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

(11) EP 4 071 425 A1

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

(43) Date of publication:
12.10.2022 Bulletin 2022/41

(21) Application number: **19955082.3**

(22) Date of filing: **04.12.2019**

(51) International Patent Classification (IPC):
F25B 49/02 *(2006.01)* ***F25B 1/00*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F25B 1/00; F25B 49/02

(86) International application number:
PCT/JP2019/047501

(87) International publication number:
WO 2021/111561 (10.06.2021 Gazette 2021/23)

(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

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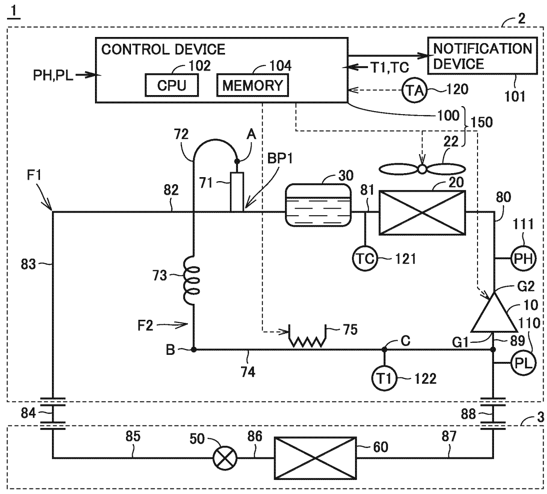
(54) **OUTDOOR UNIT AND REFRIGERATION CYCLE DEVICE**

(57) An outdoor unit (2) includes a first channel (F1), a second channel (F2), an erected pipe (71), a flow rate regulation device (73), a refrigerant heating device (75), a dryness increasing device (150), a temperature sensor (122), and a notification device (101). The compressor (10) and the condenser (20) are disposed along a first channel (F1). The second channel (F2) is configured to branch from a branching point (BP1) and return to the compressor (10) the refrigerant having passed through the condenser (20). The erected pipe (71) is provided at the branching point (BP1). The dryness increasing device (150) increases the dryness of the refrigerant that has passed through the condenser (20) in a refrigerant shortage sensing mode to be larger than in a normal mode. The temperature sensor (122) senses the temperature (T1) of the refrigerant after it passes through the refrigerant heating device (75). In the refrigerant shortage sensing mode, in accordance with to an output of the temperature sensor (122), the notification device (101) provides notification of shortage of the refrigerant.

FIG.1



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to an outdoor unit and a refrigeration cycle apparatus.

BACKGROUND ART

[0002] International Publication No. 2016/135904 discloses a refrigeration apparatus comprising a unit that uses "temperature efficiency," which is a value obtained by dividing a degree of supercooling of refrigerant at an outlet of a subcooler by a maximum temperature difference of the subcooler, to determine an amount of refrigerant introduced in a refrigerant circuit.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: WO 2016/135904

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] The method described in International Publication No. 2016/135904 may be unable to sense that the amount of refrigerant is decreased until the refrigerant is severely short after the amount of the refrigerant starts to decrease.

[0005] An object of the present disclosure is to provide an outdoor unit and a refrigeration cycle apparatus capable of detecting a shortage of refrigerant at an early stage.

SOLUTION TO PROBLEM

[0006] The present disclosure relates to an outdoor unit of a refrigeration cycle apparatus, that has a normal mode and a refrigerant shortage sensing mode and is configured to be connected to a load device including an expansion device and an evaporator. The outdoor unit includes: a first channel configured to form a circulation channel allowing refrigerant to circulate by being connected to the load device; a compressor and a condenser disposed along the first channel; a second channel branched from a branching point of the first channel downstream of the condenser in a direction in which the refrigerant circulates, and configured to return the refrigerant that has passed through the condenser to the compressor; a gas-liquid separation structure provided at the branching point; a flow rate regulation device disposed along the second channel and following the branching point, and a refrigerant heating device disposed along the second channel and following the flow rate regulation device; a dryness increasing device configured to increase a dryness of the refrigerant that has passed through the condenser in the refrigerant shortage sensing mode to be larger than in the normal mode; a temperature sensor configured to sense the temperature of the refrigerant after the refrigerant passes through the refrigerant heating device provided along the second channel; and a notification device configured to operate in the refrigerant shortage sensing mode in accordance with an output of the temperature sensor to provide notification of shortage of the refrigerant.

ADVANTAGEOUS EFFECTS OF INVENTION

[0007] The presently disclosed outdoor unit that has a refrigerant shortage sensing mode to increase dryness of refrigerant that passes through a bypass channel to be larger than in a normal operation can detect a shortage of the refrigerant at an early stage.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

Fig. 1 is a diagram showing a configuration of a refrigeration cycle apparatus 1 according to a first embodiment.
Fig. 2 is a diagram for illustrating a state in which gas-liquid separation cannot be done in a gas-liquid separation mechanism.
Fig. 3 is a diagram for illustrating a state in which gas-liquid separation can be done in the gas-liquid separation mechanism.
Fig. 4 is a Mollier diagram representing a refrigeration cycle when refrigerant has an appropriate amount.
Fig. 5 is a Mollier diagram representing a refrigeration cycle when refrigerant is short in amount.
Fig. 6 is a flowchart for controlling a fan in rotational speed in a normal operation.
Fig. 7 is a flowchart for control in a refrigerant shortage sensing mode.
Fig. 8 is a diagram representing a relationship between the rotational speed of the fan, the amount of refrigerant, and the dryness of the refrigerant.
Fig. 9 is a flowchart of details of a process (S14) for sensing an amount of refrigerant.
Fig. 10 is an example of a map for determining an amount of refrigerant from a rotational speed of the fan.
Fig. 11 is an example of a map for determining an amount of refrigerant from a frequency of the compressor.
Fig. 12 is a diagram showing a configuration of a refrigeration cycle apparatus 201 according to a second embodiment.
Fig. 13 is an example of a map for determining an amount of refrigerant from a degree of opening of an expansion valve.

DESCRIPTION OF EMBODIMENTS

[0009] Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings. Hereinafter, while a plurality of embodiments will be described, the configurations described in the embodiments are intended to be combined together, as appropriate, in the present application as originally filed. In the figures, identical or corresponding components are identically denoted and will not be described redundantly.

First Embodiment

[0010] Fig. 1 is a diagram showing a configuration of a refrigeration cycle apparatus 1 according to a first embodiment. Referring to Fig. 1, refrigeration cycle apparatus 1 comprises an outdoor unit 2, a load device 3, and extension pipes 84 and 88.

[0011] Outdoor unit 2 of refrigeration cycle apparatus 1 is configured to be connected to load device 3 by extension pipes 84 and 88.

[0012] Outdoor unit 2 includes a compressor 10, a condenser 20, a liquid receiver (a receiver) 30, and pipes 80 to 83 and 89. Liquid receiver 30 is disposed between pipe 82 and condenser 20 and configured to store refrigerant.

[0013] A channel F1 extending from compressor 10 via condenser 20 and liquid receiver 30 to a port for connection to load device 3 is configured to form a circulation channel together with load device 3 to allow the refrigerant to circulate. Hereinafter, this circulation channel will also be referred to as a "main circuit" of the refrigeration cycle.

[0014] Load device 3 includes an expansion device 50, an evaporator 60, and pipes 85, 86 and 87. Expansion device 50 is, for example, a thermal expansion valve controlled independently of outdoor unit 2.

[0015] Compressor 10 compresses refrigerant sucked from pipe 89 and discharges the compressed refrigerant to pipe 80. Compressor 10 has a suction port G1 and a discharging port G2. Compressor 10 is configured to suck through suction port G1 refrigerant having passed through evaporator 60 and discharge the refrigerant through discharging port G2 toward condenser 20.

[0016] Outdoor unit 2 further includes an erected pipe 71, a pipe 72, a flow rate regulation device 73, a pipe 74, and a refrigerant heating device 75. Pipe 72 branches from pipe 82 connected to an outlet of liquid receiver 30 on the circulation channel and is connected to one end of flow rate regulation device 73. Pipe 74 interconnects the other end of flow rate regulation device 73 and pipe 89. Refrigerant heating device 75 is configured to heat refrigerant having passed through flow rate regulation device 73. Refrigerant heating device 75 can for example be an electric heater. While as flow rate regulation device 73, for example, a capillary tube may be typically used, any device such as an orifice may be used insofar as it can reduce a channel in cross section and thus cause a pressure difference. Further, an expansion valve may be used as flow rate regulation device 73. Hereinafter, a second channel F2 that branches from the main circuit and feeds refrigerant to compressor 10 via flow rate regulation device 73 will be referred to as a "bypass channel."

[0017] In refrigeration cycle apparatus 1, the bypass channel is branched from a portion at which erected pipe 71 is connected to pipe 82 connected to the outlet of liquid receiver 30.

[0018] When the bypass channel is branched by erected pipe 71, and refrigerant leaks and is thus short, two-phase refrigerant with gaseous refrigerant mixed is introduced into pipe 72.

[0019] When the compressor has an intermediate pressure port, the bypass channel may not be connected to the suction port of compressor 10 and instead be connected to the intermediate pressure port.

[0020] Compressor 10 is configured to adjust rotational speed in response to a control signal received from a control device 100. By adjusting compressor 10 in rotational speed, an amount of refrigerant circulated is adjusted, and capacity of refrigeration cycle apparatus 1 for refrigeration can be adjusted. Compressor 10 may be of various types, such as a scroll type, a rotary type, or a screw type.

[0021] Condenser 20 condenses refrigerant discharged from compressor 10 to pipe 80 and passes the condensed refrigerant to pipe 81. Condenser 20 is configured such that high-temperature and high-pressure gaseous refrigerant discharged from compressor 10 exchanges heat with external air. The heat exchange allows the refrigerant to radiate heat, condense, and alter to liquid phase. Fan 22 supplies condenser 20 with external air with which refrigerant exchanges heat in condenser 20. Adjusting fan 22 in rotational speed can adjust pressure of refrigerant on the discharging side of compressor 10.

[0022] Outdoor unit 2 further includes pressure sensors 110 and 111, temperature sensors 120, 121 and 122, and control device 100 configured to control outdoor unit 2.

[0023] Pressure sensor 110 senses a pressure PL of refrigerant sucked into compressor 10 and outputs the sensed value to control device 100. Pressure sensor 111 senses a pressure PH of refrigerant discharged from compressor 10 and outputs the sensed value to control device 100. Temperature sensor 120 senses a temperature TA of external air sent to condenser 20 and outputs the sensed value to control device 100. Temperature sensor 121 senses a temperature TC of refrigerant in pipe 81 at the outlet of condenser 20 and outputs the sensed value to control device 100. Temperature sensor 122 senses a temperature T1 of refrigerant having passed through flow rate regulation device 73 and thereafter heated by refrigerant heating device 75, and outputs the sensed value to control device 100.

[0024] Control device 100 includes a CPU (Central Processing Unit) 102, a memory 104 (ROM (Read Only Memory) and RAM (Random Access Memory)), an input/output buffer (not shown) for inputting and outputting various signals, and the like. CPU 102 loads a program that is stored in the ROM into a RAM or the like and executes the program. The program stored in the ROM is a program describing a processing procedure for control device 100. Control device 100 controls each device in outdoor unit 2 in accordance with these programs. This control is not limited to processing by software, and processing by dedicated hardware (electronic circuity) is also possible.

[0025] As described above, in the first embodiment, there is provided a bypass channel from an outlet of liquid receiver 30 serving as a high-pressure section to a suction inlet of compressor 10 serving as a low-pressure section. Flow rate regulation device 73 and refrigerant heating device 75 are disposed along the bypass channel. Temperature sensor 122, and pressure sensor 110 for sensing a low-pressure saturation temperature are provided at a portion at which refrigerant having passed through refrigerant heating device 75 arrives. The low-pressure saturation temperature may be temperature measured at the outlet of flow rate regulation device 73.

[0026] In such a configuration, a gas-liquid separation mechanism is provided at a branching point BP1 of the bypass channel. Fig. 2 is a diagram for illustrating a state in which gas-liquid separation cannot be done in the gas-liquid separation mechanism. Fig. 3 is a diagram for illustrating a state in which gas-liquid separation can be done in the gas-liquid separation mechanism.

[0027] Referring to Figs. 2 and 3, the gas-liquid separation mechanism is configured by erected pipe 71 erected from pipe 82, which is a liquid pipe, in a direction opposite to gravity.

[0028] As shown in Fig. 2, when refrigerant passing through pipe 82 is small in dryness, two-phase refrigerant in which liquid refrigerant and gaseous refrigerant are mixed passes through erected pipe 71 and pipe 72. On the other hand, as shown in Fig. 3, when refrigerant passing through pipe 82 is large in dryness, liquid refrigerant falls by gravity in the middle of erected pipe 71, and single-phase gaseous refrigerant separated from the liquid refrigerant passes through pipe 72 via erected pipe 71.

[0029] When two-phase refrigerant passes through the bypass channel, and the refrigerant is heated by refrigerant heating device 75, the heat is absorbed as latent heat to evaporate the refrigerant. Accordingly, temperature T1 sensed by temperature sensor 122 matches the refrigerant's saturation temperature. In this state, the refrigerant has a degree of superheat SH of 0.

[0030] In contrast, when refrigerant in a form of gas passes through the bypass channel, and the refrigerant is heated by refrigerant heating device 75, the heat is absorbed by the refrigerant as sensible heat, and the refrigerant's temperature rises. Accordingly, temperature T1 sensed by temperature sensor 122 is higher than the refrigerant's saturation temperature, and the refrigerant has a degree of superheat SH larger than 0.

[0031] Fig. 4 is a Mollier diagram representing a refrigeration cycle when refrigerant has an appropriate amount. In Fig. 4, points A, B and C correspond to points A, B and C indicated in Fig. 1. Normally in liquid receiver 30 liquid refrigerant and gaseous refrigerant exist, and refrigerant at the outlet of liquid receiver 30 has a state on a line of saturated liquid such as point A indicated in Fig. 4. That is, the inlet of the bypass channel is in a liquid state (point A).

[0032] The bypass passage provides passage at a flow rate corresponding to a differential pressure determined by expansion device 50 and evaporator 60 of the main circuit. When flow rate regulation device 73 decompresses refrigerant, the refrigerant's state changes from point A to point B. And when refrigerant heating device 75 heats the refrigerant the refrigerant's state changes from point B to point C.

[0033] At that time, pipe 74 passes a large amount of liquid refrigerant, and when the refrigerant is heated and the point moves rightward, it does not exceed a saturated gas line, and the refrigerant's temperature stays at the saturation temperature and does not change.

[0034] Therefore, at point C, degree of superheat SH is zero, and it can be determined that the refrigerant is not short.

[0035] Fig. 5 is a Mollier diagram representing a refrigeration cycle when refrigerant is short in amount. When refrigerant is short, refrigerant at point A increases in dryness. Therefore, refrigerant at point A in Fig. 1 separated by the gas-liquid separation mechanism has a state on the Mollier diagram, as indicated in Fig. 5 by a point A'. When flow rate regulation device 73 decompresses the refrigerant, the refrigerant's state changes from point A' to a point B'. And when refrigerant heating device 75 heats the refrigerant the refrigerant's state changes from point B' to a point C'.

[0036] At that time, pipe 74 does not pass liquid refrigerant, and when the refrigerant in the pipe is heated, the point moves rightward and exceeds the saturated gas line. Since the heat is absorbed by the refrigerant as sensible heat, the refrigerant's temperature rises to be higher than the saturation temperature and the refrigerant thus has a degree of superheat SH > 0, and it can thus be determined that the refrigerant is short.

[0037] When refrigerant in a two-phase state is measured in pressure by a pressure sensor, the refrigerant's temperature corresponding to the measured pressure (i.e., saturation temperature) is determined. A conversion table indicating a correlation between the pressure and the saturation temperature is stored in advance in memory 104 of control device 100. Control device 100 obtains a saturation temperature corresponding to pressure PL from the conversion table, and calculates a difference from temperature T1 actually measured by a temperature sensor. When the saturation temperature is represented by T0, degree of superheat SH is SH = T1 - T0.

[0038] Fig. 6 is a flowchart for controlling a fan in rotational speed in a normal operation. In the normal operation, the rotational speed of fan 22 is determined so that each device operates efficiently. For example, it is determined such that a difference between temperature TC representing condensation temperature and external air's temperature is set to be 10°C.

[0039] Initially, in step S1, a target temperature is set to a value obtained by adding α°C to external air's temperature TA as measured with temperature sensor 120. Temperature α°C is set to a temperature at which condenser 20 provides efficient heat exchange, and it is for example 10°C. Subsequently, in step S2, condensation temperature TC is measured by temperature sensor 121, and condensation temperature TC as measured is compared with the target temperature. For TC > the target temperature (YES in S2), control device 100 increases the rotational speed of fan 22 in step S3 to decrease temperature TC. For TC < the target temperature (YES in S4), control device 100 decreases the rotational speed of fan 22 in step S5 to increase condensation temperature TC. When condensation temperature TC matches the target temperature (NO in S2 and NO in S4), control device 100 does not change and thus maintains the current rotational speed of fan 22. In order to avoid frequently changing the rotational speed of fan 22, a difference may be provided between the target temperatures in steps S2 and S4 to provide hysteresis.

[0040] An amount of liquid refrigerant held in liquid receiver 30 varies depending on the operating state of the refrigeration cycle apparatus. The amount of refrigerant should be a sufficient amount of an extent such that liquid remains in liquid receiver 30 even in an operating state in which liquid receiver 30 holds a minimal amount of liquid.

[0041] The operating state in which the receiver holds a minimal amount of liquid is a state in which condensation temperature TC rises to be high (a state in which the high-pressure section has pressure increased as it is affected by external air's temperature, the fan's rotational speed, and the like). In that case, refrigerant in the main circuit increases in density and decreases in volume. Liquid refrigerant flows out of liquid receiver 30 toward the circulation circuit by the amount corresponding to the reduction in volume of the refrigerant in the main circuit, and accordingly, liquid receiver 30 has a reduced amount of liquid.

[0042] Further, when a plurality of indoor units are used, and there is a stopped indoor unit, refrigerant corresponding to the stopped indoor unit is stored in a liquid receiver, and accordingly, when the plurality of indoor units are all in operation, the amount of liquid of refrigerant in the receiver decreases.

[0043] Therefore, in order to make it possible to sense at an early stage that refrigerant is short, in the present embodiment, in the refrigerant shortage sensing mode, dryness at the outlet of the liquid receiver provided with the gas-liquid separation mechanism is increased to be larger than in the normal operation to facilitate a refrigerant shortage sensing unit provided along the bypass channel to sense that refrigerant is short.

[0044] Fig. 7 is a flowchart for control in the refrigerant shortage sensing mode. The refrigerant shortage sensing mode is periodically run by a timer or the like, for example, once a day or once for several days.

[0045] When the refrigerant shortage sensing mode is set, in step S11, control device 100 sets the operating frequency of compressor 10 to a predetermined fixed frequency. Note that in the configuration in which an injection channel is provided as in the second embodiment, the expansion valve of the injection channel also has a fixed degree of opening.

[0046] Subsequently, in step S12, control device 100 sets the rotational speed of fan 22 to be equal to or lower than a minimum rotational speed that can be assumed in the normal operation. For example, fan 22 may be stopped from rotating. As a result, condenser 20 exchanges heat with external air less efficiently and thus less likely to condense refrigerant. Then, dryness at the outlet of liquid receiver 30 provided with the gas-liquid separation mechanism increases to be larger than in the normal operation. In other words, refrigerant has a larger ratio of gaseous refrigerant than in the normal operation.

[0047] Subsequently, in step S13, control device 100 senses whether refrigerant is short based on whether there is degree of superheat SH at the outlet of the refrigerant heating device (or point C).

[0048] Fig. 8 is a diagram representing a relationship between the rotational speed of the fan, the amount of refrigerant, and the dryness of the refrigerant. Herein, an amount of refrigerant which is 100% indicates an amount introduced as defined to be neither excessive nor insufficient in design, and it is assumed that a difference from 100% is an amount of a shortage. The apparatus, as originally installed, has refrigerant introduced in an amount with a margin, and the refrigerant may have an amount of 110% for example. And when the refrigerant leaks and has an amount decreased to be less than 100%, it is determined that the refrigerant is short.

[0049] For how much dryness gas-liquid separation can be done is a value determined depending on how the gas-liquid separation mechanism is designed. When it is assumed that dryness of a limit at which gas-liquid separation can be done is 0.05, Fig. 8 shows that, for refrigerant having an amount of 95%, gas-liquid separation cannot be done when the fan's rotational speed is reduced to 25%. For refrigerant having an amount of 85% gas-liquid separation cannot be done when the fan's rotational speed is reduced to 40%, and for refrigerant having an amount of 80% gas-liquid separation cannot be done when the fan's rotational speed is reduced to 60%.

[0050] Therefore, for example, in step S13, control device 100 reduces the fan's rotational speed to 25% and heats refrigerant by refrigerant heating device 75. At that time, control device 100 obtains saturation temperature T0 corresponding to pressure PL from the conversion table stored in advance and calculates a difference from temperature T1 actually measured with temperature sensor 122 to calculate degree of superheat SH (= T1 - T0).

For degree of superheat SH > 0, it is determined that the refrigerant is short, and for degree of superheat SH = 0, it is determined that the refrigerant has an amount equal to or larger than the defined amount.

[0051] When the refrigerant is not short (NO in S13), the refrigerant shortage sensing mode ends, and the normal operation is performed, as controlled as shown in Fig. 6.

[0052] On the other hand, when the refrigerant is short (YES in S13), in the present embodiment, control device 100 further senses an amount of refrigerant in step S14, and in step S15 notifies the user of how much the refrigerant is short. Control device 100 causes notification device 101 to output an alarm indicating that the refrigerant is short. Notification device 101 is for example a display device such as a liquid crystal display, a warning lamp, or the like, and may be a device that transmits a warning signal to an external device via a communication line.

[0053] In the above-described steps S11 to S13, in order to be able to detect at an early stage that refrigerant is short, control device 100 increases dryness at the outlet of condenser 20 and increases an amount of refrigerant circulated through the main circuit so that the receiver is close to an empty state, and thereafter, control device 100 checks degree of superheat SH at point C. By operating under a condition severer than a condition applied for normal use, whether refrigerant is short is easily determined based on degree of superheat SH.

[0054] Then, in step S14, to what level the refrigerant is reduced in amount is examined and used for maintenance and inspection of the refrigeration cycle apparatus. A result of notification allows the user to consider whether to stop the refrigeration cycle apparatus, when to repair leakage of refrigerant or to supplement shortage of refrigerant, and the like. Based on an amount of shortage as sensed, control device 100 may notify a user or a service provider of emergency or an amount to be additionally sealed.

[0055] Fig. 9 is a flowchart of details of a process (S14) for sensing an amount of refrigerant. Initially, in step S21, control device 100 gradually increases the rotational speed of fan 22 while causing refrigerant heating device 75 (e.g., a heater) to heat refrigerant. Then, in step S22, control device 100 determines a rotational speed of the fan for which the refrigerant at point C has a degree of superheat SH of zero. Then, in step S23, control device 100 determines an amount of refrigerant from a map indicating a previously stored correlation between the rotational speed of the fan and the amount of refrigerant.

[0056] Fig. 10 is an example of a map for determining an amount of refrigerant from a rotational speed of the fan. When the graph shown in Fig. 8 is transformed and the vertical axis represents the amount of refrigerant, the graph shown in Fig. 10 is obtained. Herein, when it is assumed that a boundary of whether the gas-liquid separation mechanism disposed at branching point BP1 can provide gas-liquid separation is a dryness of 0.05, a line in Fig. 10 representing the dryness of 0.05 will be a map representing a correlation between the fan's rotational speed and the amount of refrigerant. A region above the line of the dryness of 0.05 is a region in which refrigerant has an amount equal to or larger than an appropriate amount, and a region below the line is a region in which refrigerant is short in amount. For example, in step S12 of Fig. 7, the fan's rotational speed is decreased to 25% corresponding to an amount of refrigerant which is 95% for the sake of illustration, and whether the refrigerant is short is examined. When it is determined that the refrigerant is short, the fan's rotational speed is gradually increased from 25% to sense the amount of the refrigerant.

[0057] For example, when the fan's rotational speed attains 30%, and degree of superheat SH changes from SH > 0 to SH = 0 at that rotational speed, then the amount of the refrigerant can be sensed to be 90%. Similarly, when the fan's rotational speed attains 40%, and degree of superheat SH changes from SH > 0 to SH = 0 at that rotational speed, then the amount of the refrigerant can be sensed to be 85%.

Similarly, when the fan's rotational speed attains 60%, and degree of superheat SH changes from SH > 0 to SH = 0 at that rotational speed, then the amount of the refrigerant can be sensed to be 80%.

[0058] While in the example described above, fan 22 is changed in rotational speed to change refrigerant in dryness to sense an amount of the refrigerant, fan 22 may have a rotational speed fixed to 30% and the compressor's operating frequency may instead be changed to change dryness to sense an amount of refrigerant.

[0059] Fig. 11 is an example of a map for determining an amount of refrigerant from a frequency of the compressor. The vertical axis represents the amount of refrigerant (in %), and the horizontal axis represents the operating frequency (in Hz). When considering in the same manner as in the description for Fig. 10, when it is assumed that a boundary of whether the gas-liquid separation mechanism disposed at branching point BP1 can provide gas-liquid separation is a dryness of 0.05, a line in Fig. 11 representing the dryness of 0.05 will be a map representing a correlation between the compressor's operating frequency and the amount of refrigerant. A region above the line of the dryness of 0.05 is a region in which refrigerant has an amount equal to or larger than an appropriate amount, and a region below the line is a region in which refrigerant is short in amount.

[0060] For example, the rotational speed of fan 22 is set to 30% and the operating frequency of the compressor is set to 80 Hz to determine whether the refrigerant is short, and when the refrigerant is short, then, the operating frequency of the compressor is gradually decreased from 80 Hz to examine an operating frequency of the compressor for which degree of superheat SH is zero. For example, when the operating frequency is 70 Hz, the amount of refrigerant can be sensed to be 85%, and when the operating frequency is 30 Hz, the amount of refrigerant can be sensed to be 77.5%.

[0061] Thus, in the first embodiment, initially, the fan's rotational speed is set to be lower than that in the normal operation or zeroed to reduce condenser 20 in capacity so that refrigerant passing through the condenser is high in dryness to facilitate detecting shortage of refrigerant. Thus, shortage of refrigerant can be detected even at an early stage thereof. Further, when refrigerant is short, the fan or the like can operated to gradually reduce dryness of refrigerant passing through the condenser to detect an amount of refrigerant. Thus, a user or a service provider can be notified of emergency or an amount to be additionally sealed, based on the amount of refrigerant sensed.

Second Embodiment

[0062] While in the first embodiment the fan's rotational speed is decreased or the compressor's frequency is increased as means for increasing dryness at the gas-liquid separator, when an injection channel and an internal heat exchanger are included the injection channel may have its expansion valve opened by an increased angle or these may be composited together.

[0063] Fig. 12 is a diagram showing a configuration of a refrigeration cycle apparatus 201 according to a second embodiment. Refrigeration cycle apparatus 201 has the configuration of refrigeration cycle apparatus 1 shown in Fig. 1 with outdoor unit 2 replaced with an outdoor unit 202. Load device 3 will not be described repeatedly as it is the same in configuration.

[0064] Outdoor unit 202 has the configuration of outdoor unit 2 having compressor 10 and control device 100 replaced with a compressor 210 and a control device 300, and further including a heat exchanger 40, an expansion valve 92, and pipes 93 and 94. Outdoor unit 202 has a remainder similar in configuration to outdoor unit 2, and accordingly, will not be described repeatedly.

[0065] Heat exchanger 40 has a first passage HI and a second passage H2, and is configured to exchange heat between refrigerant passing through first passage HI and refrigerant passing through second passage H2. Liquid receiver 30 is disposed between first passage HI of heat exchanger 40 and condenser 20 and configured to store refrigerant.

[0066] Compressor 210 has an intermediate pressure port G3 in addition to suction port G1 and discharging port G2. Compressor 10 is configured to suck through suction port G1 refrigerant having passed through evaporator 60 and discharge the refrigerant through discharging port G2 toward condenser 20 together with refrigerant sucked through intermediate pressure port G3.

[0067] Expansion valve 92, pipe 93, second passage H2 of heat exchanger 40, and pipe 94 constitute a third channel F3 passing refrigerant from a branching point BP2 of the main circuit to intermediate pressure port G3 of compressor 210. Third channel F3 will also be referred to as an "injection channel."

[0068] While in an example described in the first embodiment the rotational speed of fan 22 is changed to change refrigerant in dryness to sense an amount of the refrigerant, in the second embodiment, the rotational speed of fan 22 and the operating frequency of the compressor are fixed and a degree of opening of expansion valve 92 is instead changed to change dryness.

[0069] Fig. 13 is an example of a map for determining an amount of refrigerant from a degree of opening of an expansion valve. The vertical axis represents the amount of refrigerant (in %), and the horizontal axis represents a pulse count of a control signal corresponding to a degree of opening of expansion valve 92. As the pulse count increases, the degree of opening of expansion valve 92 increases. Hereinafter, a degree of opening of the expansion valve is represented by a pulse count. When considering in the same manner as in the descriptions for Figs. 10 and 11, when it is assumed that a boundary of whether the gas-liquid separation mechanism disposed at branching point BP1 can provide gas-liquid separation is a dryness of 0.05, a line in Fig. 13 representing the dryness of 0.05 will be a map representing a correlation between the compressor's operating frequency and the amount of refrigerant. A region above the line of the dryness of 0.05 is a region in which refrigerant has an amount equal to or larger than an appropriate amount, and a region below the line is a region in which refrigerant is short in amount.

[0070] For example, the rotational speed of fan 22 is set to 30% and the degree of opening of expansion valve 92 is set to 60 pulses to determine whether refrigerant is short, and when the refrigerant is short, then, the degree of opening of expansion valve 92 is gradually decreased to examine a degree of opening of expansion valve 92 at which degree of superheat SH is zero. For example, when the degree of opening of expansion valve 92 is 50 pulses, the amount of refrigerant can be sensed to be 77%, and when the degree of opening of expansion valve 92 is 30 pulses, the amount of refrigerant can be sensed to be 74.5%.

[0071] In the second embodiment as well, in order to change dryness of refrigerant when detecting an amount thereof, a change of either the rotational speed of fan 22 or the operating frequency of compressor 210 may be used in combination with a change of the degree of opening of expansion valve 92.

[0072] Finally, reference will again be made to the drawings to summarize the first and second embodiments. Referring to Fig. 1, outdoor unit 2 of refrigeration cycle apparatus 1 has a normal mode and a refrigerant shortage sensing mode and is configured to be connected to load device 3 including expansion device 50 and evaporator 60. Outdoor unit 2 includes first channel F1, compressor 10, condenser 20, second channel F2, erected pipe 71 as a gas-liquid separation structure, flow rate regulation device 73, refrigerant heating device 75, dryness increasing device 150, temperature sensor 122, and notification device 101.

[0073] First channel F1 is configured to form a circulation channel through which refrigerant circulates by being connected to load device 3. Compressor 10 and condenser 20 are disposed along first channel F1. Second channel F2 branches from branching point BP1 of first channel F1 downstream of condenser 20 in a direction in which the refrigerant circulates, and second channel F2 is configured to return to compressor 10 refrigerant having passed through condenser 20. Erected pipe 71 that is a gas-liquid separation structure is provided at branching point BP1. Flow rate regulation device 73 and refrigerant heating device 75 are disposed along second channel F2 such that flow rate regulation device 73 follows branching point BP1 and refrigerant heating device 75 follows flow rate regulation device 73. Dryness increasing device 150 increases the dryness of the refrigerant that has passed through the condenser 20 in the refrigerant shortage sensing mode to be larger than in the normal mode. Temperature sensor 122 senses temperature T1 of the refrigerant after it passes through refrigerant heating device 75 on second channel F2. In the refrigerant shortage sensing mode, in accordance with an output of temperature sensor 122, notification device 101 provides notification of shortage of the refrigerant.

[0074] Preferably, dryness increasing device 150 includes fan 22 configured to deliver external air to condenser 20, and control device 100 configured to control fan 22. As shown in step S12 of Fig. 7, in the refrigerant shortage sensing mode, fan 22 has a rotational speed set to be lower than that in the normal mode or zeroed.

[0075] More preferably, notification device 101, in the refrigerant shortage sensing mode, is configured to provide notification of an amount of the refrigerant corresponding to a rotational speed of fan 22 for which degree of superheat SH calculated based on an output of temperature sensor 122 changes from positive to zero (steps S14 and S15 in Fig. 7).

[0076] More preferably, notification device 101, in the refrigerant shortage sensing mode, is configured to provide notification of an amount of the refrigerant corresponding to an operating frequency of compressor 10 for which degree of superheat SH calculated based on the output of temperature sensor 122 changes from positive to zero.

[0077] Preferably, as shown in Fig. 12, outdoor unit 202 further includes heat exchanger 40 having first passage HI and second passage H2 and configured to exchange heat between refrigerant passing through first passage HI and refrigerant passing through second passage H2, and expansion valve 92. Heat exchanger 40 has first passage HI disposed downstream of condenser 20 provided along first channel F1. Compressor 210 has intermediate pressure port G3 in addition to suction port G1 and discharging port G2. Compressor 210 is configured to suck through suction port G1 refrigerant having passed through evaporator 60 and discharge the refrigerant through discharging port G2 toward condenser 20 together with refrigerant sucked through intermediate pressure port G3.

[0078] Outdoor unit 202 further includes third channel F3 passing refrigerant from branching point BP2 of the main circuit to intermediate pressure port G3 of compressor 210. Third channel F3 includes expansion valve 92, pipe 93, second passage H2 of heat exchanger 40, and pipe 94.

[0079] Notification device 101, in the refrigerant shortage sensing mode, is configured to provide notification of an amount of the refrigerant corresponding to a degree of opening of expansion valve 92 at which degree of superheat SH calculated based on the output of temperature sensor 122 changes from positive to zero.

[0080] Preferably, as shown in Figs. 2 and 3, second channel F2 branches at erected pipe 71 on branching point BP from first channel F1 in a direction opposite to gravity.

[0081] While the present embodiment has been described while indicating as an example a refrigerator comprising refrigeration cycle apparatus 1, refrigeration cycle apparatus 1 may be utilized for an air conditioner or the like.

[0082] It should be understood that the embodiments disclosed herein have been described for the purpose of illustration only and in a non-restrictive manner in any respect. The scope of the present invention is defined by the terms of the claims, rather than the embodiments description above, and is intended to include any modifications within the meaning and scope equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0083] 1, 201 refrigeration cycle apparatus, 2, 202 outdoor unit, 3 load device, 10, 210 compressor, 20 condenser, 22 fan, 30 liquid receiver, 40 heat exchanger, 50 expansion device, 60 evaporator, 71 erected pipe, 72, 74, 80, 81, 82, 83, 85, 86, 87, 89, 93, 94 pipe, 73 flow rate regulation device, 75 refrigerant heating device, 84, 88 extension pipe, 92 expansion valve, 100, 300 control device, 101 notification device, 104 memory, 110, 111 pressure sensor, 120, 121, 122 temperature sensor, 150 dryness increasing device, BP1, BP2 branching point, F1, F2, F3 channel, G1 suction port, G2 discharging port, G3 intermediate pressure port, HI first passage, H2 second passage.

Claims

1. An outdoor unit of a refrigeration cycle apparatus, the outdoor unit having a normal mode and a refrigerant shortage sensing mode and configured to be connected to a load device including an expansion device and an evaporator, the outdoor unit comprising:

   a first channel configured to form a circulation channel allowing refrigerant to circulate by being connected to the load device;

a compressor and a condenser disposed along the first channel;
a second channel branched from a branching point of the first channel downstream of the condenser in a direction in which the refrigerant circulates, and configured to return the refrigerant to the compressor after the refrigerant passes through the condenser;
a gas-liquid separation structure provided at the branching point;
a flow rate regulation device disposed along the second channel and following the branching point, and a refrigerant heating device disposed along the second channel and following the flow rate regulation device;
a dryness increasing device configured to increase a dryness of the refrigerant that has passed through the condenser in the refrigerant shortage sensing mode to be larger than in the normal mode;
a temperature sensor configured to sense a temperature of the refrigerant after the refrigerant passes through the refrigerant heating device provided along the second channel; and
a notification device configured to operate in the refrigerant shortage sensing mode in accordance with an output of the temperature sensor to provide notification of shortage of the refrigerant.

2. The outdoor unit according to claim 1, wherein

the dryness increasing device comprises a fan configured to deliver external air to the condenser, and
in the refrigerant shortage sensing mode, the fan has a rotational speed set to a rotational speed lower than that in the normal mode or zeroed.

3. The outdoor unit according to claim 2, wherein in the refrigerant shortage sensing mode, the notification device provides notification of an amount of the refrigerant corresponding to a rotational speed of the fan at which a degree of superheat calculated based on the output of the temperature sensor changes from positive to zero.

4. The outdoor unit according to claim 2, wherein in the refrigerant shortage sensing mode the notification device provides notification of an amount of the refrigerant corresponding to an operating frequency of the compressor at which a degree of superheat calculated based on the output of the temperature sensor changes from positive to zero.

5. The outdoor unit according to claim 2, further comprising:

a heat exchanger having a first passage and a second passage and configured to exchange heat between refrigerant passing through the first passage and refrigerant passing through the second passage;
an expansion valve; and
a third channel, wherein
the heat exchanger has the first passage disposed downstream of the condenser provided along the first channel,
the compressor has a suction port, a discharging port and an intermediate pressure port,
the compressor is configured to suck through the suction port refrigerant having passed through the evaporator and discharge the refrigerant through the discharging port toward the condenser together with refrigerant sucked through the intermediate pressure port,
the third channel includes the expansion valve and the second passage of the heat exchanger,
the third channel is configured to pass refrigerant from the first channel to the intermediate pressure port of the compressor, and
in the refrigerant shortage sensing mode the notification device provides notification of an amount of refrigerant corresponding to a degree of opening of the expansion valve at which a degree of superheat calculated based on the output of the temperature sensor changes from positive to zero.

6. The outdoor unit according to claim 1, wherein the second channel branches from the first channel in the gas-liquid separation structure at the branching point in a direction opposite to gravity.

7. A refrigeration cycle apparatus comprising: the outdoor unit according to any one of claims 1 to 6; and the load device.

FIG.1

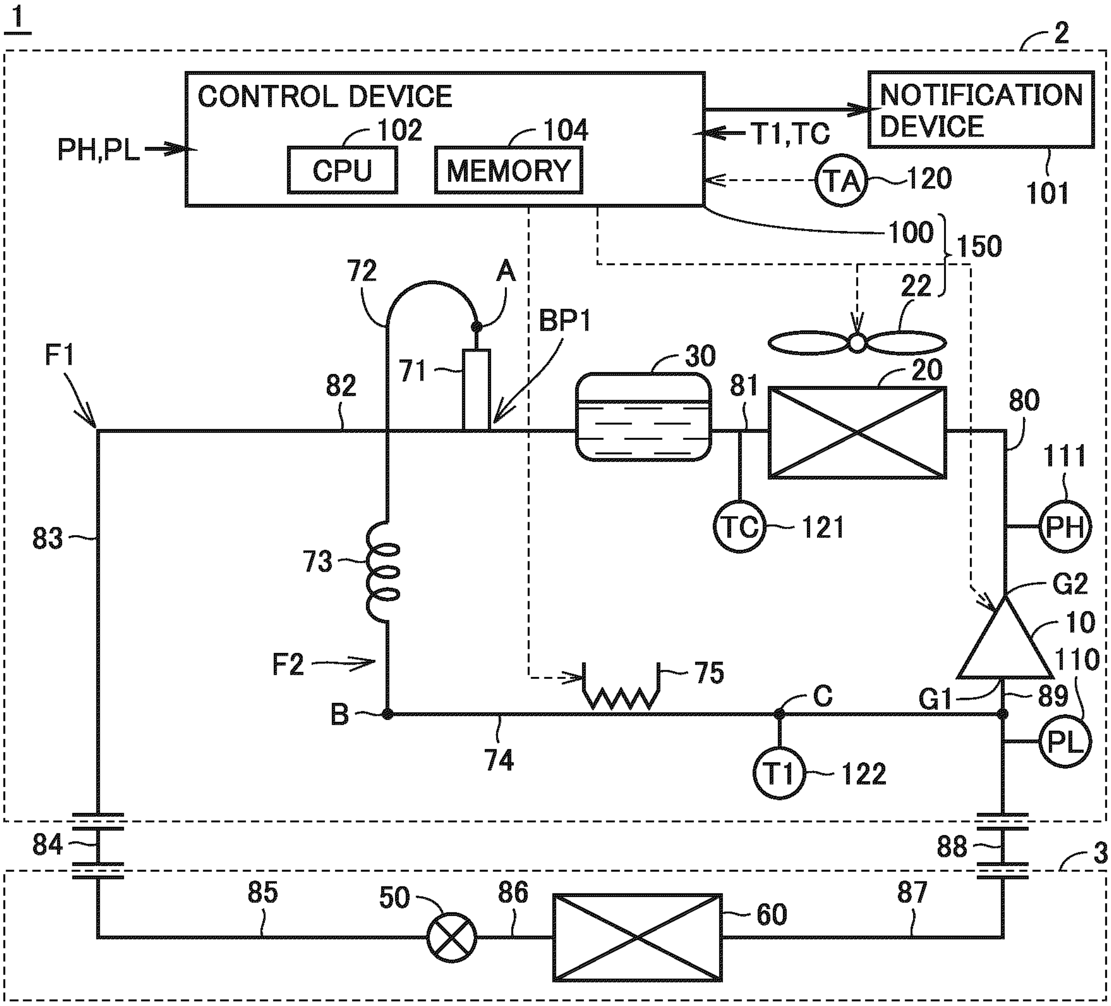

1
2
CONTROL DEVICE
102
104
CPU
MEMORY
NOTIFICATION DEVICE
PH,PL
T1,TC
TA
120
101
100
150
22
72
A
BP1
F1
71
30
20
82
81
80
111
83
TC
121
PH
73
G2
10
110
F2
75
B
C
G1
89
74
T1
122
PL
84
88
3
85
50
86
60
87

FIG.2

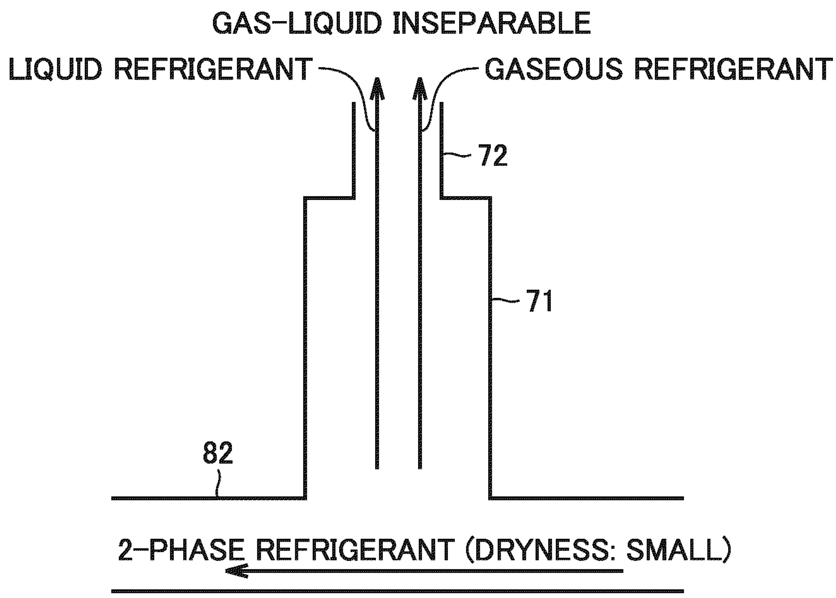

GAS-LIQUID INSEPARABLE
LIQUID REFRIGERANT
GASEOUS REFRIGERANT
72
71
82
2-PHASE REFRIGERANT (DRYNESS: SMALL)

FIG.3

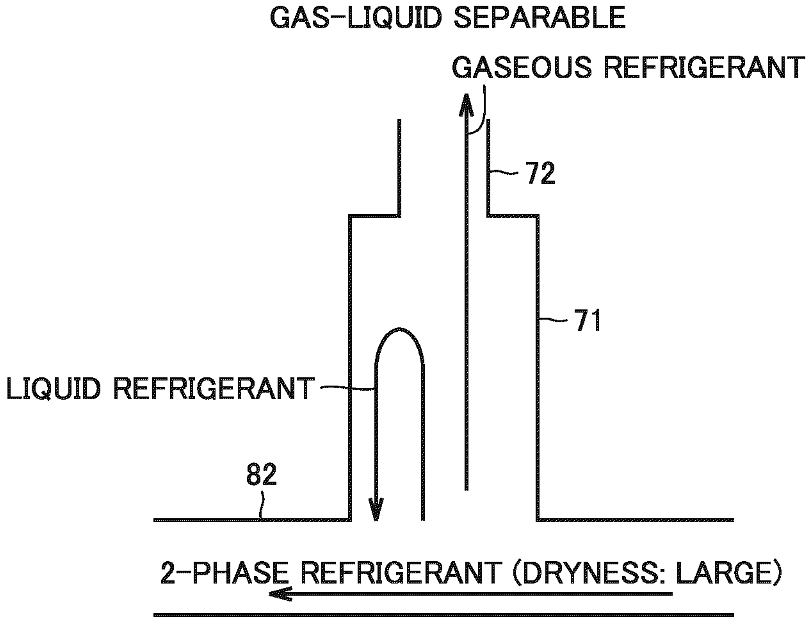

GAS-LIQUID SEPARABLE
GASEOUS REFRIGERANT
72
71
LIQUID REFRIGERANT
82
2-PHASE REFRIGERANT (DRYNESS: LARGE)

FIG.4

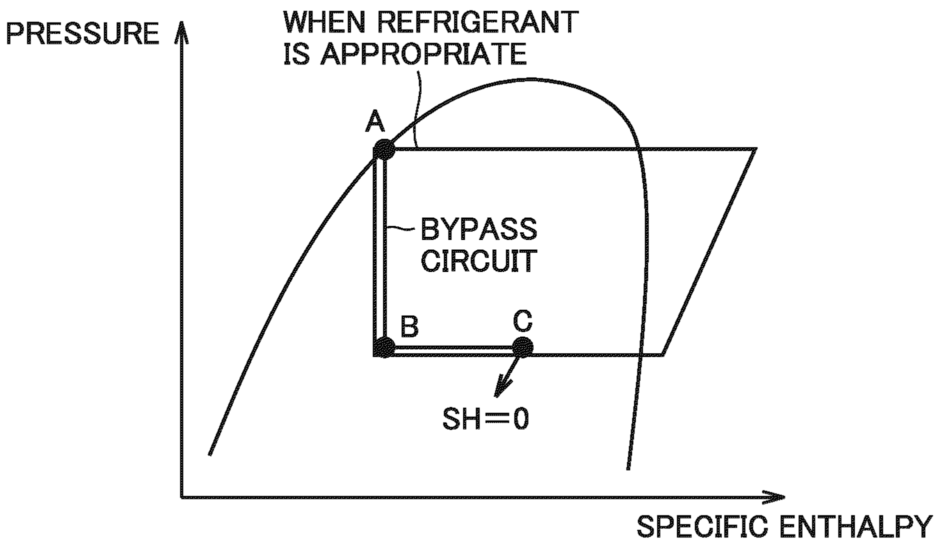

PRESSURE
WHEN REFRIGERANT IS APPROPRIATE
A
BYPASS CIRCUIT
B
C
SH=0
SPECIFIC ENTHALPY

FIG.5

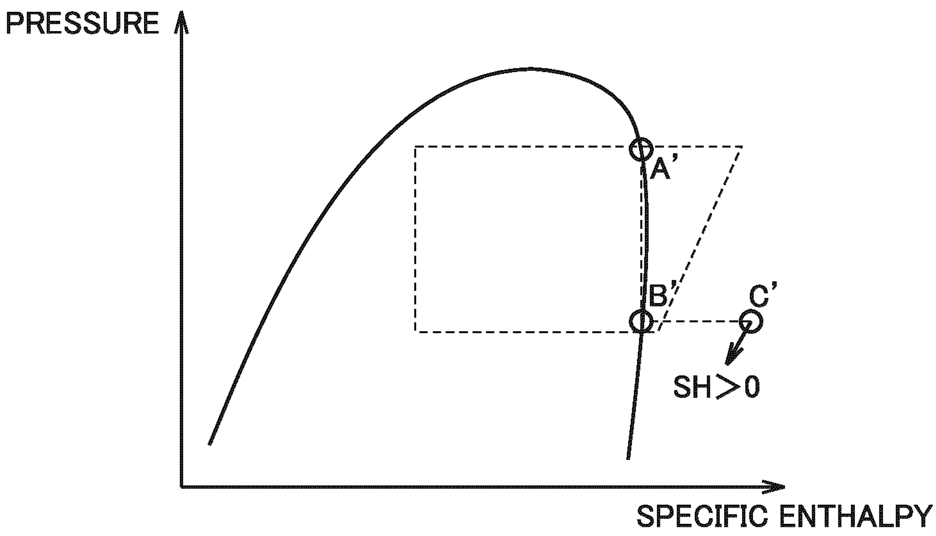

PRESSURE
A'
B'
C'
SH>0
SPECIFIC ENTHALPY

FIG.6

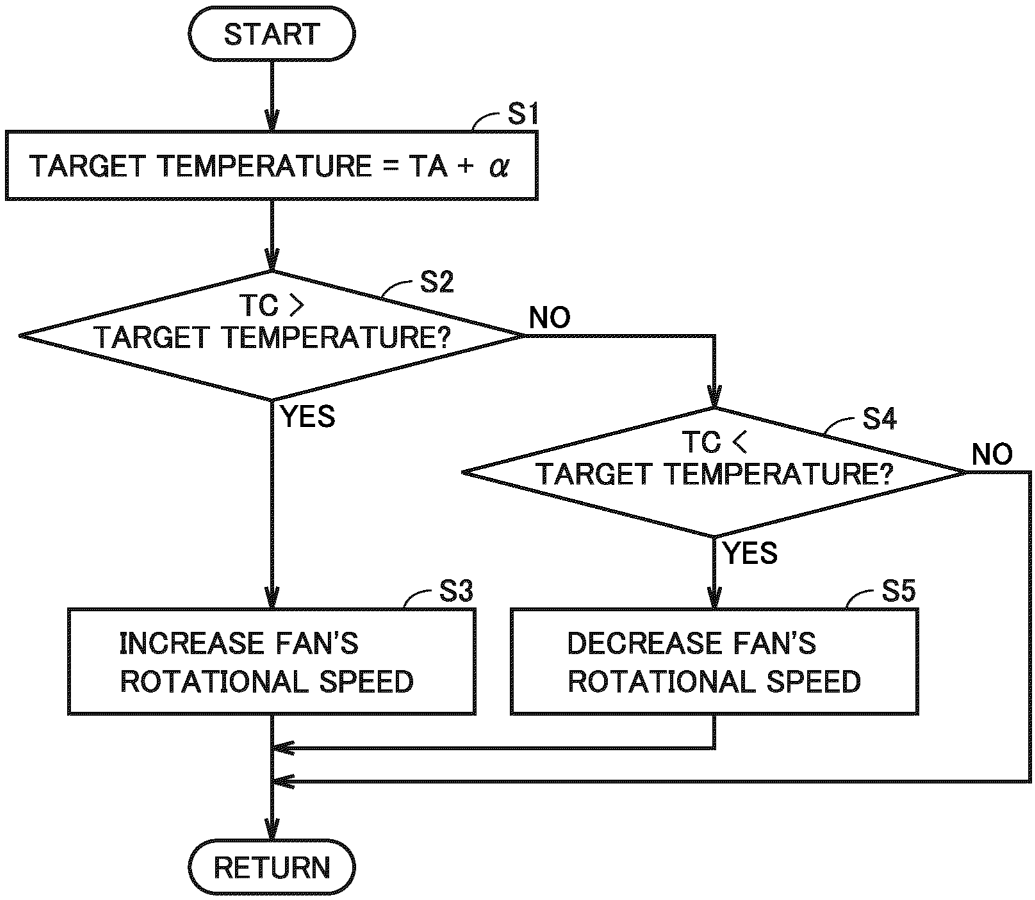

START
S1
TARGET TEMPERATURE = TA + α
S2
TC >
TARGET TEMPERATURE?
NO
YES
S4
TC <
TARGET TEMPERATURE?
NO
YES
S3
INCREASE FAN'S ROTATIONAL SPEED
S5
DECREASE FAN'S ROTATIONAL SPEED
RETURN

FIG.7

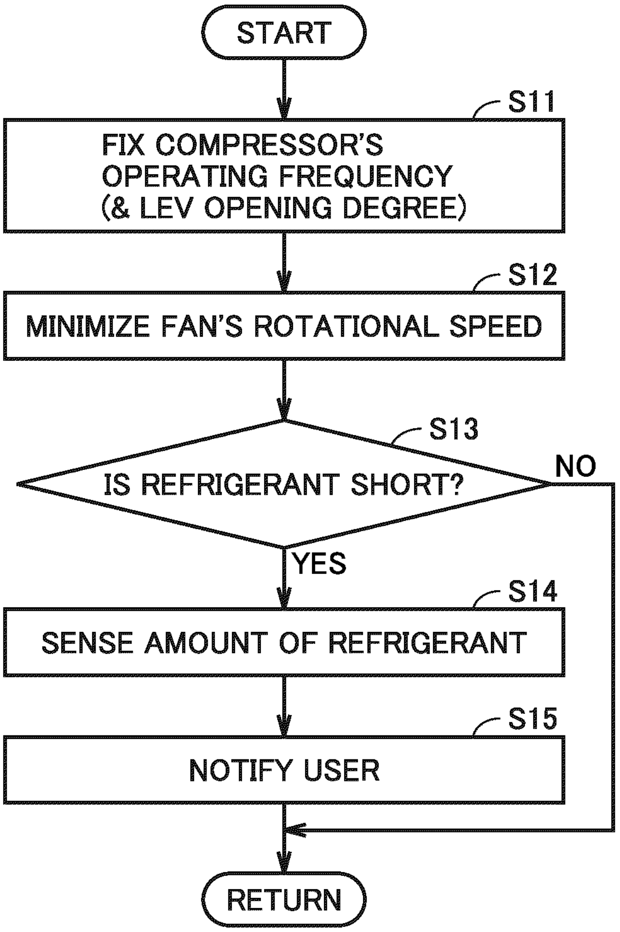

START
S11
FIX COMPRESSOR'S OPERATING FREQUENCY (& LEV OPENING DEGREE)
S12
MINIMIZE FAN'S ROTATIONAL SPEED
S13
IS REFRIGERANT SHORT?
NO
YES
S14
SENSE AMOUNT OF REFRIGERANT
S15
NOTIFY USER
RETURN

FIG.8

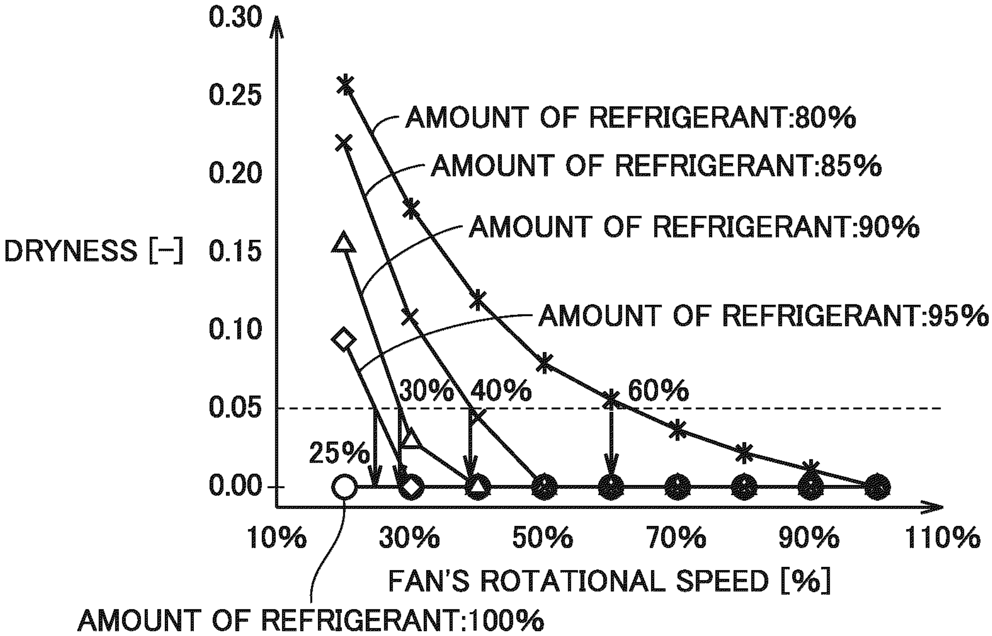

DRYNESS [−]
0.30
0.25
0.20
0.15
0.10
0.05
0.00
AMOUNT OF REFRIGERANT:80%
AMOUNT OF REFRIGERANT:85%
AMOUNT OF REFRIGERANT:90%
AMOUNT OF REFRIGERANT:95%
25%
30%
40%
60%
10%
30%
50%
70%
90%
110%
FAN'S ROTATIONAL SPEED [%]
AMOUNT OF REFRIGERANT:100%

FIG.9

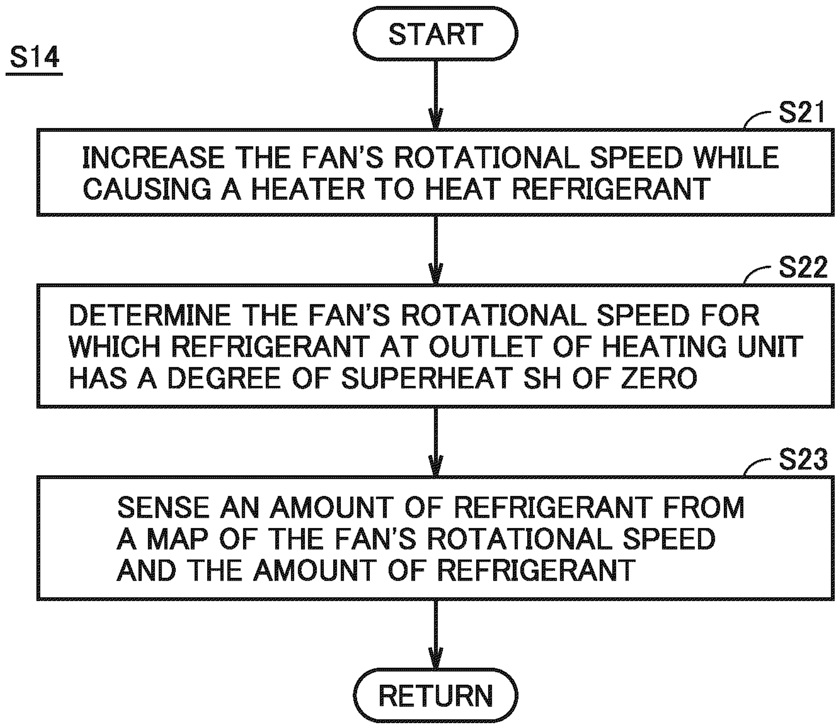

S14
START
S21
INCREASE THE FAN'S ROTATIONAL SPEED WHILE CAUSING A HEATER TO HEAT REFRIGERANT
S22
DETERMINE THE FAN'S ROTATIONAL SPEED FOR WHICH REFRIGERANT AT OUTLET OF HEATING UNIT HAS A DEGREE OF SUPERHEAT SH OF ZERO
S23
SENSE AN AMOUNT OF REFRIGERANT FROM A MAP OF THE FAN'S ROTATIONAL SPEED AND THE AMOUNT OF REFRIGERANT
RETURN

FIG.10

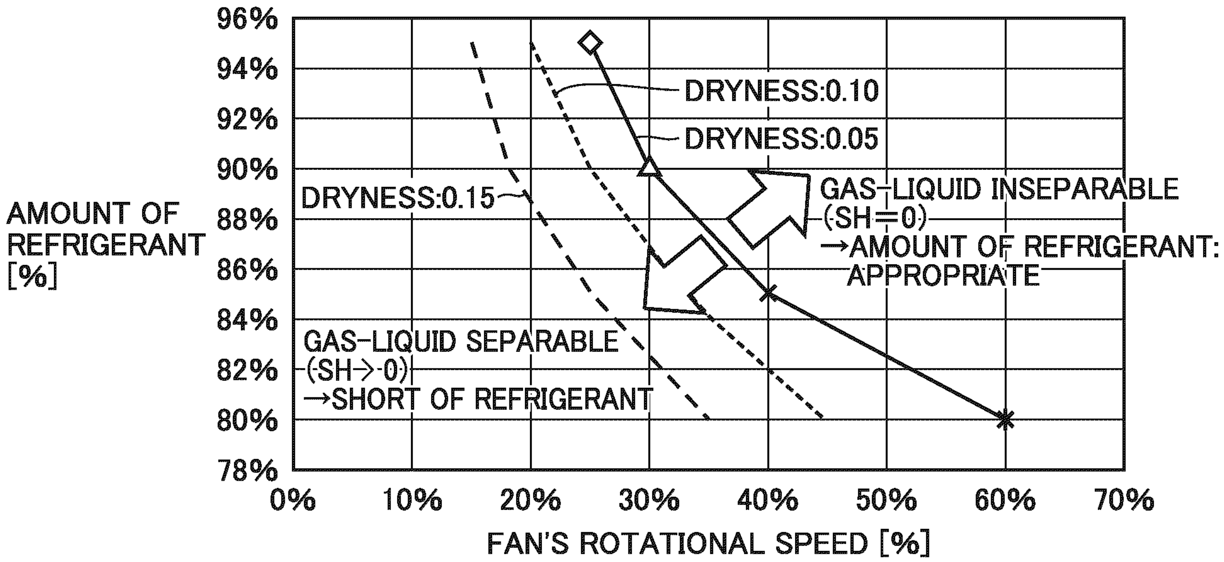

AMOUNT OF REFRIGERANT [%]
96%
94%
92%
90%
88%
86%
84%
82%
80%
78%
0%
10%
20%
30%
40%
50%
60%
70%
FAN'S ROTATIONAL SPEED [%]
DRYNESS:0.10
DRYNESS:0.05
DRYNESS:0.15
GAS-LIQUID INSEPARABLE (SH≒0)
→AMOUNT OF REFRIGERANT: APPROPRIATE
GAS-LIQUID SEPARABLE (SH>0)
→SHORT OF REFRIGERANT

FIG.11

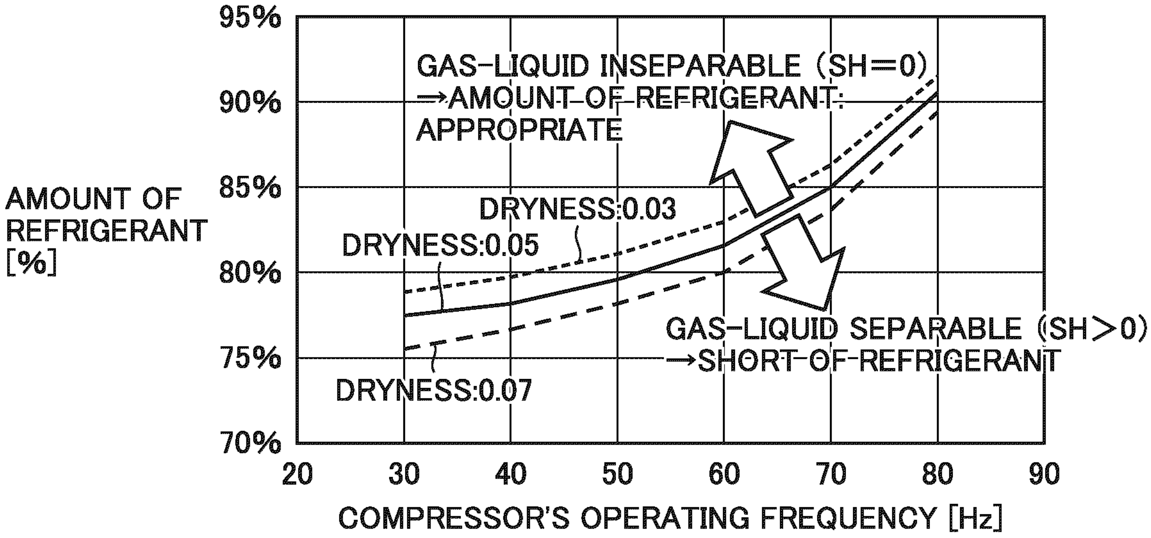

95%
90%
85%
80%
75%
70%
AMOUNT OF REFRIGERANT [%]
GAS-LIQUID INSEPARABLE (SH=0) →AMOUNT OF REFRIGERANT: APPROPRIATE
DRYNESS:0.03
DRYNESS:0.05
DRYNESS:0.07
GAS-LIQUID SEPARABLE (SH>0) →SHORT OF REFRIGERANT
20
30
40
50
60
70
80
90
COMPRESSOR'S OPERATING FREQUENCY [Hz]

FIG.12

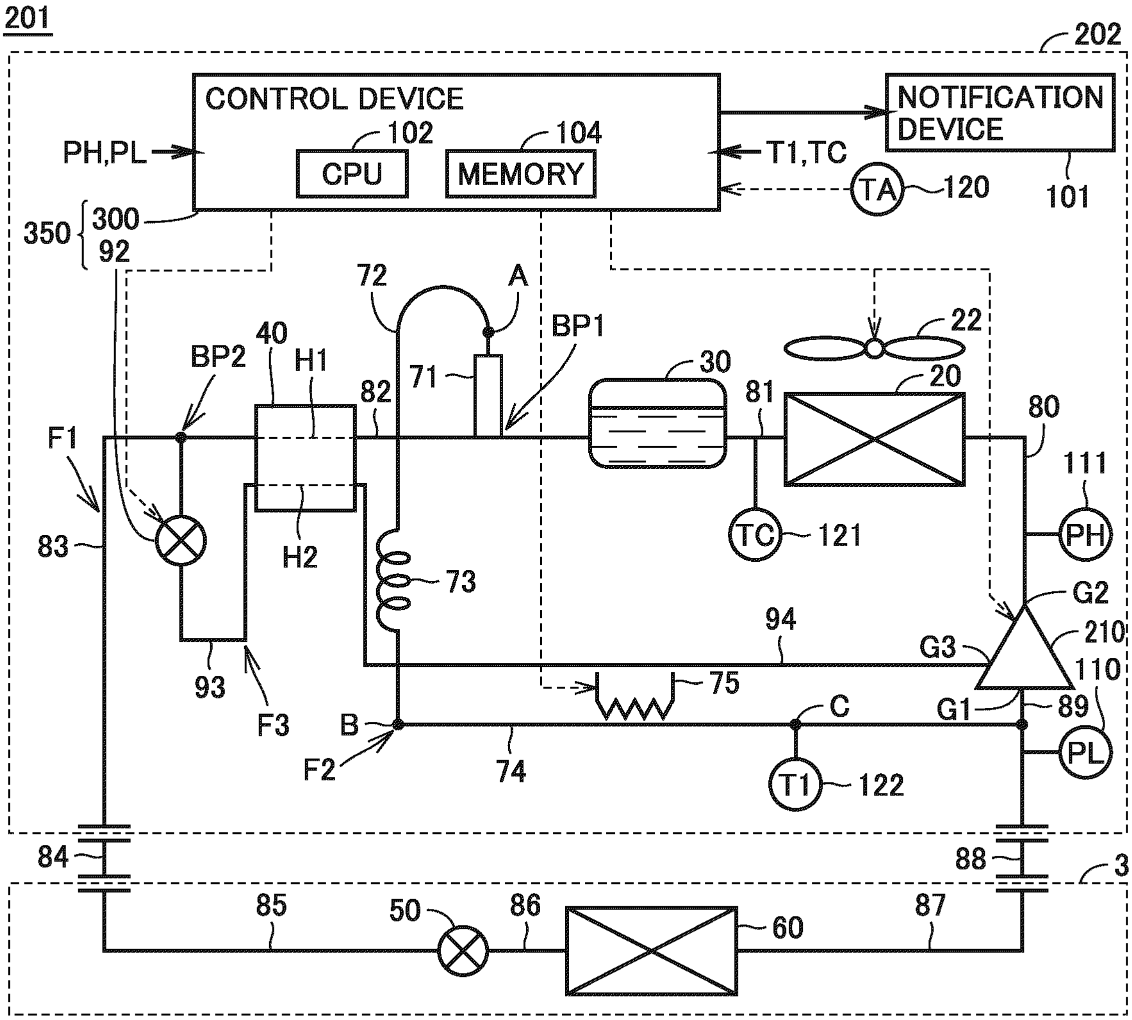
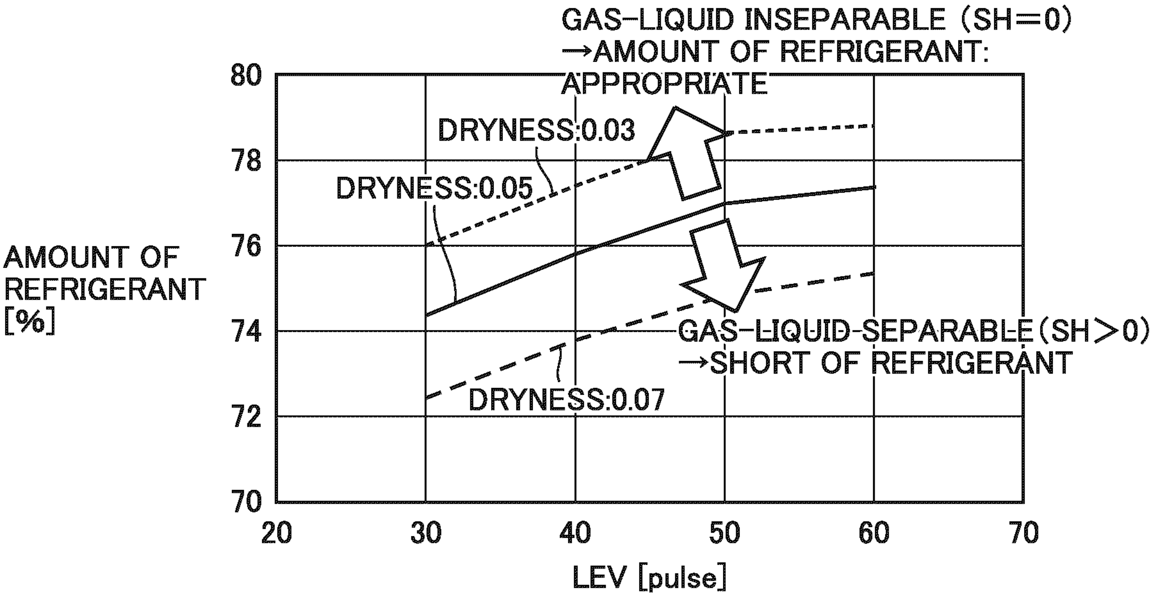

201
202
CONTROL DEVICE
CPU
102
MEMORY
104
NOTIFICATION DEVICE
101
PH,PL
T1,TC
TA
120
350
300
92
72
A
BP1
22
40
H1
BP2
30
20
82
71
81
80
F1
111
83
H2
TC
121
PH
73
G2
94
210
G3
110
75
93
F3
B
C
G1
89
F2
74
T1
122
PL
84
88
3
85
50
86
60
87

FIG.13


GAS-LIQUID INSEPARABLE (SH=0)
→AMOUNT OF REFRIGERANT: APPROPRIATE
DRYNESS:0.03
DRYNESS:0.05
DRYNESS:0.07
GAS-LIQUID-SEPARABLE (SH>0)
→SHORT OF REFRIGERANT
AMOUNT OF REFRIGERANT [%]
80
78
76
74
72
70
20
30
40
50
60
70
LEV [pulse]

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/047501

A. CLASSIFICATION OF SUBJECT MATTER
F25B 49/02(2006.01)i; F25B 1/00(2006.01)i
FI: F25B49/02 520E; F25B1/00 101E; F25B1/00 321B

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)
F25B49/02; F25B1/00

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	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2018-197616 A (DAIKIN INDUSTRIES, LTD.) 13.12.2018 (2018-12-13) paragraphs [0045]-[0050], [0068]-[0075], [0082]-[0113], fig. 1-10	1-7
A	JP 63-169461 A (MITSUBISHI ELECTRIC CORP.) 13.07.1988 (1988-07-13) page 3, upper left column, line 12 to lower right column, line 17, fig. 1-2	1-7
A	JP 4-60359 A (NIPPONDENSO CO., LTD.) 26.02.1992 (1992-02-26) page 2, lower left column, line 16 to page 3, lower left column, line 14, fig. 1-2	1-7

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
06 January 2020 (06.01.2020)	14 January 2020 (14.01.2020)

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

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2019/047501

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 2018-197616 A	13 Dec. 2018	(Family: none)	
JP 63-169461 A	13 Jul. 1988	(Family: none)	
JP 4-60359 A	26 Feb. 1992	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

• WO 2016135904 A **[0002] [0003]**