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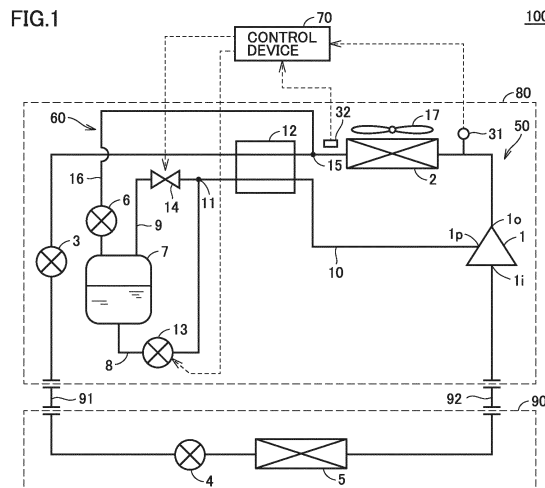
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(54) **REFRIGERATION CYCLE DEVICE**

(57) An injection circuit (60) includes a gas-liquid separator (7) to separate some of refrigerant into gas and liquid, a first pipe (8) through which liquid refrigerant is discharged from the gas-liquid separator (7), a second pipe (9) through which gas refrigerant is discharged from the gas-liquid separator (7), a third pipe (10) in which refrigerant that flows through the first pipe (8) and refrigerant that flows through the second pipe (9) merge with

each other to flow to an injection port (1p) of a compressor (1), a flow rate regulation valve (13) provided in the first pipe (8), and a solenoid valve (14) provided in the second pipe (9). A refrigeration cycle apparatus (100) includes a control device (70) to adjust an amount of refrigerant in a main circuit (50) by controlling an opening of the flow rate regulation valve (13) and an open and closed state of the solenoid valve (14).



Description

TECHNICAL FIELD

[0001] The present disclosure relates to a refrigeration cycle apparatus.

BACKGROUND ART

[0002] In order to reduce power consumption and improve capability of a refrigeration cycle, an intermediate injection refrigeration cycle apparatus has conventionally been known. This refrigeration cycle apparatus causes some of refrigerant that circulates through a main circuit to divert to an injection circuit to be injected into an intermediate pressure portion of a compressor.

[0003] Japanese Patent Laying-Open No. 2016-156557 (PTL 1) discloses a refrigeration cycle apparatus in which a gas-liquid separator is provided in an injection circuit and a flow containing a large amount of gas phase and a flow containing a large amount of liquid phase flow through first and second injection paths, respectively. A mass flow rate of refrigerant that flows through the second injection path thus becomes larger.

CITATION LIST

PATENT LITERATURE

[0004] PTL 1: Japanese Patent Laying-Open No. 2016-156557

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005] In the refrigeration cycle apparatus disclosed in PTL 1, excessive liquid refrigerant is stored in a receiver tank provided in the main circuit so as to adjust an amount of refrigerant in the main circuit. Since the receiver tank is provided in addition to a gas-liquid separator as a member where refrigerant is stored, the refrigeration cycle apparatus increases in size.

[0006] The present disclosure was made to solve the problem above, and an object thereof is to provide an intermediate injection refrigeration cycle apparatus that can be reduced in size.

SOLUTION TO PROBLEM

[0007] A refrigeration cycle apparatus in one aspect of the present disclosure includes a main circuit through which refrigerant circulates in an order of a compressor, a condenser, a decompressing apparatus, and an evaporator and an injection circuit through which some of refrigerant that flows from the condenser to the decompressing apparatus is diverted to flow into the compressor. The injection circuit includes a gas-liquid separator

to separate some of refrigerant into gas and liquid. The injection circuit includes a first pipe through which liquid refrigerant is discharged from the gas-liquid separator, a second pipe through which gas refrigerant is discharged from the gas-liquid separator, and a third pipe in which refrigerant that flows through the first pipe and refrigerant that flows through the second pipe merge with each other to flow to an injection port of the compressor. The injection circuit further includes a flow rate regulation valve provided in the first pipe and a first solenoid valve provided in the second pipe. The refrigeration cycle apparatus further includes a control device to control an opening of the flow rate regulation valve and an open and closed state of the first solenoid valve to adjust an amount of refrigerant in the main circuit.

ADVANTAGEOUS EFFECTS OF INVENTION

[0008] According to the present disclosure, the amount of refrigerant in the main circuit is adjusted with the use of the gas-liquid separator provided in the injection circuit. Thus, a receiver tank in addition to the gas-liquid separator does not have to be provided as in PTL 1, and the refrigeration cycle apparatus can be reduced in size.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

Fig. 1 is a diagram showing an internal configuration of a refrigeration cycle apparatus according to a first embodiment.

Fig. 2 is a diagram schematically showing a configuration of a gas-liquid separator.

Fig. 3 is a flowchart showing an exemplary flow in processing by a control device according to the first embodiment.

Fig. 4 is a diagram showing an internal configuration of a refrigeration cycle apparatus according to a second embodiment.

Fig. 5 is a flowchart showing an exemplary flow in processing by the control device according to the second embodiment.

Fig. 6 is a diagram showing an exemplary internal configuration of a refrigeration cycle apparatus according to a third embodiment.

Fig. 7 is a flowchart showing an exemplary flow in processing by the control device according to the third embodiment.

Fig. 8 is a diagram showing an exemplary internal configuration of a refrigeration cycle apparatus according to a fourth embodiment.

Fig. 9 is a diagram showing an exemplary correspondence table stored in the control device according to the fourth embodiment.

Fig. 10 is a diagram showing an exemplary height range set for the gas-liquid separator in the fourth embodiment.

Fig. 11 is a diagram showing a state of the gas-liquid separator when a liquid level reaches a reference height.

Fig. 12 is a flowchart showing a flow in steps S31 to S37 in processing by the control device according to the fourth embodiment.

Fig. 13 is a flowchart showing a flow in steps S38 to S44 in processing by the control device according to the fourth embodiment.

Fig. 14 is a flowchart showing a flow in steps S45 to S47 in processing by the control device according to the fourth embodiment.

Fig. 15 is a diagram showing an exemplary internal configuration of a refrigeration cycle apparatus according to a fifth embodiment.

Fig. 16 is a diagram showing an exemplary correspondence table stored in the control device according to the fifth embodiment.

Fig. 17 is a diagram showing an exemplary height range set for the gas-liquid separator in the fifth embodiment.

Fig. 18 is a flowchart showing a flow in steps S51 to S59 in processing by the control device according to the fifth embodiment.

Fig. 19 is a flowchart showing a flow in steps S60 to S66 in processing by the control device according to the fifth embodiment.

Fig. 20 is a diagram showing an internal configuration of a refrigeration cycle apparatus according to a sixth embodiment.

Fig. 21 is a diagram showing an internal configuration of a refrigeration cycle apparatus according to a seventh embodiment.

Fig. 22 is a diagram showing an internal configuration of a refrigeration cycle apparatus according to an eighth embodiment.

DESCRIPTION OF EMBODIMENTS

First Embodiment.

<Configuration of Refrigeration Cycle Apparatus>

[0010] Fig. 1 is a diagram showing an internal configuration of a refrigeration cycle apparatus 100 according to a first embodiment. Refrigeration cycle apparatus 100 shown in Fig. 1 cools, for example, a space to be cooled such as a room, a warehouse, a showcase, or a refrigerator.

[0011] Refrigeration cycle apparatus 100 includes a heat source side unit 80 and a use side unit 90. Heat source side unit 80 and use side unit 90 are connected to each other through a liquid pipe 91 and a gas pipe 92. In liquid pipe 91, supercooled liquid refrigerant flows from heat source side unit 80 toward use side unit 90. In gas pipe 92, gas refrigerant flows from use side unit 90 toward heat source side unit 80. Lengths of liquid pipe 91 and gas pipe 92 are adjusted in accordance with positions

where heat source side unit 80 and use side unit 90 are provided. Though an example in Fig. 1 shows single heat source side unit 80 and single use side unit 90, the number thereof is not limited. The number of at least one of heat source side unit 80 and use side unit 90 may be set to two or more.

[0012] Refrigeration cycle apparatus 100 includes a main circuit 50 through which refrigerant circulates in the order of a compressor 1, a condenser 2, decompressing apparatuses 3 and 4, and an evaporator 5 and an injection circuit 60 through which some of refrigerant that flows from condenser 2 to decompressing apparatus 3 is diverted to flow into compressor 1. Compressor 1, condenser 2, decompressing apparatus 3, and injection circuit 60 are provided in heat source side unit 80. Decompressing apparatus 4 and evaporator 5 are provided in use side unit 90. For example, CO₂ refrigerant is employed as refrigerant.

[0013] Compressor 1 is, for example, a scroll compressor and includes an inlet 1i and an outlet 1o. Compressor 1 compresses refrigerant suctioned through inlet 1i and discharges refrigerant through outlet 1o. Compressor 1 is a positive displacement compressor driven by a drive motor (not shown) controlled by an inverter, and it is variable in operating displacement. Compressor 1 further includes an injection port 1p to communicate with an intermediate pressure portion in a compression chamber.

[0014] Condenser 2 is connected to outlet 1o of compressor 1 through a pipe and condenses refrigerant discharged from compressor 1. Condenser 2 exchanges heat between refrigerant discharged from compressor 1 and outdoor air sent by a fan 17. Heat of refrigerant is thus dissipated to outdoor air so that refrigerant is cooled. Condenser 2 is, for example, a fin-and-tube heat exchanger including a heat transfer tube and a plurality of fins.

[0015] Decompressing apparatuses 3 and 4 are each composed of a solenoid expansion valve or a temperature expansion valve and decompress refrigerant that has passed through condenser 2. Specifically, decompressing apparatuses 3 and 4 decompress refrigerant to expand the same and to adjust a flow rate of refrigerant that flows in main circuit 50.

[0016] Evaporator 5 exchanges heat between refrigerant decompressed and expanded by decompressing apparatuses 3 and 4 and air in use side unit 90 to evaporate refrigerant. Evaporator 5 is, for example, a fin-and-tube heat exchanger including a heat transfer tube and a plurality of fins.

[0017] Injection circuit 60 includes pipes 8, 9, 10, and 16, flow rate regulation valves 6 and 13, a gas-liquid separator 7, and a solenoid valve 14.

[0018] Pipe 16 connects a branch point 15 between condenser 2 and decompressing apparatus 3 in main circuit 50 and gas-liquid separator 7 to each other. Pipe 16 diverts some of refrigerant that flows from condenser 2 to decompressing apparatus 3 to flow into gas-liquid separator 7.

[0019] Flow rate regulation valve 6 is provided in pipe 16 and adjusts the amount of refrigerant that flows in injection circuit 60. Flow rate regulation valve 6 is, for example, a solenoid expansion valve, and an opening thereof is controlled by a control device 70 which will be described later so that a flow rate of refrigerant branched to injection circuit 60 is adjusted. The opening of flow rate regulation valve 6 is controlled to be larger as a discharge temperature which is a temperature of refrigerant discharged from compressor 1 is higher and to be smaller as the discharge temperature is lower.

[0020] Gas-liquid separator 7 separates refrigerant that has passed through flow rate regulation valve 6 into refrigerant in a liquid state (which is referred to as "liquid refrigerant" below) and refrigerant in a gaseous state (which is referred to as "gas refrigerant" below).

[0021] Pipe 8 is provided to discharge liquid refrigerant from gas-liquid separator 7. Pipe 9 is provided to discharge gas refrigerant from gas-liquid separator 7. Pipe 10 allows merge between refrigerant that flows through pipe 8 and refrigerant that flows through pipe 9 so that merged refrigerant flows to injection port 1p of compressor 1. In other words, pipe 10 connects a point of merge 11 between pipes 8 and 9 and injection port 1p to each other. Pipe 8 connects a liquid refrigerant discharge port in gas-liquid separator 7 and point of merge 11 to each other. Pipe 9 connects a gas refrigerant discharge port in gas-liquid separator 7 and point of merge 11 to each other.

[0022] Flow rate regulation valve 13 is provided in pipe 8 to adjust a flow rate of refrigerant in pipe 8. An opening of flow rate regulation valve 13 is variable and controlled to one designated opening of a plurality of levels. The minimum opening is a closed state. Solenoid valve 14 is provided in pipe 9 and controlled to one of an open state and a closed state.

[0023] Refrigeration cycle apparatus 100 further includes an economizer 12, a pressure sensor 31, a temperature sensor 32, and control device 70.

[0024] Economizer 12 exchanges heat between refrigerant that flows through pipe 10 and refrigerant that flows out of condenser 2 to supercool refrigerant that flows out of condenser 2. Economizer 12 is, for example, a double tube heat exchanger or a plate heat exchanger. In the example shown in Fig. 1, economizer 12 is arranged between branch point 15 and decompressing apparatus 3. Economizer 12, however, may be arranged between condenser 2 and branch point 15.

[0025] Pressure sensor 31 measures a discharge pressure P1 which is a pressure of refrigerant discharged from compressor 1. Pressure sensor 31 outputs a result of measurement to control device 70.

[0026] Temperature sensor 32 measures a temperature T of refrigerant that has passed through condenser 2. Temperature sensor 32 outputs a result of measurement to control device 70.

[0027] Control device 70 controls an operation of each component provided in refrigeration cycle apparatus 100.

In the present embodiment, control device 70 adjusts the amount of refrigerant in main circuit 50 by controlling the opening of flow rate regulation valve 13 and an open and closed state of solenoid valve 14. In other words, the amount of refrigerant in main circuit 50 is adjusted with the use of gas-liquid separator 7 provided in injection circuit 60. Therefore, a receiver tank does not have to be provided in addition to gas-liquid separator 7 and refrigeration cycle apparatus 100 can be reduced in size.

[0028] Refrigerant diverted from main circuit 50 is stored in gas-liquid separator 7. As the amount of liquid refrigerant stored in gas-liquid separator 7 is larger, the amount of refrigerant in main circuit 50 becomes smaller. Therefore, when the amount of refrigerant in main circuit 50 is insufficient, control device 70 controls solenoid valve 14 to close. Gas refrigerant is thus not discharged from gas-liquid separator 7 but gas refrigerant is stored in gas-liquid separator 7. Consequently, discharge of liquid refrigerant from gas-liquid separator 7 to pipe 8 is promoted and the amount of refrigerant in main circuit 50 increases.

[0029] In contrast, as the amount of liquid refrigerant stored in gas-liquid separator 7 is smaller, the amount of refrigerant in main circuit 50 is larger. Therefore, when the amount of refrigerant in main circuit 50 is excessive, control device 70 controls solenoid valve 14 to open. Gas refrigerant is thus discharged from gas-liquid separator 7 and liquid refrigerant is more likely to be stored in gas-liquid separator 7. Consequently, the amount of liquid refrigerant stored in gas-liquid separator 7 increases and the amount of refrigerant in main circuit 50 decreases.

[0030] Control device 70 should only determine whether the amount of refrigerant in main circuit 50 is excessive or insufficient, for example, based on discharge pressure P1 measured by pressure sensor 31 and temperature T measured by temperature sensor 32. Details of this determination method will be described later.

[0031] Control device 70 further controls decompressing apparatuses 3 and 4 and the opening of flow rate regulation valve 6. A known technique may be adopted as a method of controlling decompressing apparatuses 3 and 4 and the opening of flow rate regulation valve 6. Therefore, detailed description of the method of controlling decompressing apparatuses 3 and 4 and the opening of flow rate regulation valve 6 will not be provided.

[0032] Control device 70 is implemented by hardware such as a circuit device that performs a function thereof. Alternatively, control device 70 may be implemented by a computing device such as a central processing unit (CPU) and a memory where software executed by the computing device is stored.

[0033] Fig. 2 is a diagram schematically showing a configuration of gas-liquid separator 7. As shown in Fig. 2, refrigerant is stored in an internal space in gas-liquid separator 7. One end of pipe 16 penetrates an upper wall of gas-liquid separator 7 and is located in the internal space. Refrigerant that has passed through pipe 16 is thus temporarily stored in the internal space in gas-liquid separator 7.

tor 7.

[0034] Furthermore, one end of pipe 8 penetrates a lower wall of gas-liquid separator 7 and is located in a lower portion of the internal space. Liquid refrigerant is stored in the lower portion of the internal space. Therefore, liquid refrigerant is discharged through pipe 8. One end of pipe 9 penetrates the upper wall of gas-liquid separator 7 and is located in an upper portion of the internal space. Gas refrigerant is stored in the upper portion of the internal space. Therefore, gas refrigerant is discharged through pipe 9.

<Flow of Processing by Control Device>

[0035] Fig. 3 is a flowchart showing an exemplary flow in processing by control device 70 according to the first embodiment.

[0036] When the amount of refrigerant in main circuit 50 is large, discharge pressure P1 of compressor 1 increases and a degree of supercooling of refrigerant at the exit of condenser 2 increases. When the amount of refrigerant in main circuit 50 is small, on the other hand, discharge pressure P1 of compressor 1 lowers and the degree of supercooling of refrigerant at the exit of condenser 2 lowers. The degree of supercooling of refrigerant at the exit of condenser 2 is thus dependent on the amount of refrigerant in main circuit 50. Therefore, control device 70 can determine whether the amount of refrigerant in main circuit 50 is excessive or insufficient based on the degree of supercooling of refrigerant at the exit of condenser 2.

[0037] Control device 70 calculates a degree of supercooling SC of refrigerant at the exit of condenser 2 based on discharge pressure P1 measured by pressure sensor 31 and temperature T measured by temperature sensor 32. Specifically, control device 70 identifies a saturation temperature CT of refrigerant discharged from compressor 1 based on discharge pressure P1. A function or a table showing correspondence between the discharge pressure and the saturation temperature is stored in advance in control device 70, and control device 70 should only identify saturation temperature CT with the use of the function or the table. Then, control device 70 calculates degree of supercooling SC in accordance with an expression (1) below.

$$SC = CT - T \quad \dots \text{Expression (1)}$$

When refrigerant is in a supercritical state, saturation temperature CT is not defined. Therefore, control device 70 should only define a temperature in terms of enthalpy at a critical point as saturation temperature CT and calculate degree of supercooling SC in accordance with the expression (1). In other words, when discharge pressure P1 exceeds the pressure at the critical point, control device 70 determines the temperature at the critical point as saturation temperature CT.

[0038] As shown in Fig. 3, control device 70 compares degree of supercooling SC with a predetermined threshold value Th1 and determines whether or not a condition of $SC \geq Th1$ is satisfied (step S1). For example, a value of the degree of supercooling at the time when a compression ratio of compressor 1 is around a lower limit of an allowable range may be adopted as threshold value Th1. The compression ratio is represented by a value calculated by dividing the pressure of refrigerant at outlet 1o (that is, discharge pressure P1) by a suction pressure which is the pressure of refrigerant at inlet 1i.

[0039] When the condition of $SC \geq Th1$ is satisfied (YES in step S1), control device 70 compares degree of supercooling SC with a predetermined threshold value Th2 and determines whether or not a condition of $SC > Th2$ is satisfied (step S2). Threshold value Th2 is larger than threshold value Th1. Threshold value Th2 is set such that supercooling can be ensured even on the occurrence of pressure loss at an assumed maximum length of liquid pipe 91 shown in Fig. 1.

[0040] When the condition of $SC > Th2$ is not satisfied (NO in step S2), that is, when a condition of $Th2 \geq SC \geq Th1$ is satisfied, control device 70 determines that the amount of refrigerant in main circuit 50 is appropriate and maintains flow rate regulation valve 13 and solenoid valve 14 in a current state. The process returns to step S1.

[0041] When the condition of $SC > Th2$ is satisfied (YES in step S2), control device 70 determines that the amount of refrigerant in main circuit 50 is excessive and performs steps S3 to S6 as processing for reducing the amount of refrigerant in main circuit 50.

[0042] In step S3, control device 70 determines whether or not the opening of flow rate regulation valve 13 is minimum, that is, flow rate regulation valve 13 is closed.

[0043] When the opening of flow rate regulation valve 13 is not minimum (NO in step S3), control device 70 decreases the opening of flow rate regulation valve 13 by one level (step S4). The amount of refrigerant that flows through pipe 8 thus decreases and liquid refrigerant is more likely to be stored in gas-liquid separator 7. Consequently, the amount of refrigerant in main circuit 50 decreases. After step S4, control device 70 has the process return to step S1.

[0044] When the opening of flow rate regulation valve 13 is minimum (YES in step S3), control device 70 determines whether or not time T1 has elapsed since the opening of flow rate regulation valve 13 became minimum (step S5). Time T1 is determined in advance, and is set, for example, to ten minutes. Control device 70 includes an internal timer for performing step S5, and when the control device determines that the opening of flow rate regulation valve 13 is minimum while the internal timer has been reset, it controls the internal timer to start counting. As the count value of the internal timer reaches time T1, control device 70 should only determine that time T1 has elapsed since the opening of flow rate regulation valve 13 became minimum.

[0045] When time T1 has not elapsed since the open-

ing of flow rate regulation valve 13 became minimum (NO in step S5), control device 70 has the process return to step S1 while it maintains the opening of flow rate regulation valve 13.

[0046] When time T1 has elapsed since the opening of flow rate regulation valve 13 became minimum (YES in step S5), control device 70 resets the internal timer for performing step S5 and controls solenoid valve 14 to open (step S6). When the condition of $SC > Th2$ is still satisfied even though the opening of flow rate regulation valve 13 has been minimum for time T1, responsiveness to control only with flow rate regulation valve 13 is poor and storage of liquid refrigerant in gas-liquid separator 7 should further be promoted. By controlling solenoid valve 14 to open, gas refrigerant stored in gas-liquid separator 7 is discharged to pipe 9. Consequently, storage of liquid refrigerant in gas-liquid separator 7 is promoted and the amount of refrigerant in main circuit 50 can be reduced. After step S6, control device 70 has the process return to step S1.

[0047] When the condition of $SC \geq Th1$ is not satisfied (NO in step S1), control device 70 determines that the amount of refrigerant in main circuit 50 is insufficient and performs steps S7 to S10 as processing for increasing the amount of refrigerant in main circuit 50.

[0048] In step S7, control device 70 determines whether or not the opening of flow rate regulation valve 13 is maximum.

[0049] When the opening of flow rate regulation valve 13 is not maximum (NO in step S7), control device 70 increases the opening of flow rate regulation valve 13 by one level (step S8). The amount of refrigerant that flows through pipe 8 thus increases and liquid refrigerant is more likely to be discharged from gas-liquid separator 7. Consequently, the amount of refrigerant in main circuit 50 increases. After step S8, control device 70 has the process return to step S1.

[0050] When the opening of flow rate regulation valve 13 is maximum (YES in step S7), control device 70 determines whether or not time T2 has elapsed since the opening of flow rate regulation valve 13 became maximum (step S9). Time T2 is determined in advance, and is set, for example, to ten minutes. Control device 70 includes an internal timer for performing step S9, and when the control device determines that the opening of flow rate regulation valve 13 is maximum while the internal timer has been reset, it controls the internal timer to start counting. As the count value of the internal timer reaches time T2, control device 70 should only determine that time T2 has elapsed since the opening of flow rate regulation valve 13 became maximum.

[0051] When time T2 has not elapsed since the opening of flow rate regulation valve 13 became maximum (NO in step S9), control device 70 has the process return to step S1 while it maintains the opening of flow rate regulation valve 13.

[0052] When time T2 has elapsed since the opening of flow rate regulation valve 13 became maximum (YES

in step S9), control device 70 resets the internal timer for performing step S9 and controls solenoid valve 14 to close (step S10). When the condition of $SC < Th1$ is still satisfied even though the opening of flow rate regulation valve 13 has been maximum for time T2, responsiveness to control only with flow rate regulation valve 13 is poor and discharge of liquid refrigerant from gas-liquid separator 7 should further be promoted. By controlling solenoid valve 14 to close, gas refrigerant is stored in gas-liquid separator 7 and discharge of liquid refrigerant is promoted. Consequently, a rate of increase in amount of refrigerant in main circuit 50 can be increased. After step S10, control device 70 has the process return to step S1.

[0053] Thus, control device 70 controls solenoid valve 14 to close in response to the degree of supercooling being lower than threshold value Th1 and the opening of flow rate regulation valve 13 being maximum. Control device 70 controls solenoid valve 14 to open in response to degree of supercooling SC of refrigerant that flows through the exit of condenser 2 exceeding threshold value Th2 and the opening of flow rate regulation valve 13 being minimum. Threshold value Th2 is larger than threshold value Th1. In other words, when the condition of $SC < Th1$ or $SC > Th2$ is satisfied, initially, the opening of flow rate regulation valve 13 is controlled to adjust the amount of refrigerant in main circuit 50. When control responsiveness is poor even though the opening of flow rate regulation valve 13 is controlled to a limit value, the open and closed state of solenoid valve 14 is controlled. The amount of refrigerant in main circuit 50 can thus be adjusted over a wide range. When refrigerant which can take a supercritical state, such as CO₂ refrigerant, is employed, a range of pressure that can be taken by refrigerant is wider and a range of the amount of refrigerant in main circuit 50 to be taken is also wider. Even in such a case, according to refrigeration cycle apparatus 100 according to the first embodiment, the amount of refrigerant in main circuit 50 can appropriately be adjusted.

40 Second Embodiment.

[0054] In transient operations until a stable state is reached, discharge pressure P1 of compressor 1 may abruptly increase. The transient operations typically include operations immediately after start-up. A refrigeration cycle apparatus according to a second embodiment appropriately adjusts the amount of refrigerant in main circuit 50 in order to avoid such increase in discharge pressure P1.

50 **[0055]** Fig. 4 is a diagram showing an internal configuration of a refrigeration cycle apparatus 100A according to the second embodiment. As shown in Fig. 4, refrigeration cycle apparatus 100A is different from refrigeration cycle apparatus 100 shown in Fig. 1 in including a pressure sensor 33.

55 **[0056]** Pressure sensor 33 measures an intermediate pressure P2 which is a pressure at injection port 1p of compressor 1 and outputs a result of measurement to

control device 70.

[0057] Fig. 5 is a flowchart showing an exemplary flow in processing by control device 70 according to the second embodiment. Control device 70 performs a flow shown in Fig. 5 in parallel to the flow shown in Fig. 3.

[0058] Initially, control device 70 determines whether or not solenoid valve 14 is closed (step S11). When solenoid valve 14 is open (NO in step S11), control device 70 has the process return to step S11.

[0059] When solenoid valve 14 is closed (YES in step S11), control device 70 compares discharge pressure P1 of compressor 1 and a threshold value Th3 with each other and compares intermediate pressure P2 of compressor 1 and a threshold value Th4 with each other. Control device 70 determines whether or not at least one of a condition (1) and a condition (2) below is satisfied (step S12).

Condition (1): $P1 > Th3$

Condition (2): $P2 > Th4$

Threshold values Th3 and Th4 are set in advance in accordance with a type or the like of refrigerant to be used. Threshold value Th3 is set, for example, to 10 MPa. Threshold value Th4 is smaller than threshold value Th3 and set, for example, to 8.5 MPa.

[0060] When neither of the condition (1) and the condition (2) is satisfied (NO in step S12), control device 70 has the process return to step S11.

[0061] When at least one of the condition (1) and the condition (2) is satisfied (YES in step S12), control device 70 controls solenoid valve 14 to open (step S13). As solenoid valve 14 is opened, gas refrigerant is discharged from gas-liquid separator 7 and storage of liquid refrigerant in gas-liquid separator 7 is promoted. The amount of refrigerant in main circuit 50 thus decreases and discharge pressure P1 and intermediate pressure P2 lower. Consequently, even in transient operations until the stable state is reached, abrupt increase in pressure of refrigerant in main circuit 50 can be suppressed.

Third Embodiment.

[0062] As an outdoor air temperature becomes lower, discharge pressure P1 of compressor 1 lowers. As discharge pressure P1 lowers, a compressed state (which is referred to as "overcompression" below) in which intermediate pressure P2 at injection port 1p becomes higher than discharge pressure P1 may occur in compressor 1.

[0063] When overcompression occurs in refrigeration cycle apparatus 100 shown in Fig. 1, a backflow of refrigerant from injection port 1p to gas-liquid separator 7 may occur. Consequently, the amount of refrigerant in main circuit 50 further decreases and discharge pressure P1 of compressor 1 further lowers. A refrigeration cycle apparatus according to a third embodiment solves also such a problem.

[0064] Fig. 6 is a diagram showing an exemplary internal configuration of a refrigeration cycle apparatus 100B according to the third embodiment. As shown in Fig. 6, refrigeration cycle apparatus 100B is different from refrigeration cycle apparatus 100 shown in Fig. 1 in including a pipe 18, solenoid valves 19 and 20, a capillary tube 22, a pressure sensor 34, and a temperature sensor 35. Pipe 18, solenoid valves 19 and 20, and capillary tube 22 are included in injection circuit 60.

[0065] Pipe 18 connects a branch point 21 of pipe 10 and inlet 1i of compressor 1 in main circuit 50 to each other. In other words, pipe 18 allows flow of some of refrigerant that flows through pipe 10 toward a suction side of compressor 1. Branch point 21 is located between economizer 12 and injection port 1p.

[0066] Solenoid valve 19 is provided in pipe 10 between branch point 21 and injection port 1p. Solenoid valve 20 is provided in pipe 18. Solenoid valve 19 or 20 is in any of an open state and a closed state.

[0067] Capillary tube 22 is provided in pipe 18 between branch point 21 and solenoid valve 20. Capillary tube 22 decompresses refrigerant diverted from pipe 10.

[0068] Pressure sensor 34 measures a suction pressure P3 which is a pressure of refrigerant on the suction side of compressor 1 and outputs a result of measurement to control device 70. Temperature sensor 35 measures an outdoor air temperature AT and outputs a result of measurement to control device 70.

[0069] Fig. 7 is a flowchart showing an exemplary flow in processing by control device 70 according to the third embodiment. Control device 70 performs a flow shown in Fig. 7 in parallel to the flow shown in Fig. 3.

[0070] Initially, control device 70 determines whether or not solenoid valve 14 is open (step S21).

[0071] When solenoid valve 14 is open (YES in step S21), control device 70 determines whether or not outdoor air temperature AT is lower than a threshold value Th5 (step S22). Threshold value Th5 is set, for example, to 0°C. When a condition of $AT < Th5$ is satisfied (YES in step S22), control device 70 compares a compression ratio $P1/P3$ which is a value calculated by dividing discharge pressure P1 by suction pressure P3 with a threshold value Th6 and determines whether or not a condition of $P1/P3 < Th6$ is satisfied (step S23). Threshold value Th6 is determined in advance so as to be slightly larger than the compression ratio at the time when overcompression occurs, and is set, for example, to 1.4. When the condition of $AT < Th5$ is not satisfied (NO in step S22) or the condition of $P1/P3 < Th6$ is not satisfied (NO in step S23), control device 70 has the process return to step S21.

[0072] When the condition of $P1/P3 < Th6$ is satisfied (YES in step S23), control device 70 controls solenoid valves 14 and 19 to close and controls solenoid valve 20 to open (step S24). As solenoid valve 14 is closed, gas refrigerant is no longer discharged from gas-liquid separator 7 and discharge of liquid refrigerant from gas-liquid separator 7 is promoted. As solenoid valve 19 is closed,

the backflow of refrigerant from injection port 1p to gas-liquid separator 7 can be prevented even on the occurrence of overcompression due to low outdoor air temperature AT. Furthermore, as solenoid valve 20 is opened, refrigerant discharged from gas-liquid separator 7 passes through pipe 18 and returns to main circuit 50. The amount of refrigerant in main circuit 50 thus increases and occurrence of overcompression can be suppressed.

[0073] Refrigerant that passes through pipe 18 is decompressed by capillary tube 22. Therefore, a pressure difference of refrigerant at a point of merge between pipe 18 and a pipe which composes main circuit 50 can be made smaller. When a difference between the pressure of refrigerant upstream from solenoid valve 20 in pipe 18 and the pressure of refrigerant suctioned into compressor 1 is large, refrigerant suddenly flows from pipe 18 into main circuit 50 as a result of opening of solenoid valve 20. Occurrence of such sudden flow-in of refrigerant may cause frothing of liquid refrigerant stored in gas-liquid separator 7. Furthermore, liquid refrigerant may be discharged from pipe 9 provided in the upper portion of gas-liquid separator 7 due to such frothing. As capillary tube 22 is provided, however, such frothing and discharge of liquid refrigerant through pipe 9 are suppressed. When the difference between the pressure of refrigerant at branch point 21 and suction pressure P3 of compressor 1 is within an allowable range, capillary tube 22 does not have to be provided.

[0074] When solenoid valve 14 is closed (NO in step S21), control device 70 determines whether or not solenoid valve 20 is open (step S25). When solenoid valve 20 is closed (NO in step S25), control device 70 has the process return to step S21.

[0075] When solenoid valve 20 is open (YES in step S25), control device 70 determines whether or not outdoor air temperature AT is lower than threshold value Th5 (step S26). When the condition of $AT < Th5$ is satisfied (YES in step S26), control device 70 compares compression ratio $P1/P3$ with threshold value Th6 and determines whether or not the condition of $P1/P3 < Th6$ is satisfied (step S27). When the condition of $P1/P3 < Th6$ is satisfied (YES in step S27), control device 70 has the process return to step S21.

[0076] When the condition of $AT < Th5$ is not satisfied (NO in step S26) or when the condition of $P1/P3 < Th6$ is not satisfied (NO in step S27), control device 70 controls solenoid valves 14 and 19 to open and controls solenoid valve 20 to close (step S28). When determination as NO is made in step S26 or when determination as NO is made in step S27, possibility of occurrence of overcompression due to low outdoor air temperature AT is low. Therefore, as solenoid valve 14 is opened, gas refrigerant is discharged from gas-liquid separator 7. As solenoid valve 19 is opened and solenoid valve 20 is closed, refrigerant flows into injection port 1p, power consumption is reduced, and capability is improved.

Fourth Embodiment.

[0077] The refrigeration cycle apparatus according to the first embodiment determines whether or not the amount of refrigerant in main circuit 50 is excessive or insufficient based on degree of supercooling SC of refrigerant that has passed through condenser 2. In contrast, a refrigeration cycle apparatus according to a fourth embodiment determines whether or not the amount of refrigerant in main circuit 50 is excessive or insufficient based on an evaporation temperature ET of refrigerant suctioned into compressor 1 and a liquid level in gas-liquid separator 7.

[0078] Fig. 8 is a diagram showing an exemplary internal configuration of a refrigeration cycle apparatus 100C according to the fourth embodiment. As shown in Fig. 8, refrigeration cycle apparatus 100C is different from refrigeration cycle apparatus 100 shown in Fig. 1 in including pressure sensor 34 and a liquid level sensor 36 instead of pressure sensor 31 and temperature sensor 32. Pressure sensor 34 measures suction pressure P3 of compressor 1 and outputs a result of measurement to control device 70 as described in the third embodiment.

[0079] Liquid level sensor 36 is a sensor to sense a liquid level (a height of a liquid surface) in gas-liquid separator 7. Liquid level sensor 36 outputs a result of sensing to control device 70.

[0080] Control device 70 calculates evaporation temperature ET of refrigerant suctioned into compressor 1 based on suction pressure P3. Control device 70 stores in advance a correspondence table in which a plurality of evaporation temperature zones and a plurality of height ranges are brought in correspondence, respectively. Control device 70 identifies an evaporation temperature zone to which evaporation temperature ET belongs among the plurality of evaporation temperature zones and determines as a subject height range, a height range corresponding to the identified evaporation temperature zone among the plurality of height ranges. Control device 70 controls the opening of flow rate regulation valve 13 and the open and closed state of solenoid valve 14 such that the liquid level in gas-liquid separator 7 is accommodated within the subject height range.

[0081] Fig. 9 is a diagram showing an exemplary correspondence table 45 stored in control device 70 according to the fourth embodiment. As shown in Fig. 9, in correspondence table 45, an evaporation temperature zone lower than -30°C and a height range Rc are brought in correspondence with each other, an evaporation temperature zone not lower than -30°C and lower than -10°C and a height range Rb are brought in correspondence with each other, and an evaporation temperature zone not lower than -10°C and a height range Ra are brought in correspondence with each other.

[0082] Fig. 10 is a diagram showing an exemplary height range set for gas-liquid separator 7 in the fourth embodiment. As evaporation temperature ET is lower, an appropriate amount of refrigerant in main circuit 50 is

smaller. Therefore, height range Rc corresponding to the evaporation temperature zone lower than -30°C is set to be higher than height range Rb corresponding to the evaporation temperature zone not lower than -30°C and lower than -10°C . Similarly, height range Rb corresponding to the evaporation temperature zone not lower than -30°C and lower than -10°C is set to be higher than height range Ra corresponding to the evaporation temperature zone not lower than -10°C . Thus, the height range corresponding to the evaporation temperature zone lower in temperature of any two evaporation temperature zones selected from among the plurality of evaporation temperature zones is set to be higher than the height range corresponding to the evaporation temperature zone higher in temperature of the two evaporation temperature zones. As the higher height range is set, the amount of liquid refrigerant stored in gas-liquid separator 7 becomes larger and the amount of refrigerant in main circuit 50 becomes smaller.

[0083] As the opening of flow rate regulation valve 13 and the open and closed state of solenoid valve 14 are controlled such that the liquid level is accommodated within the subject height range in accordance with evaporation temperature ET, the amount of refrigerant in main circuit 50 is adjusted to an appropriate amount.

[0084] Refrigerant discharged from compressor 1 contains refrigerating machine oil of compressor 1. Therefore, refrigerating machine oil is contained also in liquid refrigerant stored in gas-liquid separator 7. Refrigerating machine oil discharged from compressor 1 is preferably collected in compressor 1. In an example where refrigerating machine oil is dissolved in refrigerant, refrigerating machine oil is collected in compressor 1 as liquid refrigerant is discharged from gas-liquid separator 7 through pipe 8. Alternatively, even in an example where refrigerating machine oil is not dissolved in refrigerant, so long as refrigerating machine oil is heavier in specific gravity than refrigerant, refrigerating machine oil is stored in the lower portion of gas-liquid separator 7. Refrigerating machine oil stored in the lower portion of gas-liquid separator 7 is discharged through pipe 8 and collected in compressor 1. In contrast, in an example where refrigerating machine oil is not dissolved in refrigerant and is lighter in specific gravity than refrigerant, refrigerating machine oil is stored in a form of a layer over liquid refrigerant in gas-liquid separator 7. In this case, liquid refrigerant is mainly discharged and refrigerating machine oil is less likely to be discharged through pipe 8. Therefore, refrigerating machine oil in gas-liquid separator 7 is less likely to be collected in compressor 1.

[0085] Control device 70 controls the liquid level in gas-liquid separator 7 to reach a reference height LV (see Fig. 10) higher than one end 9a of pipe 9 every predetermined cycle in order to have refrigerating machine oil not dissolved in refrigerant and lighter in specific gravity than refrigerant collected in compressor 1.

[0086] Fig. 11 is a diagram showing a state of gas-liquid separator 7 when the liquid level reaches reference

height LV. As shown in Fig. 11, one end 9a of pipe 9 is located in gas-liquid separator 7. Since the liquid level has reached reference height LV higher than one end 9a of pipe 9, one end 9a of pipe 9 is located within a layer 40 of refrigerating machine oil stored above liquid refrigerant. Refrigerating machine oil can thus be collected in compressor 1 through pipe 9.

[0087] A flow of processing by the control device according to the fourth embodiment will be described with reference to Figs. 12 to 14. Fig. 12 is a flowchart showing a flow in steps S31 to S37 in processing by control device 70 according to the fourth embodiment. Fig. 13 is a flowchart showing a flow in steps S38 to S44 in processing by control device 70 according to the fourth embodiment. Fig. 14 is a flowchart showing a flow in steps S45 to S47 in processing by control device 70 according to the fourth embodiment.

[0088] Initially, control device 70 determines whether or not time T3 has elapsed since start-up or since the liquid refrigerant previously reached reference height LV (step S31). Time T3 is a cycle determined in advance, and set, for example, to sixty minutes. Control device 70 includes an internal timer for performing step S31, and at the time of start-up of refrigeration cycle apparatus 100C, it resets the internal timer and has the internal timer start counting. As the count value of the internal timer reaches time T3, control device 70 should only make determination as YES in step S31.

[0089] When time T3 has not elapsed (NO in step S31), control device 70 calculates evaporation temperature ET based on suction pressure P3 and determines whether or not a condition of $\text{ET} < -30^{\circ}\text{C}$ is satisfied (step S32). When the condition of $\text{ET} < -30^{\circ}\text{C}$ is not satisfied (NO in step S32), control device 70 determines whether or not a condition of $-30^{\circ}\text{C} \leq \text{ET} < -10^{\circ}\text{C}$ is satisfied (step S33).

[0090] When the condition of $\text{ET} < -30^{\circ}\text{C}$ is satisfied (YES in step S32), control device 70 reads height range Rc corresponding to the evaporation temperature zone lower than -30°C as the subject height range from correspondence table 45 shown in Fig. 9. Control device 70 determines whether or not the liquid level sensed by liquid level sensor 36 belongs to the subject height range (step S34).

[0091] When the condition of $-30^{\circ}\text{C} \leq \text{ET} < -10^{\circ}\text{C}$ is satisfied (YES in step S33), control device 70 reads height range Rb corresponding to the evaporation temperature zone not lower than -30°C and lower than -10°C as the subject height range from correspondence table 45 shown in Fig. 9. Control device 70 determines whether or not the liquid level sensed by liquid level sensor 36 belongs to the subject height range (step S35).

[0092] When the condition of $-30^{\circ}\text{C} \leq \text{ET} < -10^{\circ}\text{C}$ is not satisfied (NO in step S33), control device 70 reads height range Ra corresponding to the evaporation temperature zone not lower than -10°C as the subject height range from correspondence table 45 shown in Fig. 9. Control device 70 determines whether or not the liquid level sensed by liquid level sensor 36 belongs to the subject

height range (step S36).

[0093] When determination as YES is made in steps S34, S35, and S36, control device 70 maintains the opening of flow rate regulation valve 13 in the current state (step S37). After step S37, control device 70 has the process return to step S31.

[0094] When determination as NO is made in steps S34, S35, and S36, as shown in Fig. 13, control device 70 determines whether or not the liquid level exceeds an upper limit of the subject height range (step S38).

[0095] When the liquid level exceeds the upper limit of the subject height range (YES in step S38), control device 70 determines whether or not the opening of flow rate regulation valve 13 is maximum (step S39). When the opening of flow rate regulation valve 13 not maximum (NO in step S39), control device 70 increases the opening of flow rate regulation valve 13 by one level (step S40). The amount of refrigerant that flows through pipe 8 thus increases and liquid refrigerant is more likely to be discharged from gas-liquid separator 7. Consequently, the liquid level comes closer to the subject height range and the amount of refrigerant in main circuit 50 increases. After step S40, control device 70 has the process return to step S31.

[0096] When the opening of flow rate regulation valve 13 is maximum (YES in step S39), control device 70 controls solenoid valve 14 to close (step S41). As solenoid valve 14 is closed, gas refrigerant is stored in gas-liquid separator 7 and discharge of liquid refrigerant is promoted. Consequently, the liquid level comes closer to the subject height range and the amount of refrigerant in main circuit 50 increases. After step S41, control device 70 has the process return to step S31.

[0097] When the liquid level does not exceed the upper limit of the subject height range (NO in step S38), that is, when the liquid level is lower than a lower limit of the subject height range, control device 70 determines whether or not the opening of flow rate regulation valve 13 is minimum (step S42). When the opening of flow rate regulation valve 13 is not minimum (NO in step S42), control device 70 decreases the opening of flow rate regulation valve 13 by one level (step S43). The amount of refrigerant that flows through pipe 8 thus decreases and liquid refrigerant is more likely to be stored in gas-liquid separator 7. Consequently, the liquid level comes closer to the subject height range and the amount of refrigerant in main circuit 50 decreases. After step S43, control device 70 has the process return to step S31.

[0098] When the opening of flow rate regulation valve 13 is minimum (YES in step S42), control device 70 controls solenoid valve 14 to open (step S43). As solenoid valve 14 is opened, gas refrigerant is discharged from gas-liquid separator 7 and liquid refrigerant is further more likely to be stored in gas-liquid separator 7. Consequently, the liquid level comes closer to the subject height range and the amount of refrigerant in main circuit 50 increases. After step S43, control device 70 has the process return to step S31.

[0099] As shown in Figs. 12 and 14, when time T3 has elapsed (YES in step S31), control device 70 controls solenoid valve 14 to open and minimizes the opening of flow rate regulation valve 13 (that is, controls flow rate regulation valve 13 to close) until the liquid level reaches reference height LV (step S45). Thus, as flow rate regulation valve 13 is closed, discharge of liquid refrigerant from gas-liquid separator 7 is stopped. Furthermore, as solenoid valve 14 is opened, gas refrigerant is discharged from gas-liquid separator 7 and storage of liquid refrigerant in gas-liquid separator 7 is promoted. As shown in Fig. 11, reference height LV is higher than one end of pipe 9. Therefore, layer 40 of refrigerating machine oil is discharged through pipe 9 and refrigerating machine oil is collected in compressor 1 by the time when the liquid level reaches reference height LV after it reaches one end of pipe 9.

[0100] Control device 70 may stand by for a certain time period after the liquid level reaches reference height LV. Refrigerating machine oil in gas-liquid separator 7 is thus more reliably collected in compressor 1.

[0101] Then, control device 70 sets the opening of flow rate regulation valve 13 and the open and closed state of solenoid valve 14 back to a state before start of step S45 (step S46). Then, control device 70 resets the internal timer used for performing step S31 (step S47). Thus, step S45 is performed each time time T3 elapses and refrigerating machine oil in gas-liquid separator 7 is periodically collected in compressor 1.

Fifth Embodiment.

[0102] Refrigeration cycle apparatus 100C according to the fourth embodiment determines whether or not the amount of refrigerant in main circuit 50 is excessive or insufficient based on evaporation temperature ET of refrigerant suctioned into compressor 1 and the height of the liquid surface in gas-liquid separator 7. In contrast, a refrigeration cycle apparatus according to a fifth embodiment determines whether or not the amount of refrigerant in main circuit 50 is excessive or insufficient based on the outdoor air temperature, evaporation temperature ET, and the height of the liquid surface in gas-liquid separator 7. Specifically, control device 70 determines the subject height range based on outdoor air temperature AT and evaporation temperature ET and controls the opening of flow rate regulation valve 13 and the open and closed state of solenoid valve 14 such that the liquid level in gas-liquid separator 7 is accommodated within the subject height range.

[0103] Fig. 15 is a diagram showing an exemplary internal configuration of a refrigeration cycle apparatus 100D according to the fifth embodiment. As shown in Fig. 15, refrigeration cycle apparatus 100D is different from refrigeration cycle apparatus 100C shown in Fig. 8 in further including temperature sensor 35. Temperature sensor 35 measures outdoor air temperature AT and outputs a result of measurement to control device 70 as

described in the third embodiment.

[0104] Control device 70 stores in advance a correspondence table in which a plurality of evaporation temperature zones and a plurality of height ranges are brought in correspondence, respectively, for each of a plurality of outdoor air temperature zones.

[0105] Fig. 16 is a diagram showing an exemplary correspondence table 46 stored in control device 70 according to the fifth embodiment. As shown in Fig. 16, correspondence table 46 includes a record 46a corresponding to an outdoor air temperature zone not lower than 10°C and a record 46b corresponding to an outdoor air temperature zone lower than 10°C.

[0106] In each of records 46a and 46b, each of the evaporation temperature zone lower than -30°C, the evaporation temperature zone not lower than -30°C and lower than -10°C, and the evaporation temperature zone not lower than -10°C is brought in correspondence with the height range. In other words, each of records 46a and 46b is correspondence information in which the plurality of evaporation temperature zones and the plurality of height ranges are brought in correspondence, respectively.

[0107] In record 46a, the evaporation temperature zone lower than -30°C is brought in correspondence with a height range Rf, the evaporation temperature zone not lower than -30°C and lower than -10°C is brought in correspondence with a height range Re, and the evaporation temperature zone not lower than -10°C is brought in correspondence with a height range Rd. In record 46b, the evaporation temperature zone lower than -30°C is brought in correspondence with a height range Ri, the evaporation temperature zone not lower than -30°C and lower than -10°C is brought in correspondence with a height range Rh, and the evaporation temperature zone not lower than -10°C is brought in correspondence with a height range Rg.

[0108] Fig. 17 is a diagram showing an exemplary height range set for gas-liquid separator 7 in the fifth embodiment. As evaporation temperature ET is lower, an appropriate amount of refrigerant in main circuit 50 is smaller. Therefore, height ranges Rf and Ri corresponding to the evaporation temperature zone lower than -30°C are set to be higher than height ranges Re and Rh corresponding to the evaporation temperature zone not lower than -30°C and lower than -10°C, respectively.

Similarly, height ranges Re and Rh corresponding to the evaporation temperature zone not lower than -30°C and lower than -10°C are set to be higher than height ranges Rd and Rg corresponding to the evaporation temperature zone not lower than -10°C, respectively. As the higher height range is set, the amount of liquid refrigerant stored in gas-liquid separator 7 becomes larger and the amount of refrigerant in main circuit 50 becomes smaller.

[0109] Furthermore, as outdoor air temperature AT is higher, higher capability is required for cooling a space to be cooled. Therefore, as outdoor air temperature AT is higher, the amount of refrigerant in main circuit 50

should be increased. Therefore, height ranges Rf, Re, and Rd corresponding to the outdoor air temperature zone not lower than 10°C are set to be lower than height ranges Ri, Rh, and Rg corresponding to the outdoor air temperature zone lower than 10°C. Thus, a plurality of height ranges included in a record corresponding to an outdoor air temperature zone higher in temperature of any two outdoor air temperature zones selected from among the plurality of outdoor air temperature zones are set to be lower than a plurality of height ranges included in a record corresponding to an outdoor air temperature zone lower in temperature of the two outdoor air temperature zones.

[0110] As the opening of flow rate regulation valve 13 and the open and closed state of solenoid valve 14 are controlled such that the liquid level is accommodated within the subject height range in accordance with outdoor air temperature AT and evaporation temperature ET, the amount of refrigerant in main circuit 50 is adjusted to an appropriate amount.

[0111] Fig. 18 is a flowchart showing a flow in steps S51 to S59 in processing by control device 70 according to the fifth embodiment.

[0112] Initially, control device 70 determines whether or not time T3 has elapsed since start-up or since the liquid level previously reached reference height LV (step S51). Details of step S51 are the same as those of step S31 shown in Fig. 12.

[0113] When time T3 has not elapsed (NO in step S51), control device 70 determines whether or not outdoor air temperature AT received from temperature sensor 35 satisfies a condition of $AT \geq 10^\circ\text{C}$ (step S52).

[0114] When the condition of $AT \geq 10^\circ\text{C}$ is not satisfied (NO in step S52), that is, when a condition of $AT < 10^\circ\text{C}$ is satisfied, control device 70 reads record 46b corresponding to the outdoor air temperature zone lower than 10°C in correspondence table 46 shown in Fig. 16 (S53).

[0115] Then, control device 70 calculates evaporation temperature ET based on suction pressure P3 and determines whether or not the condition of $ET < -30^\circ\text{C}$ is satisfied (step S54). When the condition of $ET < -30^\circ\text{C}$ is not satisfied (NO in step S54), control device 70 determines whether or not the condition of $-30^\circ\text{C} \leq ET < -10^\circ\text{C}$ is satisfied (step S55).

[0116] When the condition of $ET < -30^\circ\text{C}$ is satisfied (YES in step S54), control device 70 reads height range Ri corresponding to the evaporation temperature zone lower than -30°C as the subject height range from record 46b read in step S53. Control device 70 determines whether or not the liquid level sensed by liquid level sensor 36 belongs to the subject height range (step S56).

[0117] When the condition of $-30^\circ\text{C} \leq ET < -10^\circ\text{C}$ is satisfied (YES in step S55), control device 70 reads height range Rh corresponding to the evaporation temperature zone not lower than -30°C and lower than -10°C as the subject height range from record 46b read in step S53. Control device 70 determines whether or not the liquid level sensed by liquid level sensor 36 belongs to

the subject height range (step S57).

[0118] When the condition of $-30^{\circ}\text{C} \leq \text{ET} < -10^{\circ}\text{C}$ is not satisfied (NO in step S54), control device 70 reads height range Rg corresponding to the evaporation temperature zone not lower than -10°C as the subject height range from record 46b read in step S53. Control device 70 determines whether or not the liquid level sensed by liquid level sensor 36 belongs to the subject height range (step S58).

[0119] When determination as YES is made in steps S56 to S58, control device 70 maintains the opening of flow rate regulation valve 13 in the current state (step S59). After step S59, control device 70 has the process return to step S51.

[0120] Fig. 19 is a flowchart showing a flow in steps S60 to S66 in processing by control device 70 according to the fifth embodiment.

[0121] As shown in Figs. 18 and 19, when the condition of $\text{AT} \geq 10^{\circ}\text{C}$ is satisfied (YES in step S52), control device 70 reads record 46a corresponding to the outdoor air temperature zone not lower than 10°C in correspondence table 46 shown in Fig. 16 (S60).

[0122] Then, control device 70 calculates evaporation temperature ET based on suction pressure P3 and determines whether or not the condition of $\text{ET} < -30^{\circ}\text{C}$ is satisfied (step S61). When the condition of $\text{ET} < -30^{\circ}\text{C}$ is not satisfied (NO in step S61), control device 70 determines whether or not the condition of $-30^{\circ}\text{C} \leq \text{ET} < -10^{\circ}\text{C}$ is satisfied (step S62).

[0123] When the condition of $\text{ET} < -30^{\circ}\text{C}$ is satisfied (YES in step S61), control device 70 reads height range Rf corresponding to the evaporation temperature zone lower than -30°C as the subject height range from record 46a read in step S60. Control device 70 determines whether or not the liquid level sensed by liquid level sensor 36 belongs to the subject height range (step S63).

[0124] When the condition of $-30^{\circ}\text{C} \leq \text{ET} < -10^{\circ}\text{C}$ is satisfied (YES in step S62), control device 70 reads height range Re corresponding to the evaporation temperature zone not lower than -30°C and lower than -10°C as the subject height range from record 46a read in step S59. Control device 70 determines whether or not the liquid level sensed by liquid level sensor 36 belongs to the subject height range (step S64).

[0125] When the condition of $-30^{\circ}\text{C} \leq \text{ET} < -10^{\circ}\text{C}$ is not satisfied (NO in step S62), control device 70 reads height range Rd corresponding to the evaporation temperature zone not lower than -10°C as the subject height range from record 46a read in step S59. Control device 70 determines whether or not the liquid level sensed by liquid level sensor 36 belongs to the subject height range (step S65).

[0126] When determination as YES is made in steps S63 to S65, control device 70 maintains the opening of flow rate regulation valve 13 in the current state (step S66). After step S66, control device 70 has the process return to step S51.

[0127] When determination as NO is made in steps

S56 to S58 and S63 to S65, control device 70 performs steps S38 to S44 shown in Fig. 13 and thereafter has the process return to step S51 as in the fourth embodiment.

[0128] When determination as YES is made in step S51, steps S45 to S47 shown in Fig. 14 are performed and thereafter the process returns to step S51 as in the fourth embodiment.

Sixth Embodiment.

[0129] In the first to fifth embodiments, economizer 12 exchanges heat between refrigerant that flows through pipe 10 and refrigerant that flows out of condenser 2. In contrast, in a refrigeration cycle apparatus according to a sixth embodiment, economizer 12 exchanges heat between refrigerant that flows through pipe 9 and refrigerant that flows out of condenser 2.

[0130] Fig. 20 is a diagram showing an internal configuration of a refrigeration cycle apparatus 100E according to the sixth embodiment. As shown in Fig. 20, in refrigeration cycle apparatus 100E, economizer 12 is arranged in pipe 9 between solenoid valve 14 and point of merge 11. Pipe 8 does not pass through economizer 12 but merges with pipe 9 at point of merge 11.

[0131] According to the sixth embodiment, wetness of refrigerant in a gas-liquid two-phase state that flows into injection port 1p of compressor 1 is high and capability to lower a temperature of refrigerant discharged from compressor 1 can be enhanced. A degree of wetness of refrigerant in the gas-liquid two-phase state is adjusted by the opening of flow rate regulation valve 13 provided in pipe 8.

Seventh Embodiment.

[0132] In a refrigeration cycle apparatus according to a seventh embodiment, economizer 12 exchanges heat between refrigerant that flows through pipe 8 and refrigerant that flows out of condenser 2.

[0133] Fig. 21 is a diagram showing an internal configuration of a refrigeration cycle apparatus 100F according to the seventh embodiment. As shown in Fig. 21, in refrigeration cycle apparatus 100F, economizer 12 is arranged in pipe 8 between flow rate regulation valve 13 and point of merge 11. Pipe 9 does not pass through economizer 12 but merges with pipe 8 at point of merge 11.

[0134] According to the seventh embodiment, economizer 12 can enhance efficiency in heat exchange by making use of evaporation latent heat of liquid refrigerant that flows through pipe 8.

Eighth Embodiment.

[0135] A refrigeration cycle apparatus according to an eighth embodiment can switch a path in injection circuit 60 shown in Figs. 1, 20, and 21.

[0136] Fig. 22 is a diagram showing an internal config-

uration of a refrigeration cycle apparatus 100G according to the eighth embodiment. As shown in Fig. 22, refrigeration cycle apparatus 100G is different from refrigeration cycle apparatus 100 shown in Fig. 1 in including pipes 23 to 30 and three-way valves 47 and 48.

[0137] Three-way valve 47 includes three ports 47a, 47b, and 47c, and switches between a state in which port 47a and port 47b communicate with each other and a state in which port 47a and port 47c communicate with each other.

[0138] Three-way valve 48 includes three ports 48a, 48b, and 48c, and switches between a state in which port 48a and port 48b communicate with each other and a state in which port 48a and port 48c communicate with each other.

[0139] Pipe 23 is provided to discharge liquid refrigerant from gas-liquid separator 7. Pipe 23 connects gas-liquid separator 7 and port 47a of three-way valve 47 to each other. Flow rate regulation valve 13 is provided in pipe 23.

[0140] Pipe 24 has one end connected to port 47b of three-way valve 47. Pipe 25 has one end connected to port 47c of three-way valve 47.

[0141] Pipe 26 is provided to discharge gas refrigerant from gas-liquid separator 7. Pipe 26 connects gas-liquid separator 7 and port 48a of three-way valve 48 to each other. Solenoid valve 14 is provided in pipe 26.

[0142] Pipe 27 has one end connected to port 48b of three-way valve 48. Pipe 28 has one end connected to port 48c of three-way valve 48.

[0143] Pipe 25 has the other end connected to the other end of pipe 27. Pipe 25 has the other end connected to the other end of pipe 28.

[0144] Pipe 29 connects a point of connection 11a between pipes 24 and 27 to a point of connection 11b between pipes 25 and 28. Pipe 29 passes through economizer 12. Therefore, heat is exchanged between refrigerant that flows through pipe 29 and refrigerant that has passed through condenser 2.

[0145] Pipe 30 connects point of connection 11b between pipes 25 and 28 to injection port 1p of compressor 1.

[0146] Control device 70 switches three-way valves 47 and 48 to any one of first to third states below.

First state: a state in which port 47a and port 47b of three-way valve 47 communicate with each other and port 48a and port 48b of three-way valve 48 communicate with each other

Second state: a state in which port 47a and port 47c of three-way valve 47 communicate with each other and port 48a and port 48b of three-way valve 48 communicate with each other

Third state: a state in which port 47a and port 47b of three-way valve 47 communicate with each other and port 48a and port 48c of three-way valve 48 communicate with each other

[0147] When three-way valves 47 and 48 are switched to the first state, refrigerant that has passed through flow rate regulation valve 13 flows to point of connection 11a and refrigerant that has passed through solenoid valve 14 flows to point of connection 11a. Refrigerant that merges at point of connection 11a passes through pipes 29 and 30 so that economizer 12 exchanges heat with refrigerant that has passed through condenser 2, and thereafter flows to compressor 1. A path in injection circuit 60 in the first embodiment is thus realized. In other words, pipes 23 and 24 compose pipe 8 in Fig. 1, pipes 26 and 27 compose pipe 9 in Fig. 1, and pipes 29 and 30 compose pipe 10 in Fig. 1. Point of connection 11a corresponds to point of merge 11 in Fig. 1.

[0148] As three-way valves 47 and 48 are switched to the second state, refrigerant that has passed through flow rate regulation valve 13 flows to point of connection 11b. Refrigerant that has passed through solenoid valve 14 passes through pipes 27 and 29 and flows to point of connection 11b. In other words, refrigerant that has passed through solenoid valve 14 exchanges heat with refrigerant that has passed through condenser 2 in economizer 12, and thereafter merges, at point of connection 11b, with refrigerant that has passed through flow rate regulation valve 13. Refrigerant that has passed through flow rate regulation valve 13 does not pass through economizer 12. Refrigerant that merges at point of connection 11b flows through pipe 30 to compressor 1. The path in injection circuit 60 in the sixth embodiment is thus realized. In other words, pipes 23 and 25 compose pipe 8 in Fig. 20, pipes 26, 27, and 29 compose pipe 9 in Fig. 20, and pipe 30 composes pipe 10 in Fig. 20. Point of connection 11b corresponds to point of merge 11 in Fig. 20.

[0149] As three-way valves 47 and 48 are switched to the third state, refrigerant that has passed through solenoid valve 14 flows to point of connection 11b. Refrigerant that has passed through flow rate regulation valve 13 passes through pipes 24 and 29 and flows to point of connection 11b. In other words, refrigerant that has passed through flow rate regulation valve 13 exchanges heat with refrigerant that has passed through condenser 2 in economizer 12, and thereafter merges, at point of connection 11b, with refrigerant that has passed through solenoid valve 14. Refrigerant that has passed through solenoid valve 14 does not pass through economizer 12. Refrigerant that merges at point of connection 11b flows through pipe 30 to compressor 1. The path in injection circuit 60 in the seventh embodiment is thus realized. In other words, pipes 23, 24, and 29 compose pipe 8 in Fig. 21, pipes 26 and 28 compose pipe 9 in Fig. 21, and pipe 30 composes pipe 10 in Fig. 21. Point of connection 11b corresponds to point of merge 11 in Fig. 21.

[0150] Three-way valves 47 and 48 thus switch the pipe that passes through economizer 12 to any one of pipe 8, pipe 9, and pipe 10.

[0151] When three-way valves 47 and 48 are in the first state, refrigerant that flows through main circuit 50 is efficiently supercooled and performance of refrigera-

tion cycle apparatus 100G is enhanced. When three-way valves 47 and 48 are in the second state, liquid refrigerant that has passed through flow rate regulation valve 13 does not pass through economizer 12 but is directly sent to compressor 1. Therefore, the discharge temperature of compressor 1 is readily lowered. When three-way valves 47 and 48 are in the third state, only liquid refrigerant that has passed through flow rate regulation valve 13 passes through economizer 12 and hence gas refrigerant is sent into compressor 1. Therefore, the discharge temperature of compressor 1 is readily increased. Therefore, control device 70 should only set three-way valves 47 and 48 to the first state except for the case of transient variation in discharge temperature of compressor 1. Then, control device 70 should only switch three-way valves 47 and 48 to the second state when the discharge temperature of compressor 1 abruptly increases (for example, to 115°C or higher). Furthermore, when the discharge temperature lowers and superheat of discharged refrigerant has not yet been secured (for example, superheat is equal to or lower than 20 K), control device 70 should only switch three-way valves 47 and 48 to the third state.

Modification.

[0152] The first to eighth embodiments may be combined as appropriate. For example, in the second and fourth to eighth embodiments, pipe 18, solenoid valves 19 and 20, and capillary tube 22 may be provided in injection circuit 60 as in the third embodiment.

[0153] In the fourth and fifth embodiments, liquid level sensor 36 senses the liquid level in gas-liquid separator 7. Therefore, in order to accurately sense the liquid level, the liquid surface is preferably stable in gas-liquid separator 7. In combining the third embodiment with the fourth or fifth embodiment, in pipe 18, capillary tube 22 is provided between branch point 21 and solenoid valve 20. As capillary tube 22 is provided, frothing of liquid refrigerant stored in gas-liquid separator 7 can be suppressed as described above. Consequently, the liquid surface is stabilized in gas-liquid separator 7 and liquid level sensor 36 can accurately sense the liquid level.

[0154] "Exceed(ing)" herein may be replaced with "equal to or more than" and "equal to or less than" may be replaced with "less than." In contrast, "equal to or more than" may be replaced with "exceed(ing)" and "less than" may be replaced with "equal to or less than."

[0155] It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The 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

[0156] 1 compressor; 1i inlet; 1o outlet; 1p injection port; 2 condenser; 3, 4 decompressing apparatus; 5 evaporator; 6, 13 flow rate regulation valve; 7 gas-liquid separator; 8 to 10, 16, 18, 23 to 30 pipe; 11 point of merge; 11a, 11b point of connection; 12 economizer; 14, 19, 20 solenoid valve; 15, 21 branch point; 17 fan; 22 capillary tube; 31, 33, 34 pressure sensor; 32, 35 temperature sensor; 36 liquid level sensor; 40 layer; 45, 46 correspondence table; 46a, 46b record; 47, 48 three-way valve; 47a to 47c, 48a to 48c port; 50 main circuit; 60 injection circuit; 70 control device; 80 heat source side unit; 90 use side unit; 91 liquid pipe; 92 gas pipe; 100, 100A to 100G refrigeration cycle apparatus; Ra to Ri height range

Claims

1. A refrigeration cycle apparatus comprising:
 - a main circuit through which refrigerant circulates in an order of a compressor, a condenser, a decompressing apparatus, and an evaporator; an injection circuit through which some of refrigerant that flows from the condenser to the decompressing apparatus is diverted to flow into the compressor, the injection circuit including
 - a gas-liquid separator to separate some of the refrigerant into gas and liquid,
 - a first pipe through which liquid refrigerant is discharged from the gas-liquid separator,
 - a second pipe through which gas refrigerant is discharged from the gas-liquid separator,
 - a third pipe in which refrigerant that flows through the first pipe and refrigerant that flows through the second pipe merge with each other to flow to an injection port of the compressor,
 - a flow rate regulation valve provided in the first pipe, and
 - a first solenoid valve provided in the second pipe; and
 - a control device to control an opening of the flow rate regulation valve and an open and closed state of the first solenoid valve to adjust an amount of refrigerant in the main circuit.
2. The refrigeration cycle apparatus according to claim 1, wherein
 - the control device controls the first solenoid valve to close when an amount of refrigerant in the main circuit is insufficient and controls the first solenoid valve to open when the amount of refrigerant in the main circuit is excessive.

- 3. The refrigeration cycle apparatus according to claim 1, wherein

the control device controls the first solenoid valve to close in response to a degree of supercooling of refrigerant that flows through an exit of the condenser being lower than a first threshold value and the opening of the flow rate regulation valve being maximum, and the control device controls the first solenoid valve to open in response to the degree of supercooling exceeding a second threshold value larger than the first threshold value and the opening of the flow rate regulation valve being minimum.

- 4. The refrigeration cycle apparatus according to any one of claims 1 to 3, wherein

the control device controls the first solenoid valve to open in response to satisfaction of at least one of a first condition that a pressure of refrigerant discharged from the compressor exceeds a third threshold value and a second condition that a pressure of refrigerant at the injection port exceeds a fourth threshold value.

- 5. The refrigeration cycle apparatus according to any one of claims 1 to 4, wherein

the injection circuit further includes

a fourth pipe to connect a branch point provided in the third pipe and an inlet of the compressor to each other, a second solenoid valve provided in the third pipe, between the branch point and the injection port, and a third solenoid valve provided in the fourth pipe, and

the control device controls the second solenoid valve to close and controls the third solenoid valve to open in response to an outdoor air temperature being lower than a fifth threshold value and a value calculated by dividing a pressure of refrigerant discharged from the compressor by a pressure of refrigerant suctioned into the compressor being smaller than a sixth threshold value.

- 6. The refrigeration cycle apparatus according to claim 1, further comprising a sensor to sense a liquid level in the gas-liquid separator, wherein

the control device controls the opening of the flow rate regulation valve and the open and closed state of the first solenoid valve to accommodate the liquid level within a subject height range determined in accordance with an evaporation temperature of refrigerant suctioned into the compressor.

erant suctioned into the compressor.

- 7. The refrigeration cycle apparatus according to claim 6, wherein

the control device

stores correspondence information in which a plurality of evaporation temperature zones and a plurality of height ranges are brought in correspondence, respectively, identifies an evaporation temperature zone to which the evaporation temperature belongs, among the plurality of evaporation temperature zones, and determines a height range corresponding to the identified evaporation temperature zone among the plurality of height ranges as the subject height range, and

a height range corresponding to an evaporation temperature zone lower in temperature of any two evaporation temperature zones selected from among the plurality of evaporation temperature zones is set to be higher than a height range corresponding to an evaporation temperature zone higher in temperature of the two evaporation temperature zones.

- 8. The refrigeration cycle apparatus according to claim 7, wherein

the control device

stores the correspondence information for each of a plurality of outdoor air temperature zones, identifies an outdoor air temperature zone to which an outdoor air temperature belongs, among the plurality of outdoor air temperature zones, and determines the subject height range based on the correspondence information corresponding to the identified outdoor air temperature zone, and

the plurality of height ranges included in the correspondence information corresponding to an outdoor air temperature zone higher in temperature of any two outdoor air temperature zones selected from among the plurality of outdoor air temperature zones are set to be lower than the plurality of height ranges included in the correspondence information corresponding to an outdoor air temperature zone lower in temperature of the two outdoor air temperature zones.

- 9. The refrigeration cycle apparatus according to claim

1, further comprising a sensor to sense a liquid level in the gas-liquid separator, wherein

the second pipe has one end located in the gas-liquid separator, and
the control device controls the flow rate regulation valve to close and controls the first solenoid valve to open every predetermined cycle, until the liquid level reaches a reference height higher than the one end of the second pipe.

10. The refrigeration cycle apparatus according to any one of claims 1 to 9, further comprising an economizer to exchange heat between refrigerant that flows through the third pipe and refrigerant that flows out of the condenser.

11. The refrigeration cycle apparatus according to any one of claims 1 to 9, further comprising an economizer to exchange heat between refrigerant that flows through the first pipe and refrigerant that flows out of the condenser.

12. The refrigeration cycle apparatus according to any one of claims 1 to 9, further comprising an economizer to exchange heat between refrigerant that flows through the second pipe and refrigerant that flows out of the condenser.

13. The refrigeration cycle apparatus according to any one of claims 1 to 9, further comprising:

an economizer to supercool refrigerant that flows out of the condenser; and
a switch to switch a pipe that passes through the economizer to any one of the first pipe, the second pipe, and the third pipe.

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FIG.1

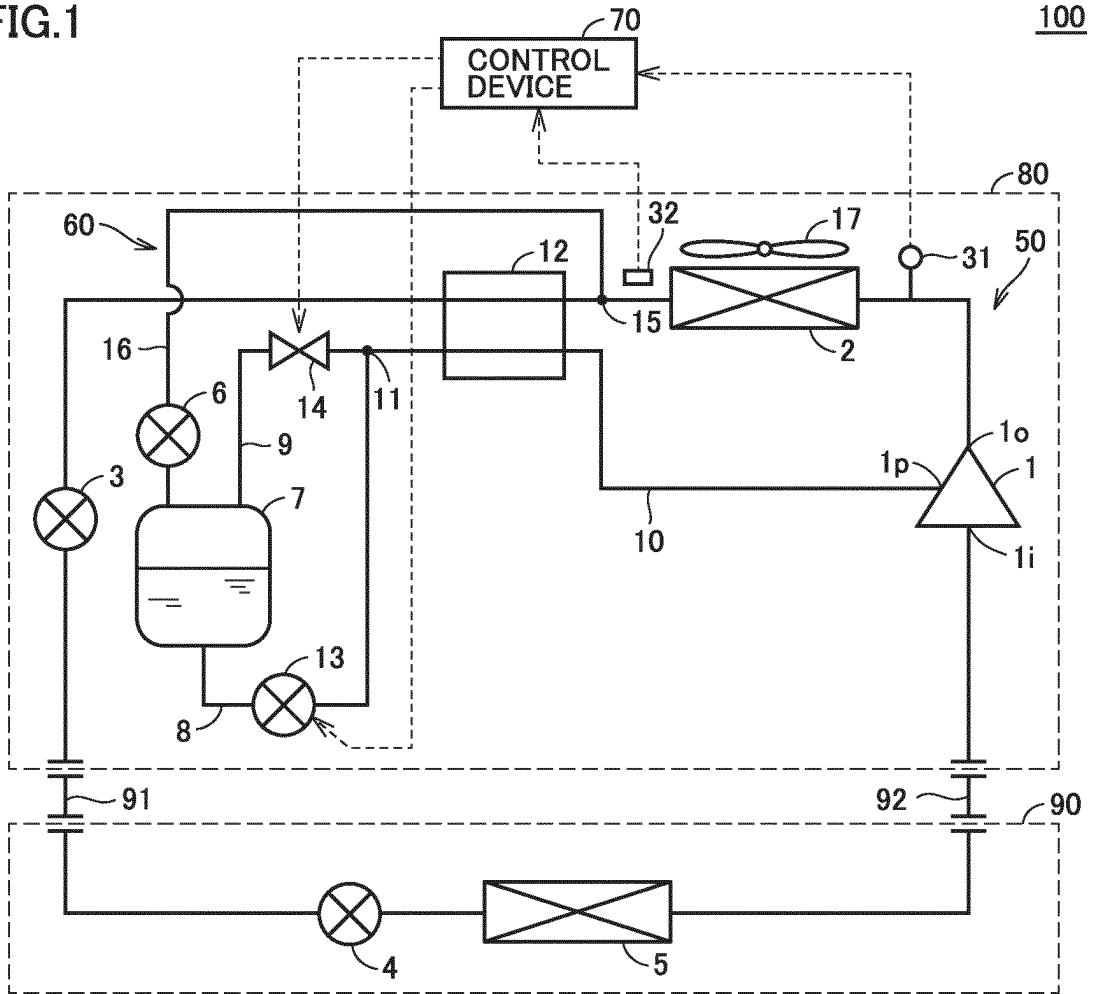


FIG.2

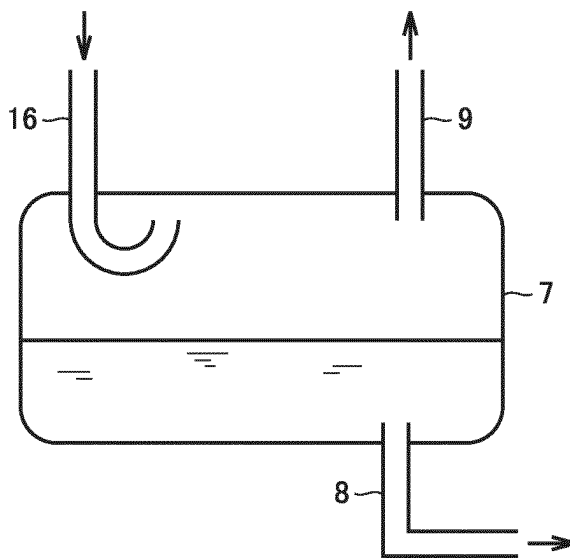


FIG.3

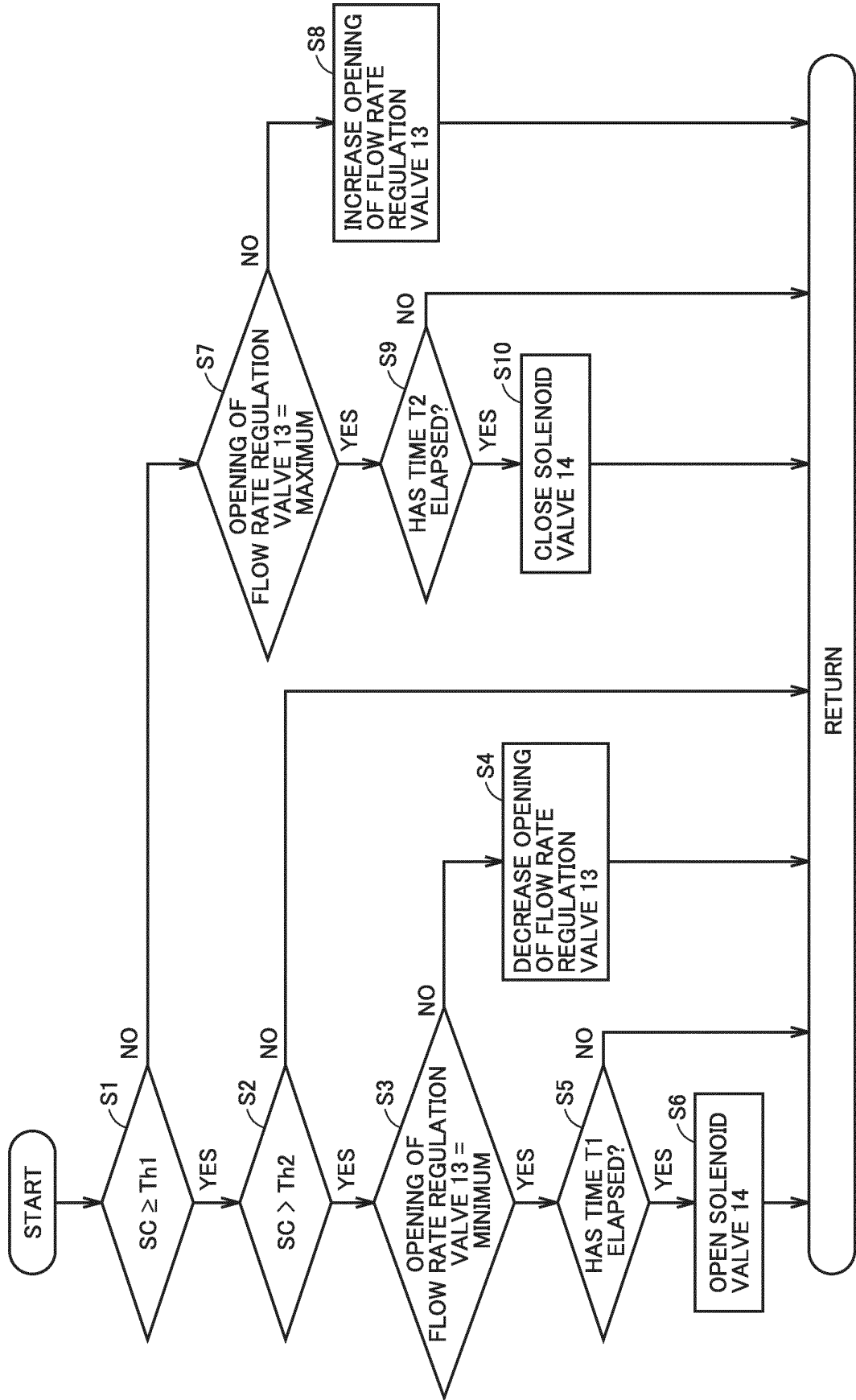


FIG.4

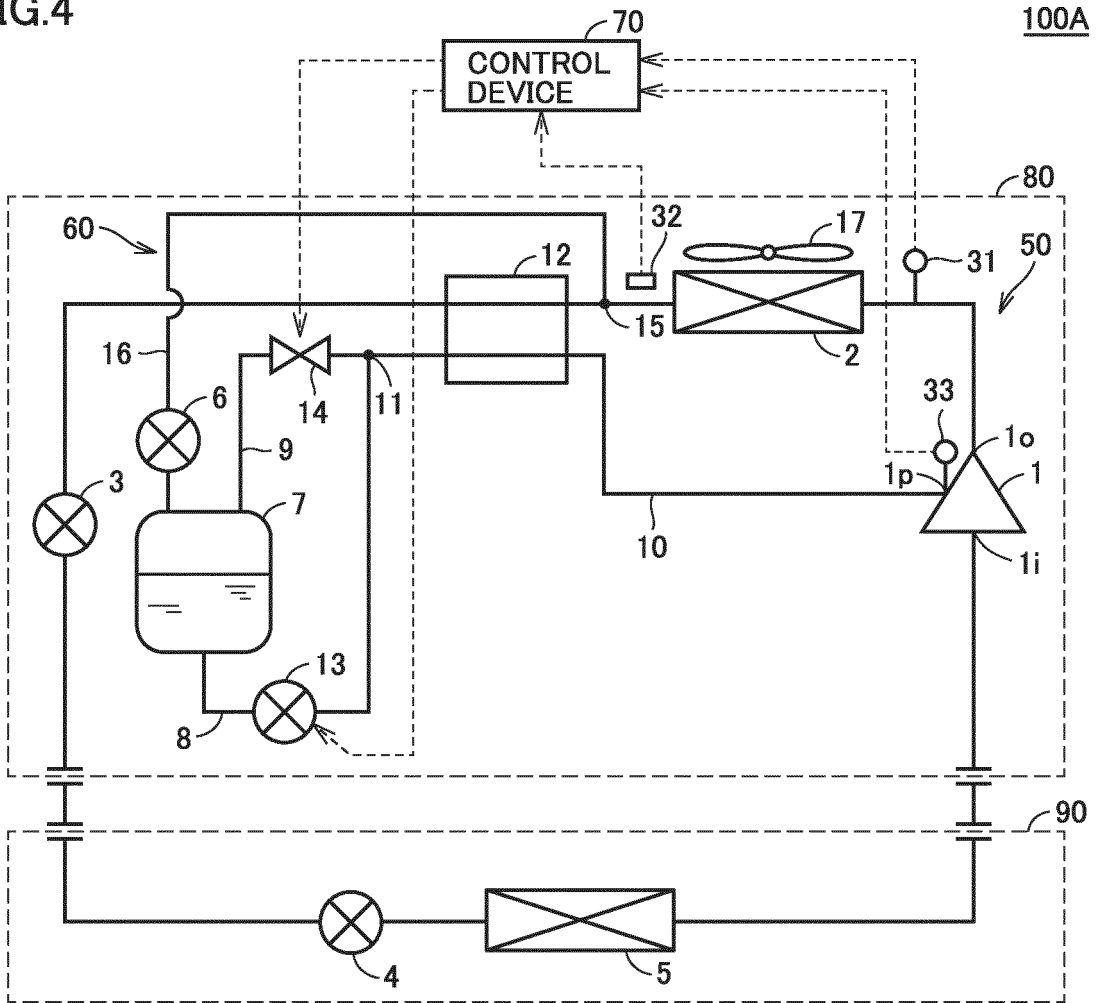


FIG.5

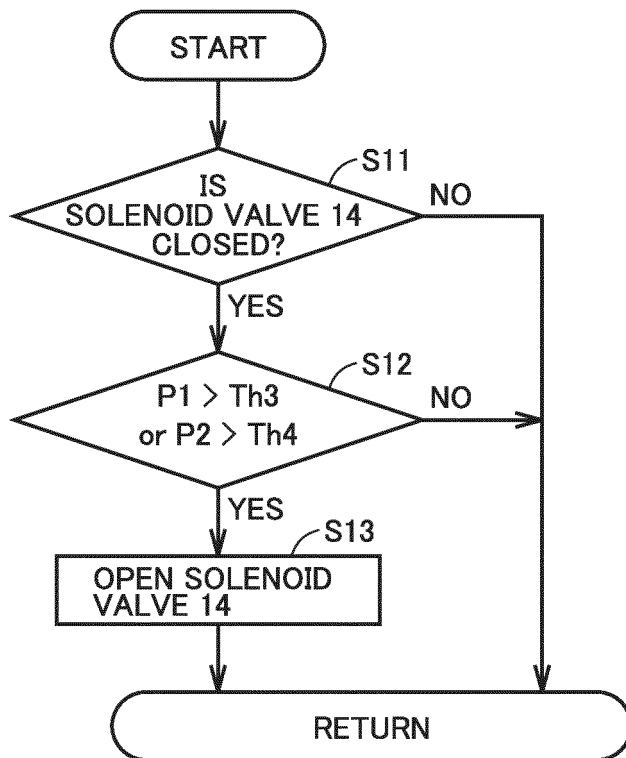


FIG.7

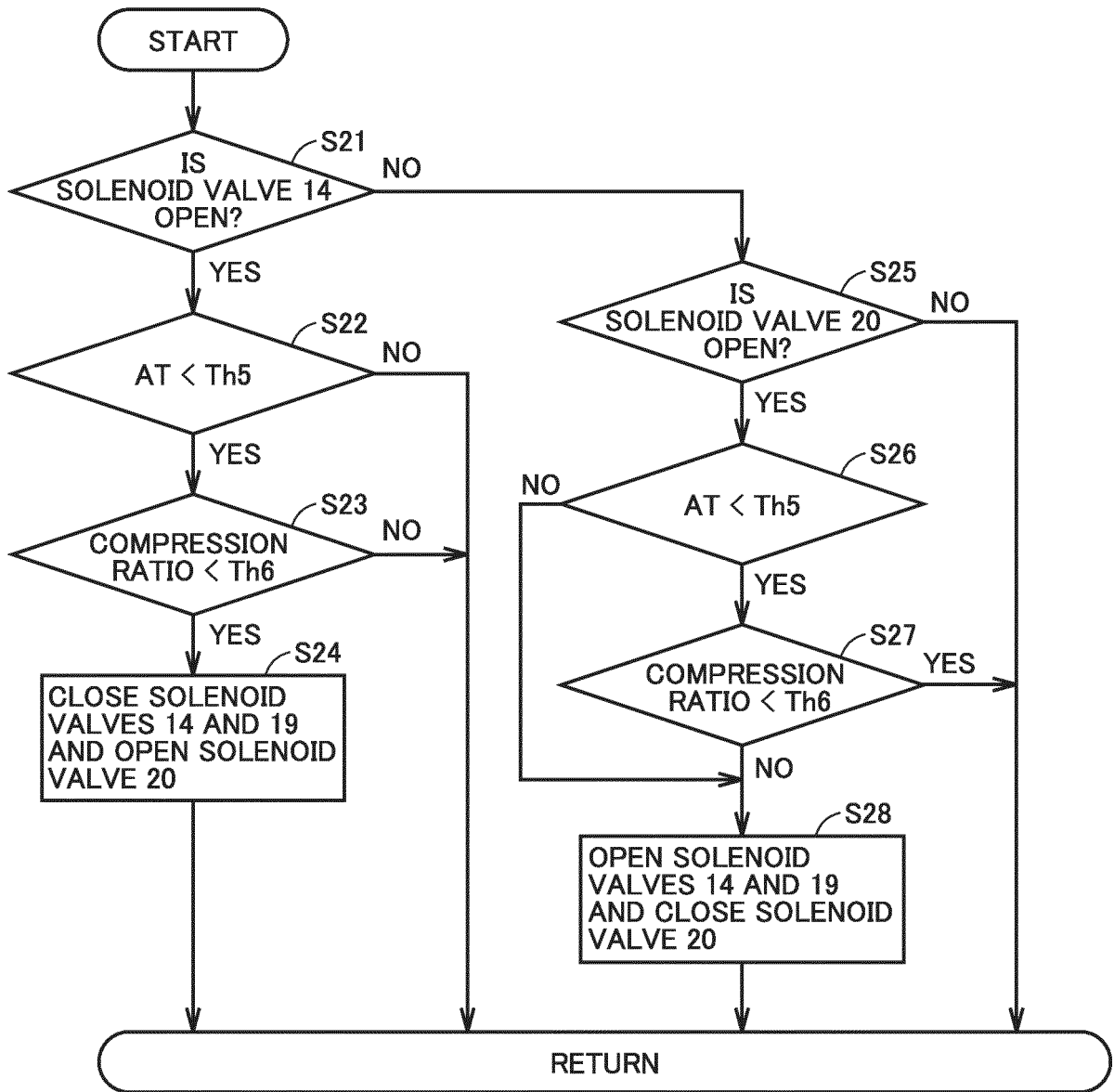


FIG.8

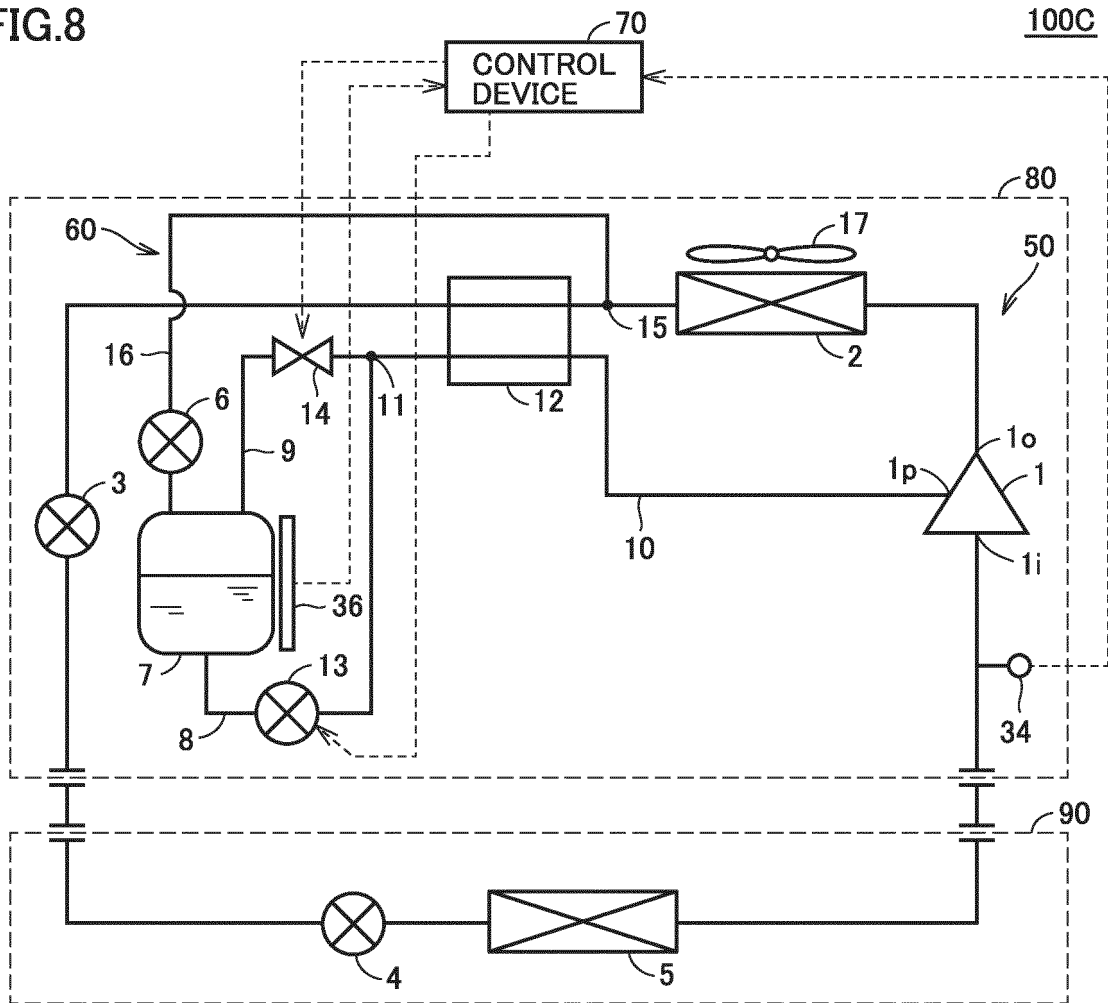


FIG.9

$ET < -30^{\circ}\text{C}$	$-30^{\circ}\text{C} \leq ET < -10^{\circ}\text{C}$	$-10^{\circ}\text{C} \leq ET$
HEIGHT RANGE R _c	HEIGHT RANGE R _b	HEIGHT RANGE R _a

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FIG.10

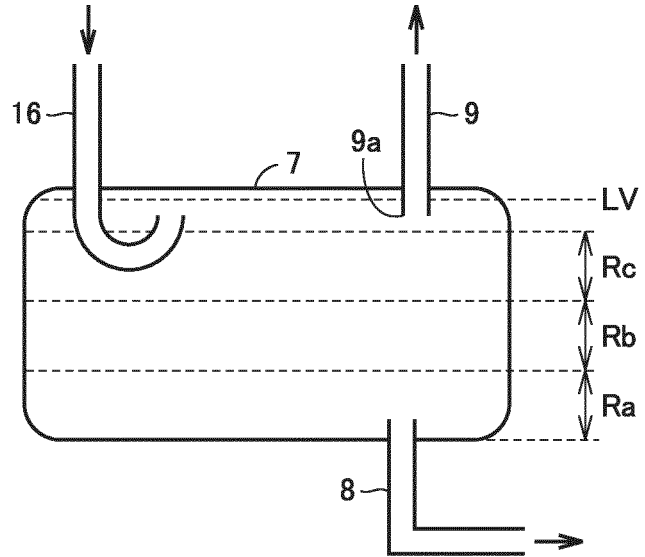


FIG.11

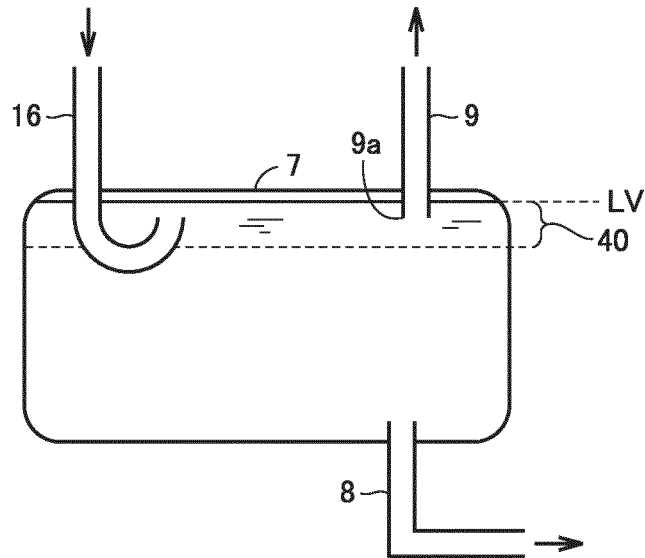


FIG.12

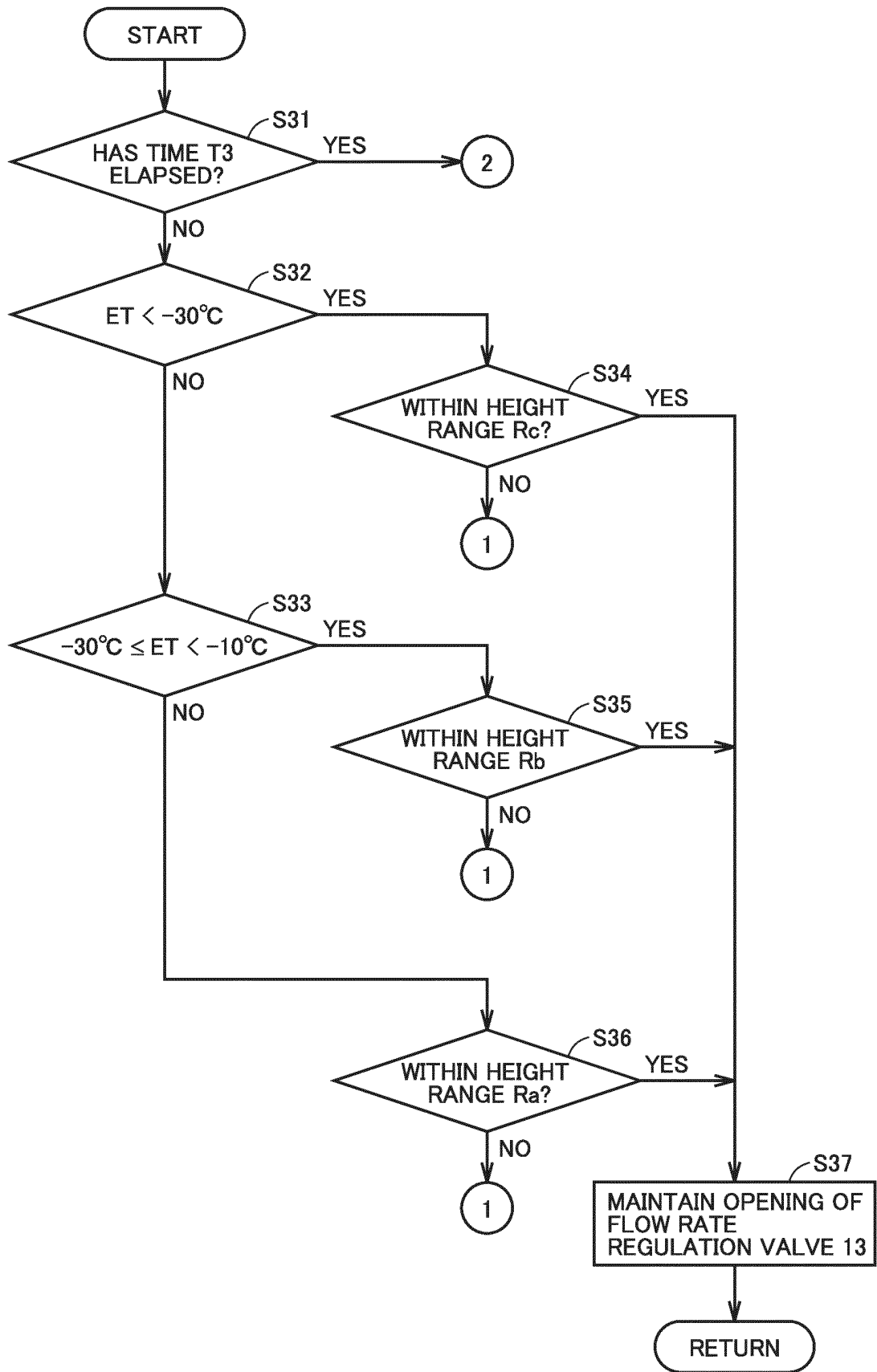


FIG.13

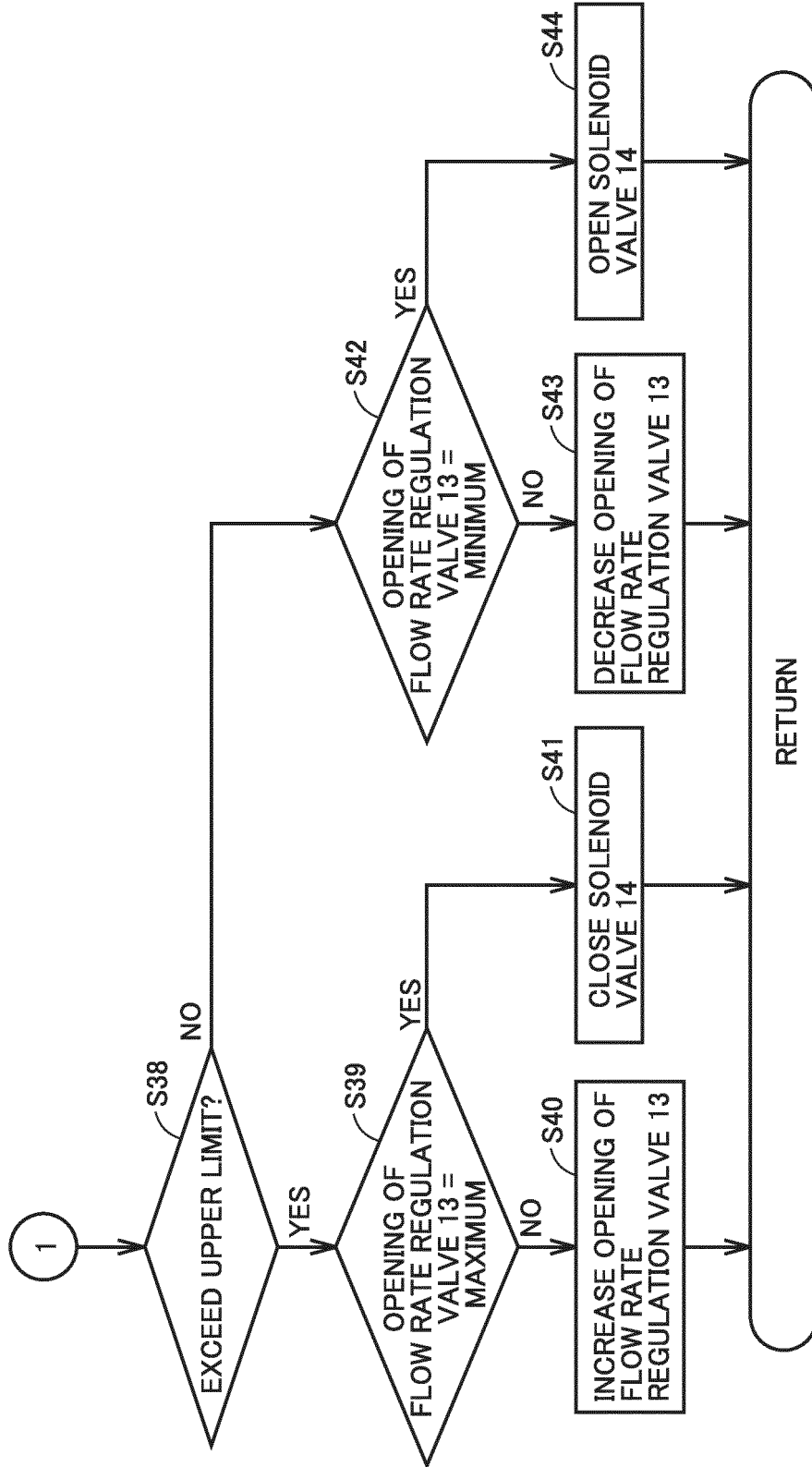


FIG.14

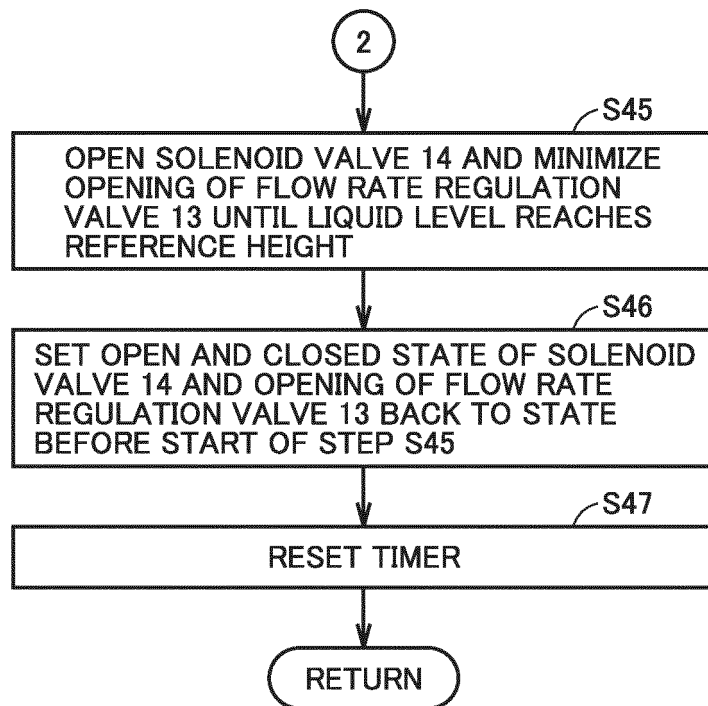


FIG.16

		$ET < -30^{\circ}\text{C}$	$-30^{\circ}\text{C} \leq ET < -10^{\circ}\text{C}$	$-10^{\circ}\text{C} \leq ET$
46a	$AT \geq 10^{\circ}\text{C}$	HEIGHT RANGE Rf	HEIGHT RANGE Re	HEIGHT RANGE Rd
46b	$AT < 10^{\circ}\text{C}$	HEIGHT RANGE Ri	HEIGHT RANGE Rh	HEIGHT RANGE Rg

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FIG.17

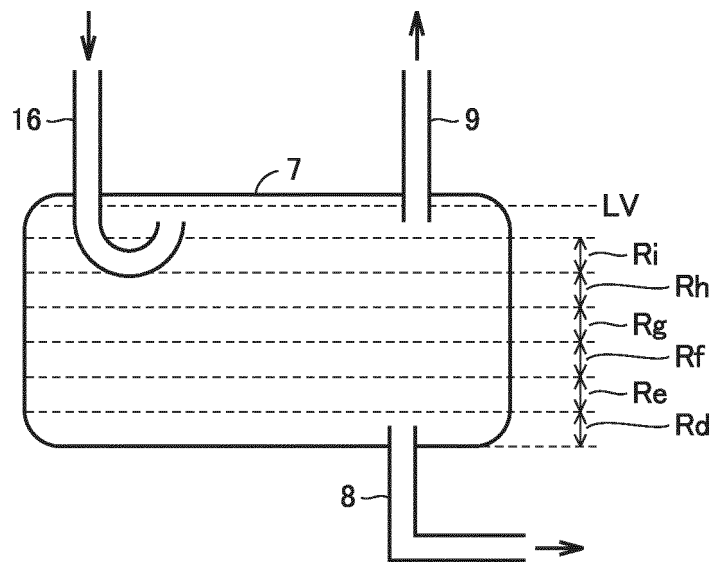


FIG.18

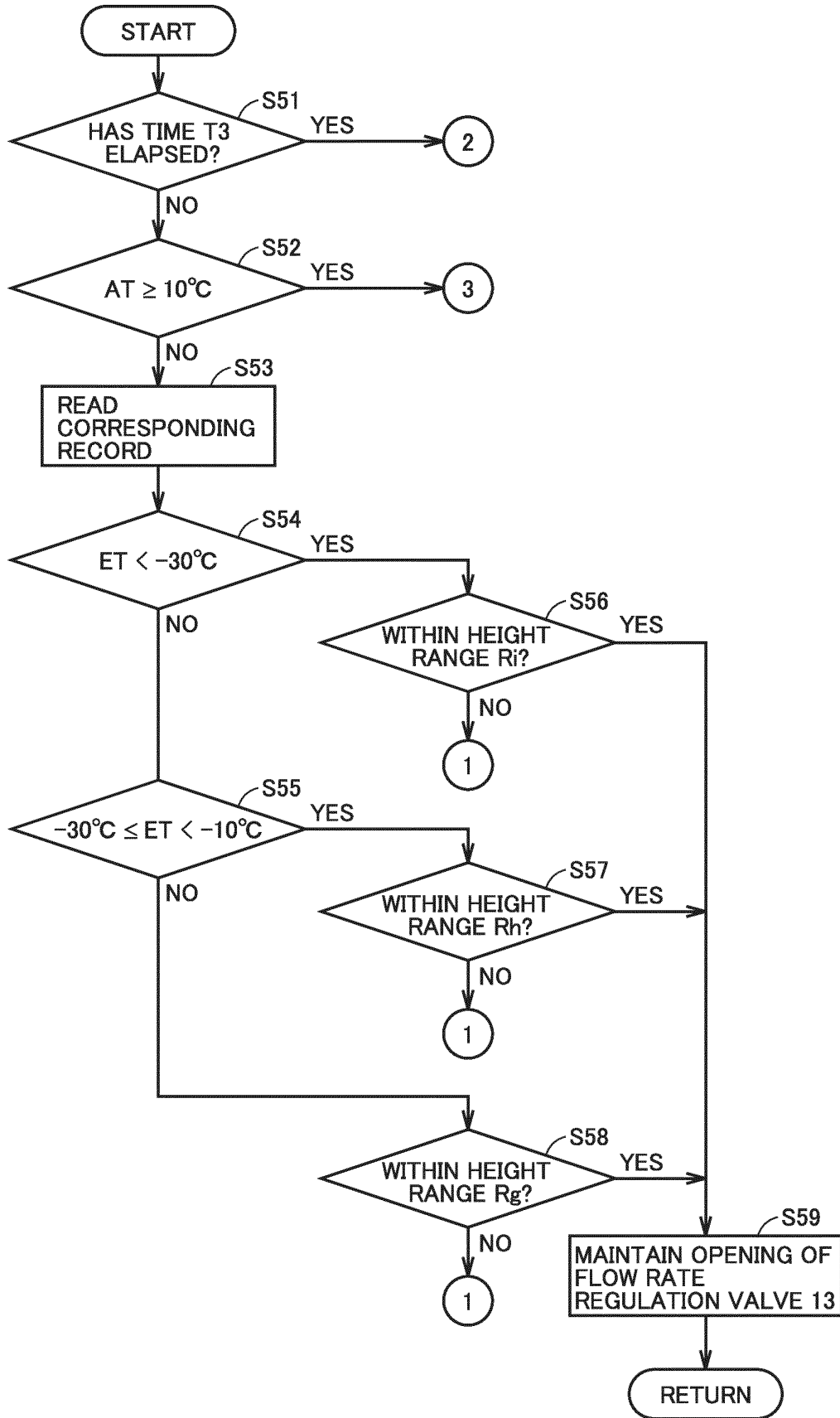


FIG.19

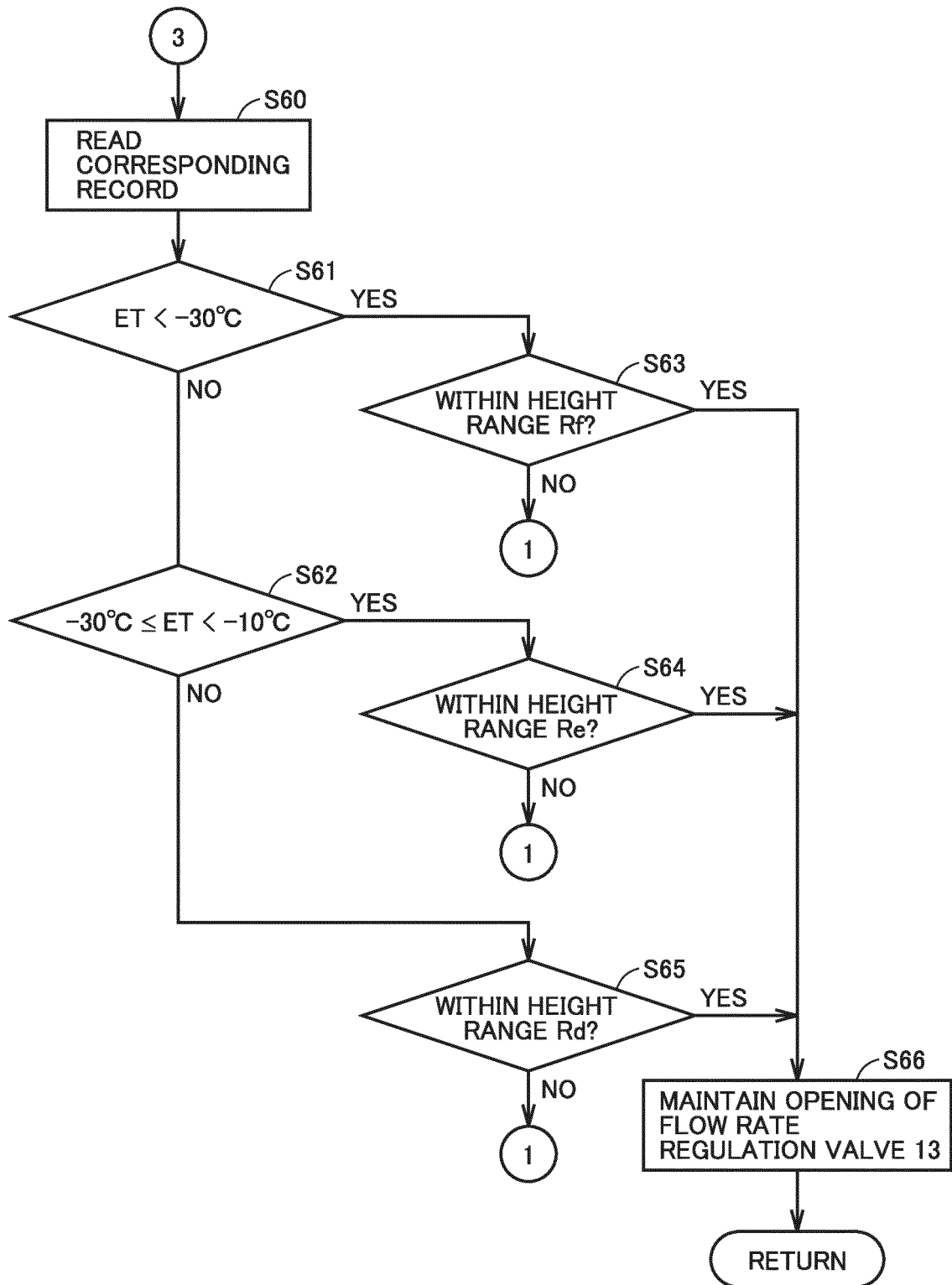


FIG.20

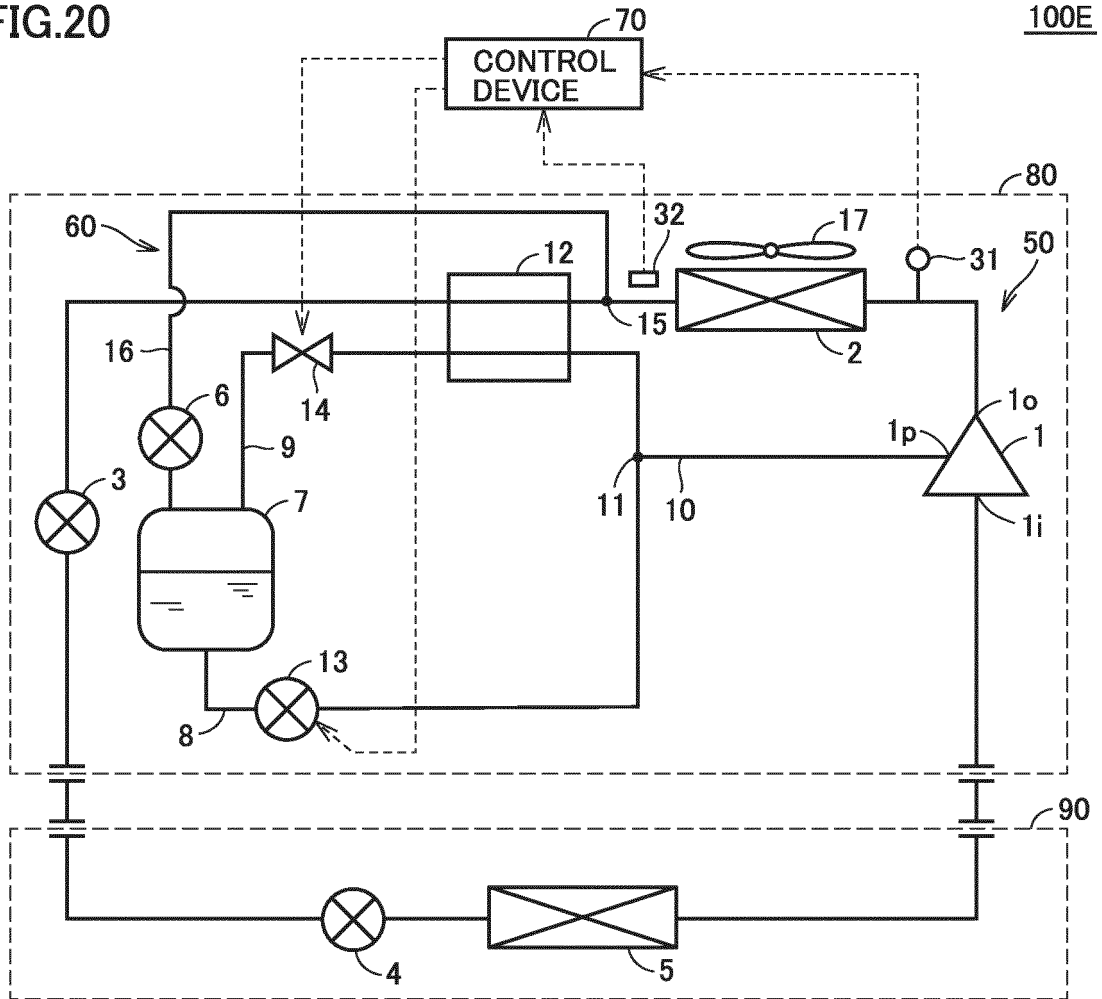
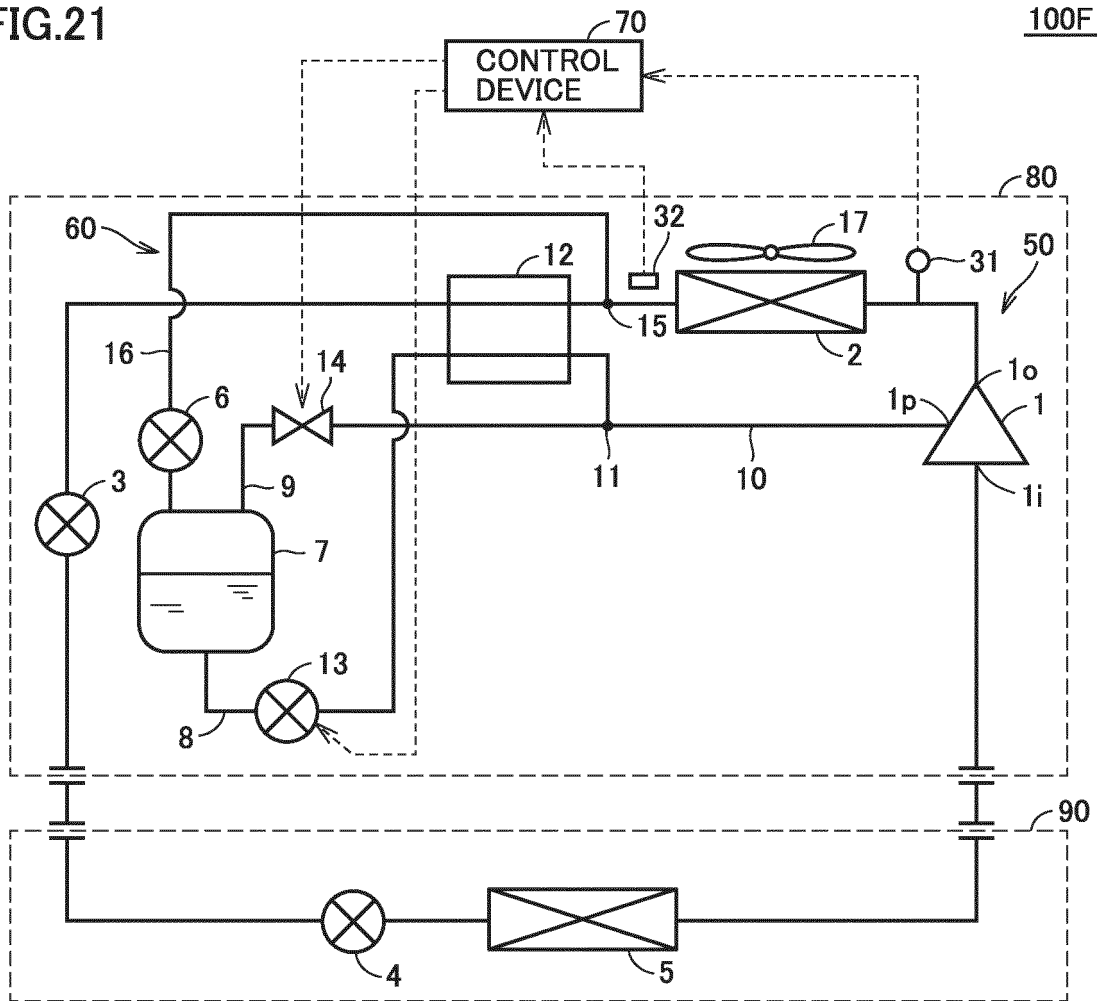


FIG.21



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/046094

A. CLASSIFICATION OF SUBJECT MATTER Int. Cl. F25B1/00 (2006.01) i FI: F25B1/00 311A, F25B1/00 385Z, F25B1/00 391, F25B1/00 387Z, F25B1/00 331E		
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. F25B1/00, F25B43/00		
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 1971-2021 Registered utility model specifications of Japan 1996-2021 Published registered utility model applications of Japan 1994-2021		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2016-156557 A (JOHNSON CONTROLS-HITACHI AIR CONDITIONING TECHNOLOGY (HONG KONG) LTD.) 01 September 2016 (2016-09-01), paragraphs [0045], [0046], [0069]-[0077], fig. 2, paragraphs [0045], [0046], [0069]-[0077], fig. 2	1, 3, 11 2, 4-10, 12-13
A	JP 2010-127531 A (MITSUBISHI ELECTRIC CORP.) 10 June 2010 (2010-06-10), paragraphs [0036], [0038], fig. 9	1-13
A	WO 2017/037788 A1 (MITSUBISHI ELECTRIC CORP.) 09 March 2017 (2017-03-09), paragraphs [0036]-[0041], fig. 3	1-13
<input type="checkbox"/> Further documents are listed in the continuation of Box C.		<input checked="" type="checkbox"/> See patent family annex.
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"P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search 14.01.2021	Date of mailing of the international search report 02.02.2021	
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.	

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/046094

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Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
JP 2016-156557 A	01.09.2016	(Family: none)	
JP 2010-127531 A	10.06.2010	(Family: none)	
WO 2017/037788 A1	09.03.2017	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

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- JP 2016156557 A [0003] [0004]