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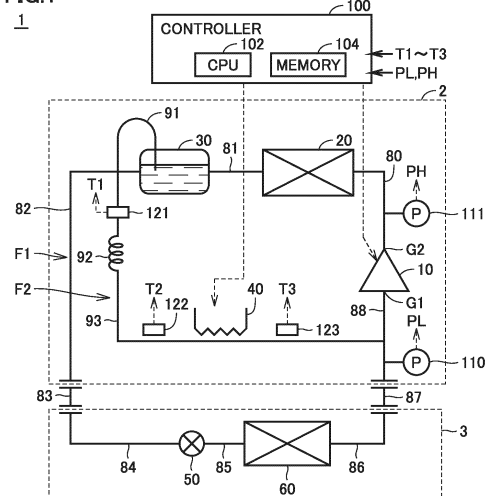
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(54) **COLD HEAT SOURCE UNIT, REFRIGERATION CYCLE DEVICE, AND REFRIGERATING MACHINE**

(57) A cold source unit (2) includes a first flow path (F1) configured to receive refrigerant from an evaporator (60) and send out the refrigerant toward a first expansion device (50) via a compressor (10) and a condenser (20); a second flow path (F2) configured to send, to the compressor (10) not via the first expansion device (50) and the evaporator (60), the refrigerant that has passed through the condenser (20); a second expansion device (92) provided at the second flow path (F2); and a plurality of temperature sensors (121 to 123) disposed at the second flow path (F2). A controller (100) is configured to control a refrigeration cycle apparatus (1) such that temperatures detected by the plurality of temperature sensors become equal to each other, and calculate an average value of the temperatures detected by the plurality of temperature sensors, and perform correction on each of the plurality of temperature sensors based on a difference between the average value and a temperature detected by a corresponding one of the plurality of temperature sensors.

FIG.1



Description

TECHNICAL FIELD

5 **[0001]** The present disclosure relates to a cold source unit, a refrigeration cycle apparatus and a refrigerator.

BACKGROUND ART

10 **[0002]** Japanese Patent No. 5505477 discloses an air conditioning apparatus that can make refrigerant amount appropriateness determination at proper operation, at low cost and with a small determination error, even under the influence of disturbances such as dirt of an outdoor heat exchanger, a placement situation of an outdoor unit, and wind and rain.

CITATION LIST

15 **PATENT LITERATURE**

[0003] PTL 1: Japanese Patent No. 5505477

SUMMARY OF INVENTION

20 **TECHNICAL PROBLEM**

[0004] In Japanese Patent No. 5505477, the appropriateness of the amount of refrigerant is determined based on a degree of supercooling of the refrigerant in the air conditioning apparatus. Detection of the degree of supercooling requires detection of a temperature by a temperature sensor or the like. Generally, however, a value of the temperature detected by the temperature sensor has manufacturing variations. Therefore, there is room for improvement in accurately determining the appropriateness of the amount of refrigerant. There is a refrigeration cycle apparatus such as a refrigerator generally including a receiver provided between a condenser and an expansion valve. In the refrigeration cycle apparatus including the receiver, at the stage where an amount of liquid refrigerant is changing somewhat in the receiver, a degree of supercooling at the outlet of the condenser does not change so much, even when the amount of refrigerant decreases. Therefore, the decrease in amount of refrigerant cannot be detected by using the method described in Japanese Patent No. 5505477, unless an amount of leakage of the refrigerant is large.

[0005] Furthermore, in recent years, there has been a demand to suppress emission of CFCs. A refrigerator has been demanded to enclose refrigerant having a global warming potential (GWP) lower than 1500, and a facility manager has been required to report an amount of leakage of the refrigerant equal to or larger than a certain amount.

35 **[0006]** An object of the present disclosure is to disclose a cold source unit of a refrigeration cycle apparatus, a refrigeration cycle apparatus and a refrigerator, which make it possible to accurately detect leakage of refrigerant at the stage of a small amount of leakage.

40 **SOLUTION TO PROBLEM**

[0007] The present disclosure relates to a cold source unit that is connectable to a load device including a first expansion device and an evaporator and that is included in a refrigeration cycle apparatus. The cold source unit includes: a compressor; a condenser; a first flow path configured to receive refrigerant from the evaporator and send out the refrigerant toward the first expansion device via the compressor and the condenser; a second flow path configured to send, to the compressor not via the first expansion device and the evaporator, the refrigerant that has passed through the condenser; a second expansion device provided at the second flow path; a plurality of temperature sensors disposed at the second flow path; and a controller configured to control the refrigeration cycle apparatus based on outputs of the plurality of temperature sensors. The controller is configured to control the refrigeration cycle apparatus such that temperatures detected by the plurality of temperature sensors become equal to each other, and calculate an average value of the temperatures detected by the plurality of temperature sensors. The controller is configured to perform correction on each of the plurality of temperature sensors based on a difference between the average value and a temperature detected by a corresponding one of the plurality of temperature sensors.

55 **ADVANTAGEOUS EFFECTS OF INVENTION**

[0008] According to the cold source unit of the refrigeration cycle apparatus, the refrigeration cycle apparatus and the refrigerator of the present disclosure, it is possible to accurately detect leakage of refrigerant at the stage of a small

amount of leakage.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

Fig. 1 shows a configuration of a refrigeration cycle apparatus 1 in a first embodiment.

Fig. 2 is a diagram for illustrating a configuration of a receiver in the first embodiment.

Fig. 3 is a flowchart for illustrating a process of determining a refrigerant shortage, which is performed by a controller 100.

Fig. 4 is a diagram for illustrating correction on temperature sensors.

Fig. 5 is a graph showing a relationship between a detection error range of the temperature sensors and a required heater capacity.

Fig. 6 is a flowchart for illustrating detection of a composition of refrigerant and control in accordance with the composition.

Fig. 7 is a diagram for illustrating detection of the composition of the refrigerant in step S26.

Fig. 8 is a diagram for illustrating a relationship between a composition and an evaporation temperature.

Fig. 9 is a graph showing a relationship between the number of averaged sensors and a temperature error.

Fig. 10 shows a configuration of a refrigeration cycle apparatus 1A in a second embodiment.

Fig. 11 shows a first example of a shape of branching at a branch point BP.

Fig. 12 shows a second example of a shape of branching at branch point BP.

DESCRIPTION OF EMBODIMENTS

[0010] Embodiments will be described in detail hereinafter with reference to the drawings. Although a plurality of embodiments will be described below, it is originally intended to combine as appropriate the features described in the embodiments. In the drawings, the same or corresponding portions are denoted by the same reference characters, and description thereof will not be repeated.

First Embodiment

[0011] In recent years, from the perspective of prevention of global warming, mixed refrigerant has sometimes been used in an air conditioning apparatus. The mixed refrigerant has a global warming potential (GWP) that is reduced by mixing refrigerant composed of a single component with another refrigerant having a lower GWP. The mixed refrigerant includes azeotropic refrigerant and non-azeotropic refrigerant.

[0012] The azeotropic refrigerant shows a certain boiling point, shows the same composition both in a gas phase and in a liquid phase, and shows a phase change like single-component refrigerant, when multiple-component refrigerant is mixed at a certain ratio. The azeotropic refrigerant has such a characteristic that a temperature does not change under the same pressure during a phase change in a two-phase state, whereas the non-azeotropic refrigerant has such a characteristic that a temperature changes during a phase change under the same pressure.

[0013] In the case of a refrigeration cycle apparatus including non-azeotropic refrigerant, a composition of the circulating refrigerant varies depending on an operating state of the refrigeration cycle apparatus, and thus, it is preferable to change control in accordance with the composition. A configuration of the refrigeration cycle apparatus will be described below.

[0014] Fig. 1 shows a configuration of a refrigeration cycle apparatus 1 in a first embodiment. Non-azeotropic mixed refrigerant is used in this refrigeration cycle apparatus. Fig. 1 functionally shows connection relationships and arrangement configurations of the devices in the refrigeration apparatus, and does not necessarily show arrangement in a physical space.

[0015] Referring to Fig. 1, refrigeration cycle apparatus 1 includes a cold source unit 2, a load device 3, and extension pipes 83 and 87.

[0016] Cold source unit 2 of refrigeration cycle apparatus 1 is connectable to load device 3 by extension pipes 83 and 87. Although cold source unit 2 is not particularly limited, cold source unit 2 is also referred to as "outside unit" or "outdoor unit" because cold source unit 2 is generally often disposed outside a room or outdoors.

[0017] Cold source unit 2 includes a compressor 10, a condenser 20, a receiver 30, and pipes 80 to 82 and 88. Receiver 30 is disposed between pipe 81 and pipe 82, and is configured to store the refrigerant.

[0018] Load device 3 includes a first expansion device 50, an evaporator 60 and pipes 84, 85 and 86. First expansion device 50 is implemented by, for example, a temperature expansion valve controlled independently of cold source unit 2.

[0019] A first flow path F1 extending from pipe 88 through compressor 10, pipe 80, condenser 20, pipe 81, and receiver 30 to pipe 82 is configured to form, together with load device 3, a circulation flow path in which the refrigerant circulates.

Hereinafter, this circulation flow path will also be referred to as "main circuit" of a refrigeration cycle. First flow path F1 is configured to receive the refrigerant from evaporator 60 and send out the refrigerant toward first expansion device 50 via compressor 10 and condenser 20.

[0020] Cold source unit 2 further includes a second flow path F2. Second flow path F2 is configured to send, to compressor 10 not via first expansion device 50 and evaporator 60, the refrigerant that has passed through condenser 20. Second flow path F2 includes a pipe 91, a pipe 93, and a second expansion device 92 disposed between pipe 91 and pipe 93. A capillary tube can, for example, be used as second expansion device 92. Pipe 91 is configured to cause the refrigerant to flow from receiver 30 in first flow path F1 to second expansion device 92. Pipe 93 is configured to cause the refrigerant having passed through second expansion device 92 to flow to pipe 88 connected to an inlet of compressor 10. Hereinafter, second flow path F2 that branches off from the main circuit and sends the refrigerant to compressor 10 via second expansion device 92 will also be referred to as "injection flow path".

[0021] Receiver 30 is disposed downstream of condenser 20 in first flow path F1, and is connectable to a first end of second flow path F2.

[0022] Cold source unit 2 further includes a heater 40 and temperature sensors 121 to 123. Heater 40 is provided downstream of second expansion device 92 in second flow path F2, and heats the refrigerant flowing through pipe 93. Thermistors can, for example, be used as temperature sensors 121 to 123.

[0023] A suction port G1 of compressor 10 is connected to pipe 88, and a discharge port G2 of compressor 10 is connected to pipe 80. Compressor 10 includes suction port G1 and discharge port G2. Compressor 10 is configured to suction the refrigerant having passed through evaporator 60 from suction port G1, and discharge the refrigerant from discharge port G2 toward condenser 20.

[0024] Compressor 10 is configured to adjust a rotation speed in accordance with a control signal from a controller 100. By adjusting the rotation speed of compressor 10, an amount of circulation of the refrigerant is adjusted, and thus, a refrigeration capacity of refrigeration cycle apparatus 1 can be adjusted. Various types of compressors can be used as compressor 10, and a scroll-type compressor, a rotary-type compressor, a screw-type compressor or the like can, for example, be used.

[0025] Condenser 20 condenses the refrigerant discharged from compressor 10 to pipe 80, and causes the condensed refrigerant to flow to pipe 81. Condenser 20 is configured to exchange heat between the high-temperature and high-pressure gas refrigerant discharged from compressor 10 and the outdoor air. As a result of this heat exchange, the refrigerant having dissipated heat condenses to a liquid phase or two phases. A not-shown fan supplies, to condenser 20, the outdoor air for heat exchange with the refrigerant in condenser 20. By adjusting the rotation speed of the fan, a refrigerant pressure on the discharge side of compressor 10 can be adjusted.

[0026] Receiver 30 stores the liquid refrigerant that flows in from condenser 20. Gas refrigerant mixed in the liquid refrigerant is separated from the liquid refrigerant in receiver 30, and thus, the liquid refrigerant is discharged from pipe 82.

[0027] Cold source unit 2 further includes pressure sensors 110 and 111, and controller 100 that controls cold source unit 2.

[0028] Pressure sensor 110 detects a pressure PL of the refrigerant suctioned into compressor 10, and outputs a detection value to controller 100. Pressure sensor 111 detects a pressure PH of the refrigerant discharged from compressor 10, and outputs a detection value to controller 100.

[0029] Temperature sensor 121 detects a temperature T1 of the refrigerant in pipe 91 that connects receiver 30 and second expansion device 92, and outputs a detection value to controller 100. Temperature sensor 122 detects a temperature T2 of the refrigerant flowing through a portion of pipe 93 on the upstream side of heater 40, and outputs a detection value to controller 100. Temperature sensor 123 detects a temperature T3 of the refrigerant flowing through a portion of pipe 93 on the downstream side of heater 40, and outputs a detection value to controller 100.

[0030] Controller 100 includes a central processing unit (CPU) 102, a memory 104 (a read only memory (ROM) and a random access memory (RAM)), an input/output buffer (not shown) for inputting/outputting various signals, and the like. CPU 102 loads programs stored in the ROM to the RAM or the like and performs the programs. The programs stored in the ROM are programs describing a process procedure of controller 100. In accordance with these programs, controller 100 performs control of the devices in cold source unit 2. This control is not limited to processing by software, and may be performed by processing by dedicated hardware (electronic circuit).

[0031] In the present embodiment, controller 100 is configured to a) determine an amount of the refrigerant enclosed in refrigeration cycle apparatus 1, and b) control cold source unit 2 in accordance with a composition of the refrigerant circulating in the main circuit of refrigeration cycle apparatus 1.

[0032] Fig. 2 is a diagram for illustrating a configuration of the receiver in the first embodiment.

[0033] Referring to Fig. 2, receiver 30 includes a housing 31 that stores the liquid refrigerant, an inlet pipe IP1, a first outlet pipe OP1, and a second outlet pipe OP2.

[0034] An outlet of receiver 30 to first flow path F1, which is a part of the main circuit, is first outlet pipe OP1. Second outlet pipe OP2 is an outlet of receiver 30 different from first outlet pipe OP1.

[0035] Pipe 91 is configured to cause the refrigerant to flow from second outlet pipe OP2 to second expansion device

92. In receiver 30, an inlet port of second outlet pipe OP2 is disposed at a position higher than an inlet port of first outlet pipe OP1. Based on a state of the refrigerant suctioned from pipe 91, the appropriateness of the amount of the refrigerant enclosed in refrigeration cycle apparatus 1 can be determined.

[0036] Specifically, a height L1 of the inlet port of first outlet pipe OP1 and a height L2 of the inlet port of second outlet pipe OP2 are lower than a liquid level height L0 when the amount of the refrigerant is appropriate. However, height L2 of the inlet port of second outlet pipe OP2 is between height L1 and height L0, and a position in a height direction is determined in accordance with the sensitivity of detection of a refrigerant shortage. When height L2 is brought closer to height L0, the gas refrigerant is suctioned due to only a little drop of the liquid level of the refrigerant, and thus, the sensitivity of detection of a refrigerant shortage becomes higher. In contrast, when height L2 is brought closer to height L1, the gas refrigerant is not suctioned due to a little drop of the liquid level of the refrigerant, and thus, the sensitivity of detection becomes lower although a refrigerant shortage can be detected.

[0037] Fig. 3 is a flowchart for illustrating a process of determining a refrigerant shortage, which is performed by controller 100. The process in this flowchart is periodically performed during operation of refrigeration cycle apparatus 1. For example, the frequency of performance can, for example, be set to approximately once a day. Referring to Fig. 3, in step S11, controller 100 turns off heater 40. As a result, a refrigerant temperature on the upstream side of heater 40 and a refrigerant temperature on the downstream side of heater 40 become equal to each other. Therefore, temperature T2 and temperature T3 should be equal to each other if there is no error in temperature sensors 122 and 123.

[0038] In step S12, controller 100 detects refrigerant temperature T2 on the inlet side of heater 40 and refrigerant temperature T3 on the outlet side of heater 40, and performs correction on temperature sensors 122 and 123. As an example of correction, it is conceivable to use a difference between an average value and a measured value as an amount of correction. Specifically, a difference $\Delta T2$ between an average value Tave and a detected temperature T2c at the time of correction is subtracted from detected temperature T2, and a difference $\Delta T3$ between average value Tave and a detected temperature T3c at the time of correction is subtracted from detected temperature T3.

[0039] An example of specific correction equations is given by Equations (1) to (3) below:

$$Tave=(T2c+T3c)/2 \text{ (heater off state) ... (1)}$$

$$\Delta T2=T2c-Tave \text{ (heater off state) ... (2)}$$

$$\Delta T3=T3c-Tave \text{ (heater off state) ... (3).}$$

[0040] Each symbol in Equations (1) to (3) indicates the following:

T2c: heater inlet detected temperature at the time of correction

T3c: heater outlet detected temperature at the time of correction

Tave: average temperature of heater inlet temperature and heater outlet temperature at the time of correction

$\Delta T2$: correction value for heater inlet temperature detecting means

$\Delta T3$: correction value for heater outlet temperature detecting means.

[0041] Next, in step S13, controller 100 turns on heater 40 and corrects the temperatures detected by temperature sensors 122 and 123 in accordance with Equations (4) and (5) below:

$$T2'=T2-\Delta T2 \text{ (heater on state) ... (4)}$$

$$T3'=T3-\Delta T3 \text{ (heater on state) ... (5).}$$

[0042] Each symbol in Equations (4) and (5) indicates the following:

T2: heater inlet detected temperature before correction

T3: heater outlet detected temperature before correction

T2': heater inlet detected temperature after correction

T3': heater outlet detected temperature after correction.

[0043] After this, and until the next correction, values T_2' and T_3' corrected by correction values ΔT_2 and ΔT_3 are used as the values measured by temperature sensors 122 and 123.

[0044] Fig. 4 is a diagram for illustrating correction on the temperature sensors.

[0045] Generally, when n samples are randomly extracted from a normal population $N(\mu, \sigma^2)$ and an average is taken, a new normal population $N(\mu, \sigma^2/n)$ is obtained. This means that when the heater is turned off and an average value of the value detected by temperature sensor 122 and the value detected by temperature sensor 123 is taken, a detection error of $1/\sqrt{2}$ is obtained.

[0046] Furthermore, by making n larger than 2, the error can be further reduced. For example, temperature sensor 121 disposed upstream of second expansion device 92 can also be used in a stable state such as when compressor 10 is not operating. In this case, $n=3$, and thus, average value T_{ave} , correction values ΔT_1 to ΔT_3 , and temperatures T_1' to T_3' after correction are given by Equations (6) to (12) below:

$$T_{ave} = (T_{1c} + T_{2c} + T_{3c}) / 3 \text{ (heater and compressor off state) ... (6)}$$

$$\Delta T_1 = T_{1c} - T_{ave} \text{ (heater off state) ... (7)}$$

$$\Delta T_2 = T_{2c} - T_{ave} \text{ (heater off state) ... (8)}$$

$$\Delta T_3 = T_{3c} - T_{ave} \text{ (heater off state) ... (9)}$$

$$T_1' = T_1 - \Delta T_1 \text{ (heater on state) ... (10)}$$

$$T_2' = T_2 - \Delta T_2 \text{ (heater on state) ... (11)}$$

$$T_3' = T_3 - \Delta T_3 \text{ (heater on state) ... (12).}$$

[0047] Furthermore, when another temperature sensor is used during the refrigeration cycle, the number of n may be increased and correction may be performed on the temperature sensors under such an operation condition that n temperature sensors (n is the natural number equal to or more than 4) including this temperature sensor detect the same temperature.

[0048] Referring again to Fig. 3, after the heater is turned on in step S13, the amount of the refrigerant is determined in steps S14 and S15.

[0049] As a prerequisite for performing the process of determining the amount of the refrigerant, the position of second outlet pipe OP2 that introduces the liquid refrigerant into the injection flow path as shown in Fig. 2 needs to be appropriate. By appropriately setting height L2, the liquid refrigerant is sent from receiver 30 to the injection flow path when the amount of the refrigerant is appropriate, and the gas refrigerant is sent to the injection flow path when the liquid refrigerant is insufficient.

[0050] When the amount of the refrigerant is appropriate, the liquid refrigerant is decompressed by second expansion device 92, and as a result, the refrigerant in a two-phase state flows through pipe 93. This refrigerant is heated by heater 40.

[0051] Next, in step S14, controller 100 detects temperature T_2 of the refrigerant on the upstream side of heater 40 and temperature T_3 of the refrigerant on the downstream side of heater 40, using temperature sensors 122 and 123. Then, controller 100 determines whether a difference between temperature T_2 and temperature T_3 of the refrigerant is larger than a threshold value.

[0052] When the amount of the refrigerant is appropriate and the refrigerant in a two-phase state flows through pipe 93, the temperature difference is equal to or smaller than the threshold value (NO in S14). In contrast, when the amount of the refrigerant is smaller than the appropriate amount, the refrigerant flowing through pipe 93 changes to a gas state in the middle, and thus, all of the heat provided by heating is converted into sensible heat and the temperature difference becomes larger than the threshold value (YES in S14). When the temperature difference is larger than the threshold value, controller 100 determines that the refrigerant is insufficient and notifies a user in step S15.

[0053] Heater 40 is used to determine a refrigerant shortage as in Fig. 3. Reducing the error of the temperature sensors provides such an advantage that a capacity of heater 40 can be small.

[0054] Heater 40 requires a heater capacity that allows the temperature sensors to detect whether the temperature rises when the refrigerant is heated by heater 40. Therefore, when the detection error of the temperature sensors is large, a large amount of heat generated per hour is necessary in order to allow the temperature sensors to reliably detect that the temperature of the refrigerant has risen. The amount of heat generated per hour is proportional to the heater capacity (W). In contrast, when the detection error of the temperature sensors is small, the heater capacity can be small.

[0055] Fig. 5 is a graph showing a relationship between a detection error range of the temperature sensors and a required heater capacity. For example, when the error of the temperature sensors is 1.5°C, the required heater capacity is 9 W. However, when the present embodiment causes the error of the temperature sensors to decrease to 1.1 °C in the same apparatus, the heater capacity can decrease to approximately 6.6 W. This is shown in Fig. 5.

[0056] In other words, without error correction, the temperature sensors have the maximum error of 1.5°C. When the two sensors are used with averaging and correction, the maximum error can be expected to decrease to 1.1°C. A heater of 9 W was required to raise the temperature of the refrigerant by 1.5°C or more. However, by using the temperature sensors with correction, detection by the temperature sensors becomes possible when the temperature of the refrigerant is raised by 1.1 °C or more. Therefore, a capacity of a heater that is usable in this case can be reduced to 6.6 W.

[0057] Furthermore, in the present embodiment, detection of a composition of the refrigerant is performed in addition to the detection of a refrigerant shortage.

[0058] Fig. 6 is a flowchart for illustrating detection of a composition of the refrigerant and control in accordance with the composition.

[0059] Referring to Fig. 6, when the determination of a refrigerant shortage in Fig. 5 has preliminarily been performed, controller 100 determines whether the amount of the refrigerant is appropriate in step S21. When the amount of the refrigerant is not appropriate (NO in S21), controller 100 stops the operation of the refrigeration cycle apparatus. In contrast, when the amount of the refrigerant is appropriate (YES in S21), controller 100 performs a process of detecting a composition of the refrigerant in step S22 and the subsequent steps. It is not essential to perform the processing in step S21 simultaneously with the detection of the composition.

[0060] In step S22, controller 100 turns off heater 40 because heater 40 is not used for the detection of the composition. Then, in step S24, the controller detects temperatures T1 to T3 and pressure PL. Corrected values are used as temperatures T1 to T3.

[0061] In the case of the non-azeotropic refrigerant, the composition of the refrigerant circulating in the refrigeration cycle apparatus is determined by a ratio of the mass of the gas refrigerant in receiver 30 to the total mass of the enclosed refrigerant. For example, when receiver 30 is filled with the liquid and the gas refrigerant is not present, the composition of the circulating refrigerant is equal to the composition when the refrigerant is enclosed. However, when the gas refrigerant is present in receiver 30, the gas refrigerant stays in receiver 30 and does not circulate in the refrigeration cycle apparatus. Therefore, the composition of the refrigerant circulating in the refrigeration cycle apparatus is equal to the composition of the refrigerant excluding the gas refrigerant in receiver 30.

[0062] First, in step S24, controller 100 converts temperature T1 into enthalpy H1. In a liquid-phase region of a p-h diagram, an isothermal line has the unchanging enthalpy even if the pressure of the refrigerant changes. Therefore, when the temperature of the liquid refrigerant is measured, the temperature corresponds to the enthalpy in a one-to-one relationship. Therefore, by referring to a conversion table prestored in the memory, temperature T1 can be immediately converted into enthalpy H1. This enthalpy H1 does not change when adiabatic expansion is performed in second expansion device 92. Therefore, the enthalpy of the refrigerant flowing through pipe 93 disposed downstream of second expansion device 92 is also enthalpy H1.

[0063] Next, in step S25, controller 100 calculates average value Tave of the detection values by temperature sensors 122 and 123 before and after heater 40. When heater 40 is off, a reduction in temperature detection error can be expected by using average value Tave as a detection value.

[0064] Then, in step S26, controller 100 detects the composition of the refrigerant based on enthalpy H1, pressure PL and temperature Tave.

[0065] Generally, if a composition of non-azeotropic mixed refrigerant can be identified, a saturation temperature thereof can be obtained based on a pressure and enthalpy. Conversely, if the pressure, the enthalpy and the saturation temperature are known, the composition can be identified.

[0066] More specifically, assuming that the composition is known, if two of the pressure, the enthalpy and the temperature of the refrigerant are identified, the remaining one is obtained. If all of the pressure, the enthalpy and the temperature are identified, the composition is obtained.

[0067] This principle is applied. Using pressure PL measured by pressure sensor 110, temperature Tave, and enthalpy H1 calculated from temperature T1 measured by temperature sensor 121, and using a preliminarily created function or conversion map, controller 100 identifies the composition of the refrigerant.

[0068] Fig. 7 is a diagram for illustrating the detection of the composition of the refrigerant in step S26. Fig. 7 shows a relationship between the composition and the temperature in a state where the pressure and the enthalpy are fixed. Fig. 7 shows the relationship between the composition and the temperature in a portion that detects the composition of

the refrigerant, i.e., in a low pressure portion (pressure PL) in the injection flow path in the refrigeration cycle apparatus. In Fig. 7, the vertical axis represents average temperature Tave of the temperatures of the refrigerant detected by the two temperature sensors disposed at the outlet of second expansion device 92, and the horizontal axis represents a weight ratio between an amount of the gas refrigerant and an amount of the enclosed refrigerant in receiver 30 in terms of percent. In Fig. 7, enthalpy H1 converted from temperature T1 and pressure PL are fixed at certain values. Under this condition, temperature Tave corresponds to the weight ratio between the amount of the gas refrigerant and the amount of the enclosed refrigerant in a one-to-one relationship. Let us assume, for example, that temperature Tave when receiver 30 is filled with the liquid and the composition of the circulating refrigerant is a pure composition of the non-azeotropic refrigerant is -39.8°C, and actual temperature Tave is -38°C. Therefore, a temperature deviation ΔT from the temperature in the case of the pure composition corresponds to 25% in the weight ratio (%) between the amount of the gas refrigerant and the amount of the enclosed refrigerant indicated by the horizontal axis.

[0069] The weight ratio between the amount of the gas refrigerant and the amount of the enclosed refrigerant corresponds to the composition of the circulating refrigerant. Therefore, when temperature Tave is known, the composition of the circulating refrigerant can be determined. Such a relationship shown in the graph is present for each pressure and for each enthalpy. Therefore, a map for determining the composition of the refrigerant can be created based on pressure PL, temperature Tave and enthalpy H1 (or temperature T1).

[0070] The process of determining the composition of the circulating refrigerant described above is performed in step S26. Next, in step S27, controller 100 associates the detected composition with a conversion equation between the pressure and the evaporation temperature. The evaporation temperature herein refers to an average evaporation temperature of a dew point and a boiling point.

[0071] Fig. 8 is a diagram for illustrating a relationship between the composition and the evaporation temperature. Fig. 8 shows the relationship between the composition and the temperature in a state where the pressure and the enthalpy are fixed. Fig. 8 shows the relationship between the composition and the temperature in a portion reflected in the control of the refrigeration cycle apparatus, i.e., in a low pressure portion in the refrigeration cycle apparatus. In Fig. 8, the vertical axis represents the average evaporation temperature of evaporator 60, and the horizontal axis represents the weight ratio between the amount of the gas refrigerant and the amount of the enclosed refrigerant in receiver 30 in terms of percent.

[0072] The graph shown in Fig. 8 corresponds to a map for reflecting the detected composition in the control. For example, when the weight ratio (%) between the amount of the gas refrigerant and the amount of the enclosed refrigerant corresponding to the composition, i.e., 25% is applied to the map shown in Fig. 8, assuming that the average evaporation temperature when receiver 30 is filled with the liquid and the composition of the circulating refrigerant is a pure composition of the non-azeotropic refrigerant is -40°C, the average evaporation temperature is -38.5°C.

[0073] Next, in step S27, controller 100 determines, as a suction pressure, pressure PL for controlling the refrigeration cycle apparatus to achieve the average evaporation temperature obtained in step S36, and then, controller 100 changes the operation frequency of compressor 10 to achieve pressure PL.

[0074] That is, controller 100 controls compressor 10 by using a pressure corresponding to a saturation temperature corresponding to the detected composition as a target value of pressure PL on the inlet side of compressor 10.

[0075] When the processing in step S27 is completed, the control returns to the main routine. In the case of the non-azeotropic refrigerant, the flowchart in Fig. 6 is repeatedly performed, and thus, the control of compressor 10 is performed in accordance with the composition of the circulating refrigerant, when an amount of the liquid in receiver 30 changes. As described above, controller 100 is configured to reflect a change in composition of the circulating non-azeotropic refrigerant in the control and maintain the refrigeration capacity of the refrigeration cycle apparatus.

[0076] Fig. 9 is a graph showing a relationship between the number of averaged sensors and a temperature error. According to the present embodiment, even when the accuracy of detection by the temperature sensors is low, the capacity maintaining control corresponding to the composition of the non-azeotropic refrigerant can be performed accurately. For example, as shown by circle marks in Fig. 9, by averaging and performing correction on the two sensors, the error of the temperature sensors decreases from 1.5°C to 1.1°C. Therefore, the accuracy of controlling the evaporation temperature is increased.

[0077] In addition, it is desirable to bring an evaporation temperature control error shown by triangular marks closer to zero. When the error of the sensor detection temperatures, which are inputs, decreases, an error of a control target value ET of the evaporation temperature derived therefrom also decreases as shown in Fig. 9.

[0078] By setting n (the number of averaged sensors) to be equal to or more than 2, a further reduction in error can be expected.

[0079] The refrigerant shortage determination control by liquid level detection shown in Fig. 3 may be performed before or after the refrigerant composition detection control shown in Fig. 6. However, the accuracy of the refrigerant composition detection process in Fig. 6 may deteriorate when the refrigerant is insufficient, and thus, it is preferable to perform the control in the order of Fig. 3 and Fig. 6. For example, the refrigerant shortage determination process may be performed once a day and the refrigerant composition detection process may be performed with higher frequency.

Second Embodiment

[0080] In the first embodiment, the end of second flow path F2 (injection flow path) is directly connected to the upper part of receiver 30. However, in a second embodiment, description will be given of an example in which the end of second flow path F2 (injection flow path) is connected to another portion.

[0081] Fig. 10 shows a configuration of a refrigeration cycle apparatus 1A in the second embodiment. Referring to Fig. 10, refrigeration cycle apparatus 1A includes a cold source unit 2A, load device 3, and extension pipes 83 and 87. Cold source unit 2A is configured to be connectable to load device 3 by extension pipes 83 and 87. Since load device 3 and extension pipes 83 and 87 are the same as those in the first embodiment shown in Fig. 1, description will not be repeated.

[0082] Cold source unit 2A is different from cold source unit 2 shown in Fig. 1 in that cold source unit 2A includes a receiver 30A instead of receiver 30, and includes pipes 82A and 91A instead of pipes 82 and 91. Since the remaining configuration of cold source unit 2A is the same as that of cold source unit 2, description will not be repeated.

[0083] Receiver 30A is different from receiver 30 shown in Figs. 1 and 2 in that pipe 91 is removed and receiver 30A is connected to pipe 82A instead of pipe 82. Connection of housing 31 and pipe 81 in receiver 30A is the same as that in receiver 30.

[0084] In the second embodiment, as shown in Fig. 10, pipe 91A branches off from pipe 82A at branch point BP. That is, in the second embodiment, second flow path F2 (injection flow path) is connected to the pipe, not the receiver. The second embodiment is configured such that gas-liquid separation of the refrigerant is performed at branch point BP. The following is a description of a specific example of a gas-liquid separation mechanism that makes it easier for only gas refrigerant to flow into pipe 91A when the refrigerant is insufficient.

[0085] Fig. 11 shows a first example of a shape of branching at branch point BP. In Fig. 11, at branch point BP, pipe 82A extends in a horizontal direction, and pipe 91A branches off from pipe 82A in a vertically upward direction. When the refrigerant is insufficient, the refrigerant in a two-phase state flows through pipe 82A from receiver 30A. With the configuration shown in Fig. 11, the liquid refrigerant falls by the gravity force and only the gas refrigerant rises and flows into pipe 91A, when the refrigerant is insufficient. Therefore, gas-liquid separation can be performed at branch point BP.

[0086] Fig. 12 shows a second example of a shape of branching at branch point BP. In Fig. 12, at branch point BP, pipe 82A is bent from a horizontal direction toward a vertically downward direction, and pipe 91A branches off from pipe 82A in a vertically upward direction. With the configuration shown in Fig. 12, the liquid refrigerant flows remarkably downward by the gravity force as compared with the configuration shown in Fig. 11, and only the gas refrigerant rises and flows into pipe 91A. Therefore, in the configuration shown in Fig. 12, gas-liquid separation is more reliably performed at branch point BP when the refrigerant is insufficient.

(Conclusion)

[0087] As shown in Figs. 1 and 10, the present disclosure relates to cold source unit 2 or 2A that is connectable to load device 3 including first expansion device 50 and evaporator 60 and that is included in refrigeration cycle apparatus 1 or 1A. Cold source unit 2 or 2A includes: compressor 10; condenser 20; first flow path F1 configured to receive refrigerant from evaporator 60 and send out the refrigerant toward first expansion device 50 via compressor 10 and condenser 20; second flow path F2 configured to send, to compressor 10 not via first expansion device 50 and evaporator 60, the refrigerant that has passed through condenser 20; second expansion device 92 provided at second flow path F2; a plurality of temperature sensors (121 to 123) disposed at second flow path F2; and controller 100 configured to control refrigeration cycle apparatus 1 or 1A based on outputs of the plurality of temperature sensors. Controller 100 is configured to control refrigeration cycle apparatus 1 or 1A such that temperatures detected by the plurality of temperature sensors become equal to each other, and calculate an average value of the temperatures detected by the plurality of temperature sensors. Controller 100 is configured to perform correction on each of the plurality of temperature sensors based on a difference between the average value and a temperature detected by a corresponding one of the plurality of temperature sensors.

[0088] With such a configuration, a deviation from correct values caused by variations in values detected by the plurality of temperature sensors decreases as a whole, and thus, the accuracy of control of the refrigeration cycle apparatus can be expected to increase.

[0089] Preferably, cold source unit 2 shown in Fig. 1 further includes: receiver 30 disposed downstream of condenser 20 in first flow path F1, receiver 30 being connectable to a first end of second flow path F2 and configured to store the refrigerant in a liquid phase; and heater 40 provided downstream of second expansion device 92 in second flow path F2. As shown in Figs. 1 and 2, the first end of second flow path F2 is disposed to suction the refrigerant in a liquid phase from receiver 30 when an amount of the refrigerant enclosed in refrigeration cycle apparatus 1 is not insufficient. A second end of second flow path F2 is connectable to suction port G1 of compressor 10. The plurality of temperature sensors include first temperature sensor 122 and second temperature sensor 123. First temperature sensor 122 and

second temperature sensor 123 are disposed upstream and downstream of heater 40 in second flow path F2, respectively. With heater 40 being off, controller 100 is configured to perform correction on first temperature sensor 122 and second temperature sensor 123. With heater 40 being on, controller 100 is configured to determine whether the amount of the refrigerant enclosed in refrigeration cycle apparatus 1 is insufficient, based on a difference ($T_3 - T_2$) between a temperature detected by first temperature sensor 122 and a temperature detected by second temperature sensor 123.

[0090] With such a configuration, a refrigerant shortage can be accurately detected, with a smaller capacity of heater 40.

[0091] More preferably, cold source unit 2 further includes pressure sensor 110 configured to detect a pressure of the refrigerant suctioned by compressor 10. The plurality of temperature sensors further include third temperature sensor 121 disposed upstream of second expansion device 92 in second flow path F2. First temperature sensor 122 is disposed between second expansion device 92 and heater 40 in second flow path F2. The refrigerant is non-azeotropic mixed refrigerant. Controller 100 is configured to determine a composition of the refrigerant based on outputs of pressure sensor 110 and first to third temperature sensors 122, 123 and 121, and control refrigeration cycle apparatus 1 by using a pressure corresponding to a saturation temperature corresponding to the composition as a target value of the pressure detected by pressure sensor 110.

[0092] As described above, in the present embodiment, the accuracy of detecting the composition of the refrigerant and the accuracy of determining a refrigerant shortage can be increased by focusing attention on the detection error of the temperature sensors such as thermistors and reducing the detection error.

[0093] Correction may be performed using an average value of the values detected by temperature sensors 121 and 122. Preferably, cold source unit 2 or 2A further includes pressure sensor 110 configured to detect a pressure of the refrigerant suctioned by compressor 10. The plurality of temperature sensors include first temperature sensor (121) and second temperature sensor (122). First temperature sensor (121) and second temperature sensor (122) are disposed upstream and downstream of second expansion device 92 in second flow path F2, respectively. Controller 100 is configured to perform correction on first temperature sensor (121) and second temperature sensor (122), with compressor 10 being not operating. The refrigerant is non-azeotropic mixed refrigerant. Controller 100 is configured to determine a composition of the refrigerant based on outputs of pressure sensor 110, first temperature sensor (121) and second temperature sensor (122), and control refrigeration cycle apparatus 1 by using a pressure corresponding to a saturation temperature corresponding to the composition as a target value of the pressure detected by pressure sensor 110.

[0094] For example, even when determination of a refrigerant shortage using the heater is not performed, the accuracy of detecting the composition of the refrigerant can be increased by focusing attention on the detection error of the temperature sensors such as thermistors and reducing the detection error.

[0095] Preferably, as shown in Figs. 10 and 11, on a downstream side of condenser 20 in first flow path F1, second flow path F2 branches off in a vertically upward direction from a horizontally extending portion of first flow path F1.

[0096] Preferably, as shown in Figs. 10 and 12, at branch point BP on a downstream side of condenser 20 in first flow path F1, second flow path F2 branches off from first flow path F1. At branch point BP, first flow path F1 extends from a horizontal direction toward a vertically downward direction. At branch point BP, second flow path F2 extends toward a vertically upward direction.

[0097] In another aspect, the present disclosure relates to refrigeration cycle apparatus 1, 1A including any cold source unit 2 or 2A described above, and load device 3. The present disclosure also relates to a refrigerator including refrigeration cycle apparatus 1, 1A.

[0098] It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The basic scope of the present disclosure is defined by the terms of the claims, rather than the description of the embodiments above, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0099] 1, 1A refrigeration cycle apparatus; 2, 2A cold source unit; 3 load device; 10 compressor; 20 condenser; 30, 30A receiver; 31 housing; 40 heater; 50 first expansion device; 60 evaporator; 80, 81, 82, 82A, 84, 85, 86, 88, 91, 91A, 93 pipe; 83, 87 extension pipe; 92 second expansion device; 100 controller; 102 CPU; 104 memory; 110, 111 pressure sensor; 121 to 123 temperature sensor; BP branch point; F1, F2 flow path; G1 suction port; G2 discharge port; IP1 inlet pipe; OP1 first outlet pipe; OP2 second outlet pipe.

Claims

1. A cold source unit that is connectable to a load device including a first expansion device and an evaporator and that is included in a refrigeration cycle apparatus, the cold source unit comprising:

a compressor;
 a condenser;
 a first flow path configured to receive refrigerant from the evaporator and send out the refrigerant toward the first expansion device via the compressor and the condenser;
 5 a second flow path configured to send, to the compressor not via the first expansion device and the evaporator, the refrigerant that has passed through the condenser;
 a second expansion device provided at the second flow path;
 a plurality of temperature sensors disposed at the second flow path; and
 a controller configured to control the refrigeration cycle apparatus based on outputs of the plurality of temperature
 10 sensors, wherein
 the controller is configured to control the refrigeration cycle apparatus such that temperatures detected by the plurality of temperature sensors become equal to each other, and calculate an average value of the temperatures detected by the plurality of temperature sensors, and
 the controller is configured to perform correction on each of the plurality of temperature sensors based on a
 15 difference between the average value and a temperature detected by a corresponding one of the plurality of temperature sensors.

2. The cold source unit according to claim 1, further comprising:

20 a receiver disposed downstream of the condenser in the first flow path, the receiver being connectable to a first end of the second flow path and configured to store the refrigerant in a liquid phase; and
 a heater provided downstream of the second expansion device in the second flow path, wherein
 the first end of the second flow path is disposed to suction the refrigerant in a liquid phase from the receiver when an amount of the refrigerant enclosed in the refrigeration cycle apparatus is not insufficient,
 25 a second end of the second flow path is connectable to a refrigerant inlet of the compressor,
 the plurality of temperature sensors include a first temperature sensor and a second temperature sensor,
 the first temperature sensor and the second temperature sensor are disposed upstream and downstream of the heater in the second flow path, respectively,
 with the heater being off, the controller is configured to perform correction on the first temperature sensor and
 30 the second temperature sensor, and
 with the heater being on, the controller is configured to determine whether the amount of the refrigerant enclosed in the refrigeration cycle apparatus is insufficient, based on a difference between a temperature detected by the first temperature sensor and a temperature detected by the second temperature sensor.

3. The cold source unit according to claim 2, further comprising

a pressure sensor configured to detect a pressure of the refrigerant suctioned by the compressor, wherein
 the plurality of temperature sensors further include a third temperature sensor disposed upstream of the second
 expansion device in the second flow path,
 40 the first temperature sensor is disposed between the second expansion device and the heater in the second flow path,
 the refrigerant is non-azeotropic mixed refrigerant, and
 the controller is configured to determine a composition of the refrigerant based on outputs of the pressure sensor and the first to third temperature sensors, and control the refrigeration cycle apparatus by using a pressure
 45 corresponding to a saturation temperature corresponding to the composition as a target value of the pressure detected by the pressure sensor.

4. The cold source unit according to claim 1, further comprising

50 a pressure sensor configured to detect a pressure of the refrigerant suctioned by the compressor, wherein
 the plurality of temperature sensors include a first temperature sensor and a second temperature sensor,
 the first temperature sensor and the second temperature sensor are disposed upstream and downstream of the second expansion device in the second flow path, respectively,
 the controller is configured to perform correction on the first temperature sensor and the second temperature
 55 sensor, with the compressor being not operating,
 the refrigerant is non-azeotropic mixed refrigerant, and
 the controller is configured to determine a composition of the refrigerant based on outputs of the pressure sensor, the first temperature sensor and the second temperature sensor, and control the refrigeration cycle

apparatus by using a pressure corresponding to a saturation temperature corresponding to the composition as a target value of the pressure detected by the pressure sensor.

5 **5.** The cold source unit according to claim 1, wherein
on a downstream side of the condenser in the first flow path, the second flow path branches off in a vertically upward direction from a horizontally extending portion of the first flow path.

6. The cold source unit according to claim 1, wherein

10 at a branch point on a downstream side of the condenser in the first flow path, the second flow path branches off from the first flow path,
at the branch point, the first flow path extends from a horizontal direction toward a vertically downward direction, and
15 at the branch point, the second flow path extends toward a vertically upward direction.

7. A refrigeration cycle apparatus comprising:

the cold source unit as recited in any one of claims 1 to 6; and
the load device.

20 **8.** A refrigerator comprising the refrigeration cycle apparatus as recited in claim 7.

FIG.1

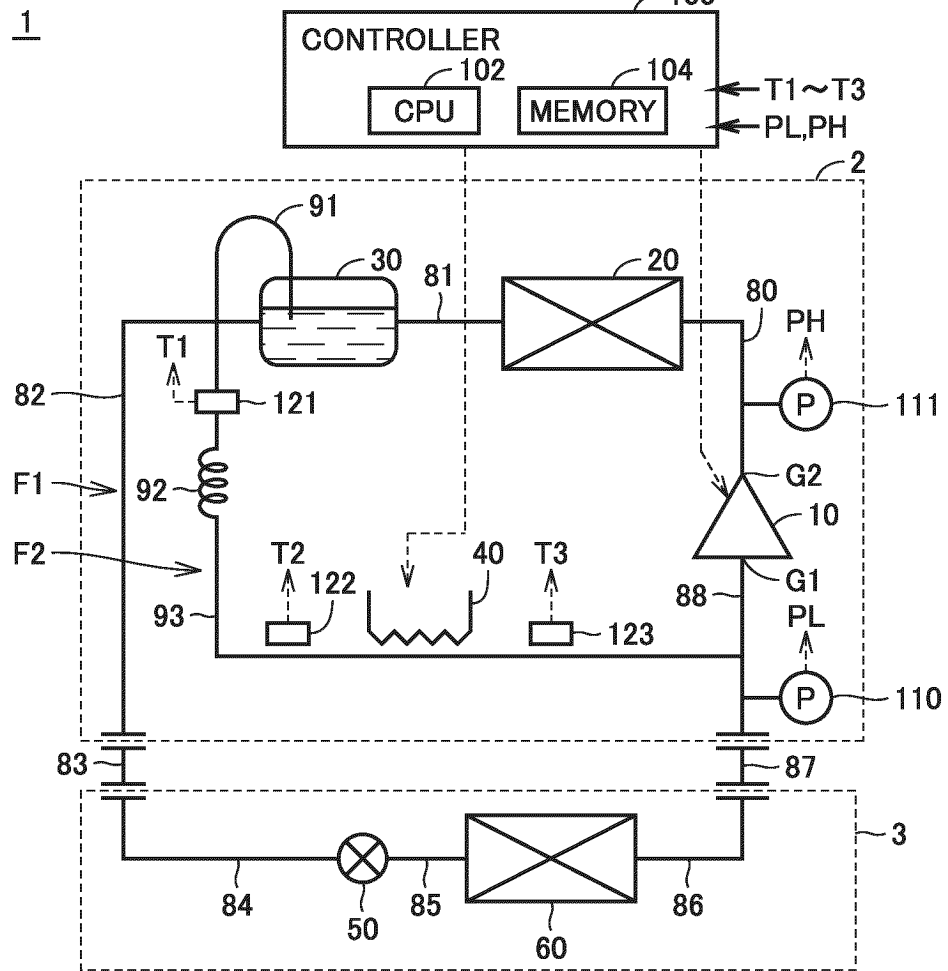


FIG.2

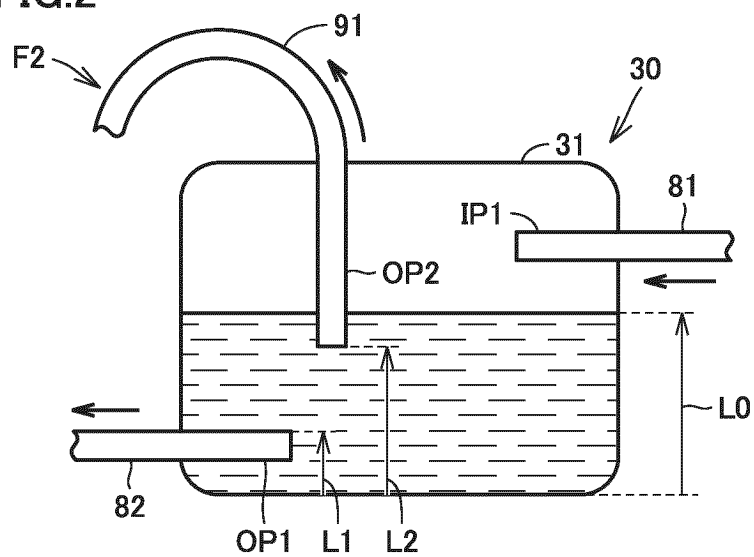


FIG.3

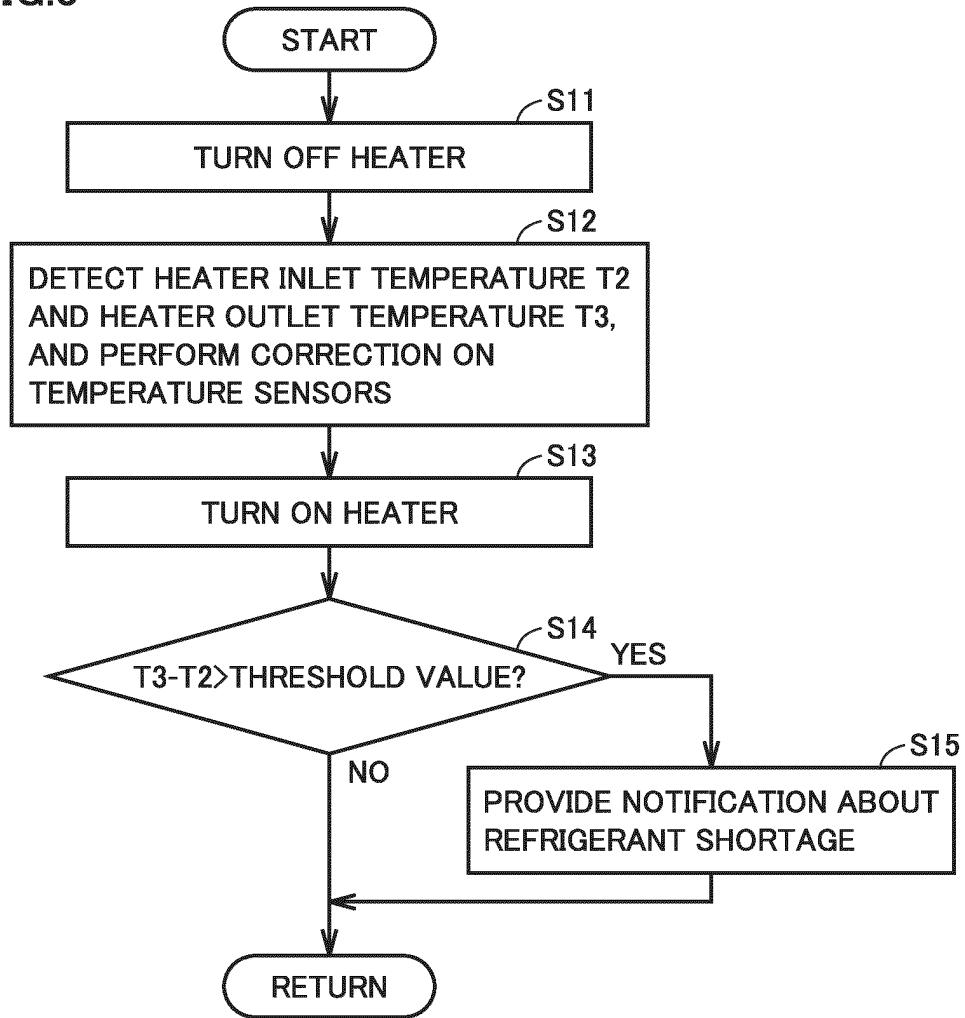


FIG.4

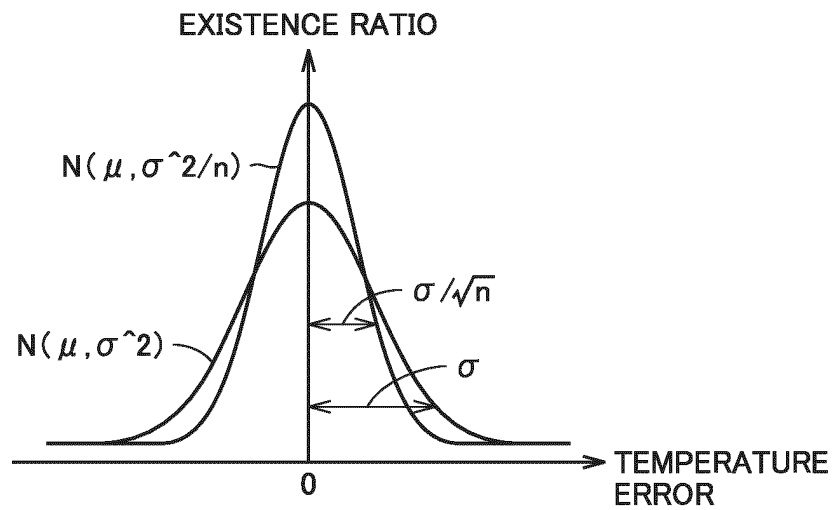


FIG.5

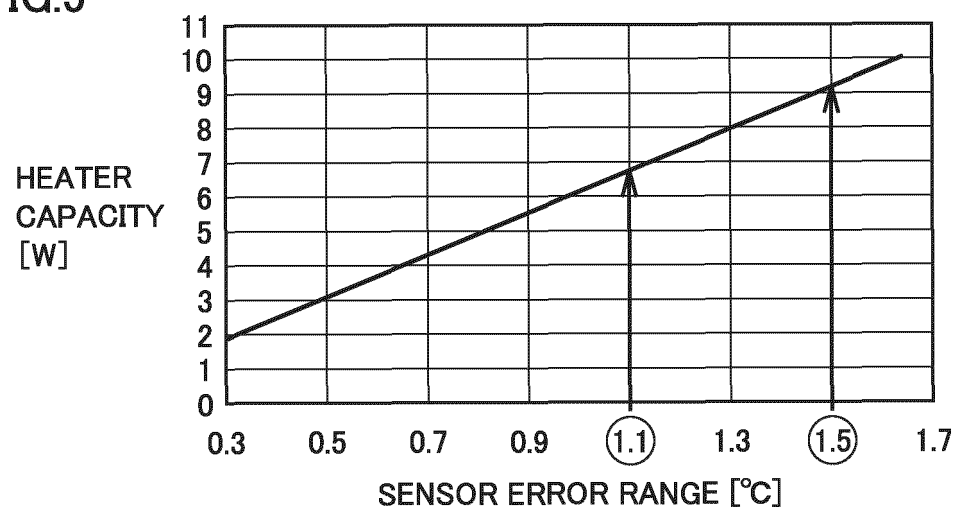


FIG.6

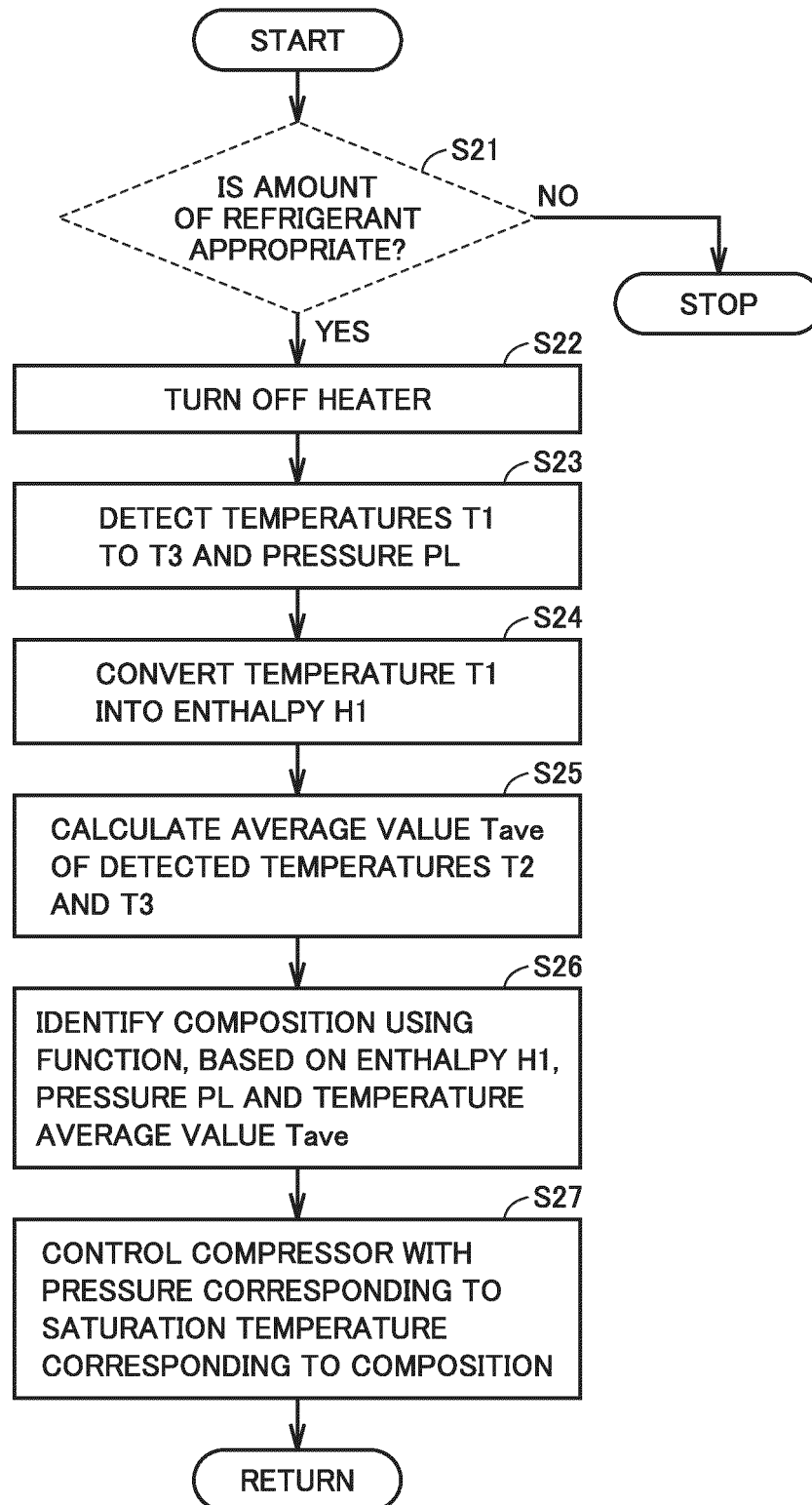


FIG.7

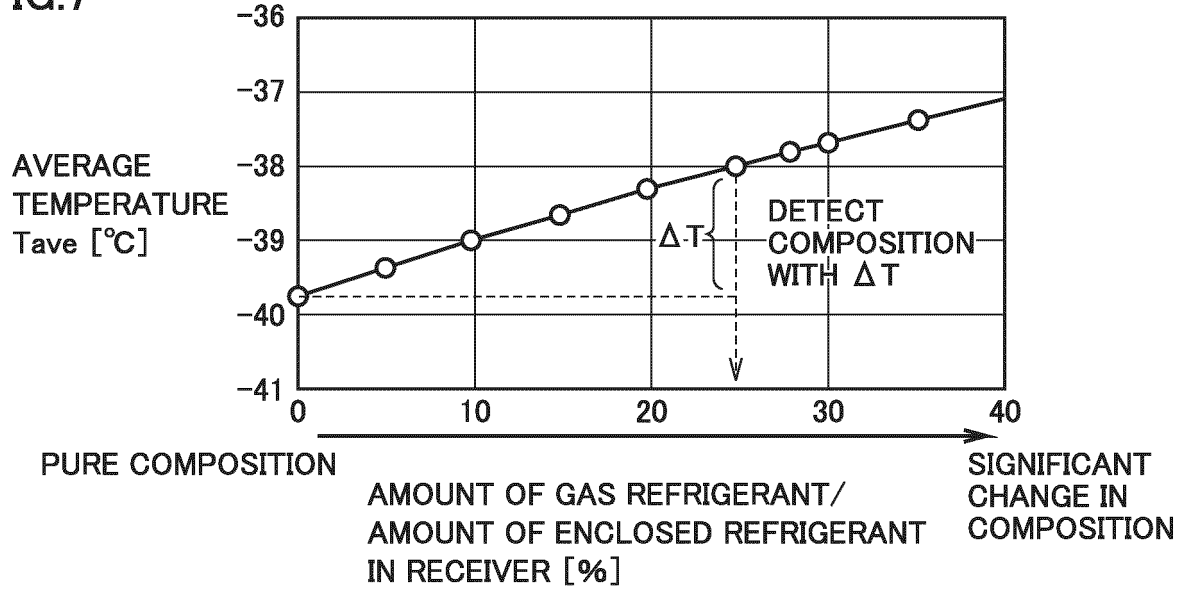


FIG.8

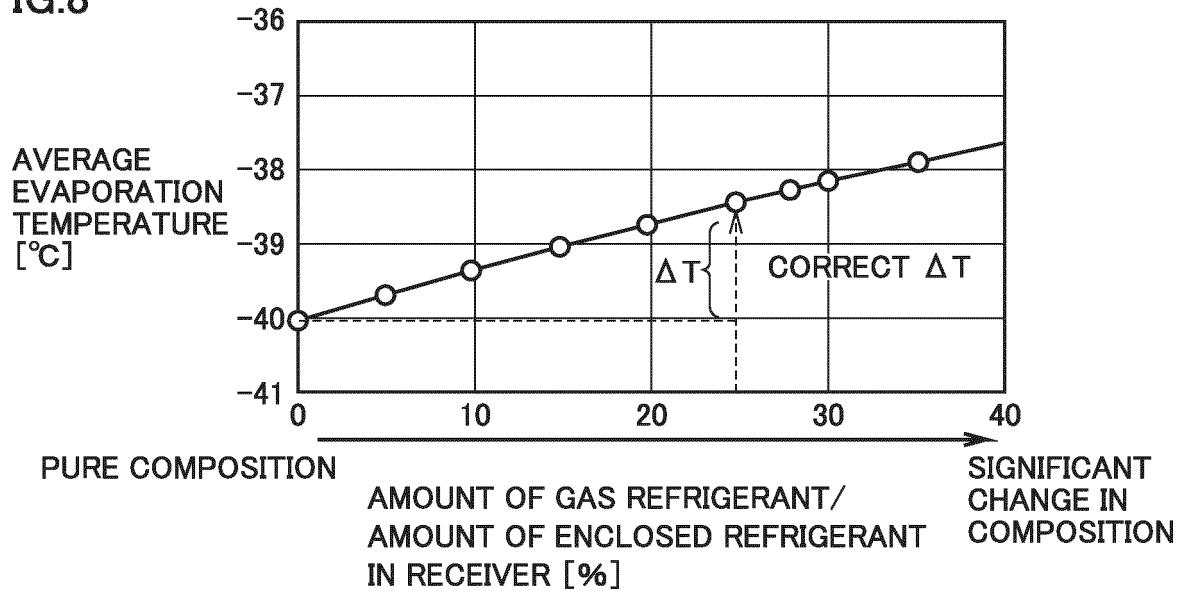


FIG.9

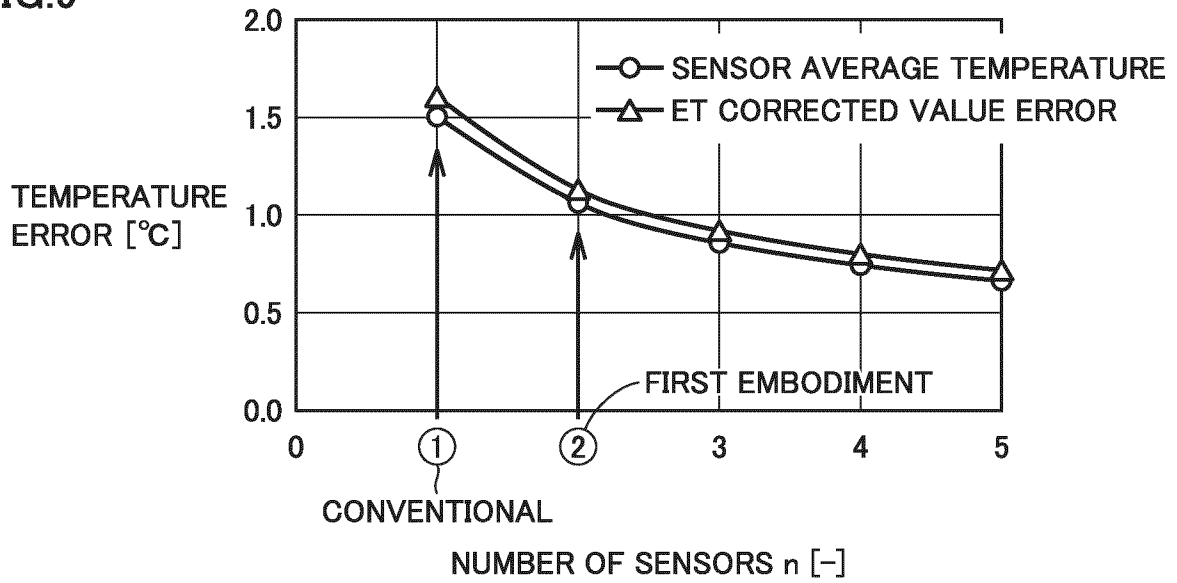


FIG.10

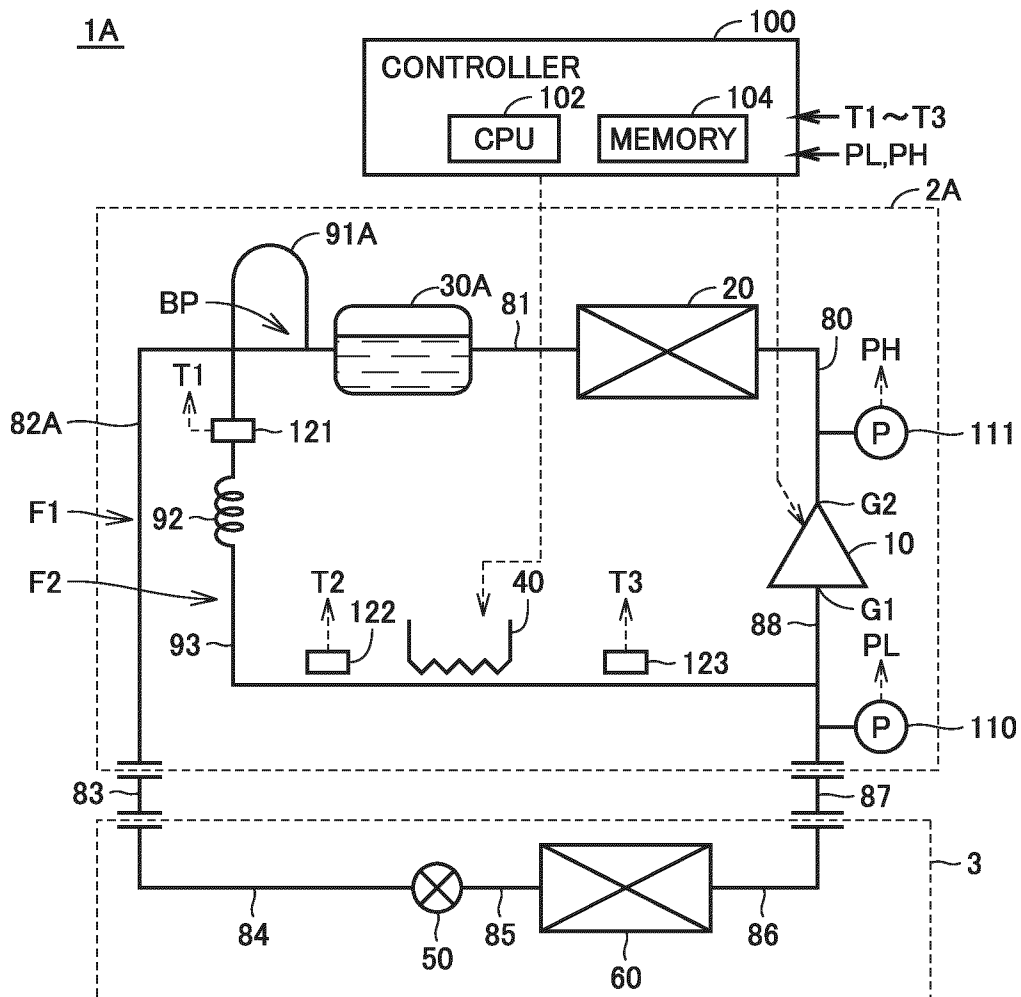


FIG.11

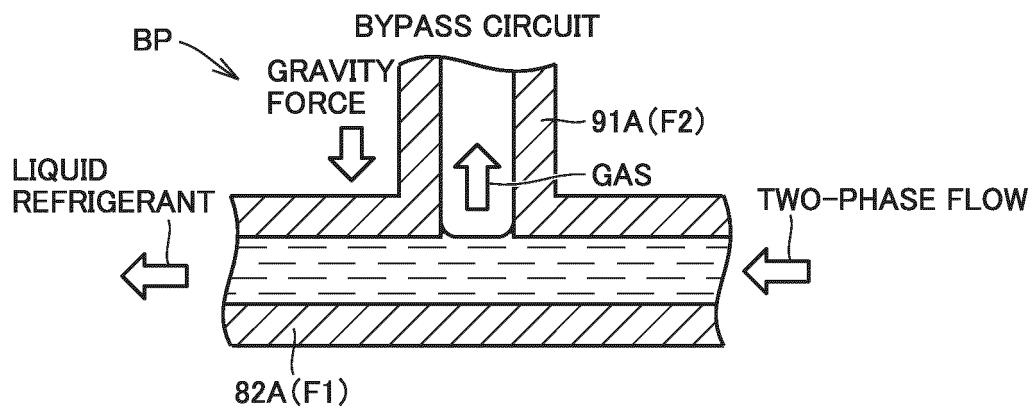
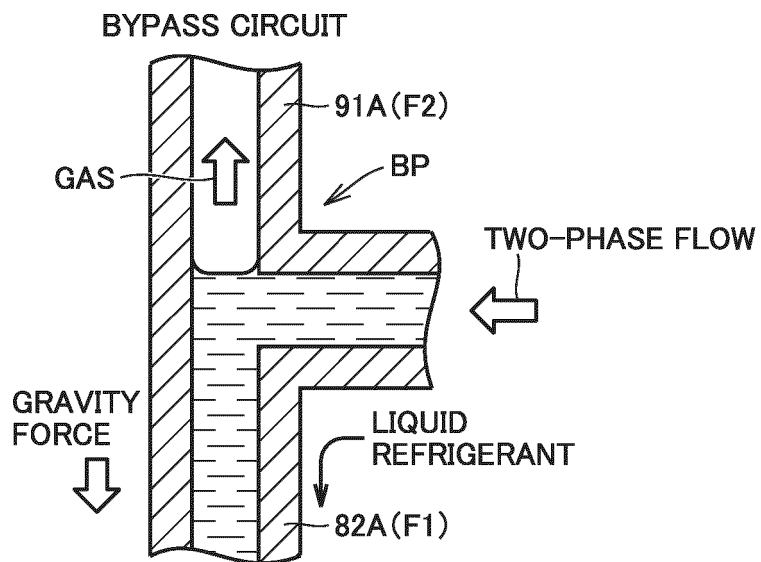


FIG.12



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/020738

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. F25B49/02 (2006.01) i, F25B1/00 (2006.01) i

FI: F25B49/02 A, F25B49/02 520E, F25B1/00 396B

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. 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

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Further documents are listed in the continuation of Box C.



See patent family annex.

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"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
21.07.2020Date of mailing of the international search report
04.08.2020Name 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/JP2020/020738

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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

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 Information on patent family members

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- JP 5505477 B [0002] [0003] [0004]