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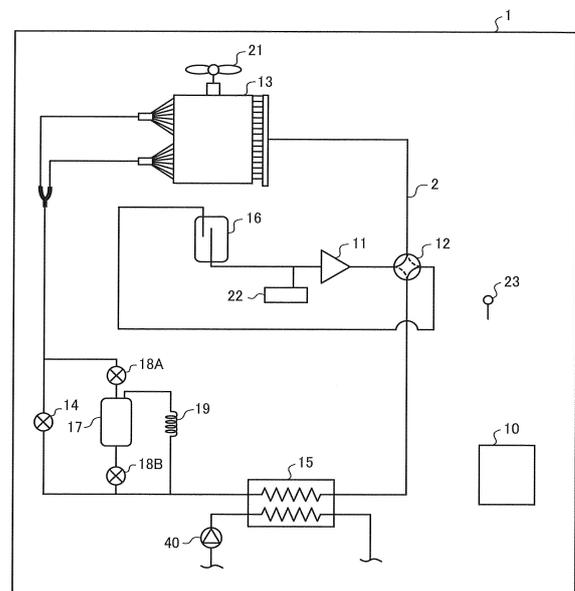
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(54) **REFRIGERATION CYCLE DEVICE**

(57) Provided is a refrigeration cycle apparatus including a refrigerant circuit sequentially connecting, with pipes, a compressor, a refrigerant-flow switching device, an air-side heat exchanger, a main expansion valve, and a water-side heat exchanger, and configured to allow refrigerant to circulate in the refrigerant circuit, the refrigeration cycle apparatus including a refrigerant amount adjustment tank arranged in parallel with the main expansion valve, and configured to store the refrigerant, a first refrigerant flow control valve provided to a pipe connected to one end of the refrigerant amount adjustment tank, the pipe being branched from a pipe connecting the air-side heat exchanger and the main expansion valve, the first refrigerant flow control valve being configured to adjust a flow rate of the refrigerant flowing into and out of the refrigerant amount adjustment tank on the basis of an opening degree of the first refrigerant flow control valve, and a second refrigerant flow control valve provided to a pipe connected to another end of the refrigerant amount adjustment tank, the pipe being branched from a pipe connecting the main expansion valve and the water-side heat exchanger, the second refrigerant flow control valve being configured to adjust a flow rate of the refrigerant flowing into and out of the refrigerant amount adjustment tank on the basis of an opening degree of the

second refrigerant flow control valve.

FIG. 1



**EP 3 367 021 A1**

**Description**

## Technical Field

**[0001]** The present invention relates to a refrigeration cycle apparatus including a refrigerant circuit in which refrigerant circulates.

## Background Art

**[0002]** In an air-cooled chiller, in general, a water-side heat exchanger is superior in condensing efficiency of refrigerant than an air-side heat exchanger, thereby being capable of reducing a volume of the water-side heat exchanger. Further, in cooling operation and in heating operation, an amount of refrigerant required to a refrigeration cycle apparatus is smaller in the heating operation.

**[0003]** For this reason, in the heating operation in which the water-side heat exchanger serves as a condenser, the amount of required refrigerant is smaller than that in the cooling operation, surplus refrigerant is required to be stored.

**[0004]** Consequently, there is proposed a refrigeration cycle apparatus capable of storing the surplus refrigerant caused as described above (for example, see Patent Literature 1).

## Citation List

## Patent Literature

**[0005]** Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2003-83644

## Summary of Invention

## Technical Problem

**[0006]** However, in the technology described in Patent Literature 1, in the cooling operation, when an ambient temperature of the refrigerant amount adjustment tank is lower than an evaporating temperature of the refrigerant, the refrigerant in the refrigerant amount adjustment tank is cooled. In this case, due to characteristics of the refrigerant, a refrigerant liquid stagnates in the refrigerant amount adjustment tank, and hence there is a problem in that the refrigerant, which circulates in a refrigerant circuit, is liable to be insufficient.

**[0007]** The present invention has been made in view of the problem of the related art described above, and has an object to provide a refrigeration cycle apparatus capable of reducing stagnation of the refrigerant in a refrigerant amount adjustment tank even in a case in which an ambient temperature of the refrigerant amount adjustment tank is lower than an evaporating temperature of the refrigerant.

## Solution to Problem

**[0008]** According to one embodiment of the present invention, there is provided a refrigeration cycle apparatus including a refrigerant circuit sequentially connecting, with pipes, a compressor, a refrigerant-flow switching device, an air-side heat exchanger, a main expansion valve, and a water-side heat exchanger, and configured to allow refrigerant to circulate in the refrigerant circuit, the refrigeration cycle apparatus including a refrigerant amount adjustment tank arranged in parallel with the main expansion valve, and configured to store the refrigerant, a first refrigerant flow control valve provided to a pipe connected to one end of the refrigerant amount adjustment tank, the pipe being branched from a pipe connecting the air-side heat exchanger and the main expansion valve, the first refrigerant flow control valve being configured to adjust a flow rate of the refrigerant flowing into and out of the refrigerant amount adjustment tank on the basis of an opening degree of the first refrigerant flow control valve, and a second refrigerant flow control valve provided to a pipe connected to another end of the refrigerant amount adjustment tank, the pipe being branched from a pipe connecting the main expansion valve and the water-side heat exchanger, the second refrigerant flow control valve being configured to adjust a flow rate of the refrigerant flowing into and out of the refrigerant amount adjustment tank on the basis of an opening degree of the second refrigerant flow control valve.

## Advantageous Effects of Invention

**[0009]** As described above, according to one embodiment of the present invention, even in a case in which an ambient temperature of the refrigerant amount adjustment tank is lower than an evaporating temperature of the refrigerant, the refrigerant is allowed to flow into the refrigerant amount adjustment tank to prevent liquefaction of the refrigerant in the refrigerant amount adjustment tank, and thereby stagnation of the refrigerant in the refrigerant amount adjustment tank can be reduced.

## Brief Description of Drawings

**[0010]**

[Fig. 1] Fig. 1 is a schematic diagram for illustrating an example of a circuit structure of a refrigeration cycle apparatus according to Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 is a schematic diagram for illustrating a mounting example of a refrigerant amount adjustment tank illustrated in the refrigeration cycle apparatus of Fig. 1.

[Fig. 3] Fig. 3 is a flow chart for illustrating an example of a process for controlling a flow rate of refrigerant flowing into the refrigerant amount adjustment tank illustrated in the refrigeration cycle apparatus of Fig.

1.

[Fig. 4] Fig. 4 is a flow chart for illustrating an example of a process for controlling a flow rate of refrigerant flowing into a refrigerant amount adjustment tank illustrated in a refrigeration cycle apparatus according to Embodiment 2 of the present invention.

[Fig. 5] Fig. 5 is a schematic diagram for illustrating an example in which a plurality of refrigerant circuits are provided in the refrigeration cycle apparatus according to Embodiment 1 and Embodiment 2 of the present invention.

## Description of Embodiments

### Embodiment 1

**[0011]** Description is made below of a refrigerant cycle apparatus according to Embodiment 1 of the present invention.

**[0012]** Fig. 1 is a schematic diagram for illustrating an example of a circuit structure of a refrigeration cycle apparatus 1 according to Embodiment 1 of the present invention.

#### [Circuit Configuration of Refrigeration Cycle Apparatus]

**[0013]** As illustrated in Fig. 1, a refrigeration cycle apparatus 1 includes a compressor 11, a refrigerant-flow switching device 12, such as a four-way valve, an air-side heat exchanger 13, a main expansion valve 14, a water-side heat exchanger 15, an accumulator 16, a refrigerant amount adjustment tank 17, a sub-expansion valve 18A and a sub-expansion valve 18B serving as two refrigerant flow control valves, a gas purge circuit 19, and a heat source device controller 10 serving as a controller.

**[0014]** Further, the compressor 11, the refrigerant-flow switching device 12, the air-side heat exchanger 13, the main expansion valve 14, the water-side heat exchanger 15, and the accumulator 16 are connected annularly via refrigerant pipes 2, to thereby form a main circuit of a refrigerant circuit. In addition, a sub-circuit of the refrigerant circuit is formed by the refrigerant amount adjustment tank 17, the sub-expansion valve 18A, the sub-expansion valve 18B, and the gas purge circuit 19.

**[0015]** The compressor 11 sucks low-temperature and low-pressure refrigerant, compresses the refrigerant into high-temperature and high-pressure gas refrigerant, and discharges the refrigerant. As the compressor 11, there may be used, for example, an inverter compressor capable of controlling a flow rate, which is an amount of refrigerant delivered per unit time, in accordance with arbitrary change in a drive frequency.

**[0016]** Further, on a suction side of the compressor 11, a low-pressure pressure sensor 22 is provided to measure a pressure of the refrigerant to be sucked into the compressor 11. Information indicating the measured pressure is supplied to a heat source device controller 10 described later.

**[0017]** The refrigerant-flow switching device 12 switches between cooling operation and heating operation by switching a flow direction of the refrigerant. As the refrigerant-flow switching device 12, for example, the four-way valve may be used, and other valves may be used in combination.

**[0018]** The air-side heat exchanger 13 exchanges heat between air supplied by an air-side air sending device 21, such as a fan disposed in its vicinity, and the refrigerant. Specifically, the air-side heat exchanger 13 is configured to serve, in the cooling operation, as a condenser for condensing the refrigerant by radiating heat of the refrigerant to the air. Further, the air-side heat exchanger 13 also serves, in the heating operation, as an evaporator for evaporating the refrigerant and cooling outside air using a heat of evaporation at a time of evaporation.

**[0019]** The main expansion valve 14 has functions of reducing and expanding the pressure of the refrigerant flowing in the refrigerant circuit. The main expansion valve 14 may be configured by, for example, an electronic expansion valve or other valve capable of controlling an opening degree of the valve.

**[0020]** The water-side heat exchanger 15 serves as a condenser or an evaporator, and exchanges heat between the refrigerant flowing in the refrigerant circuit and a heat medium, such as water, flowing in a heat medium circuit by use of a pump 40.

**[0021]** The accumulator 16 is provided on a suction side, which is a low pressure side of the compressor 11. The accumulator 16 is configured to store surplus refrigerant caused by the difference between the operation conditions of the cooling operation and the heating operation, surplus refrigerant caused by change in transitional operation, and another surplus refrigerant.

**[0022]** The refrigerant amount adjustment tank 17 is provided in parallel with the main expansion valve 14, and is configured to store the surplus refrigerant caused by the difference between the operation conditions of the cooling operation and the heating operation.

**[0023]** The refrigerant amount adjustment tank 17 has one end connected to a pipe branched from the refrigerant pipe 2 connecting the air-side heat exchanger 13 and the main expansion valve 14. Further, the refrigerant amount adjustment tank 17 has the other end connected to a pipe branched from the refrigerant pipe 2 connecting the main expansion valve 14 and the water-side heat exchanger 15.

**[0024]** With this configuration, when the amount of refrigerant required for the refrigerant circuit in the cooling operation and that in the heating operation are compared, as the water-side heat exchanger 15 is more efficient in refrigerant condensation than that of air-side heat exchanger 13, the volume on the refrigerant side of the water-side heat exchanger 15 can be smaller than that of the air-side heat exchanger 13. Consequently, the amount of refrigerant that is required for the refrigerant circuit in the heating operation is smaller than that in the cooling operation.

**[0025]** Specifically, in the heating operation, the amount of refrigerant required for the refrigerant circuit becomes surplus, and hence the surplus refrigerant liquid is caused to flow into the refrigerant amount adjustment tank 17 to be stored in the refrigerant amount adjustment tank 17.

**[0026]** Meanwhile, when the heating operation is changed to the cooling operation, shortage of the amount of refrigerant required for the refrigerant circuit occurs. The refrigerant liquid stored in the refrigerant amount adjustment tank 17 is caused to flow into the refrigerant circuit, accordingly.

**[0027]** The sub-expansion valves 18A and 18B each serve as a refrigerant flow control valve for controlling the flow rate of refrigerant flowing into and out of the refrigerant amount adjustment tank 17 depending on the opening degree of the valve.

**[0028]** The sub-expansion valve 18A is provided on one end side of the refrigerant amount adjustment tank 17, specifically, on an upstream side of the refrigerant amount adjustment tank 17 in the cooling operation. Further, the sub-expansion valve 18B is provided on the other end side of the refrigerant amount adjustment tank 17, specifically, on a downstream side of the refrigerant amount adjustment tank 17 in the cooling operation.

**[0029]** The gas purge circuit 19 has one end connected to the refrigerant amount adjustment tank 17 and the other end connected to the refrigerant pipe 2 connecting the main expansion valve 14 and the water-side heat exchanger 15.

**[0030]** The gas purge circuit 19 is configured to prevent, even when the sub-expansion valves 18A and 18B provided on both end sides of the refrigerant amount adjustment tank 17 are fully closed, the refrigerant in the refrigerant amount adjustment tank 17 from being liquid-sealed.

**[0031]** The low-pressure pressure sensor 22 measures a pressure of the refrigerant flowing into the compressor 11, and supplies pressure information of a measurement result to the heat source device controller 10.

**[0032]** The low-pressure pressure sensor 22 is connected to the refrigerant pipe 2 on the suction side of the compressor 11.

**[0033]** An outside-air temperature sensor 23 measures an ambient temperature of the refrigerant amount adjustment tank 17, and supplies temperature information of a measurement result to the heat source device controller 10.

**[0034]** The outside-air temperature sensor 23 is provided in a vicinity of the refrigerant amount adjustment tank 17, but an area in which the outside-air temperature sensor 23 is provided is not limited to the vicinity of the refrigerant amount adjustment tank 17. The outside-air temperature sensor 23 may be provided, for example, at a position far from the refrigerant amount adjustment tank 17. Further, for example, a temperature sensor (not shown) provided to an air suction position of the air-side heat exchanger 13 may be used as the outside-air tem-

perature sensor 23.

**[0035]** The heat source device controller 10 is configured by a microcomputer, for example, and controls an entire of the refrigeration cycle apparatus 1. For example, the heat source device controller 10 receives information indicating measurement results from various measurement units, such as the low-pressure pressure sensor 22 and the outside-air temperature sensor 23. Then, the heat source device controller 10 controls a drive frequency of the compressor 11, a number of revolution of the air-side air sending device 21 (including activation and deactivation of the air-side air sending device 21), switching of the refrigerant-flow switching device 12, the opening degree of the main expansion valve 14, the opening degrees of sub-expansion valves 18A and 18B, and other operations, on the basis of operation information of the refrigeration cycle apparatus 1 based on the measurement results, and in accordance with an operation content instructed by a user.

[Mounting Position of Refrigerant Amount Adjustment Tank]

**[0036]** Next, description is made of a mounting position of the refrigerant amount adjustment tank 17 in the refrigeration cycle apparatus 1. Fig. 2 is a schematic diagram for illustrating a mounting example of the refrigerant amount adjustment tank 17 illustrated in the refrigeration cycle apparatus 1 of Fig. 1.

**[0037]** As illustrated in Fig. 2, various devices of the refrigeration cycle apparatus 1 are housed in the machine chamber 30, and the air-side heat exchanger 13 is disposed on top of the machine chamber 30. Further, the air-side air sending device 21 is disposed on top of the air-side heat exchanger 13.

**[0038]** Specifically, various devices housed in the machine chamber 30 include the compressor 11, the refrigerant-flow switching device 12, the main expansion valve 14, the water-side heat exchanger 15, and the accumulator 16, which form the main circuit of the refrigerant circuit, and the heat source device controller 10. In addition, the machine chamber 30 also houses the refrigerant amount adjustment tank 17 and the sub-expansion valves 18A and 18B, which form the sub-circuit of the refrigerant circuit.

**[0039]** In the meantime, in the related-art refrigeration cycle apparatus, the refrigerant is heated so that a temperature in the refrigerant amount adjustment tank is constantly higher than an evaporating temperature of the refrigerant, and hence such a configuration has been suggested in which the refrigerant amount adjustment tank is disposed downstream of an air flow of the air-side heat exchanger, namely, on top of the machine chamber.

**[0040]** However, when the refrigerant amount adjustment tank is disposed as described above, there is a fear that a pipe structure connected to the refrigerant amount adjustment tank is complicated.

**[0041]** Further, in general, the refrigerant amount ad-

justment tank is heavy, and hence the strength of the machine chamber is required to be enhanced to dispose the refrigerant amount adjustment tank on top of the machine chamber. Consequently, there is a fear that the total weight of the refrigeration cycle apparatus increases, resulting in increasing a manufacturing cost.

**[0042]** In addition, when the heavy refrigerant amount adjustment tank is disposed on top of the machine chamber, a center of gravity of the refrigeration cycle apparatus is located at an upper part, and hence there is a fear that the stability of the refrigeration cycle apparatus is reduced when the refrigeration cycle apparatus is disposed.

**[0043]** To solve the above-mentioned problem, in Embodiment 1 of the present invention, the refrigerant amount adjustment tank 17 is housed in the machine chamber 30.

**[0044]** When the refrigerant amount adjustment tank 17 is housed in the machine chamber 30, the refrigerant amount adjustment tank 17 is connected via the refrigerant pipes 2 by the substantially shortest distance to devices, such as the water-side heat exchanger 15, which are required to be connected in the refrigerant circuit.

**[0045]** As described above, when the refrigerant amount adjustment tank 17 is housed in the machine chamber 30, compared to the related-art refrigeration cycle apparatus in which the refrigerant amount adjustment tank is disposed downstream of the air flow of the air-side heat exchanger, the structure of the refrigeration cycle apparatus 1 may be simplified.

**[0046]** Further, the refrigerant amount adjustment tank 17 is housed in the machine chamber 30, and hence the refrigerant pipes 2 connected to the refrigerant amount adjustment tank 17 may be connected by the substantially shortest distance. As a result, the refrigerant pipes 2 in the refrigeration cycle apparatus 1 may be reduced in length, and thereby the structure of the refrigeration cycle apparatus 1 can be simplified.

**[0047]** In addition, there is no need to enhance the strength of the machine chamber 30, and thereby not only the weight but also the manufacturing cost of the refrigeration cycle apparatus 1 can be reduced.

**[0048]** Furthermore, the center of gravity of the refrigeration cycle apparatus 1 is located at a lower part, and hence it is possible to improve the stability when the refrigeration cycle apparatus 1 is disposed.

**[0049]** Here, in the case in which the refrigerant amount adjustment tank 17 is housed in the machine chamber 30, when the evaporating temperature of the refrigerant is higher than an outside-air temperature, the refrigerant is cooled by an outside air via container walls of the refrigerant amount adjustment tank 17. As a result, the refrigerant in the refrigerant amount adjustment tank 17 is liquefied, the refrigerant liquid may stagnate in the refrigerant amount adjustment tank 17.

**[0050]** In this case, to prevent the refrigerant liquid from stagnating in the refrigerant amount adjustment tank 17,

in the case in which supply of a certain amount of the refrigerant to the refrigerant amount adjustment tank 17 is constantly continued, even when the outside-air temperature is higher than the evaporating temperature of the refrigerant, a certain amount of the refrigerant liquid may stagnate in the refrigerant amount adjustment tank 17.

**[0051]** Consequently, a required amount of refrigerant in the cooling operation is increased, and a difference of the required amount of refrigerant between in the heating operation and in the cooling operation increases, with the result that it is required to increase a volume of the refrigerant amount adjustment tank 17.

**[0052]** In Embodiment 1 of the present invention, the sub-expansion valves 18A and 18B are provided at both ends of the refrigerant amount adjustment tank 17 to appropriately adjust the flow rate of the refrigerant flowing into the refrigerant amount adjustment tank 17 in the cooling operation.

**[0053]** With this configuration, the refrigerant amount adjustment tank 17 may be housed in the machine chamber 30, and the stagnation of the refrigerant in the refrigerant amount adjustment tank 17 may be reduced when the evaporating temperature of the refrigerant is higher than the outside-air temperature.

[Control of Flow Rate of Refrigerant Flowing into Refrigerant Amount Adjustment Tank]

**[0054]** Fig. 3 is a flow chart for illustrating an example of a process for controlling a flow rate of refrigerant flowing into the refrigerant amount adjustment tank 17 illustrated in the refrigeration cycle apparatus 1 of Fig. 1.

**[0055]** At this time, a case is assumed where the control of the flow rate of the refrigerant flowing into the refrigerant amount adjustment tank 17 is continuously performed, and a flowchart process illustrated in Fig. 3 is repeated periodically. For example, the process indicated in Fig. 3 is repeated at every predetermined time.

**[0056]** First, in Step S1, the heat source device controller 10 determines whether a unit operation is performed. It should be noted that a state "in which the unit operation is performed," represents a state in which the compressor 11 is in an operation state, the refrigerant circulates in the refrigerant circuit, and an operation mode is the cooling operation.

**[0057]** When the determination is made that the unit operation is performed (Step S1, YES), the process proceeds to Step S2. Meanwhile, when the determination is made that the unit operation is not performed (Step S1, NO), the process proceeds to Step S4.

**[0058]** In Step S2, the heat source device controller 10 converts pressure information obtained by the low-pressure pressure sensor 22 into an evaporating temperature, which is a saturation temperature of the refrigerant. Then, the heat source device controller 10 compares the obtained evaporating temperature of the refrigerant and the outside-air temperature that is based on temperature

information obtained by the outside-air temperature sensor 23 to determine whether the evaporating temperature of the refrigerant is higher than the outside-air temperature.

**[0059]** In this example, on the basis of the measurement results of the low-pressure pressure sensor 22, the evaporating temperature of the refrigerant is obtained, but the basis is not limited to this example. For example, a temperature sensor may be provided on a refrigerant exit side of the of the air-side heat exchanger 13 in the cooling operation, and the evaporating temperature of the refrigerant may be obtained from the measurement results of the temperature sensor.

**[0060]** Here, the evaporating temperature of the refrigerant is a temperature obtained on the basis of a pressure of the refrigerant at the low pressure, which is measured by the low-pressure pressure sensor 22, but the pressure of the refrigerant of this case differs from a pressure of the refrigerant flowing into the refrigerant amount adjustment tank 17. For this reason, an error lies between the evaporating temperature of the refrigerant at the low pressure, which is based on the measurement results of the low-pressure pressure sensor 22 and the evaporating temperature of the refrigerant based on the pressure of the refrigerant flowing into the refrigerant amount adjustment tank 17.

**[0061]** Further, the outside-air temperature is a temperature, which is obtained on the basis of the temperature measured by the outside-air temperature sensor 23, but an error lies between the outside-air temperature and an actual temperature of the refrigerant amount adjustment tank 17.

**[0062]** To solve the problem, in Embodiment 1 of the present invention, a set temperature to correct these errors is preset, and a comparison is made between the evaporating temperature of the refrigerant at the low pressure and a temperature obtained by adding the set temperature to the outside-air temperature.

**[0063]** The temperature obtained by adding the set temperature to the outside-air temperature is simply referred to as the "outside-air temperature" for the description below.

**[0064]** When determination is made that the evaporating temperature of the refrigerant is equal to or lower than the outside-air temperature (Step S2, NO), the process proceeds to Step S4.

**[0065]** When the evaporating temperature of the refrigerant is equal to or lower than the outside-air temperature, the refrigerant in the refrigerant amount adjustment tank 17 is heated by an ambient outside air. Here, the refrigerant is heated to be brought into a gas state, even when the sub-expansion valve 18B is opened to release pipes connecting the refrigerant amount adjustment tank 17 and the water-side heat exchanger 15, the refrigerant liquid does not stagnate in the refrigerant amount adjustment tank 17.

**[0066]** Thus, in Step S4, the heat source device controller 10 sets the opening degree of the sub-expansion

valve 18A to "full close", and sets the opening degree of the sub-expansion valve 18B to "full open".

**[0067]** Meanwhile, in Step S2, when the evaporating temperature of the refrigerant is determined to be higher than the outside-air temperature (Step S2, YES), the process proceeds to Step S3.

**[0068]** When the evaporating temperature of the refrigerant is higher than the outside-air temperature, the refrigerant in the refrigerant amount adjustment tank 17 is cooled by the ambient outside air. As a result, the refrigerant in the refrigerant amount adjustment tank 17 is liquefied by condensation, and even when the sub-expansion valve 18B is opened to release the pipes connecting the refrigerant amount adjustment tank 17 and the water-side heat exchanger 15, the refrigerant liquid stagnates in the refrigerant amount adjustment tank 17. Then, the refrigerant liquid stagnates in the refrigerant amount adjustment tank 17, and hence the refrigerant in the refrigerant circuit is insufficient for the refrigerant required in the cooling operation. As a result, there is a fear that a stable operation cannot be made.

**[0069]** Thus, in Step S3, the heat source device controller 10 sets the opening degree of the sub-expansion valve 18A to a "set opening degree" that is preset, and the opening degree of the sub-expansion valve 18B is set to "full open".

**[0070]** With this configuration, the liquefaction of the refrigerant in the refrigerant amount adjustment tank 17 is reduced, and thereby an unstable operation due to the stagnation of the refrigerant can be prevented.

**[0071]** In such a case, as the refrigerant in the refrigerant amount adjustment tank 17 is brought into a gas state as described above, the refrigerant does not stagnate in the refrigerant amount adjustment tank 17, and most of the refrigerant filled in the refrigerant circuit circulates in the refrigerant circuit. For this reason, the required amount of refrigerant in the cooling operation may be smaller than that in a case in which the refrigerant is constantly continuously flowing into the refrigerant amount adjustment tank 17.

**[0072]** The required amount of refrigerant in the heating operation is smaller than the required amount in the cooling operation, surplus refrigerant is required to be stored in the refrigerant amount adjustment tank 17. Consequently, in this case, the sub-expansion valve 18B is set to "full open" to release the pipes connecting the refrigerant amount adjustment tank 17 and the water-side heat exchanger 15, and the surplus refrigerant is stored in the refrigerant amount adjustment tank 17.

**[0073]** Note that, in this stage, when the refrigerant repeats flowing into and out of the refrigerant amount adjustment tank 17, there is a risk that refrigerating machine oil stagnates in the refrigerant amount adjustment tank 17, and hence, to reduce the residual of the refrigerating machine oil, the sub-expansion valve 18A is set to a minimum opening degree. With this configuration, a minimum circulation amount of the refrigerant circuit may be circulated.

**[0074]** As described above, in Embodiment 1 of the present invention, the refrigerant amount adjustment tank 17 to store the surplus refrigerant is provided in parallel with the main expansion valve 14, and the sub-expansion valves 18A and 18B are provided on both ends of the refrigerant amount adjustment tank 17. Then, on the basis of the evaporating temperature of the refrigerant in the refrigerant amount adjustment tank 17 and the outside-air temperature, the opening degrees of the sub-expansion valves 18A and 18B are controlled to control the flow rate of the refrigerant flowing into and out of the refrigerant amount adjustment tank 17.

**[0075]** With this configuration, in the cooling operation, to prevent the refrigerant stagnating in the refrigerant amount adjustment tank 17 from being liquefied by the outside-air temperature, the refrigerant may be caused to flow in the refrigerant amount adjustment tank 17 to reduce the stagnation of the refrigerant in the refrigerant amount adjustment tank 17.

**[0076]** Further, in Embodiment 1 of the present invention, by reducing the stagnation of the refrigerant in the refrigerant amount adjustment tank 17 as described above, the refrigerant amount adjustment tank is not required to be disposed, as in the related art, downstream of the flow of the air of the air-side heat exchanger. As a result, the refrigerant amount adjustment tank 17 may be housed in the machine chamber, and the structure of the refrigeration cycle apparatus 1 may be simplified.

**[0077]** The opening degree of the sub-expansion valve 18B is always set to, in the cooling operation and in the heating operation, "full open," and hence the sub-expansion valve 18B may be omitted.

#### Embodiment 2

**[0078]** Next, description is made of an air conditioning apparatus according to Embodiment 2 of the present invention.

**[0079]** In the refrigeration cycle apparatus 1 illustrated in Fig. 1, during standstill of the compressor 11, the refrigerant amount adjustment tank 17 may be cooled. Consequently, for a predetermined period of time from a start-up of the compressor 11, a heat quantity for cooling the refrigerant is larger than that for the stable operation time period. Consequently, for the predetermined period of time from the start-up of the compressor 11, it is required that the flow rate of the refrigerant flowing into the refrigerant amount adjustment tank 17 is larger than that for the stable operation time period, and the refrigerant amount adjustment tank 17 is heated by the flowing refrigerant.

**[0080]** For this reason, according to Embodiment 2 of the present invention, depending on an elapsed time period since the start-up of the compressor 11, the opening degree of the sub-expansion valve 18A is changed to control the flow rate of the refrigerant flowing into the refrigerant amount adjustment tank 17.

**[0081]** Note that, regarding the circuit configuration of

the refrigeration cycle apparatus and the mounting position of the refrigerant amount adjustment tank according to Embodiment 2 of the present invention are the same as those of Embodiment 1, and hence their descriptions are omitted.

[Control of Flow Rate of Refrigerant Flowing into Refrigerant Amount Adjustment Tank]

**[0082]** Fig. 4 is a flow chart for illustrating an example of a process for controlling a flow rate of refrigerant flowing into the refrigerant amount adjustment tank 17 illustrated in a refrigeration cycle apparatus 1 according to Embodiment 2 of the present invention.

**[0083]** At this time, a case is assumed where the control of the flow rate of the refrigerant flowing into the refrigerant amount adjustment tank 17 is continuously performed, and a flowchart process illustrated in Fig. 4 is repeated periodically. For example, the process indicated in Fig. 4 is repeated at every predetermined time.

**[0084]** First, in Step S11, the heat source device controller 10 determines whether a unit operation is performed. When the determination is made that the unit operation is performed (Step S11, YES), the process proceeds to Step S12.

**[0085]** In Step S12, the heat source device controller 10 converts pressure information obtained by the low-pressure pressure sensor 22 into an evaporating temperature, which is a saturation temperature of the refrigerant. Then, the heat source device controller 10 compares the obtained evaporating temperature of the refrigerant and the outside-air temperature, which is based on temperature information obtained by the outside-air temperature sensor 23 to determine whether the evaporating temperature of the refrigerant is higher than the outside-air temperature.

**[0086]** When the determination is made that the evaporating temperature of the refrigerant is higher than the outside-air temperature (Step S12, YES), the process proceeds to Step S13.

**[0087]** In Step S13, the heat source device controller 10 determines whether four minutes have elapsed since the start-up of the compressor 11. This operation is to determine, as described above, whether the compressor 11 is in a stable operation state.

**[0088]** Note that, the time period to determine whether the compressor 11 is in the stable operation is not limited to four minutes. For example, taking into account a performance of the compressor 11, the time period may be appropriately set.

**[0089]** When the determination is made that four minutes have not yet elapsed (Step S13, NO), the process proceeds to Step S15.

**[0090]** In Step S15, the heat source device controller 10 sets the opening degree of the sub-expansion valve 18A to a preset "first opening degree." Specifically, the heat source device controller 10 sets, for example, the opening degree of the sub-expansion valve 18A, as the

"first opening degree," to about 20% of "full open."

**[0091]** Meanwhile, in Step S13, when the heat source device controller 10 determines that four minutes have elapsed (Step S13, YES), the process proceeds to Step S14.

**[0092]** In Step S14, the heat source device controller 10 sets the opening degree of the sub-expansion valve 18A to a "second opening degree" that is smaller than the opening degree set in Step S15. Specifically, the heat source device controller 10 sets the opening degree of the sub-expansion valve 18A as the "second opening degree" to about 10% of "full open."

**[0093]** Meanwhile, when the heat source device controller 10 determines that the unit operation is not performed, in Step S11 (Step S11, NO), and the evaporating temperature of the refrigerant is equal to or lower than the outside-air temperature, in Step S12 (Step S12, NO), the process proceeds to Step S16.

**[0094]** In Step S16, the heat source device controller 10 sets the opening degree of the sub-expansion valve 18A to "full close" and sets the opening degree of the sub-expansion valve 18B to "full open."

**[0095]** Note that, in Step S14, the opening degree of the sub-expansion valve 18A may be set to a larger opening degree that is the same opening degree as in Step S15.

**[0096]** However, by reducing the flow rate of the refrigerant flowing in the stable operation, the flow ratio of the refrigerant flowing into the refrigerant amount adjustment tank 17 may be made smaller than the flow rate of the refrigerant flowing into the main expansion valve 14. As a result, influence of the refrigerant flow control to the main expansion valve 14 may be made smaller, and thereby a stable operation can be performed.

**[0097]** As described above, according to Embodiment 2 of the present invention, depending on the elapsed time period since the start-up of the compressor 11, the opening degree of the sub-expansion valve 18A is changed. Then, from the start-up of the compressor 11 to the elapse of the predetermined time, the opening degree of the sub-expansion valve 18A is made larger than that in the stable operation, the flow rate of the refrigerant flowing into the refrigerant amount adjustment tank 17 can be made larger, and thereby the refrigerant stagnating in the refrigerant amount adjustment tank 17 can be more heated.

**[0098]** Further, the opening degree of the sub-expansion valve 18A when the compressor 11 is in the stable operation is made smaller than the opening degree of the sub-expansion valve 18A at the time of start-up of the compressor 11, the influence to the refrigerant flow rate control of the main expansion valve 14 may be made smaller, and thereby the more stable operation may be performed.

**[0099]** Descriptions are made of Embodiment 1 and Embodiment 2 of the present invention as described above, but the present invention is not limited to the above-mentioned Embodiment 1 and Embodiment 2 of

the present invention, and the present invention is applicable to various modifications and applications within a scope not departing from a gist of the present invention.

**[0100]** For example, in Embodiment 1 and Embodiment 2 described above, description is made of a case in which the number of the refrigerant circuit is one, but the number of the refrigerant circuit is not limited to one. For example, a plurality of refrigerant circuits may be provided in the same refrigeration cycle apparatus 1.

**[0101]** Fig. 5 is a schematic diagram for illustrating an example in which a plurality of refrigerant circuits are provided in the refrigeration cycle apparatus according to Embodiment 1 and Embodiment 2 of the present invention. In the example illustrated in Fig. 5, in one refrigeration cycle apparatus 1, four refrigerant circuits are provided as illustrated.

**[0102]** In this example, there is illustrated a state in which heat is exchanged between the refrigerant flowing in each of four refrigerant circuits and a heat medium flowing in one heat medium circuit by a single pump 40.

#### Reference Signs List

**[0103]** 1 refrigeration cycle apparatus 2 refrigerant pipe 10 heat source device controller 11 compressor 12 refrigerant-flow switching device 13 air-side heat exchanger 14 main expansion valve 15 water-side heat exchanger 16 accumulator 17 refrigerant amount adjustment tank 18A, 18B sub-expansion valve 19 gas purge circuit 21 air-side air sending device 22 low-pressure pressure sensor 23 outside-air temperature sensor 30 machine chamber 40 pump

#### Claims

1. A refrigeration cycle apparatus including a refrigerant circuit sequentially connecting, with pipes, a compressor, a refrigerant-flow switching device, an air-side heat exchanger, a main expansion valve, and a water-side heat exchanger, and configured to allow refrigerant to circulate in the refrigerant circuit, the refrigeration cycle apparatus comprising:

a refrigerant amount adjustment tank arranged in parallel with the main expansion valve, and configured to store the refrigerant;

a first refrigerant flow control valve provided to a pipe connected to one end of the refrigerant amount adjustment tank, the pipe being branched from a pipe connecting the air-side heat exchanger and the main expansion valve, the first refrigerant flow control valve being configured to adjust a flow rate of the refrigerant flowing into and out of the refrigerant amount adjustment tank on a basis of an opening degree of the first refrigerant flow control valve; and  
a second refrigerant flow control valve provided

- to a pipe connected to an other end of the refrigerant amount adjustment tank, the pipe being branched from a pipe connecting the main expansion valve and the water-side heat exchanger, the second refrigerant flow control valve being configured to adjust a flow rate of the refrigerant flowing into and out of the refrigerant amount adjustment tank on a basis of an opening degree of the second refrigerant flow control valve. 5 10
2. The refrigeration cycle apparatus of claim 1, wherein the refrigerant amount adjustment tank is accommodated in a machine chamber accommodating at least the compressor, the expansion valve, and the water-side heat exchanger that form the refrigerant circuit. 15
3. The refrigeration cycle apparatus of claim 1 or 2, further comprising a gas purge circuit including one end connected to the refrigerant amount adjustment tank and an other end connected to a pipe connecting the main expansion valve and the water-side heat exchanger. 20
4. The refrigeration cycle apparatus of any one of claims 1 to 3, further comprising a controller configured to control the compressor, the expansion valve, the first refrigerant flow control valve, and the second refrigerant flow control valve, wherein, in cooling operation, the controller is configured to control the opening degree of the first refrigerant flow control valve on a basis of an outside-air temperature that is an ambient temperature of the refrigerant amount adjustment tank and an evaporating temperature of the refrigerant. 25 30 35
5. The refrigeration cycle apparatus of claim 4, wherein when the evaporating temperature of the refrigerant is higher than the outside-air temperature, the controller is configured to set the opening degree of the first refrigerant flow control valve to a preset opening degree, and when the evaporating temperature of the refrigerant is lower than the outside-air temperature, the controller is configured to fully close the opening degree of the first refrigerant flow control valve. 40 45
6. The refrigeration cycle apparatus of claim 4, wherein when the evaporating temperature of the refrigerant is higher than the outside-air temperature and a preset time period has not elapsed since the compressor is activated, the controller is configured to set the opening degree of the first refrigerant flow control valve to a first opening degree that is preset, and when the preset time period has elapsed since the compressor is activated, the controller is configured to set the opening degree of the first refrigerant flow control valve to a second opening degree that is 50 55
- smaller than the first opening degree.
7. The refrigeration cycle apparatus of any one of claims 1 to 6, comprising a plurality of the refrigerant circuits.

FIG. 1

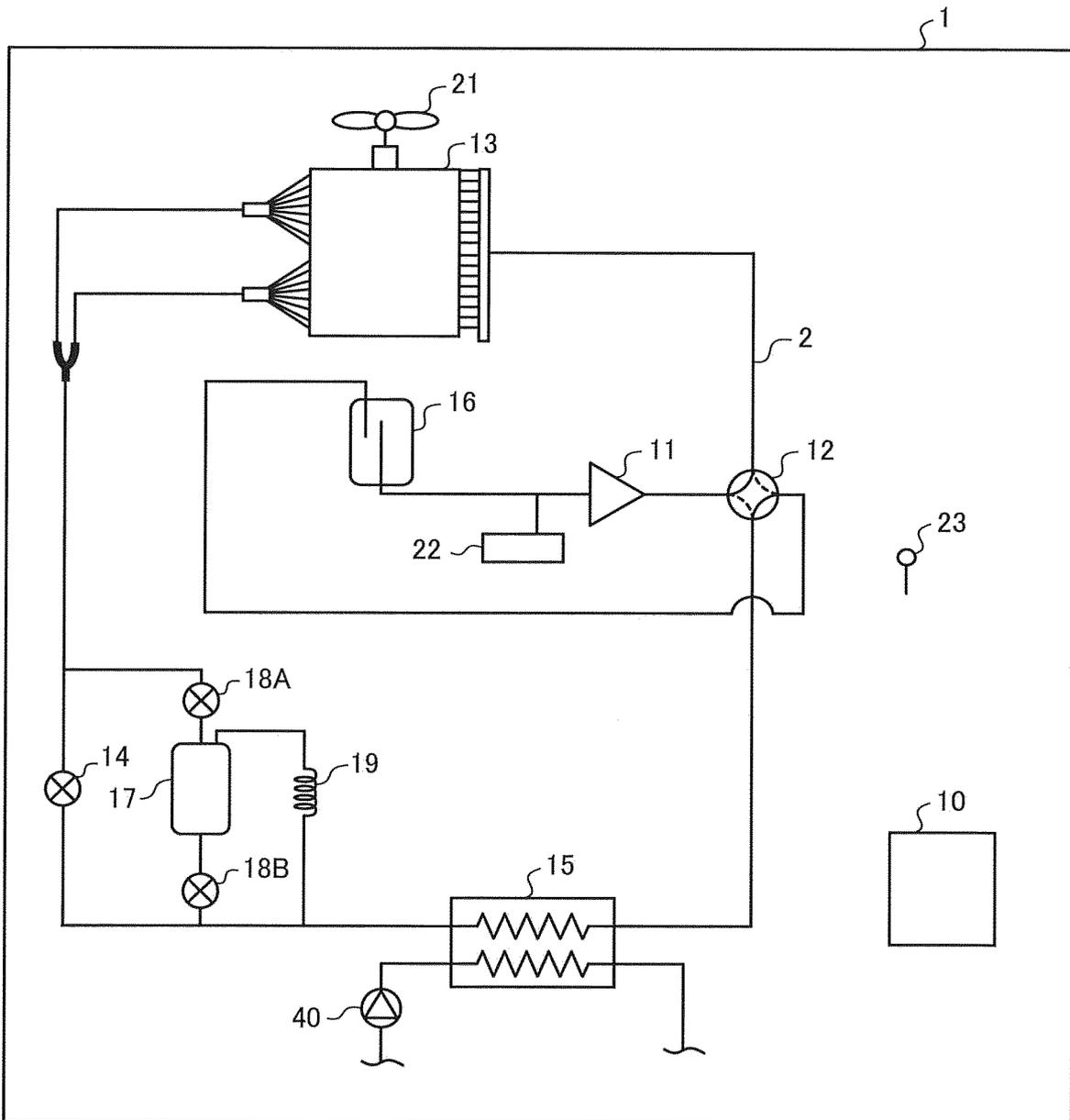


FIG. 2

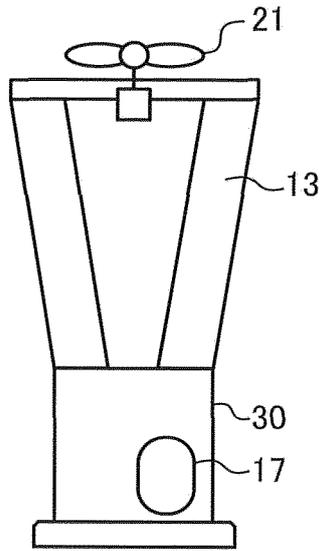


FIG. 3

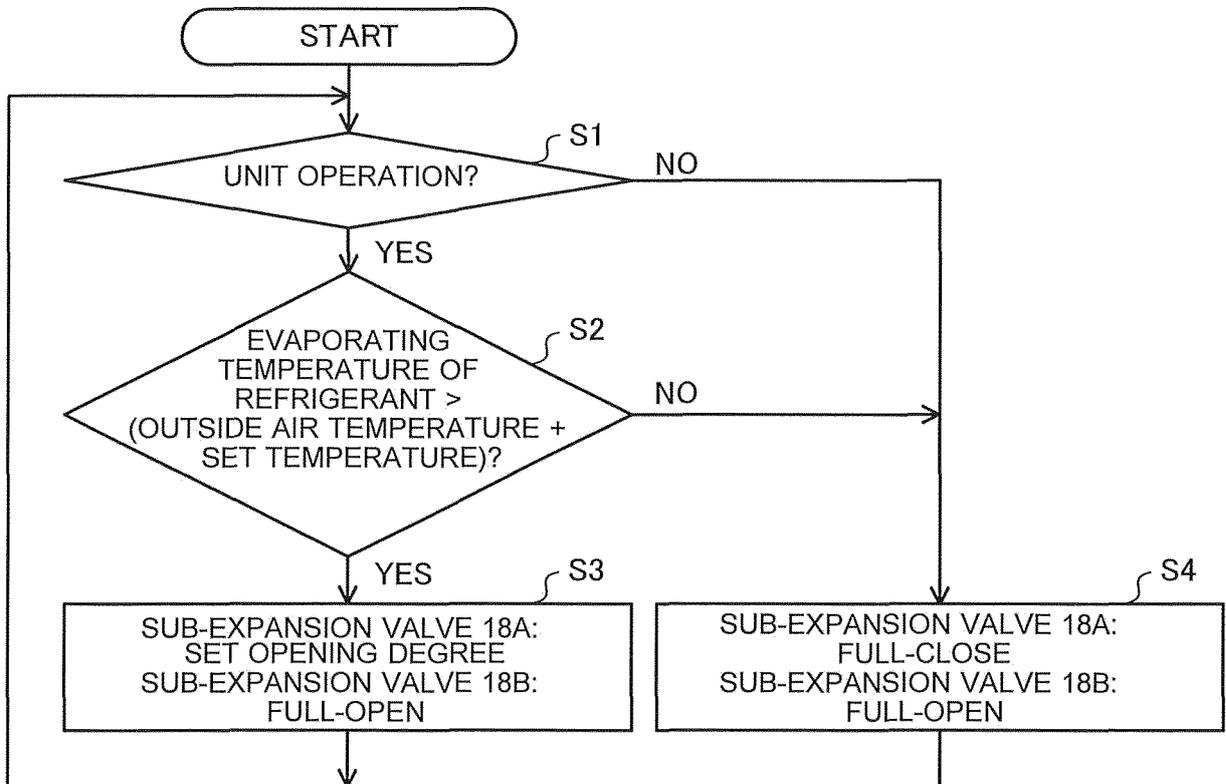


FIG. 4

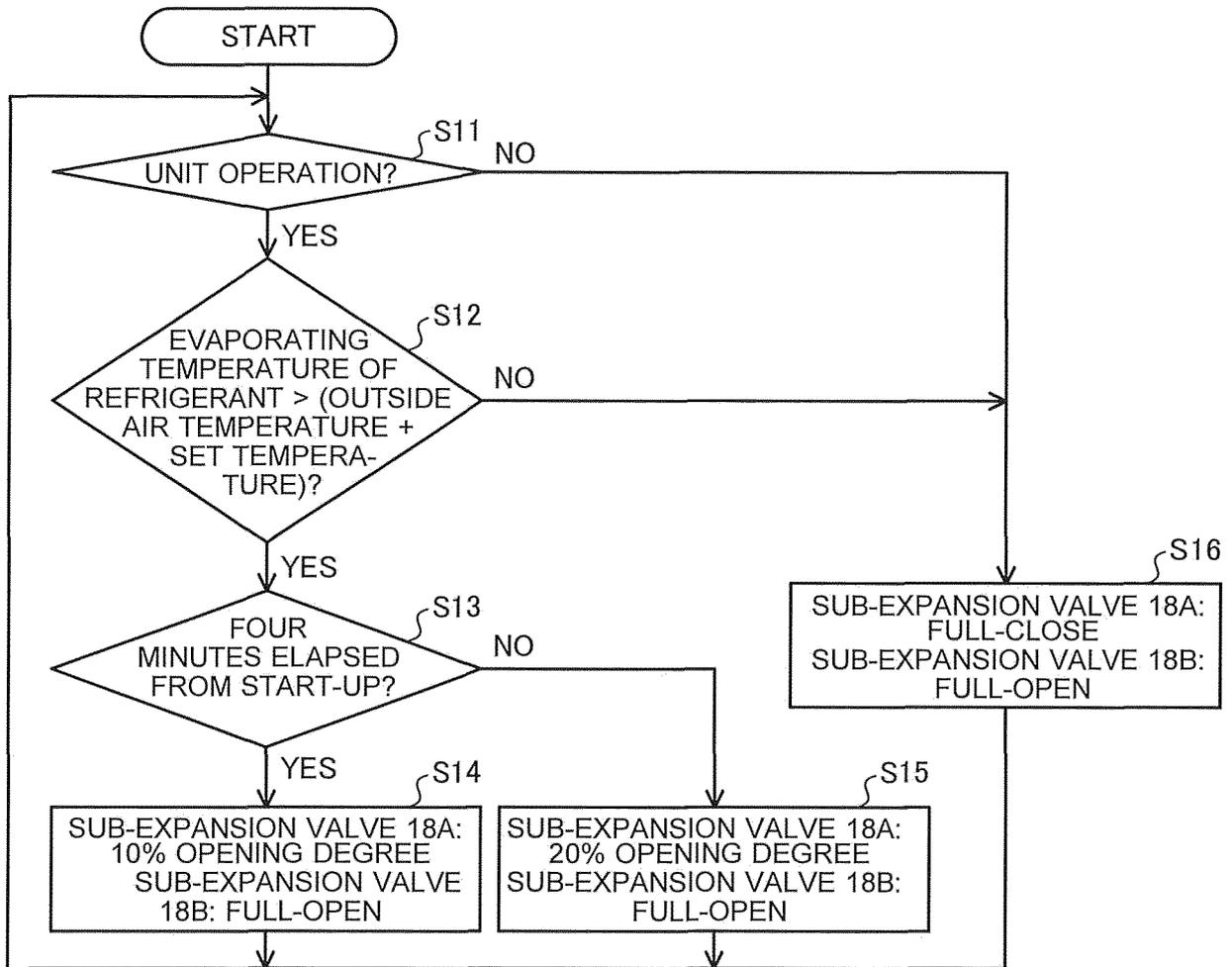
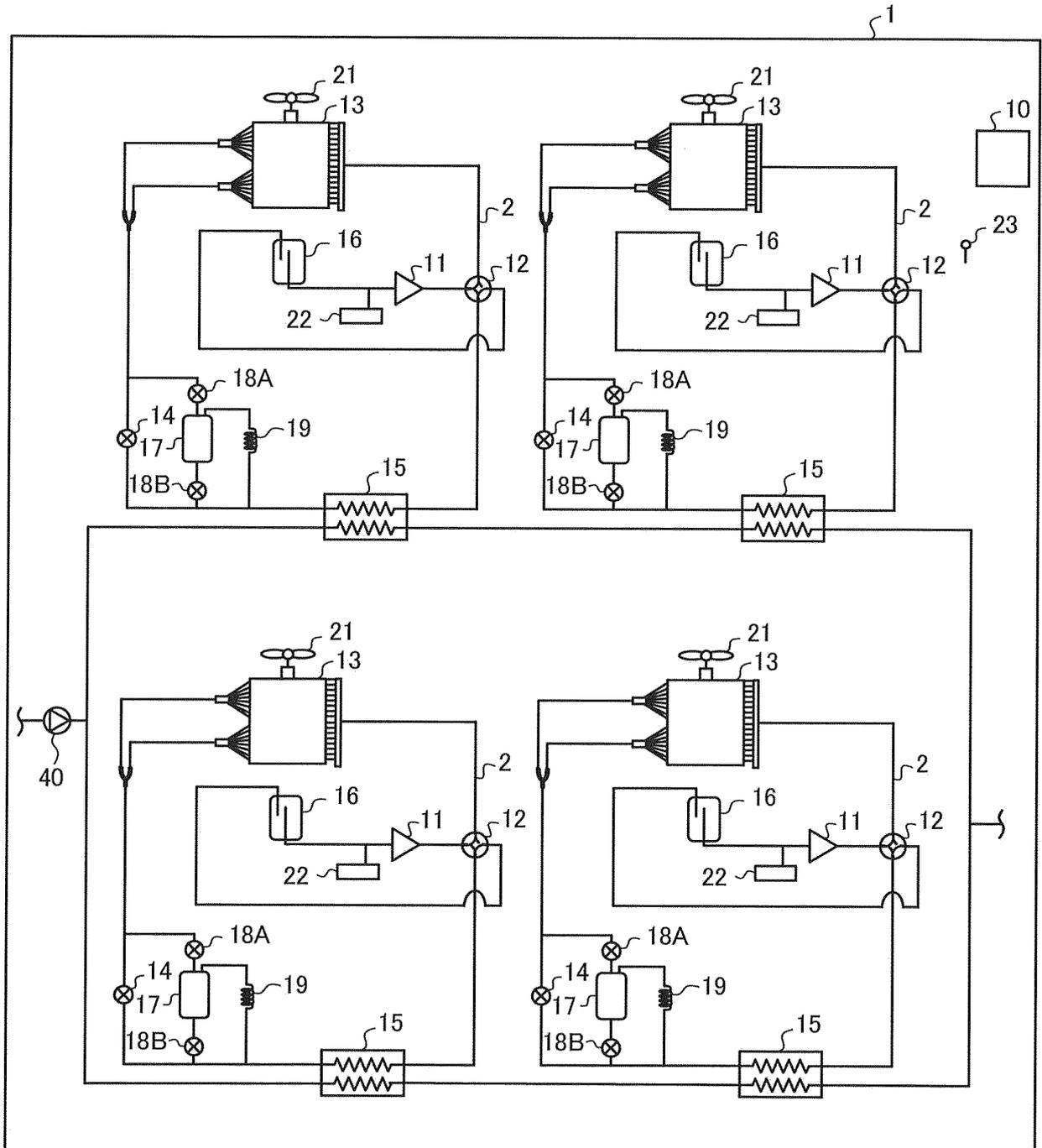


FIG. 5



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/079553

## A. CLASSIFICATION OF SUBJECT MATTER

F25B43/00(2006.01) i

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)

F25B43/00

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015

Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 1-269873 A (Mitsubishi Electric Corp.), 27 October 1989 (27.10.1989), page 2, lower right column, lines 1 to 20; fig. 1 (Family: none)	1-3, 7
Y	JP 2014-66420 A (Hitachi Appliances, Inc.), 17 April 2014 (17.04.2014), paragraphs [0011] to [0014]; fig. 1 (Family: none)	1-3, 7
Y	JP 2003-83644 A (Mitsubishi Electric Corp.), 19 March 2003 (19.03.2003), paragraph [0019]; fig. 1 & EP 1293735 A2 paragraph [0038]	3, 7

 Further documents are listed in the continuation of Box C.
  See patent family annex.

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"&amp;" document member of the same patent family

Date of the actual completion of the international search  
30 November 2015 (30.11.15)Date of mailing of the international search report  
26 January 2016 (26.01.16)Name and mailing address of the ISA/  
Japan Patent Office  
3-4-3, Kasumigaseki, Chiyoda-ku,  
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.  
PCT/JP2015/079553

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2000-146328 A (Sanyo Electric Co., Ltd.), 26 May 2000 (26.05.2000), paragraph [0011]; fig. 1 (Family: none)	1-7

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 2003083644 A [0005]