at the outlet of the indoor condenser 22 detected by the third refrigerant temperature sensor Sb3 and a set temperature of that refrigerant temperature; a difference between the refrigerant temperature at the outlet of the indoor condenser 22 detected by the third refrigerant temperature sensor Sb3 and the temperature of refrigerant flowing through the indoor condenser 22 detected by the fifth refrigerant temperature sensor Sb5; or a difference between the refrigerant temperature at the inlet of the indoor condenser 22 detected by the fourth refrigerant temperature sensor Sb4 and the refrigerant temperature at the outlet of the indoor condenser 22 detected by the third

refrigerant temperature sensor Sb3.

<Applied Control 1>

- 5 **[0058]** In the basic control described above, the upper limit value R_{Max} of the opening degree of the reheat expansion valve 23 is a fixed value. However, if the cooling capacity of the evaporator 15 is lowered in accordance with a decrease in external load such as heat entering from the outside during the operation of the air conditioner 1, the reheat capacity may become relatively too high, making it difficult for the cooling expansion valve 14 to adjust the degree of superheating. Details of this situation will be described below.
- 10 **[0059]** FIG. 4 is an explanatory diagram illustrating the relationship between a cooling capacity and a reheat capacity associated with a change in external load, where (a) corresponds to a comparative example and (b) corresponds to Applied Control 1.
- [0060]** FIG. 4(a) illustrates the relationship among the external load, the cooling capacity of the air conditioner, and the reheat capacity of the air conditioner, in a case where the opening degree of the reheat expansion valve 23 is fixed at a predetermined upper limit value. The external load decreases from the upper stage (I) to the lower stage (III) of the drawing.
- 15 **[0061]** The cooling capacity φ_C and the reheat capacity φ_R represented by the above formulas (1) and (2), respectively, depend largely on the flow rate coefficients CV_C and CV_R of the expansion valves 14 and 23 in a case where the changes in the differential pressures ΔP_C and ΔP_R and the enthalpy differences h_C and h_R are small. Therefore, for example, in order to decrease the cooling capacity φ_C , it is only necessary to decrease the flow rate coefficients CV_C and CV_R of the expansion valves 14 and 23 to decrease the opening degrees of the expansion valves 14 and 23 and decrease the circulation amount of the refrigerant. However, in a case where the opening degree of the reheat expansion valve 23 is fixed (case where the flow rate coefficient CV_R is constant), it is necessary to only decrease the flow rate coefficient CV_C of the cooling expansion valve 14 in order to decrease the cooling capacity φ_C .
- 25 **[0062]** In a case where the external load is large as illustrated in (I) of FIG. 4(a), the circulation amount of the refrigerant flowing through the evaporator 15 is large and the cooling capacity φ_C is high. In contrast, therefore, the circulation amount of the refrigerant flowing through the indoor condenser 22 and the reheat capacity φ_R are relatively small. That is, the ratio of the reheat capacity φ_R of the indoor condenser 22 to the cooling capacity φ_C of the evaporator 15 decreases, making it relatively easy for the cooling expansion valve 14 to adjust the degree of superheating.
- 30 **[0063]** When the opening degree of the reheat expansion valve 23 is fixed, as illustrated in (II), the circulation amount of the refrigerant in the indoor condenser 22 hardly changes even with a decrease in the external load; however, in contrast, the circulation amount of the refrigerant in the evaporator 15 decreases (the flow rate coefficient CV_C decreases). As a result, the ratio of the reheat capacity φ_R to the cooling capacity φ_C gradually increases.
- [0064]** When the cooling capacity further decreases due to a decrease in the external load as illustrated in (III), for example, when the cooling capacity φ_C is halved compared to (I), the ratio of the reheat capacity φ_R to the cooling capacity φ_C is almost doubled. In other words, the ratio of the circulation amount of the refrigerant in the indoor condenser 22 to the circulation amount of the refrigerant in the evaporator 15 becomes about twice that in (I). This makes it very difficult for the cooling expansion valve 14 to adjust the degree of superheating.
- 35 **[0065]** In order to eliminate such inconvenience, in Applied Control 1, the upper limit of the opening degree of the reheat expansion valve 23 is adjusted in accordance with the change in the cooling capacity. Specifically, in the case where the external load gradually decreases from (I) to (III), the reheat capacity φ_R is decreased at a constant ratio with respect to the cooling capacity φ_C as illustrated in FIG. 4(b). More specifically, the circulation amount of the refrigerant flowing through the indoor condenser 22 is decreased at a constant ratio with respect to the circulation amount of the refrigerant flowing through the evaporator 15. For this purpose, the upper limit of the opening degree of the reheat expansion valve 23 is decreased at a predetermined ratio in accordance with the change in the opening degree of the cooling expansion valve 14. This prevents an excessive increase in the ratio of the circulation amount of the refrigerant in the indoor condenser 22 to the circulation amount of the refrigerant in the evaporator 15, and enables the cooling expansion valve 14 to adjust the degree of superheating. This control is exercised by the function of the upper limit adjustment unit 33 in the control apparatus 30, as illustrated in FIG. 2.
- 40 **[0066]** Details of Applied Control 1 will be described below.
- [0067]** FIG. 5 is a flowchart illustrating a procedure of Applied Control 1 of the air conditioner.
- [0068]** Steps S11 to S17, S19, and S20 in FIG. 5 are substantially the same as steps S1 to S9 in FIG. 3, respectively. In Applied Control 1, the upper limit of the opening degree of the reheat expansion valve 23 is changed in accordance with the opening degree of the cooling expansion valve 14 in step S18 in FIG. 5.
- 45 **[0069]** Specifically, as indicated in the following formula (11), the opening degree C_{Pls} of the cooling expansion valve 14 calculated in step S14 is multiplied by a predetermined coefficient ζ and a ratio between maximum flow rate coefficients CV_C and CV_R of the cooling expansion valve 14 and the reheat expansion valve 23 to thereby calculate an upper limit value R_{Max}' of the opening degree of the reheat expansion valve 23.

$$R_{\text{Max}}' = \zeta \cdot CV_c / CV_r \cdot C_{\text{Pls}} \dots \quad (11)$$

[0070] The predetermined coefficient ζ is set based on the above formulas (1), (2), and (10) in consideration of, for example, the ratio ξ between the cooling capacity φ_C and the reheat capacity φ_R , the ratio between the differential pressures ΔP_C and ΔP_R between the high pressure and the low pressure of the refrigerant, the ratio between the enthalpy differences h_C and h_R between the cooling side and the reheat side, and the ratio between the high pressure-side specific gravity ratios G_C and G_R . This coefficient ζ is for converting the opening degree of the cooling expansion valve 14 into the opening degree of the reheat expansion valve 23 within a range in which the cooling expansion valve 14 can adjust the degree of superheating.

[0071] Next, in step S19, the control apparatus 30 compares the opening degree R_{Pls} of the reheat expansion valve 23 calculated in step S17 with the upper limit value R_{Max}' of the opening degree calculated in step S18, and determines the smaller value as the opening degree R_{Pls} of the reheat expansion valve 23 to be actually used. Controlling the opening degree of the reheat expansion valve 23 using the thus determined opening degree R_{Pls} prevents an excessive increase in the ratio of the circulation amount of the refrigerant in the indoor condenser 22 to the circulation amount of the refrigerant in the evaporator 15, and enables the cooling expansion valve 14 to suitably adjust the degree of superheating.

<Modification of Applied Control 1>

[0072] The cooling capacity of the evaporator 15 and the reheat capacity of the indoor condenser are expressed by the above formulas (1) and (2), respectively, but may alternatively be expressed by other methods. For example, as indicated in the following formula (12), the cooling capacity of the evaporator 15 may be expressed by a difference T1 between a temperature t1 detected by the first air temperature sensor Sa1 and a temperature t3 detected by the third air temperature sensor Sa3 (decrement of the temperature lowered by the evaporator 15), and the reheat capacity of the indoor condenser 22 may be expressed by a difference T2 between a temperature t2 detected by the second air temperature sensor Sa2 and the temperature t3 detected by the third air temperature sensor Sa3 (increment of the temperature raised by the indoor condenser 22). Adjusting the upper limit of the opening degree of the reheat expansion valve 23 such that a ratio between the temperature differences T1 and T2 is equal to or less than a predetermined value α makes it possible to adjust the upper limit of the opening degree of the reheat expansion valve 23 in accordance with the change in the cooling capacity.

$$T2/T1 \leq \alpha \dots \quad (12)$$

(where

$$T1 = t1 - t3, T2 = t2 - t3$$

)

[0073] The ratio α between the temperature differences T1 and T2 can be set, for example, within a range of $0 < \alpha \leq 1$, where, for example, $\alpha = 0.3$. In this modification, the upper limit of the opening degree of the reheat expansion valve 23 can be easily adjusted using the detection signals from the air temperature sensors.

<Applied Control 2>

[0074] In the basic control and Applied Control 1 described above, the upper limit of the opening degree of the reheat expansion valve 23 is set, and the circulation amount of the refrigerant flowing through the indoor condenser 22 is considered. In Applied Control 2, in addition, the opening degree of the reheat expansion valve 23 is controlled such that the degree of subcooling at the outlet of the indoor condenser 22 is appropriately secured.

[0075] FIGS. 6 and 7 are flowcharts illustrating a procedure of Applied Control 2 of the air conditioner.

[0076] Steps S21 to S26 in FIG. 6 are substantially the same as steps S1 to S6 in FIG. 3, respectively. The control apparatus 30 calculates the degree of superheating SH based on the evaporator outlet temperature T_{co} and the evaporator intermediate temperature T_{cm} , and operates the cooling expansion valve 14 such that the cooling expansion valve 14 has the opening degree C_{Pls} that results in the target degree of superheating SH. In step S26, the first air temperature sensor Sa1 detects the suction temperature T_a of the indoor air sucked into the indoor unit 3.

[0077] In step S27, the control apparatus 30 acquires the operation amount ΔR_{Pls} of the opening degree of the reheat expansion valve 23 such that the suction temperature T_a is set to a predetermined target value. Specifically, first, the control apparatus 30 calculates the difference ΔT_a between the current suction temperature T_a and the target suction temperature T_{am} by the above formula (7).

[0078] As indicated in the above formula (8), the control apparatus 30 calculates the operation amount ΔR_{Pls} of the opening degree of the reheat expansion valve 23 based on the difference ΔT_a in the suction temperature through feedback control such as PID control.

[0079] Next, in step S28 of FIG. 7, the third refrigerant temperature sensor Sb3 detects a refrigerant temperature T_{rev} , and the first pressure sensor Sc1 detects a refrigerant pressure P_{rev} . In step S29, a degree of subcooling SC at the outlet of the indoor condenser 22 is calculated using these values T_{rev} and P_{rev} . Specifically, first, a saturated liquid temperature T_{sl} is calculated based on the refrigerant pressure P_{rev} at the outlet of the indoor condenser 22 (before reaching the reheat expansion valve 23). Then, the degree of subcooling SC is calculated by the following formula (13) based on the saturated liquid temperature T_{sl} and the refrigerant temperature T_{rev} at the outlet of the indoor condenser 22 (before reaching the reheat expansion valve 23).

$$SC = T_{sl} - T_{rev} \dots (13)$$

[0080] Next, in step S30, the control apparatus 30 determines whether the degree of subcooling SC is larger than a predetermined threshold, in this case "3 degrees".

[0081] In a case where the degree of subcooling SC is larger than 3 degrees, it is considered that the degree of subcooling is sufficiently secured. In this case, in step S31, an adjustment amount dSC_{Pls} of the reheat expansion valve 23 based on the degree of subcooling SC is set to 0, and the processing proceeds to step S34.

[0082] In a case where the degree of subcooling SC is equal to or less than 3 degrees, on the other hand, it is considered that the degree of subcooling is not sufficiently secured. In this case, in step S32, the adjustment amount dSC_{Pls} of the reheat expansion valve 23 is calculated by the following formula (14).

$$dSC_{Pls} = \gamma \cdot \{3 - \max(SC, 0)\} \dots (14)$$

[0083] Here, in a case where the degree of subcooling SC exceeds 0 degrees, the adjustment amount dSC_{Pls} is calculated in such a manner that the degree of subcooling SC is subtracted from the threshold "3 degrees" and the resultant value is multiplied by a predetermined correction coefficient γ . In a case where the degree of subcooling SC is equal to or less than 0 degrees, the adjustment amount dSC_{Pls} is calculated in such a manner that the threshold "3 degrees" is multiplied by the predetermined correction coefficient γ .

[0084] The correction coefficient γ is set in order to secure an appropriate degree of subcooling SC in accordance with the conditions and the installation environment of the air conditioner, for example. For example, the correction coefficient γ is a pulse conversion coefficient used to convert the required degree of subcooling SC into the number of pulses of the motor for the reheat expansion valve 23. This pulse conversion coefficient γ can be calculated as follows.

[0085] As illustrated in FIG. 8, an enthalpy h equivalent to 1 degree of subcooling is given by the following formula (15), where h_{sl} represents an enthalpy at a measurement point of the degree of subcooling SC, h_{sl} represents a saturated liquid enthalpy at the measurement point of the degree of subcooling SC, and h_{ri} represents an enthalpy at the inlet of the indoor condenser 22.

$$h = (h_{sl} - h_{SC})/SC \dots (15)$$

[0086] The ratio of the circulation amounts of the refrigerant at this time is $h/(h_{ri} - h_{SC})$, and the pulse conversion coefficient γ required to change the degree of subcooling SC by 1 degree is given by the following formula (16).

$$\gamma = Cv' \times h/(h_{ri} - h_{SC})/Cv \times MaxPls \dots (16)$$

where Cv' represents a flow rate coefficient with respect to the current opening degree of the reheat expansion valve 23, Cv represents a flow rate coefficient when the reheat expansion valve 23 is fully opened (so-called CV value), and $MaxPls$ represents the number of pulses when the reheat expansion valve 23 is fully opened.

[0087] Next, in step S33, the control apparatus 30 compares the operation amount ΔR_{Pls} of the opening degree of the

reheat expansion valve 23 calculated in step S27 with 0, and determines the larger value as the operation amount ΔR_{Pls} to be actually used.

[0088] The operation amount ΔR_{Pls} of the opening degree of the reheat expansion valve 23 calculated in step S27 is a positive value ($\Delta R_{Pls} > 0$) in a case where the suction temperature T_a is higher than the target suction temperature T_{am} ($T_a > T_{am}$), and is conversely a negative value ($\Delta R_{Pls} < 0$) in a case where the suction temperature T_a is lower than the target suction temperature T_{am} ($T_a < T_{am}$). Therefore, when ΔR_{Pls} is a positive value, the reheat expansion valve 23 is to be closed in order to decrease the reheat capacity, whereas when ΔR_{Pls} is a negative value, the reheat expansion valve 23 is to be opened since a higher reheat capacity is needed. In Applied Control 2, however, priority is given to securing the degree of subcooling SC. Therefore, step S33 excludes the operation of opening the reheat expansion valve 23; the reheat expansion valve 23 is either not operated or is to be closed.

[0089] Next, in step S34, the adjustment amount dSC_{Pls} calculated in step S31 or S32 is added to the operation amount ΔR_{Pls} of the opening degree of the reheat expansion valve 23 calculated in step S33, whereby the operation amount ΔR_{Pls} to be actually used is obtained. Then, a value obtained by subtracting the operation amount ΔR_{Pls} from the current opening degree R_{Pls} of the reheat expansion valve 23 is compared with the predetermined upper limit value R_{Max} , and the smaller value is determined as the actual opening degree R_{Pls} of the reheat expansion valve 23. In step S35, the control apparatus 30 operates the reheat expansion valve 23.

[0090] In this Applied Control 2, in a case where the degree of subcooling SC is smaller than a predetermined threshold (for example, "3 degrees"), the reheat expansion valve 23 is operated in a direction of sufficiently securing the degree of subcooling SC. This can eliminate the inconvenience due to an insufficient degree of subcooling SC. The inconvenience mentioned here includes the following. That is, gas-liquid two-phase refrigerant flows into the reheat expansion valve 23 and the circulation amount of the refrigerant in the indoor condenser 22 suddenly decreases, making superheating control difficult, and the outdoor unit 2 enters thermo-off and the dehumidifying capacity is lowered. Conversely, when the gas-liquid two-phase state is resolved, the circulation amount of the refrigerant is recovered rapidly, and the dryness of the refrigerant at the outlet of the evaporator 15 suddenly decreases, making it difficult to protect the compressor.

[0091] The degree of subcooling SC at the outlet of the indoor condenser 22 can be calculated in such a manner that the temperatures at the outlet of and inside the indoor condenser 22 are detected by the refrigerant temperature sensors Sb3 and Sb5, respectively, and the temperature inside the indoor condenser 22 is subtracted from the temperature at the outlet of the indoor condenser 22. Alternatively, the degree of subcooling SC may be calculated in such a manner that the discharge pressure of the compressor 12 is corrected by a pipe pressure loss.

[Second embodiment]

[0092] FIG. 9 is a schematic configuration diagram of an air conditioner according to a second embodiment of the present invention.

[0093] This air conditioner (refrigeration apparatus) 1 includes an outdoor unit (heat source-side unit) 2 and an indoor unit (utilization-side unit) 3, as illustrated in FIG. 9. In a cooling circuit 10, a receiver 18 and a cooling electromagnetic valve 25 are provided between an outdoor condenser (heat source-side heat exchanger) 13 of the outdoor unit 2 and a cooling expansion valve 14 of the indoor unit 3. The receiver 18 is provided in the outdoor unit 2, while the cooling electromagnetic valve 25 is provided in the indoor unit 3.

[0094] A path 11a serving as a heat source-side gas pipe is connected between a discharge side of a compressor 12 and a gas-side end of the outdoor condenser (heat source-side heat exchanger) 13. One end of a pressure adjustment passage 19 that adjusts a pressure inside the receiver 18 is connected to the path 11a. The other end of the pressure adjustment passage 19 is connected to a container of the receiver 18 at an upper side of the container. The pressure adjustment passage 19 is provided with a pressure adjustment electromagnetic valve 27. Opening and closing the pressure adjustment electromagnetic valve 27 at a predetermined timing (repeatedly opening and closing the valve) makes it possible to change the amount of discharge gas (high-pressure gas) to be introduced from the compressor 12 into the receiver 18, thereby adjusting the pressure inside the receiver 18. A lower end of the receiver 18 is connected to the cooling electromagnetic valve 25 of the indoor unit 3 through a refrigerant pipe.

[0095] In a reheat path 21, a reheat electromagnetic valve (first reheat on-off valve) 26 is provided in a reheat refrigerant pipe 45 on a refrigerant inflow side of an indoor condenser (reheat heat exchanger) 22. A reheat bypass pipe 46 that bypasses the first reheat on-off valve 26 is connected to the reheat refrigerant pipe 45. A second reheat on-off valve 28 having a smaller diameter than the first reheat on-off valve 26 is connected to the reheat bypass pipe 46.

[0096] The indoor unit 3 is further provided with a suction air humidity sensor Sd1 that measures the humidity of air sucked into the evaporator 15.

[0097] The control apparatus 30 can control operations in a reheat dehumidification mode and, additionally, in a cooling mode. In the reheat dehumidification mode, air that has been cooled and dehumidified by the evaporator 15 as described in the first embodiment is heated by the indoor condenser 22. In the cooling mode, the air that has been cooled and dehumidified by the evaporator 15 just passes through the indoor condenser 22. For example, the control apparatus 30

is configured to, during the operation in the cooling mode, also control the operation in the reheat dehumidification mode in which the air that has been cooled by the utilization-side heat exchanger 15 serving as the evaporator is heated by the indoor condenser (reheat heat exchanger) 22.

[0098] Specifically, the control apparatus 30 performs the operation in the reheat dehumidification mode when the temperature of air sucked into the evaporator 15 is within a range of a target temperature (for example, within a range of 13°C to 17°C) and the relative humidity of the sucked air is equal to or higher than a target humidity (for example, 45%). Meanwhile, the control apparatus 30 performs the operation in the cooling mode when the temperature of the air sucked into the evaporator is higher than the target temperature, or when the temperature of the sucked air is within the range of the target temperature (for example, within the range of 13°C to 17°C) and the relative humidity of the sucked air is lower than the target humidity.

<Operation>

[0099] During the operation of the air conditioner (refrigeration apparatus) 1 of the present embodiment, the control apparatus 30 controls switching between the cooling mode and the reheat dehumidification mode.

[0100] For example, at the time of starting the air conditioner 1, it is necessary to cool the interior of, for example, a meat storage into which meat is to be brought. In this case, therefore, the operation in the cooling mode among an area indicated as a cooling and reheat mode in FIG. 10 (cooling pull-down for rapidly cooling the interior of the meat storage) is performed. While the interior temperature is in the range of 13°C to 17°C, the operation is performed while being switched between the cooling mode and the reheat dehumidification mode.

[0101] Specifically, the control apparatus 30 performs the operation in the reheat dehumidification mode when the temperature of the air sucked into the evaporator 15 (interior air temperature) is within the target temperature range of 13°C to 17°C and the relative humidity of the sucked air is equal to or higher than the target humidity (45% RH). Meanwhile, the control apparatus 30 performs the operation in the cooling mode when the temperature of the air sucked into the evaporator 15 is higher than the target temperature (17°C), or when the temperature of the sucked air is within the target temperature range of 13°C to 17°C and the relative humidity of the sucked air is lower than the target humidity (45% RH).

[0102] Note that, as illustrated in FIG. 10, the air conditioner of the present embodiment is also configured to operate in a refrigeration mode and in a freezer mode. The refrigeration mode is performed when the set temperature is 0°C (the interior temperature is approximately 10°C to -5°C). The freezer mode is performed when the set temperature is -20°C (the interior temperature is lower than -5°C).

(Switching of operating mode)

[0103] Next, the operation of switching the operating modes described above will be described more specifically based on the flowchart of FIG. 11.

[0104] In step S41, it is determined whether the air conditioner 1 is in operation. In a case where the determination result is "YES", i.e., the air conditioner 1 is in operation, the processing proceeds to step S42 where it is determined whether the temperature of the air sucked into the evaporator 15 is 17°C or higher. In a case where the determination result of step S41 is "NO", i.e., the air conditioner 1 is not in operation, on the other hand, the processing proceeds to step S43 to stop the processing, and then returns to step S41.

[0105] In a case where the determination result of step S42 is "YES", i.e., the temperature of the sucked air is 17°C or higher, the processing proceeds to step S44 where the air conditioner enters thermo-on and operates in the cooling mode. During the operation in the cooling mode, the determination in step S41 is constantly performed.

[0106] In a case where the determination result of step S42 is "NO", i.e., the temperature of the sucked air is lower than 17°C, the processing proceeds to step S45 where it is determined whether the temperature of the sucked air is 13°C or lower. The determination result of "NO" in this step corresponds to a case where the temperature of the sucked air is lower than 17°C and higher than 13°C. In this case, it is determined in step S46 whether the relative humidity RH is 45% or higher. In a case where the determination result is "NO", the relative humidity RH is lower than 45%, which means that the humidity is not high. In this case, the processing proceeds to step S44, the operation in the cooling mode is performed, and then the processing returns to the determination of step S41.

[0107] In a case where the determination result of step S45 as to whether the temperature of the sucked air is 13°C or lower is "YES", the interior of the storage is sufficiently cooled. In this case, the processing proceeds to step S47 where the air conditioner enters thermo-off and operates in a fan-only mode in the storage. Even in the fan-only mode, the determination of step S41 is constantly performed as in the cooling mode.

[0108] In a case where the determination result of step S45 as to whether the relative humidity RH is 45% or higher is "YES", the humidity in the storage is lower than 17°C and higher than 13°C (within the predetermined range of the present invention) but the humidity is high. In this case, the processing proceeds to step S48 where the operating mode is switched to the reheat dehumidification mode, in which the dehumidification is performed while the temperature is

maintained. Even in the reheat dehumidification mode, the determination of step S41 is constantly performed as in the cooling mode.

<State of refrigerant circuit components in each operating mode>

[0109] Next, the operation in each mode will be described. In the respective modes, various valves, fans, and the compressor are controlled to have the states indicated in FIG. 12. In FIG. 12, a "unit cooler" represents the indoor unit (utilization-side unit) 3, and a refrigerator represents the outdoor unit (heat source-side unit) 2. "SV1" represents the cooling electromagnetic valve 25, "SV2" represents the reheat electromagnetic valve 26, "EV1" represents the cooling expansion valve 14, "EV2" represents the reheat expansion valve 23, and "MF1" represents the indoor fan (utilization-side fan) 17. "MF2" represents the outdoor fan (heat source-side fan) 16, "MC" represents the compressor 12, and "SV4" represents the pressure adjustment electromagnetic valve 27.

(Cooling mode)

[0110] During the operation in the cooling mode (thermo-on), the cooling electromagnetic valve 25 is "opened", the reheat electromagnetic valve 26 is "closed", the cooling expansion valve 14 is controlling the degree of superheating (the opening degree of the cooling expansion valve 14 is controlled such that the degree of superheating of the refrigerant at the outlet of the evaporator 15 becomes a target value), the reheat expansion valve 23 is "closed (fully closed)", the indoor fan 17 has a high air volume (H air volume), the outdoor fan 16 and the pressure adjustment electromagnetic valve 27 are controlled based on a target high pressure (high pressure control), and the frequency of the compressor 12 is controlled by the inverter control such that the compressor 12 has a target operating capacity.

[0111] In this state, the refrigerant discharged from the compressor 12 flows into the outdoor condenser 13 where heat is dissipated from the refrigerant. At this time, in a case where the pressure of the refrigerant flowing out of the outdoor condenser 13 cannot be controlled to a target pressure, opening and closing of the pressure adjustment electromagnetic valve 27 are controlled. Specifically, when a low pressure of the refrigerant circuit is lower than a predetermined value, the pressure adjustment electromagnetic valve 27 is opened to introduce high-pressure refrigerant into the receiver 18, and the pressure of the high-pressure liquid refrigerant flowing through a liquid-side connection pipe that connects the receiver 18 to the indoor unit 3 is adjusted.

[0112] In the indoor unit 3, the high-pressure liquid refrigerant passes through the cooling electromagnetic valve 25, is decompressed by the cooling expansion valve 14, and is evaporated at the evaporator 15 by absorbing heat from the air inside the storage. At this time, the air inside the storage is cooled in the evaporator 15. The evaporated refrigerant returns to the outdoor unit 2 and is sucked into the compressor 12.

[0113] The operation in the cooling mode (thermo-on) is performed with the refrigerant circulating through the refrigerant circuit as described above.

[0114] During the operation in the cooling mode (thermo-off), the indoor fan 17 rotates with a high air volume, while various valves and the compressor 12 are stopped, and air is only blown in the storage.

(Reheat dehumidification mode)

[0115] In the reheat dehumidification mode, the control of, for example, various valves is partially different from that in the cooling mode. Specifically, the reheat electromagnetic valve 26 is controlled to be "opened", the reheat expansion valve 23 is controlled based on the temperature of sucked air, and the indoor fan 17 has a low air volume (L air volume).

[0116] In this state, the refrigerant discharged from the compressor 12 circulates through the refrigerant circuit using the heat source-side heat exchanger 13 and the reheat heat exchanger 22 as radiators (condensers) and the utilization-side heat exchanger 15 as an evaporator. In the indoor unit 3, the interior (indoor) air is cooled and dehumidified by the evaporator 15 and then heated by the indoor condenser 22, and therefore, the humidity decreases while a decrease in the interior temperature is suppressed.

[0117] When starting the operation in the reheat dehumidification mode, the control apparatus 30 is configured to perform a liquid refrigerant removal operation in which the control apparatus 30 opens the reheat expansion valve 23 with the reheat electromagnetic valve (first reheat on-off valve) 26 closed, then opens the second reheat on-off valve 28 after a predetermined time (for example, five seconds), and then opens the first reheat on-off valve 26 after a predetermined time (for example, five minutes).

[0118] When ending the operation in the reheat dehumidification mode, the control apparatus 30 closes the first reheat on-off valve 26 and the second reheat on-off valve 28, and then closes the reheat expansion valve 23 after a predetermined time (for example, four minutes). As described above, the on-off valves 26 and 28 having different diameters (one larger than the other) are provided in parallel on the refrigerant inflow side of the indoor condenser (reheat heat exchanger) 22 and, when the operation in the reheat dehumidification mode is performed, the on-off valve 28 having a smaller

diameter is opened first, and then the on-off valve 26 having a larger diameter is opened a predetermined time after the on-off valve 28. The reason for this configuration is as follows. The on-off valve 26 is closed during the cooling operation; therefore, in a case where the refrigerant flowing into the reheat refrigerant pipe 45 accumulates and liquefies, if the on-off valve 26 is immediately opened at the time of starting the reheat dehumidification mode, the liquid refrigerant rushes

into the reheat expansion valve 23. This makes it difficult to properly handle the refrigerant at the reheat expansion valve 23, the opening degree of which is controlled to give priority to the degree of subcooling, whereby the pipe may vibrate.

[0119] The operation in the reheat dehumidification mode will be specifically described with reference to the time chart of FIG. 13.

[0120] When the operation in the reheat dehumidification mode is started at time T1, the reheat expansion valve 23 (indicated as EV2 in FIG. 13) is opened at that time. At this time, the first reheat on-off valve 26 (indicated as SV2 in FIG. 13) and the second reheat on-off valve 28 (indicated as SV5 in FIG. 13) remain closed.

[0121] When t1 seconds (for example, five seconds) elapse from the time T1 and time T2 is reached, the second reheat on-off valve 28 is opened with the first reheat on-off valve 26 still closed. Since the second reheat on-off valve 28 has a smaller diameter than the first reheat on-off valve 26, the liquid refrigerant accumulated in the reheat refrigerant pipe 45 during the cooling operation passes through the indoor condenser 22 and then through the reheat expansion valve 23 little by little. During the operation in the reheat dehumidification mode, the opening degree of the reheat expansion valve 23 is adjusted such that priority is given to the degree of subcooling of the refrigerant on the outlet side of the indoor condenser 22, and thus the opening degree may be set small. In the present embodiment, however, the second reheat on-off valve 28 has a small diameter, and the flow rate of the refrigerant flowing to the reheat expansion valve 23 is limited. This prevents the liquid refrigerant from rushing through the reheat expansion valve 23, and thus the vibration of the pipe is suppressed.

[0122] When the operation in this state continues for t2 seconds (for example, 300 seconds (five minutes)) and time T3 is reached, it is determined that the liquid refrigerant accumulated in the reheat refrigerant pipe 45 has passed through the reheat expansion valve 23, and the second reheat on-off valve 28 is switched on (open). After that, the following operation is performed for t3 seconds until time T4. That is, while the opening degree of the reheat expansion valve 23 is controlled, the interior air that has been cooled and dehumidified by the evaporator 15 is heated by the indoor condenser 22, and the humidity inside the storage is lowered while the temperature drop inside the storage is suppressed.

[0123] When the operation in the reheat dehumidification mode ends at the time T4, the first reheat on-off valve 26 and the second reheat on-off valve 28 are closed, and for subsequent t4 seconds (for example, 240 seconds (four minutes)), the reheat expansion valve 23 is opened; in this way, the liquid refrigerant in the indoor condenser 22 is evaporated by the evaporator 15 and returned to the compressor 12.

<Effect of second embodiment>

[0124] According to the present embodiment, when the temperature of the air sucked into the evaporator 15 is within the target temperature range (13°C to 17°C) and the relative humidity of the sucked air is equal to or higher than the target humidity (45% RH), the humidity is relatively high with respect to the interior temperature. Therefore, the operation in the reheat dehumidification mode is performed in order to lower the humidity without lowering the temperature. On the other hand, when the temperature of the air sucked into the evaporator 15 is higher than the target temperature, or when the temperature of the air sucked into the evaporator 15 is within the target temperature range (13°C to 17°C) and the relative humidity of the sucked air is lower than the target humidity, the operation in the cooling mode is performed in order to lower the temperature in preference to the humidity. The reheat dehumidification mode or the cooling mode is selected in accordance with the state of the sucked air as described above. This makes it possible to control the humidity and temperature of the space inside the storage to appropriate values.

[0125] According to the present embodiment, it is possible to suppress the liquid refrigerant rushing into the reheat expansion valve 23 at the time of starting the operation in the reheat dehumidification mode, and therefore, noise generated from the vibrating pipe can be suppressed. In FIG. 13 of the present embodiment, for example, the time indicated as t1 to t4 may be appropriately changed in accordance with the lengths of the reheat refrigerant pipe 45 and the pipe constituting the reheat path 21. In addition, for example, the diameter of the second reheat on-off valve 28 may be appropriately determined, as long as the diameter is smaller than that of the first reheat on-off valve 26, in accordance with the amount of liquid refrigerant that is expected to accumulate in the reheat refrigerant pipe 45 during the cooling operation.

[0126] The present invention is not limited to the above-described embodiments and modification, but can be variously modified within the scope described in the claims.

[0127] For example, the air conditioner of the present invention is not limited to use in a meat factory, but can be used in any environment.

[0128] In the above embodiments, the control apparatus 30 performs the operation in the reheat dehumidification mode when the temperature of the air sucked into the evaporator 15 is within the target temperature range (13°C to

17°C) and the relative humidity of the sucked air is equal to or higher than the target humidity (45% RH). Meanwhile, the control apparatus 30 performs the operation in the cooling mode when the temperature of the air sucked into the evaporator (17) is higher than the target temperature, or when the temperature of the sucked air is within the target temperature range (13°C to 17°C) and the relative humidity of the sucked air is lower than the target humidity. However, the present invention is not limited to this configuration and, even under the control based on this configuration, the target temperature and the target humidity described above can appropriately be changed.

REFERENCE SIGNS LIST

[0129]

- 1: AIR CONDITIONER
- 11: COOLING CIRCUIT
- 11a: PATH
- 11b: PATH
- 12: COMPRESSOR
- 13: OUTDOOR CONDENSER
- 14: COOLING EXPANSION VALVE
- 15: EVAPORATOR
- 21: REHEAT PATH
- 22: INDOOR CONDENSER
- 23: REHEAT EXPANSION VALVE
- 30: CONTROL APPARATUS
- 31: COOLING CONTROL UNIT
- 32: REHEAT CONTROL UNIT
- 33: UPPER LIMIT ADJUSTMENT UNIT

Claims

1. An air conditioner comprising:

a compressor (12);
 an outdoor condenser (13) that condenses refrigerant compressed by the compressor (12);
 a cooling expansion valve (14) that decompresses the refrigerant condensed by the outdoor condenser (13);
 an evaporator (15) that evaporates the refrigerant decompressed by the cooling expansion valve (14) by exchanging heat with indoor air, and cools and dehumidifies the indoor air;
 a cooling circuit (11) connecting the compressor (12), the outdoor condenser (13), the cooling expansion valve (14), and the evaporator (15) in that order;
 a reheat path (21) that branches from a path (11a) connecting the compressor (12) and the outdoor condenser (13) in the cooling circuit (11), and is connected to a path (11b) connecting the cooling expansion valve (14) and the evaporator (15);
 an indoor condenser (22) that condenses, in the reheat path (21), the refrigerant compressed by the compressor (12) by exchanging heat with the indoor air cooled and dehumidified by the evaporator (15), and heats the indoor air;
 a reheat expansion valve (23) that decompresses, in the reheat path (21), the refrigerant condensed by the indoor condenser (22); and
 a control apparatus (30) that controls opening degrees of the cooling expansion valve (14) and the reheat expansion valve,
 wherein the control apparatus (30) includes:

a cooling control unit (31) that adjusts a degree of superheating of the refrigerant that has passed through the evaporator (15) by adjusting a circulation amount of the refrigerant in the evaporator (15) through control of the opening degree of the cooling expansion valve (14); and
 a reheat control unit (32) that adjusts a room temperature by adjusting a circulation amount of the refrigerant in the indoor condenser (22) through control of the opening degree of the reheat expansion valve (23), and

an upper limit of the opening degree of the reheat expansion valve (23) controlled by the reheat control unit

(32) is set based on a ratio between a cooling capacity of the evaporator (15) and a reheat capacity of the indoor condenser (22), the ratio enabling the cooling expansion valve (14) to adjust the degree of superheating.

2. The air conditioner according to claim 1,
wherein the control apparatus (30) further includes an upper limit adjustment unit (33) that adjusts the upper limit of the opening degree of the reheat expansion valve (23) in accordance with a change in the cooling capacity of the evaporator (15) during operation.
3. The air conditioner according to claim 2,
wherein the upper limit of the opening degree of the reheat expansion valve (23) is adjusted based on a ratio between a circulation amount of the refrigerant flowing through the cooling expansion valve (14) and a circulation amount of the refrigerant flowing through the reheat expansion valve (23).
4. The air conditioner according to claim 2,
wherein the upper limit of the opening degree of the reheat expansion valve (23) is adjusted based on a ratio between an air temperature difference before and after air passes through the evaporator (15) and an air temperature difference before and after the air passes through the indoor condenser (22).
5. The air conditioner according to any one of claims 1 to 4,
wherein the reheat control unit (32) corrects an amount of controlling the opening degree of the reheat expansion valve (23) in accordance with a degree of subcooling of the refrigerant at an outlet of the indoor condenser (22), and adjusts the degree of subcooling.
6. The air conditioner according to any one of claims 1 to 5,
wherein the control apparatus (30) is configured to further control an operation in a reheat dehumidification mode in which the air cooled and dehumidified by the evaporator (15) is heated by the indoor condenser (22), control an operation in a cooling mode in which the air cooled and dehumidified by the evaporator (15) just passes through the indoor condenser (22), perform the operation in the reheat dehumidification mode when a temperature of air sucked into the evaporator (15) is within a range of a target temperature and a relative humidity of the sucked air is equal to or higher than a target humidity, and perform the operation in the cooling mode when the temperature of the air sucked into the evaporator (15) is higher than the target temperature, or when the temperature of the sucked air is within the range of the target temperature and the relative humidity of the sucked air is lower than the target humidity.
7. The air conditioner according to claim 6,
wherein a first reheat on-off valve (26) is connected to a reheat refrigerant pipe (45) on a refrigerant inflow side of the indoor condenser (22) during the operation in the reheat dehumidification mode, and the reheat expansion valve (23) is connected to a refrigerant outflow side of the indoor condenser (22), and
a reheat bypass pipe (46) that bypasses the first reheat on-off valve (26) is connected to the reheat refrigerant pipe (45), and a second reheat on-off valve (28) having a smaller diameter than the first reheat on-off valve (26) is connected to the reheat bypass pipe (46).
8. The air conditioner according to claim 7,
wherein when starting the operation in the reheat dehumidification mode, the control apparatus (30) is configured to perform a liquid refrigerant removal operation in which the control apparatus (30) opens the reheat expansion valve (23) with the first reheat on-off valve (26) closed, then opens the second reheat on-off valve (28) after a predetermined time, and then opens the first reheat on-off valve (26) after a predetermined time.
9. The air conditioner according to claim 8,
wherein when ending the operation in the reheat dehumidification mode, the control apparatus (30) is configured to close the first reheat on-off valve (26) and the second reheat on-off valve (28), and then close the reheat expansion valve (23) after a predetermined time.

FIG. 1

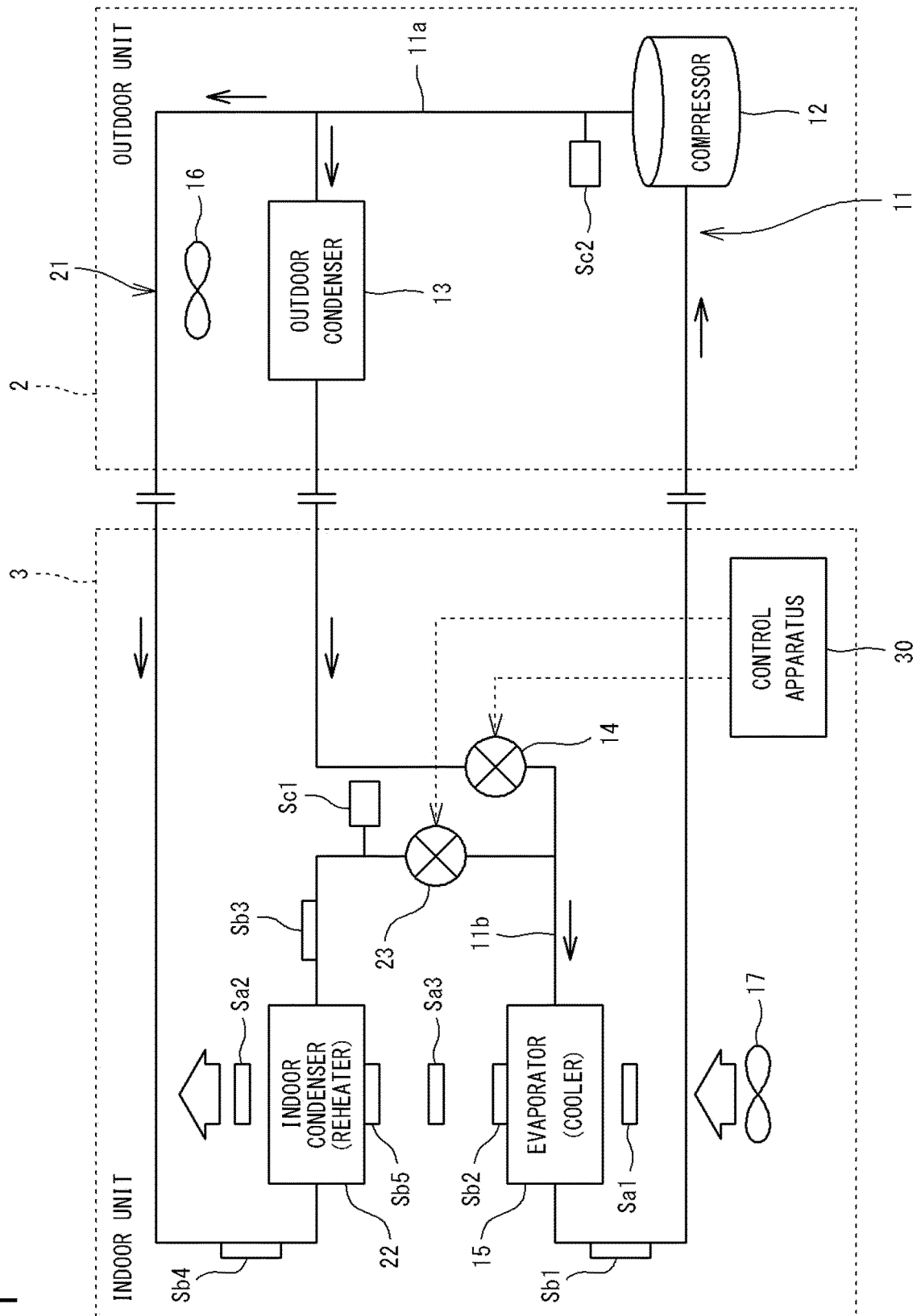


FIG. 2

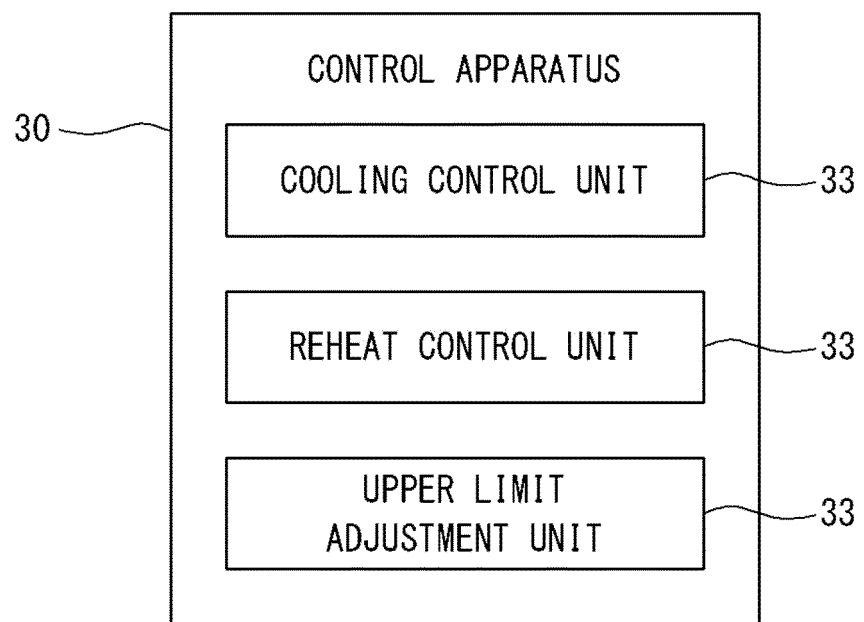


FIG. 3

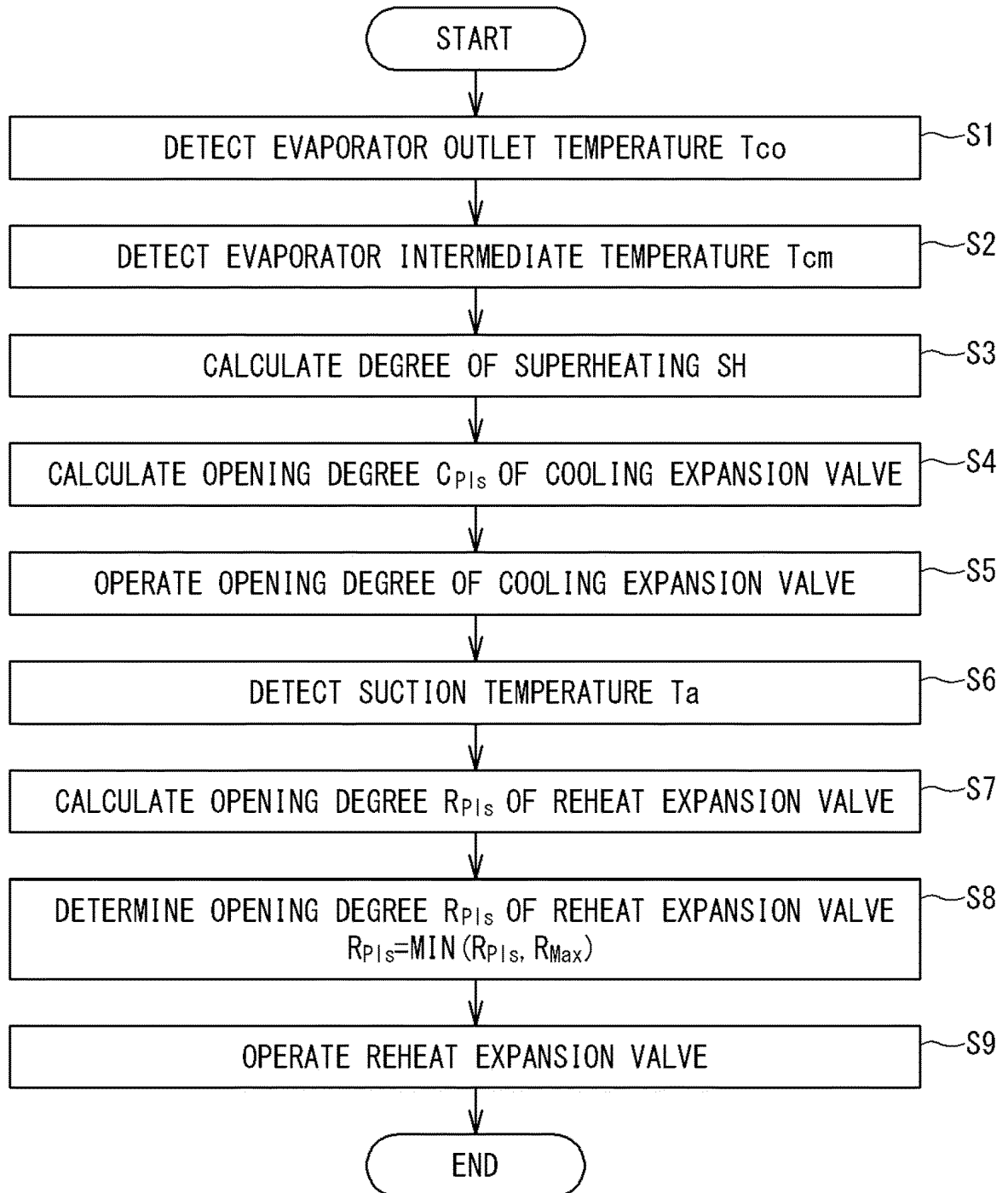


FIG. 4

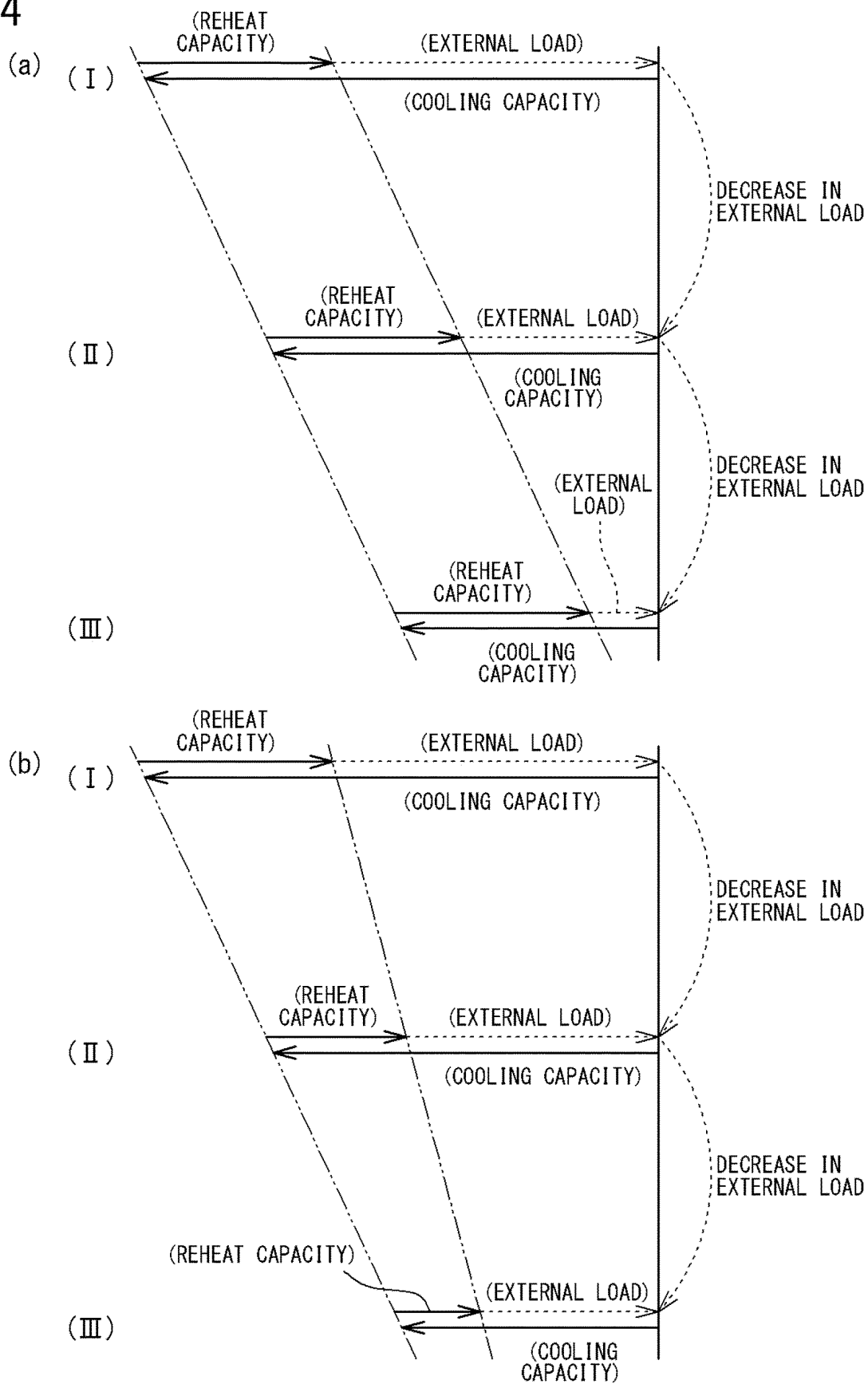


FIG. 5

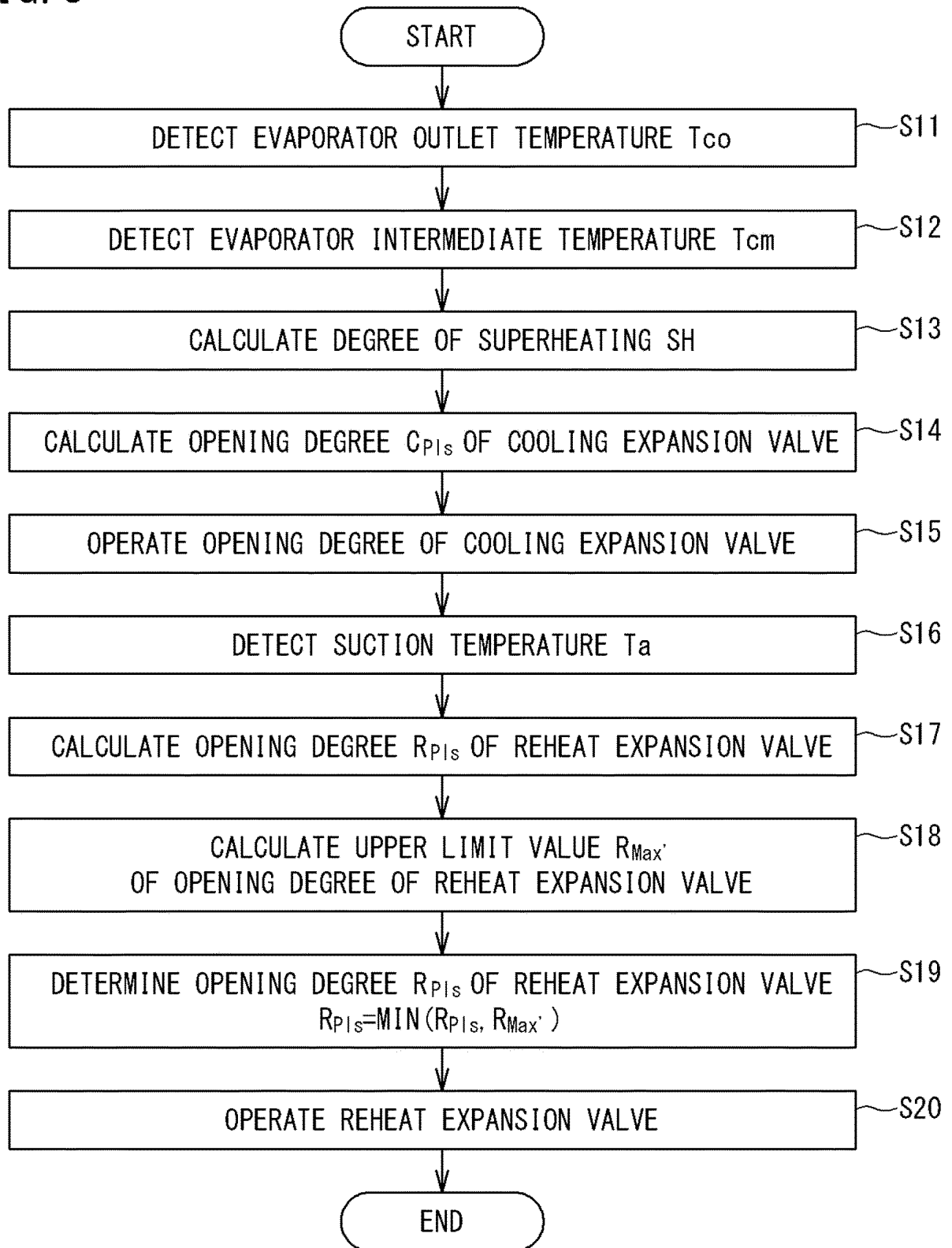


FIG. 6

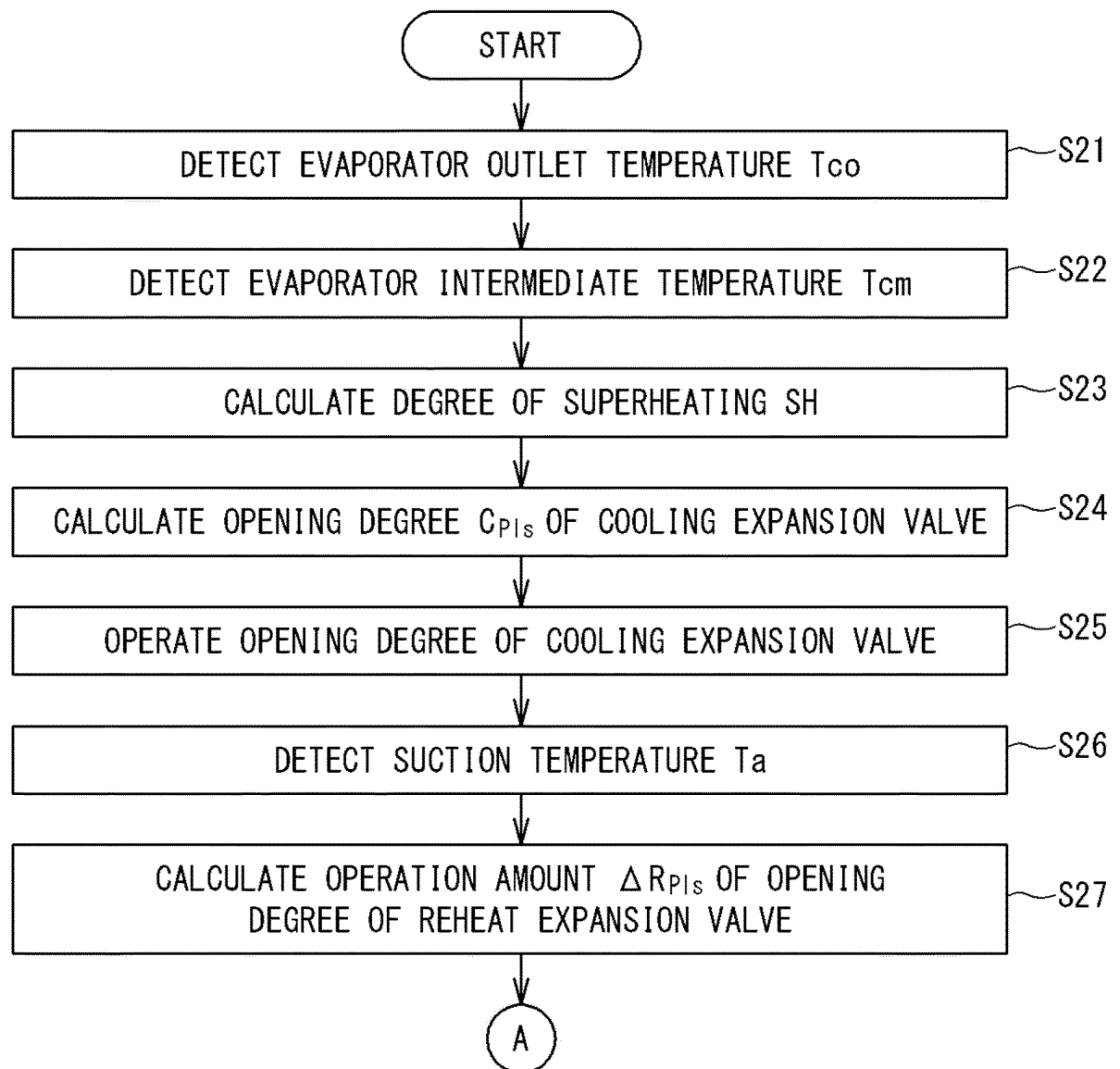


FIG. 7

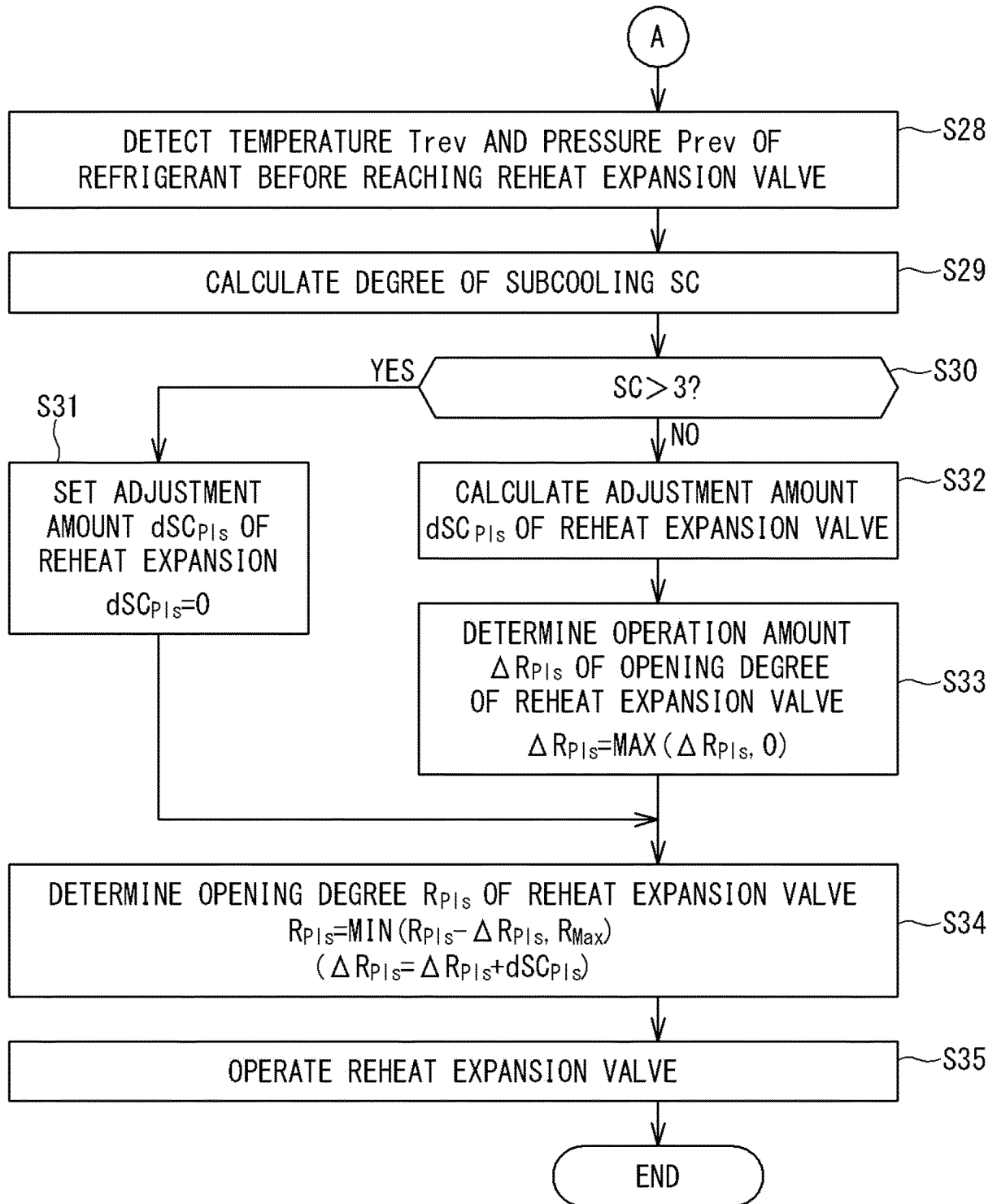


FIG. 8

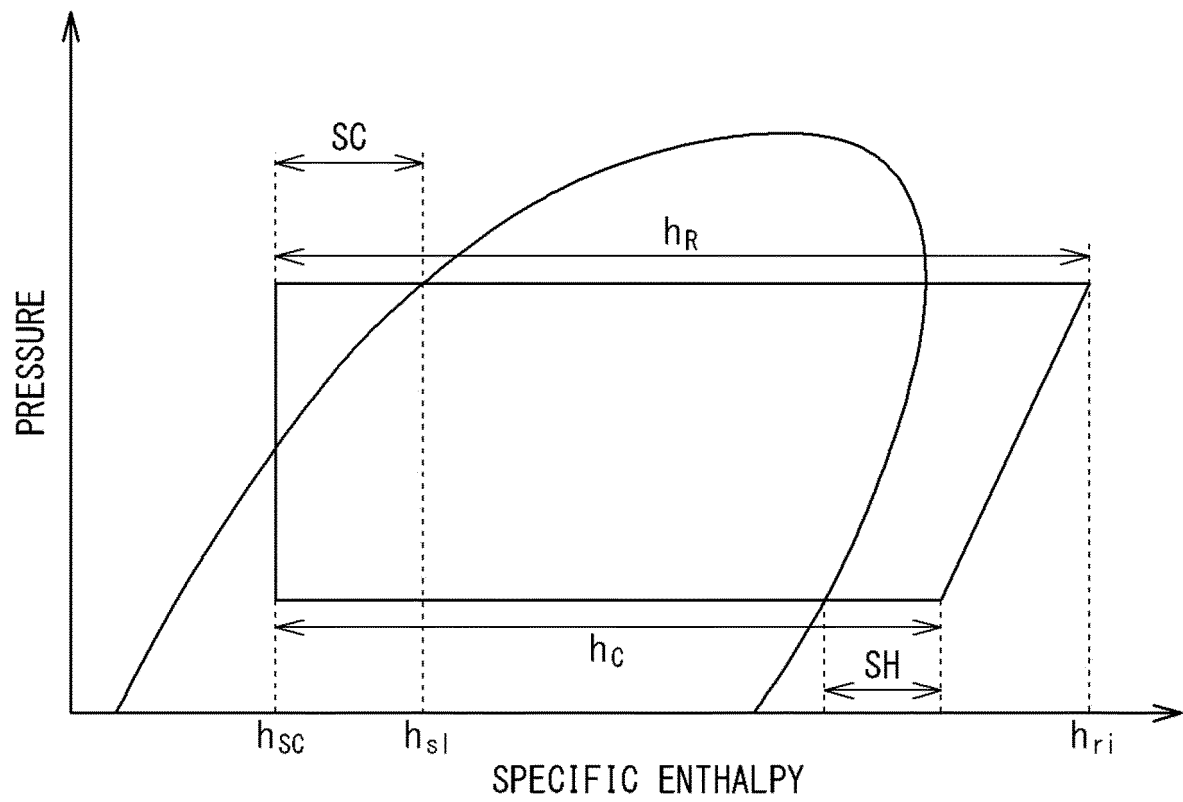


FIG. 9

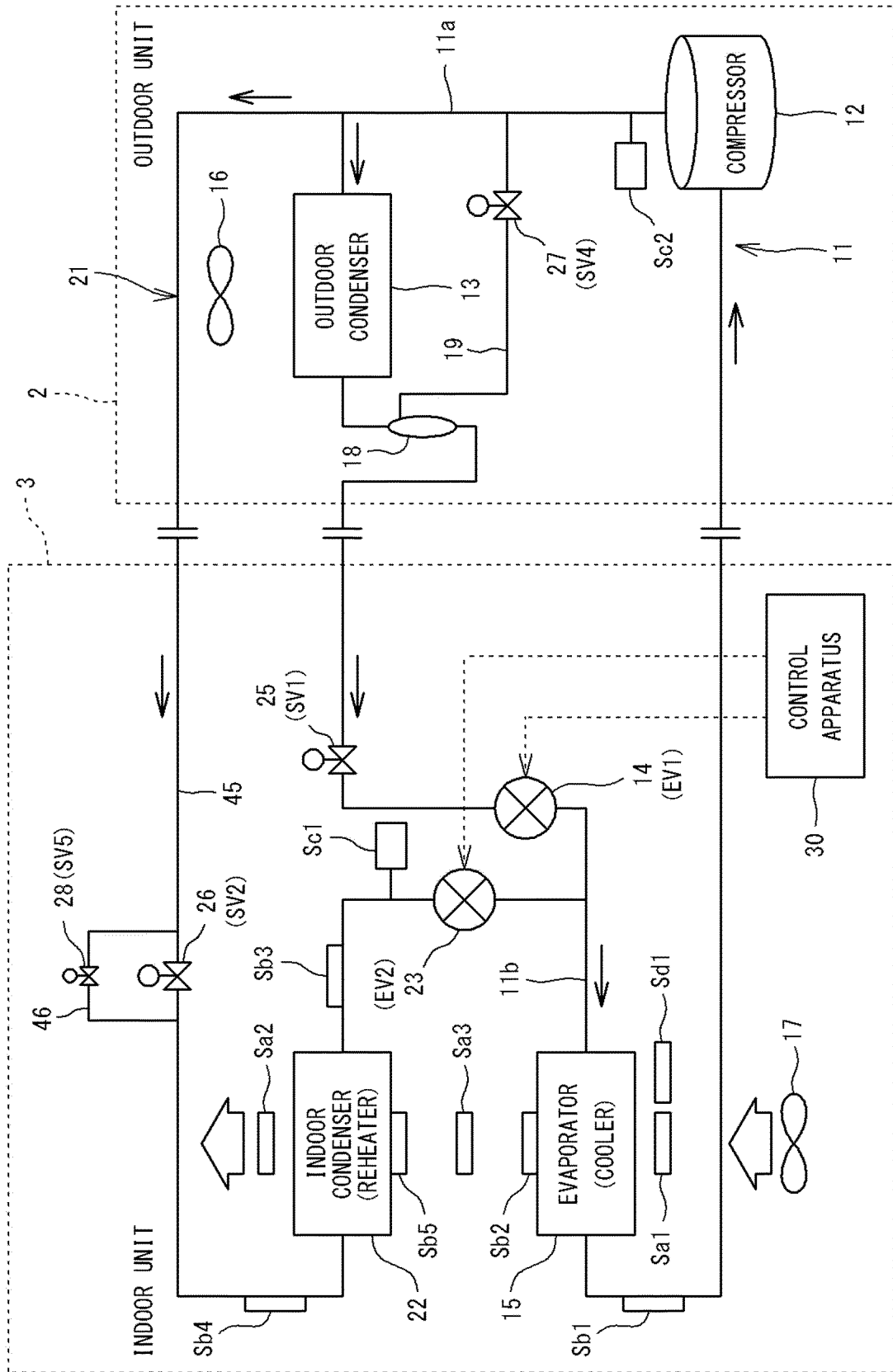


FIG. 10

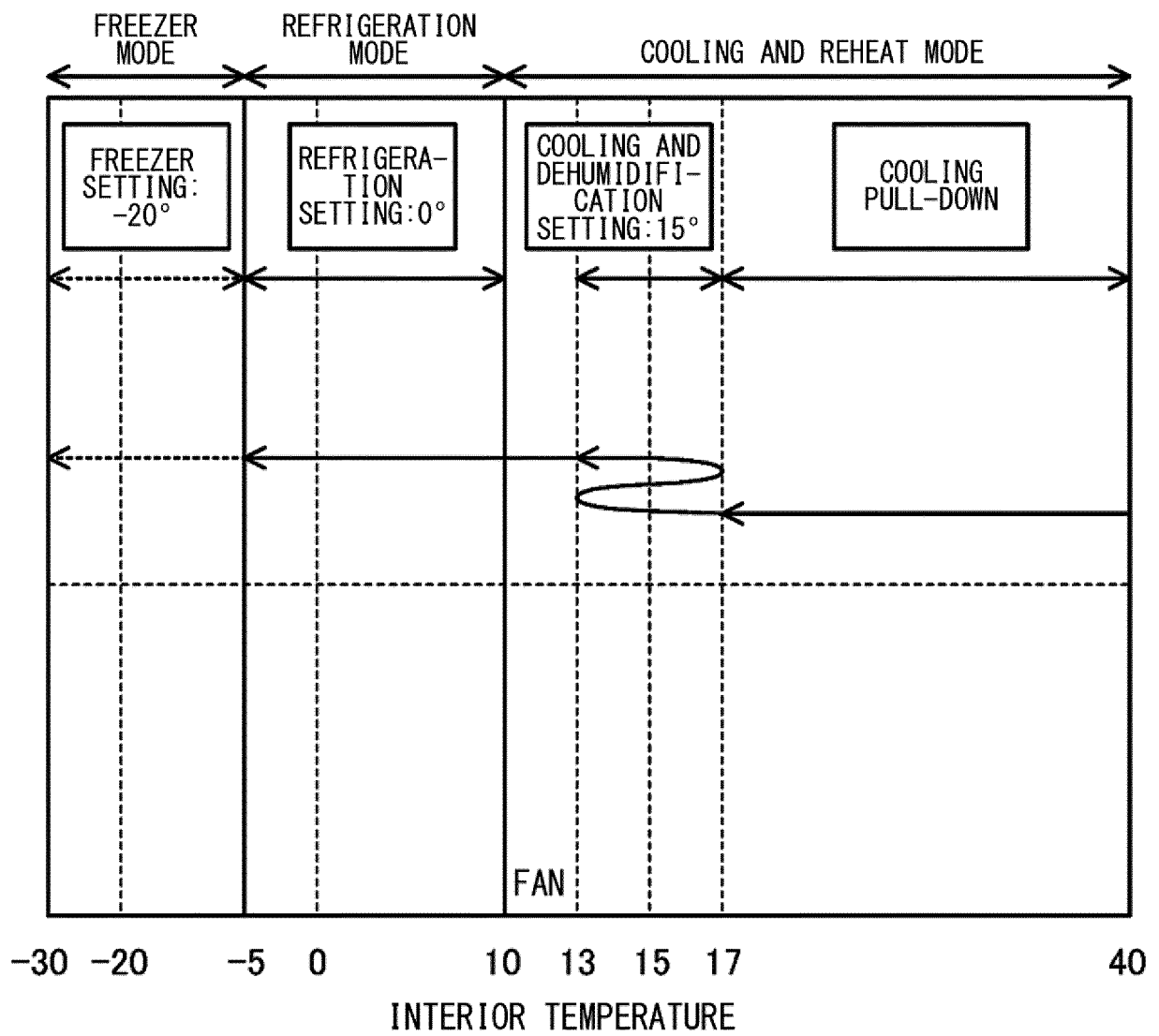


FIG. 11

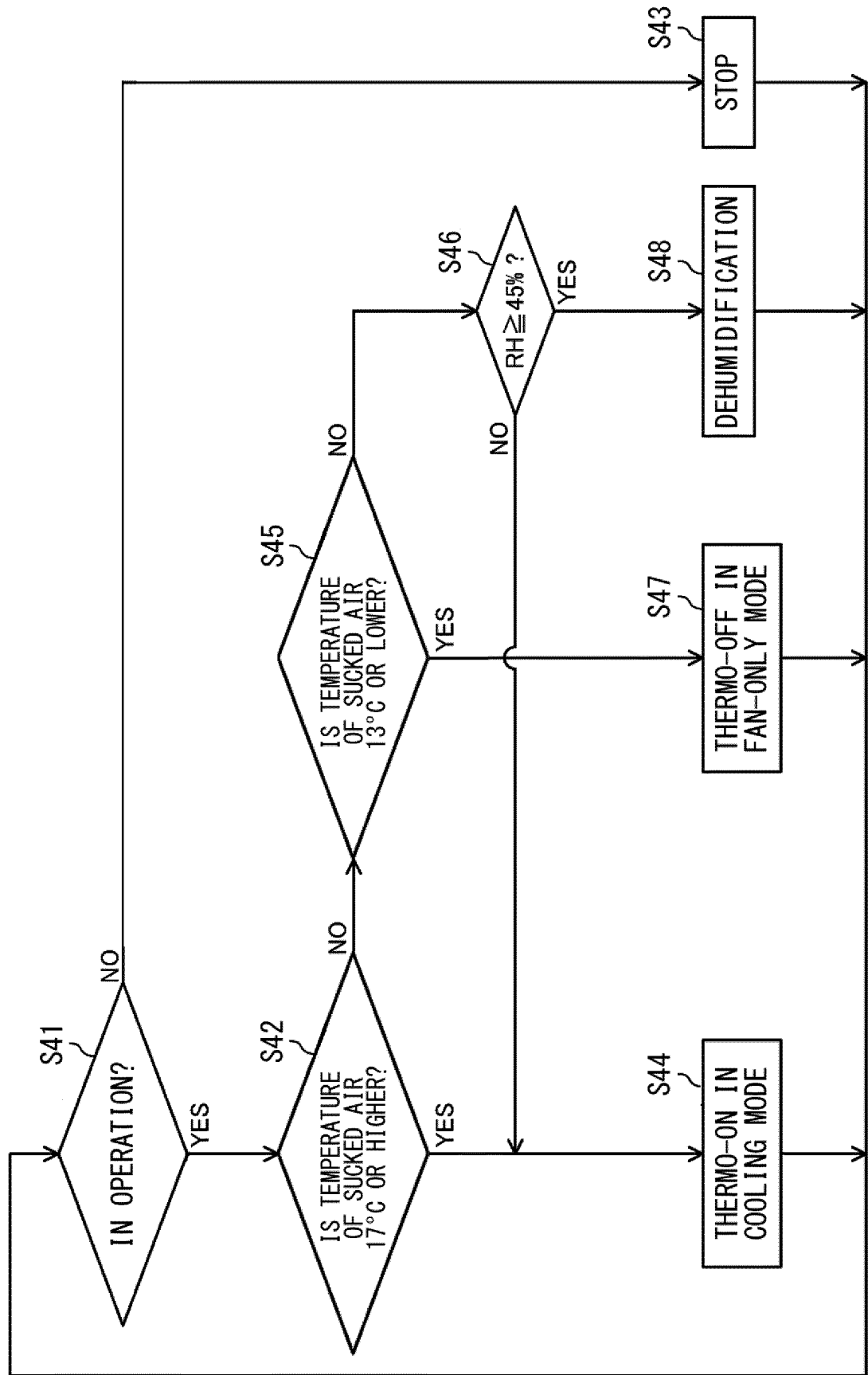
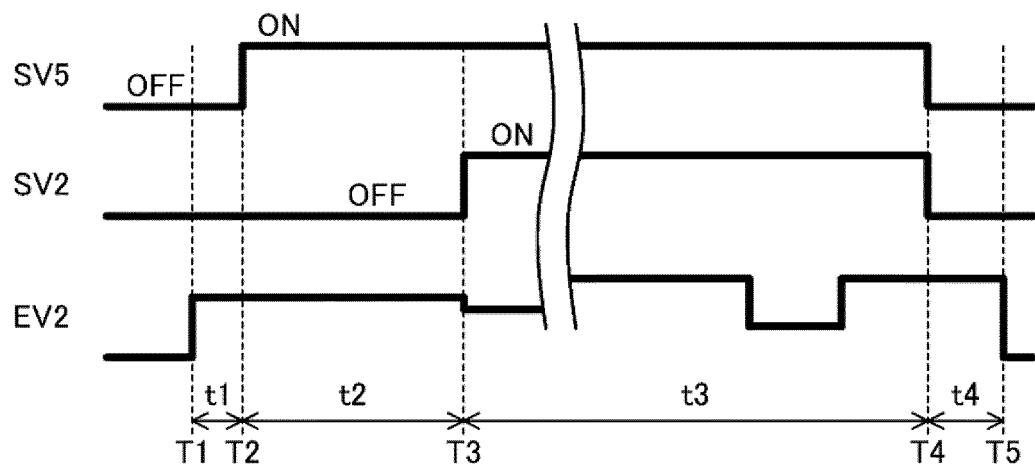


FIG. 12

	UNIT COOLER (INDOOR UNIT)					REFRIGERATOR (OUTDOOR UNIT)		
	SV1	SV2	EV1	EV2	MF1	MF2	MC	SV4
COOLING	THERMO -ON	CLOSED	SH CONTROL	CLOSED	H AIR VOLUME	HIGH PRESSURE CONTROL	HZ CONTROL	HIGH PRESSURE CONTROL
	THERMO -OFF	CLOSED	CLOSED	CLOSED	H AIR VOLUME	STOP	STOP	OFF
REHEAT DEHU- MIDIFICATION	OPENED	OPENED	SH CONTROL	SUCKED AIR TEMPERATURE CONTROL	L AIR VOLUME	HIGH PRESSURE CONTROL	HZ CONTROL	HIGH PRESSURE CONTROL

FIG. 13



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/0120954

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F25B29/00 (2006.01) i, F24F11/86 (2018.01) i, F25B6/02 (2006.01) i,
F24F140/20 (2018.01) n

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. F25B29/00, F24F11/86, F25B6/02, F24F140/20

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 5-340594 A (KUBOTA CORP.) 21 December 1993, paragraphs [0014]-[0031], fig. 1-4 (Family: none)	1-7 8-9
Y A	JP 2012-137241 A (MITSUBISHI ELECTRIC AIR CONDITIONING & REFRIGERATION SYSTEMS CO., LTD.) 19 July 2012, paragraphs [0027]-[0039], fig. 2 (Family: none)	1-7 8-9
Y	JP 2005-16858 A (MITSUBISHI ELECTRIC CORP.) 20 January 2005, paragraph [0041] (Family: none)	4-7



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
25 July 2018 (25.07.2018)

Date of mailing of the international search report
07 August 2018 (07.08.2018)

Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/0120954

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 4-131645 A (DAIKIN INDUSTRIES, LTD.) 06 May 1992, claim 3 (Family: none)	4-7
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 047716/1971 (Laid-open No. 006861/1973) (TOKYO SHIBAURA ELECTRIC CO., LTD.) 25 January 1973, specification, page 3, line 3 to page 6, line 5, drawings (Family: none)	7
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 154278/1983 (Laid-open No. 060661/1985) (DAIKIN INDUSTRIES, LTD.) 26 April 1985, specification, page 9, line 4 to page 18, line 11, fig. 1 (Family: none)	8-9

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

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- JP 2011133171 A [0004]
- JP 1222137 A [0004]