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(71) Applicant: **MITSUBISHI ELECTRIC CORPORATION**
Chiyoda-ku
Tokyo 100-8310 (JP)

(72) Inventor: **TSUKIYAMA, Ryo**
Tokyo 1008310 (JP)

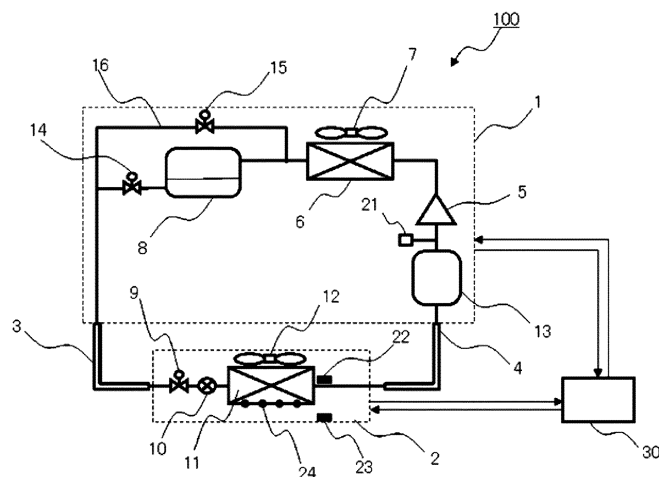
(74) Representative: **Pfenning, Meinig & Partner mbB**
Patent- und Rechtsanwälte
Theresienhöhe 11a
80339 München (DE)

(54) **REFRIGERATION CYCLE DEVICE**

(57) To provide a highly-reliable refrigeration cycle apparatus that avoids the occurrence of a liquid-back phenomenon during a precooling operation that is performed after a defrosting operation ends. The refrigeration cycle apparatus includes: a refrigerant circuit in which a compressor 5, a condenser 6, a receiver 8, an expansion valve 10, an evaporator 11, and an accumulator 13 are connected sequentially; a defrosting unit 24

configured to melt frost depositing on the evaporator 11; and a control unit 30 configured to select any of a cooling operation, a defrosting operation, or a precooling operation, wherein in the precooling operation, a predetermined amount of refrigerant is held in the receiver 8, such that a smaller amount of refrigerant circulates in the refrigerant circuit than in the cooling operation and in the defrosting operation.

FIG. 1



Description

Technical Field

5 **[0001]** The disclosure of the present specification relates to a refrigeration cycle apparatus that cools interior air. Particularly, the disclosure of the present specification relates to a refrigeration cycle apparatus that performs a defrosting operation to remove frost depositing on an evaporator.

Background Art

10 **[0002]** In general, a refrigeration cycle apparatus is configured to perform a defrosting operation at intervals, since frost sticks to an evaporator when the refrigeration cycle apparatus performs a cooling operation to cool a freezer storage, which is a target to be cooled, to 0 degrees C or lower. There are several defrosting methods available, such as heating the evaporator by using an electric heater or circulating high-temperature refrigerant to the evaporator. In any of the
15 methods, the evaporator is heated to a high temperature at the end of defrosting operation.

[0003] If the refrigeration cycle apparatus starts the cooling operation again, while the evaporator remains in a high-temperature state, then the freezer storage is supplied with high-temperature air, which may adversely affect products stored in the freezer storage. A solution to avoid this adverse effect is known that is performing a precooling operation after the end of defrosting operation to circulate refrigerant to the evaporator while air delivery to the freezer storage
20 remains stopped (for example, Patent Literature 1).

Citation List

Patent Literature

25 **[0004]** Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2017-166730

Summary of Invention

30 Technical Problem

[0005] However, a refrigerator described in Patent Literature 1 continues the precooling operation until an evaporator outlet reaches a predetermined temperature or until a predetermined time has elapsed. Thus, liquid refrigerant, which has not yet evaporated in the evaporator during the precooling operation, may flow back to an accumulator.

35 **[0006]** When this liquid-back phenomenon has occurred, the liquid refrigerant stays accumulated in the accumulator. This may lead to a refrigerant shortage even when the cooling operation is resumed after the end of precooling operation. When the accumulator overflows with liquid refrigerant, this causes a compressor to suction the liquid refrigerant, which can seriously damage the inside of the compressor.

40 **[0007]** The present disclosure has been made to solve the above problems, and it is an object of the present disclosure to provide a highly-reliable refrigeration cycle apparatus that avoids the occurrence of a liquid-back phenomenon immediately before the end of precooling operation.

Solution to Problem

45 **[0008]** To achieve the above object, one of refrigeration cycle apparatus disclosed includes: a refrigerant circuit in which a compressor, a condenser, a receiver, an expansion valve, and an evaporator are connected sequentially, the refrigerant circuit being filled with refrigerant; a defrosting unit configured to melt frost depositing on the evaporator; and a control unit configured to select any of a cooling operation, a defrosting operation, or a precooling operation, wherein
50 in the precooling operation, a predetermined amount of refrigerant is held in the receiver, such that a smaller amount of refrigerant circulates in the refrigerant circuit than in the cooling operation and in the defrosting operation.

Advantageous Effects of Invention

55 **[0009]** The refrigeration cycle apparatus according to an embodiment of the present disclosure holds a predetermined amount of liquid refrigerant in the receiver during a precooling operation, and performs the precooling operation using a smaller amount of refrigerant than usual. Thus, even when the refrigeration cycle apparatus continuously performs the precooling operation until the evaporator is sufficiently cooled, only a small amount of liquid refrigerant flows back to the accumulator. Therefore, the highly-reliable refrigeration cycle apparatus can be obtained.

Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 is a refrigerant circuit configuration diagram illustrating an example of a refrigeration cycle apparatus according to Embodiment 1.

[Fig. 2] Fig. 2 is a flowchart illustrating the basic operation for an operating-mode control executed by the refrigeration cycle apparatus according to Embodiment 1.

[Fig. 3] Fig. 3 is a flowchart illustrating the control operation of the refrigeration cycle apparatus according to Embodiment 1 in a cooling mode.

[Fig. 4] Fig. 4 is a flowchart illustrating the control operation of the refrigeration cycle apparatus according to Embodiment 1 in a defrosting mode.

[Fig. 5] Fig. 5 is a refrigerant circuit configuration diagram of the refrigeration cycle apparatus according to Embodiment 1 to perform hot-gas defrosting.

[Fig. 6] Fig. 6 is a flowchart illustrating the control operation of the refrigeration cycle apparatus according to Embodiment 1 in a precooling mode.

[Fig. 7] Fig. 7 is a refrigerant circuit configuration diagram illustrating an example of a refrigeration cycle apparatus according to Embodiment 2.

[Fig. 8] Fig. 8 is a refrigerant circuit configuration diagram illustrating an example of a refrigeration cycle apparatus according to Embodiment 3.

[Fig. 9] Fig. 9 is a refrigerant circuit configuration diagram illustrating an example of a refrigeration cycle apparatus according to Embodiment 4.

Description of Embodiments

[0011] Hereinafter, a refrigeration cycle apparatus according to the embodiments of the present disclosure will be described with reference to the drawings. Note that in a plurality of embodiments, parts corresponding to the matters described in the preceding embodiment are denoted by the same reference numerals, and redundant descriptions are omitted.

Embodiment 1

[0012] Fig. 1 is a refrigerant circuit configuration diagram illustrating an example of a refrigeration cycle apparatus according to Embodiment 1 of the present disclosure. As illustrated in Fig. 1, in a refrigeration cycle apparatus 100, an outdoor unit 1 and an indoor unit 2 are connected by a liquid pipe 3 and a gas pipe 4, forming a single refrigerant circuit. This refrigerant circuit is filled with R407C that is a refrigerant mixture of three types of HFC refrigerants with different boiling points. The refrigerant to be filled is not limited to this refrigerant mixture. For example, a refrigerant mixture of HFO refrigerants, R1234yf and R32, may also be employed. A refrigerant mixture containing an HC refrigerant such as R290 or a natural refrigerant such as CO₂ as one of the components may also be employed.

[0013] The outdoor unit 1 has a compressor 5, an outdoor heat exchanger 6, a receiver 8, a first opening-closing valve 14, and a bypass circuit 16 incorporated therein. The compressor 5 connects to an accumulator 13 on its suction side. The bypass circuit 16 connects an inlet of the receiver 8 to an outlet of the first opening-closing valve 14, and includes a second opening-closing valve 15. An outdoor fan 7 provided along with the outdoor heat exchanger 6 changes the amount of air to be delivered to the outdoor heat exchanger 6 to adjust the amount of heat exchange between refrigerant and outside air. The receiver 8 has a function of storing surplus refrigerant to the refrigerant filled in the refrigerant circuit. Between the compressor 5 and the accumulator 13, a pressure sensor 21 is installed to detect a low-pressure Ps during a refrigeration cycle operation.

[0014] The indoor unit 2 is installed in a refrigeration storage in which its interior air temperature is adjusted to, for example, around -5 degrees C. The indoor unit 2 has a refrigerant circuit incorporated therein. In the refrigerant circuit, a liquid solenoid valve 9, an expansion valve 10, and an indoor heat exchanger 11 are connected sequentially. An indoor fan 12 is located along with the indoor heat exchanger 11 to adjust the amount of heat exchange between refrigerant and interior air. The expansion valve 10 is, for example, a thermostatic expansion valve whose opening degree is adjusted to such a degree that refrigerant at the outlet of the indoor heat exchanger 11 reaches a predetermined degree of superheat.

[0015] Electric heaters 24 used for defrosting are joined to the indoor heat exchanger 11 on its air suctioning side. The indoor heat exchanger 11 includes a temperature sensor 22 to detect a representative temperature T_{eva} on the refrigerant outlet side, and a temperature sensor 23 to detect an interior air temperature T_a.

[0016] The refrigeration cycle apparatus 100 according to Embodiment 1 includes a controller 30 to identify the operating

state of the outdoor unit 1 and the indoor unit 2, and control actuators. The controller 30 activates/deactivates the compressor 5 and the outdoor fan 7, and manipulates opening and closing of the first opening-closing valve 14 and the second opening-closing valve 15 in the outdoor unit 1. The controller 30 also activates/deactivates the indoor fan 12, manipulates opening and closing of the liquid solenoid valve 9, and controls energization/disconnection of the electric heaters 24 in the indoor unit 2.

[0017] This controller 30 may be built in the outdoor unit 1 or the indoor unit 2, or may be installed in a user's residential space. The controller 30 further includes a user interface that allows a user to set a target interior temperature T_{set} .

[0018] Fig. 2 is a flowchart illustrating the basic operation for an operating-mode control executed by the refrigeration cycle apparatus 100 according to Embodiment 1. When the refrigeration cycle apparatus 100 starts operating, this refrigeration cycle apparatus 100 first performs a cooling operation in step S100 to maintain the interior air at the target interior temperature T_{set} set by a user. When the condition for starting defrosting during the cooling operation is met, the refrigeration cycle apparatus 100 shifts to step S200.

[0019] In step S200, the refrigeration cycle apparatus 100 performs a defrosting operation to remove frost depositing on the indoor heat exchanger 11. During the defrosting operation, when the condition for ending this defrosting operation, the refrigeration cycle apparatus 100 shifts to step S300 is met.

[0020] In step S300, the refrigeration cycle apparatus 100 performs a precooling operation to cool the indoor heat exchanger 11, having been heated to a high temperature during the defrosting operation, to a predetermined temperature. When ending the precooling operation, the refrigeration cycle apparatus 100 returns to step S100 to resume the cooling operation. The refrigeration cycle apparatus 100 repeats this operating cycle. Subsequently, the series of control operations is further described in detail.

<Cooling operation>

[0021] Fig. 3 is a flowchart illustrating the control operation of the refrigeration cycle apparatus 100 according to Embodiment 1 in a cooling mode. When a cooling operation is started, the controller 30 in the refrigeration cycle apparatus 100 forms a cooling circuit in which the liquid solenoid valve 9 and the first opening-closing valve 14 are opened, while the second opening-closing valve 15 is closed. The controller 30 also activates the compressor 5 and the indoor fan 12 in step S101. The outdoor fan 7 is activated/deactivated always in conjunction with the compressor 5, and thus descriptions of the activation/deactivation of the outdoor fan 7 are omitted.

[0022] Due to the control operation in step S101, in the outdoor unit 1, high-temperature high-pressure gas refrigerant discharged from the compressor 5 transfers heat to the outside air in the outdoor heat exchanger 7, thereby to condense and liquefy, and then flows via the receiver 8 and the first opening-closing valve 14 to the liquid pipe 3. At this time, surplus liquid refrigerant is stored in the receiver 8.

[0023] The refrigerant having entered from the liquid pipe 3 to the indoor unit 2 passes through the liquid solenoid valve 9, is thereafter reduced in pressure by the expansion valve 10 into a low-pressure two-phase state, and then enters the indoor heat exchanger 11. The low-pressure two-phase refrigerant, having entered the indoor heat exchanger 11, exchanges heat with the interior air suctioned by the indoor fan 12, and thus evaporates into gas refrigerant. The refrigerant brought into a gas state in the indoor unit 2 flows back to the outdoor unit 1 via the gas pipe 4.

[0024] The refrigerant having flowed back to the outdoor unit 1 passes through the accumulator 13 and is suctioned again into the compressor 5. Through the series of operations, the interior air is suctioned into the indoor unit 2 by the indoor fan 12, then cooled to a low temperature by exchanging heat with the indoor heat exchanger 11, and consequently circulates in the interior. In this manner, a cooling operation to maintain the interior at a predetermined temperature is continued.

[0025] Step S102 is a control step of determining whether a defrosting operation is needed. When determining in step S102 that the defrosting condition is satisfied, the controller 30 ends the cooling operation, and shifts to a defrosting operation. In step S102, for example, the controller 30 may determine that the defrosting condition is satisfied by detecting continuation of the cooling operation for a predetermined time that is set by a timer in advance. Alternatively, the controller 30 may determine that the defrosting condition is satisfied when there is a temperature difference of 15 degrees C or greater between the interior air temperature T_a and a saturation temperature at the low-pressure P_s .

[0026] When the refrigeration cycle apparatus 100 continues the cooling operation in a state where the defrosting condition remains unsatisfied, the controller 30 monitors the interior air temperature in step S103 to prevent the interior air temperature from excessively decreasing. In step S103, for example, when the interior air temperature T_a is decreased lower than the target interior temperature T_{set} by 5 degrees C or greater, then the controller 30 shifts to step S104 from which a thermostat-off operation starts.

[0027] In the thermostat-off operation, first in step S104, the controller 30 closes the liquid solenoid valve 9 to perform a refrigerant collecting operation. When the liquid solenoid valve 9 is closed, the indoor unit 2 is prevented from being supplied with refrigerant from the liquid pipe 3, so that refrigerant present in the indoor unit 2 and the gas pipe 4 is collected toward the outdoor unit 1. At this time, the low-pressure P_s in the refrigeration cycle detected by the pressure

sensor 22 gradually decreases.

[0028] In step S105 of determining whether to deactivate the compressor, when the low-pressure P_s decreases to, for example, an atmospheric pressure or lower, then the controller 30 determines that refrigerant collection has completed, and deactivates the compressor 5 in step S106. Upon deactivation of the compressor 5, the refrigerant collecting operation completes. When the refrigerant collecting operation has completed, only lean gas refrigerant is present in the indoor unit 2 and the gas pipe 4. The major portion of refrigerant is present in the receiver 8 and the liquid pipe 3.

[0029] When the refrigerant collecting operation has completed in step S106, the indoor unit 2 does not cool the interior air, so that the interior air temperature T_a gradually increases. In step S107, the controller 30 monitors whether the interior air temperature T_a becomes higher than the target interior temperature T_{set} . In step S107, for example, when the interior air temperature T_a becomes equal to or higher than the target interior temperature T_{set} , then the controller 30 ends the thermostat-off operation and returns to step S101 to start a cooling operation.

[0030] Through the series of cooling-mode control operations, the interior air temperature T_a is adjusted to fall within the range between the target interior temperature T_{set} and a temperature lower than T_{set} by -5 degrees C. Subsequently, a defrosting-operation control is described, which is a control operation to be performed after the end of cooling operation.

<Defrosting operation>

[0031] Fig. 4 is a flowchart illustrating the control operation of the refrigeration cycle apparatus 100 according to Embodiment 1 in a defrosting mode. As described above, when the controller 30 determines that the defrosting condition is satisfied in step S102 during the cooling operation, the controller 30 ends the cooling operation, and shifts to a defrosting operation. At this point in time, the controller 30 assumes that a predetermined amount of frost sticks to the indoor heat exchanger 11 on its interior-air suction side.

[0032] When the defrosting operation is started, first the controller 30 closes the liquid solenoid valve 9 in step S201, and continues this defrosting operation until the low-pressure P_s becomes equal to or lower than the atmospheric pressure in the subsequent step S202. This control operation is the same as in the refrigerant collecting operation described in steps S104 and S105 in the cooling-operation control in Fig. 3. When making sure in step S202 that the low-pressure P_s has become equal to or lower than the atmospheric pressure, the controller 30 shifts to step S203, and deactivates the compressor 5 and the indoor fan 12, while energizing the electric heaters 24.

[0033] Since the electric heaters 24 are joined to the indoor heat exchanger 11, the temperature of the indoor heat exchanger 11 increases as the electric heaters 24 start being energized, which melts frost depositing on the indoor heat exchanger 11. The representative temperature T_{eva} of the indoor heat exchanger 11 detected by the temperature sensor 22 starts increasing as more of the frost is melted.

[0034] While energizing the electric heaters 24, the controller 30 monitors whether defrosting has completed in step S204. A determination that defrosting has completed is made by determining that all the frost has been melted in the indoor heat exchanger 11. For example, when the representative temperature T_{eva} detected by the temperature sensor 22 becomes equal to or higher than 30 degrees C, the controller 30 shifts to step S205 to end energization of the electric heaters 24. With this control operation, the defrosting operation completes. Accordingly, the controller 30 shifts to a precooling operation.

<Modification> hot-gas defrosting

[0035] Figs. 1 to 4 illustrate an example of the defrosting operation using the electric heaters 24. However, the defrosting method is not limited thereto. For example, the defrosting operation may be performed using high-temperature gas refrigerant discharged from the compressor 5.

[0036] Fig. 5 is a refrigerant circuit configuration diagram of a refrigeration cycle apparatus that performs hot-gas defrosting. The outdoor unit 1 includes a hot-gas branch pipe 41 that branches off from the compressor outlet. The hot-gas branch pipe 41 is connected to a hot-gas pipe 43 via a hot-gas valve 42 that is openable and closable. The hot-gas pipe 43 is a third connection pipe that connects the outdoor unit 1 and the indoor unit 2. The hot-gas pipe 43 is connected to a branch pipe extending between the expansion valve 10 and the indoor heat exchanger 11 in the indoor unit 2.

[0037] When performing a defrosting operation, this refrigeration cycle apparatus 101 closes the liquid solenoid valve 9 and opens the hot-gas valve 42 after the cooling operation ends. When the hot-gas valve 42 is opened, high-temperature gas refrigerant discharged from the compressor 5 enters the indoor unit 2 via the hot-gas pipe 43 and heats the indoor heat exchanger 11. In the same manner as the heater defrosting described above, this hot-gas defrosting is also continued until the representative temperature T_{eva} of the indoor heat exchanger 11 detected by the temperature sensor 22 becomes 30 degrees C, and thereafter the defrosting operation is ended. The hot-gas defrosting operation is ended by closing the hot-gas valve 42.

<Precooling operation>

[0038] When the defrosting operation is ended, the controller 30 shifts to a precooling operation. Fig. 6 is a flowchart illustrating the control operation of the refrigeration cycle apparatus 100 described in Embodiment 1 in a precooling mode. When the precooling operation is started, the controller 30 switches the refrigerant circuit of the refrigeration cycle apparatus 100 to a precooling circuit in step S301.

[Table 1]

	COOLING CIRCUIT	DEFROSTING CIRCUIT	PRECOOLING CIRCUIT
LIQUID SOLENOID VALVE 9	OPEN	CLOSE	OPEN
FIRST OPENING-CLOSING VALVE 14	OPEN	CLOSE	CLOSE
SECOND OPENING-CLOSING VALVE 15	CLOSE	CLOSE	OPEN
COMPRESSOR 5	ON	OFF	ON
INDOOR FAN 12	ON	OFF	OFF

[0039] Table 1 illustrates respective control states of a group of actuators in the cooling circuit, the defrosting circuit, and the precooling circuit of the refrigeration cycle apparatus 100. When the refrigerant circuit is set to the precooling circuit in step S301, the controller 30 opens the liquid solenoid valve 9 and the second opening-closing valve 15, closes the first opening-closing valve 14, and activates the compressor 5.

[0040] A refrigerant-amount distribution in the refrigerant circuit before it is set to the precooling circuit remains the same as when a refrigerant collecting operation has been performed during the defrosting operation. For this reason, the major portion of the refrigerant filled in the refrigerant circuit is present in the receiver 8 and the liquid pipe 3 as liquid refrigerant. In this state, when the refrigerant circuit is set to the precooling circuit, the liquid refrigerant stored in the receiver 8 is prevented from being discharged from the receiver 8.

[0041] Subsequently, although the controller activates the compressor 5 in step S302, a very small amount of refrigerant forms the refrigeration cycle. Thus, high-temperature refrigerant discharged from the compressor 5 transfers heat to the outside air in the outdoor heat exchanger 6. However, this refrigerant flows out of the outdoor heat exchanger 6 before becoming completely liquefied. This refrigerant in a two-phase state containing a slight amount of liquid refrigerant passes through the second opening-closing valve 15 without entering the receiver 8, and then flows into the liquid pipe 3 and the indoor unit 2.

[0042] The high-pressure two-phase refrigerant having entered the indoor unit 2 flows through the liquid solenoid valve 9, is reduced in pressure by the expansion valve 10, and then enters the indoor heat exchanger 11. The indoor heat exchanger 11 has been heated to a high temperature of 30 degrees C or greater at the point in time when the precooling operation starts, that is, when the defrosting operation ends. Thus, the indoor heat exchanger 11 is cooled by an inflow of the refrigerant gradually to a low temperature. At this time, since the indoor fan 12 is deactivated, the refrigerant does not receive heat from the interior air, but receives heat only from the indoor heat exchanger 11 and evaporates.

[0043] Subsequently, the controller 30 determines whether to end the precooling operation in step S303. For example, in Embodiment 1, when the representative temperature T_{eva} of the indoor heat exchanger 11 becomes below 0 degrees C, the controller 30 ends the precooling operation. In the final stages of this precooling operation, the indoor heat exchanger 11 is cooled to a low temperature, while the outdoor fan 12 is in a deactivated state. Consequently, the refrigerant containing a slight amount of liquid refrigerant flows out of the indoor heat exchanger 11 before evaporating completely.

[0044] Conventionally, a precooling operation is performed with an amount of refrigerant equal to that for a cooling operation. In that case, a large amount of liquid refrigerant that cannot evaporate is accumulated in the accumulator 13. However, in Embodiment 1, a precooling operation is performed with a greater amount of refrigerant stored in the receiver 8, so that the refrigerant is prevented from being accumulated in the accumulator 13. This operational effect prevents the refrigeration cycle apparatus 100 from experiencing a refrigerant shortage when the cooling operation is resumed after the end of precooling operation, and allows the refrigeration cycle apparatus 100 to immediately perform the cooling operation.

[0045] Since liquid refrigerant is prevented from being accumulated in the accumulator 13, the refrigeration cycle apparatus 100 can continue the precooling operation until the indoor heat exchanger 11 is cooled sufficiently to a low temperature. This operational effect prevents high-temperature air from being blown to the interior at the start of cooling

operation. Consequently, the goods stored at a low temperature in the interior can avoid thermal damage.

[0046] Since liquid refrigerant is prevented from overflowing from the accumulator 13 and thus from being suctioned into the compressor 5, the reliability of the refrigeration cycle apparatus can improve and the accumulator 13 can be downsized.

[0047] As described above, the refrigeration cycle apparatus according to Embodiment 1 of the present disclosure operates in such a manner as to store the majority of the refrigerant filling the refrigerant circuit in the receiver 8 during the precooling operation. Thus, even immediately before the end of precooling operation, only a very slight amount of liquid refrigerant flows back to the accumulator 13. This operational effect prevents the refrigeration cycle apparatus 100 from experiencing a refrigerant shortage when the cooling operation is resumed, and allows the refrigeration cycle apparatus 100 to immediately perform the cooling operation.

[0048] The indoor heat exchanger 11 is sufficiently cooled by a precooling operation, which therefore prevents the interior from being supplied with high-temperature air during the subsequent cooling operation, so that a high quality freezer compartment can be provided.

[0049] In a defrosting operation, the indoor heat exchanger 11 can be sufficiently heated up until frost melts completely. This makes it possible to provide a highly-reliable refrigeration cycle apparatus that avoids problems such as deformation or clogging of the indoor heat exchanger 11 due to a rapid growth of frost and water droplets that have not been completely removed by the defrosting operation.

[0050] Since liquid refrigerant is prevented from being accumulated in the accumulator 13, this accumulator 13 can be downsized, and device costs can be reduced accordingly. A large amount of liquid refrigerant is prevented from flowing back to the compressor 5, and consequently the reliability of the compressor 5 improves.

Embodiment 2

[0051] Fig. 7 is a refrigerant circuit configuration diagram illustrating the configuration of a refrigeration cycle apparatus according to Embodiment 2. In Fig. 7, the receiver 8 includes the usual outlet located on the lower side, and in addition, a second outlet 40 located on the upper side. A pipe extending from the second outlet 40 merges with an outlet of the first opening-closing valve 14 via the second opening-closing valve 15.

[0052] This pipe extending from the second outlet 40 has a function of adjusting the refrigerant amount during the precooling operation described above. For example, in a case where the outdoor unit 1 and the indoor unit 2 are installed at a long distance from each other, the liquid pipe 3 needs to be relatively long. For this reason, the refrigerant amount during the precooling operation may be excessive for the configuration of the refrigeration cycle apparatus 100 described above. In a refrigeration cycle apparatus 102, after a precooling operation is started, two-phase refrigerant, having transferred heat in the indoor heat exchanger 6 and containing liquid refrigerant, enters the receiver 8 once. The two-phase refrigerant having entered the receiver 8 is separated into gas and liquid in the receiver 8. While only the gas refrigerant flows out of the second outlet 40, the liquid refrigerant separated from the gas refrigerant stays in the receiver 8. That is, the refrigeration cycle apparatus 102 operates in such a manner as to store refrigerant, having been present at a location other than the receiver 8 at the start of precooling operation, in the receiver 8 during the precooling operation.

[0053] As described above, the refrigeration cycle apparatus according to Embodiment 2 of the present disclosure can reduce the effective refrigerant amount circulating during a precooling operation, compared to that at the start of precooling operation. This can further reduce the amount of liquid refrigerant flowing back to the accumulator 13 during the precooling operation, and can improve the reliability of the refrigeration cycle apparatus 102.

Embodiment 3

[0054] Fig. 8 is a refrigerant circuit configuration diagram illustrating the configuration of a refrigeration cycle apparatus according to Embodiment 3. As illustrated in Fig. 8, a refrigeration cycle apparatus 103 includes a check valve 51 located at an inlet of the receiver 8. The check valve 51 has a function of preventing refrigerant from flowing out of the receiver 8 even when a condensation pressure in the refrigeration cycle is decreased lower than the pressure in the receiver 8 during a precooling operation. With this function, refrigerant stored in the receiver 8 is completely separated from the refrigerant circuit when the first opening-closing valve 14 is closed due to setting the refrigerant circuit to a precooling circuit.

[0055] As described above, the refrigeration cycle apparatus according to Embodiment 3 of the present disclosure prevents refrigerant from flowing out of the receiver 8 during a precooling operation, and can therefore stabilize the precooling operation without an increase or a decrease in the refrigerant amount during the precooling operation.

Embodiment 4

[0056] Fig. 9 is a refrigerant circuit configuration diagram illustrating the configuration of a refrigeration cycle apparatus

according to Embodiment 4. In a refrigeration cycle apparatus 104, a three-way switching valve 52 is located in place of the first opening-closing valve 14 and the second opening-closing valve 15 in the refrigeration cycle apparatus 103 in Embodiment 3 illustrated in Fig. 8.

[0057] Each of the refrigeration cycle apparatus 100, 102, and 103 opens a first opening-closing valve while closing a second opening-closing valve in a cooling operation and a defrosting operation. In a precooling operation, each of the refrigeration cycle apparatus 100, 102, and 103 closes the first opening-closing valve while opening the second opening-closing valve. That is, the first opening-closing valve 14 and the second opening-closing valve 15 are operated such that either one of them is always opened while the other is closed.

[0058] The refrigeration cycle apparatus 104 replaces the two opening-closing valves with a single three-way switching valve 52, and can therefore change the refrigerant circuit to a precooling circuit or a cooling circuit by using only a single switching signal. With this configuration, only a single terminal and a single signal line for the circuit switching signal suffice for a control board.

[0059] As described above, the refrigeration cycle apparatus according to Embodiment 4 of the present disclosure only needs a single switching signal to open or close the valve located on the outlet side of the receiver 8, and can accordingly simplify the configuration of the control board. This can reduce the component costs.

[0060] The configurations described in the foregoing embodiments are examples of the present disclosure. Combining these configurations with other publicly known techniques is possible, and partial omissions and modifications of the configurations are possible without departing from the scope of the present disclosure.

Reference Signs List

[0061]

1: outdoor unit, 2: indoor unit, 3: liquid pipe, 4: gas pipe, 5: compressor,
6: outdoor heat exchanger, 7: outdoor fan, 8: receiver, 9: liquid solenoid valve,
10: expansion valve, 11: indoor heat exchanger, 12: indoor fan, 13: accumulator, 14: first opening-closing valve,
15: second opening-closing valve, 16: bypass circuit, 21: pressure sensor, 22, 23: temperature sensor, 24: defrosting heater, 30: controller, 40: second outlet, 41: hot-gas branch pipe, 42: hot-gas valve, 43: hot-gas pipe, 51: check valve, 52: three-way switching valve, 100, 101, 102, 103, 104: refrigeration cycle apparatus

Claims

1. A refrigeration cycle apparatus comprising:

a refrigerant circuit in which a compressor, a condenser, a receiver, an expansion valve, and an evaporator are connected sequentially, the refrigerant circuit being filled with refrigerant;
a defrosting unit configured to melt frost depositing on the evaporator; and
a control unit configured to select any of a cooling operation, a defrosting operation, or a precooling operation, wherein
in the precooling operation, a predetermined amount of refrigerant is held in the receiver, such that a smaller amount of refrigerant circulates in the refrigerant circuit than in the cooling operation and in the defrosting operation.

2. The refrigeration cycle apparatus of claim 1, wherein the refrigerant circuit includes

a first opening-closing valve provided between the receiver and the expansion valve, and
a second opening-closing valve provided in a bypass circuit branching from between the condenser and the receiver, and merging with a pipe extending between the first opening-closing valve and the expansion valve.

3. The refrigeration cycle apparatus of claim 1, wherein the receiver includes

a first outlet pipe provided on a lower side from which the refrigerant flows out, the first outlet pipe including a first opening-closing valve, and
a second outlet pipe provided on an upper side from which the refrigerant flows out, the second outlet pipe merging with the first outlet pipe through a second opening-closing valve.

4. The refrigeration cycle apparatus of any one of claims 1 to 3, wherein in the precooling operation, the refrigeration

cycle apparatus closes the first opening-closing valve, opens the second opening-closing valve, and operates the compressor with a fan being deactivated.

- 5 **5.** The refrigeration cycle apparatus of any one of claims 1 to 4, wherein the defrosting unit is an electric heater joined to the evaporator.
6. The refrigeration cycle apparatus of any one of claims 1 to 5, wherein the defrosting unit is a hot-gas circuit connecting an outlet of the compressor and an inlet of the evaporator through a defrosting opening-closing valve.
- 10 **7.** The refrigeration cycle apparatus of any one of claims 1 to 6, comprising a third opening-closing valve configured to prevent refrigerant from moving from the receiver to the condenser.

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FIG. 1

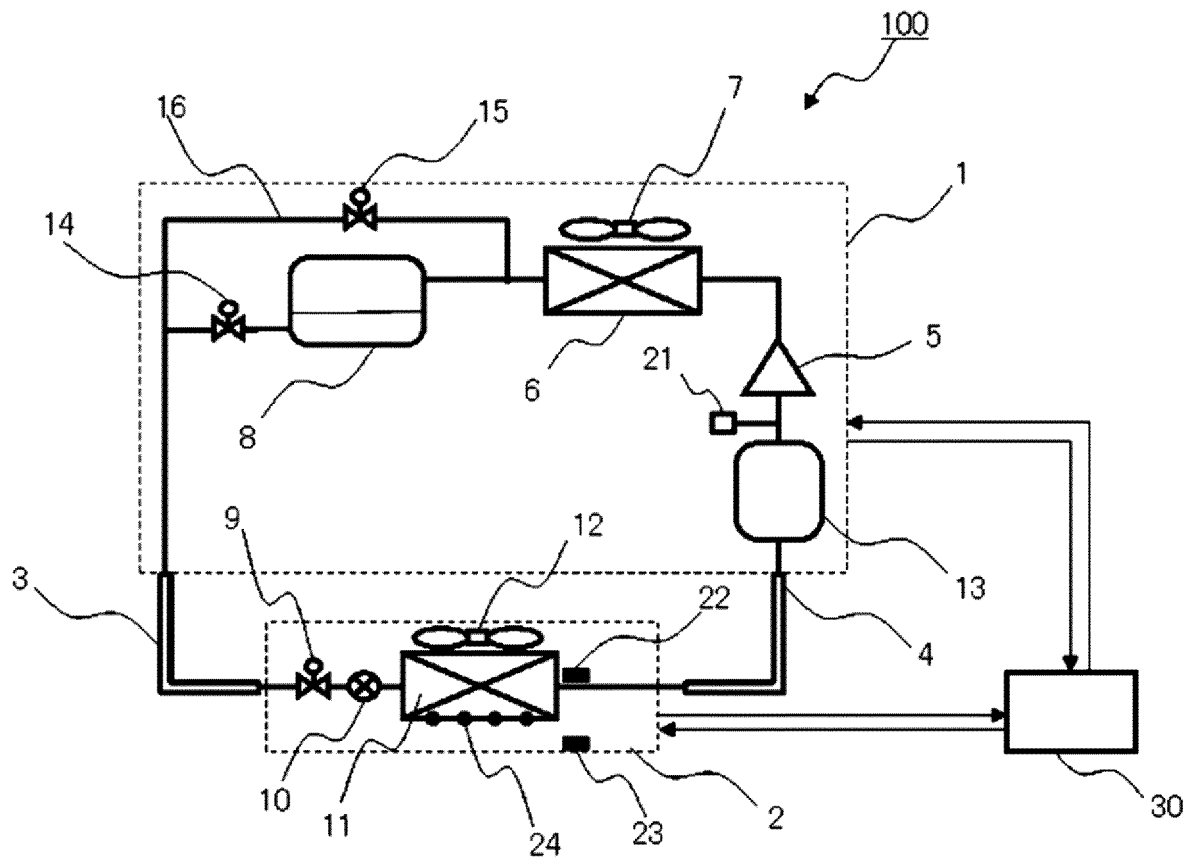


FIG. 2

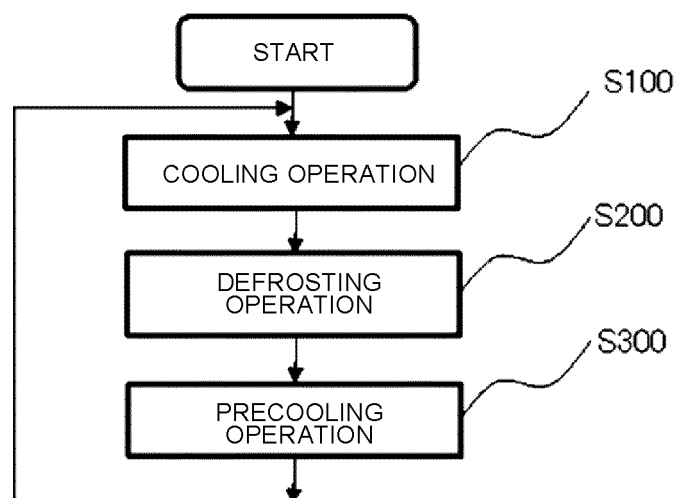


FIG. 3

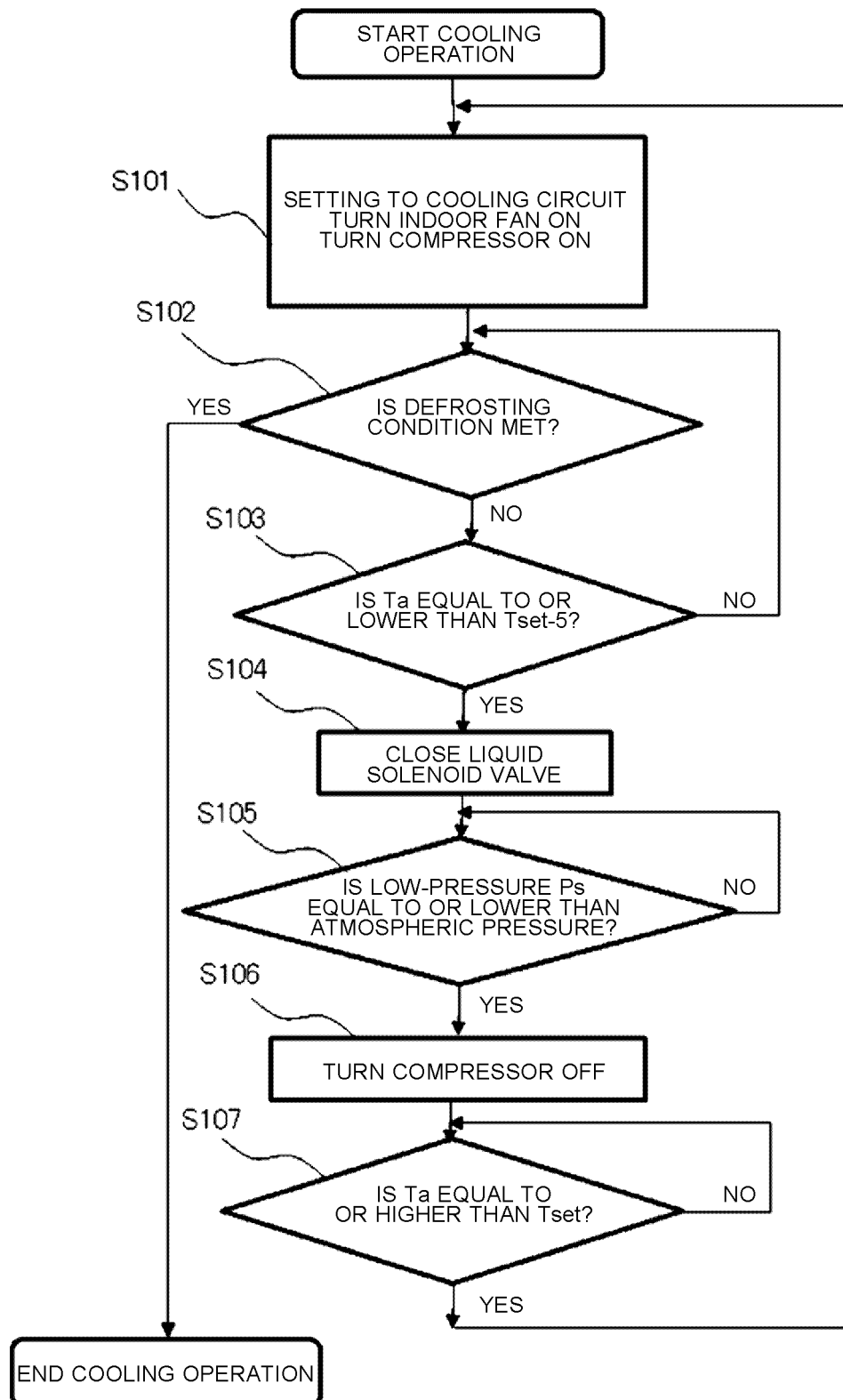


FIG. 4

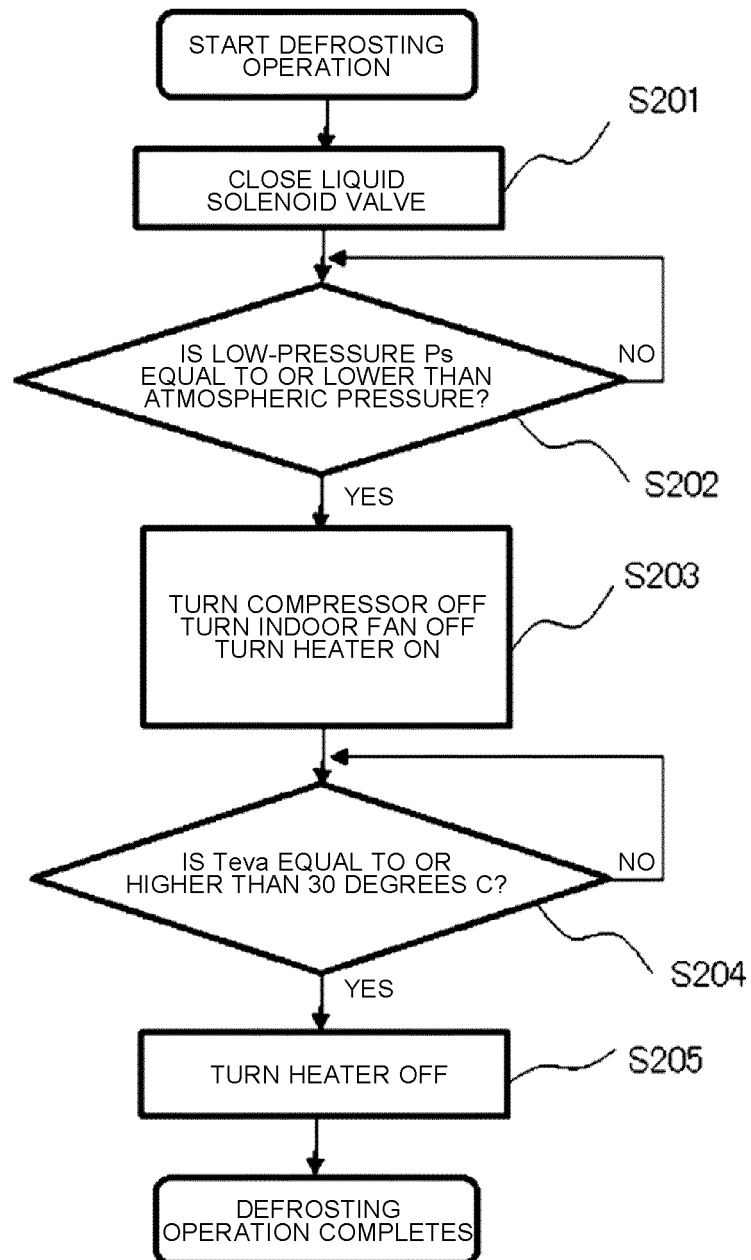


FIG. 5

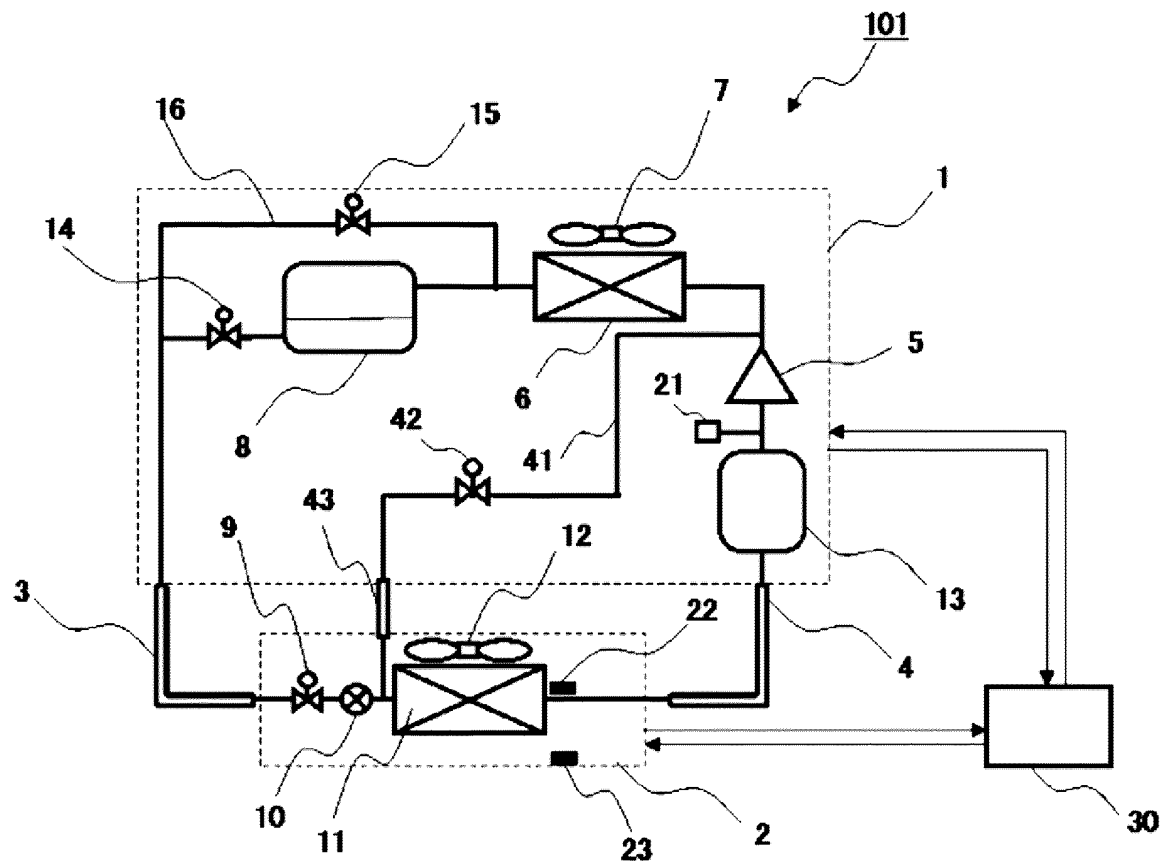


FIG. 6

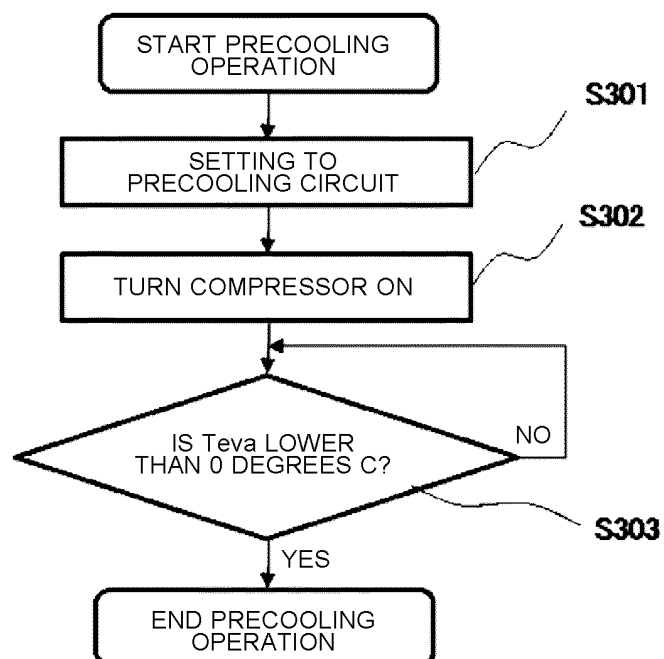


FIG. 7

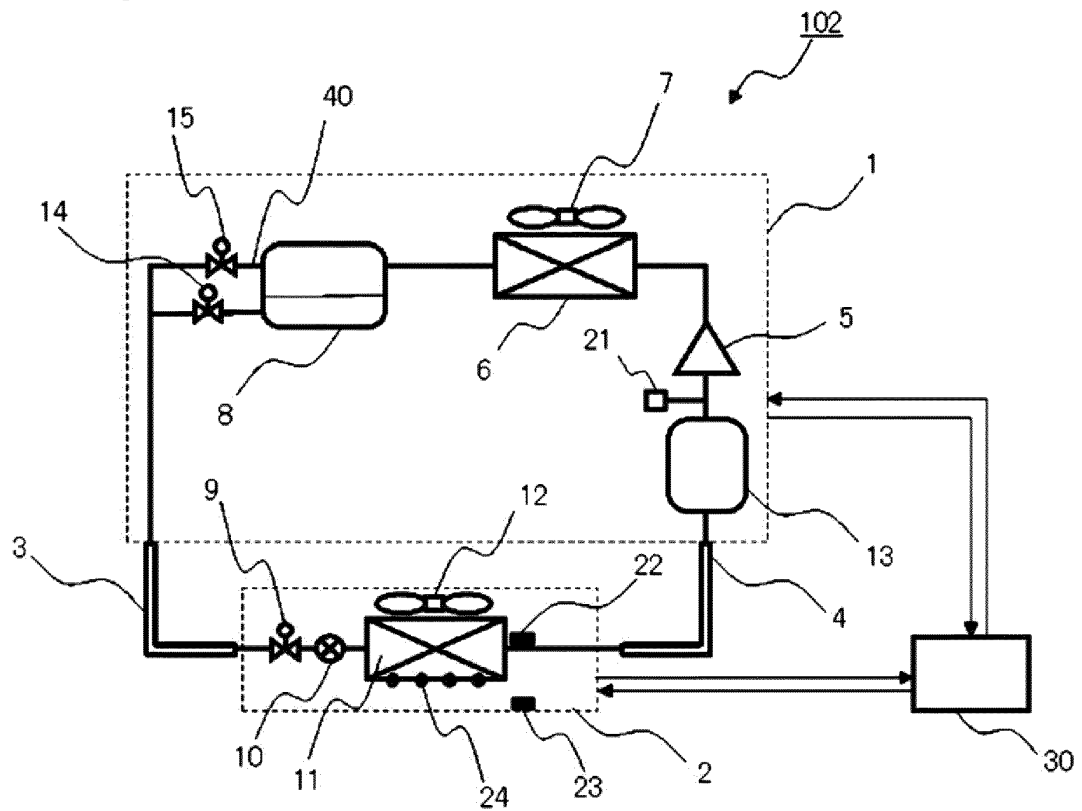


FIG. 8

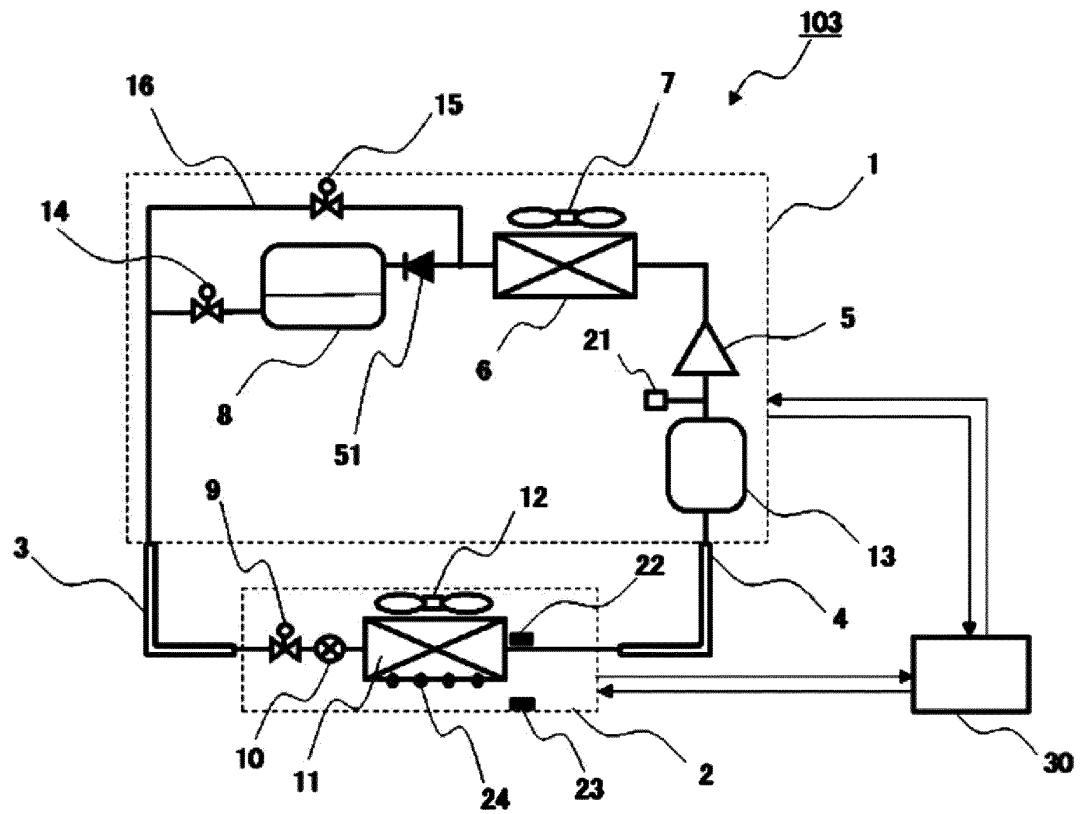
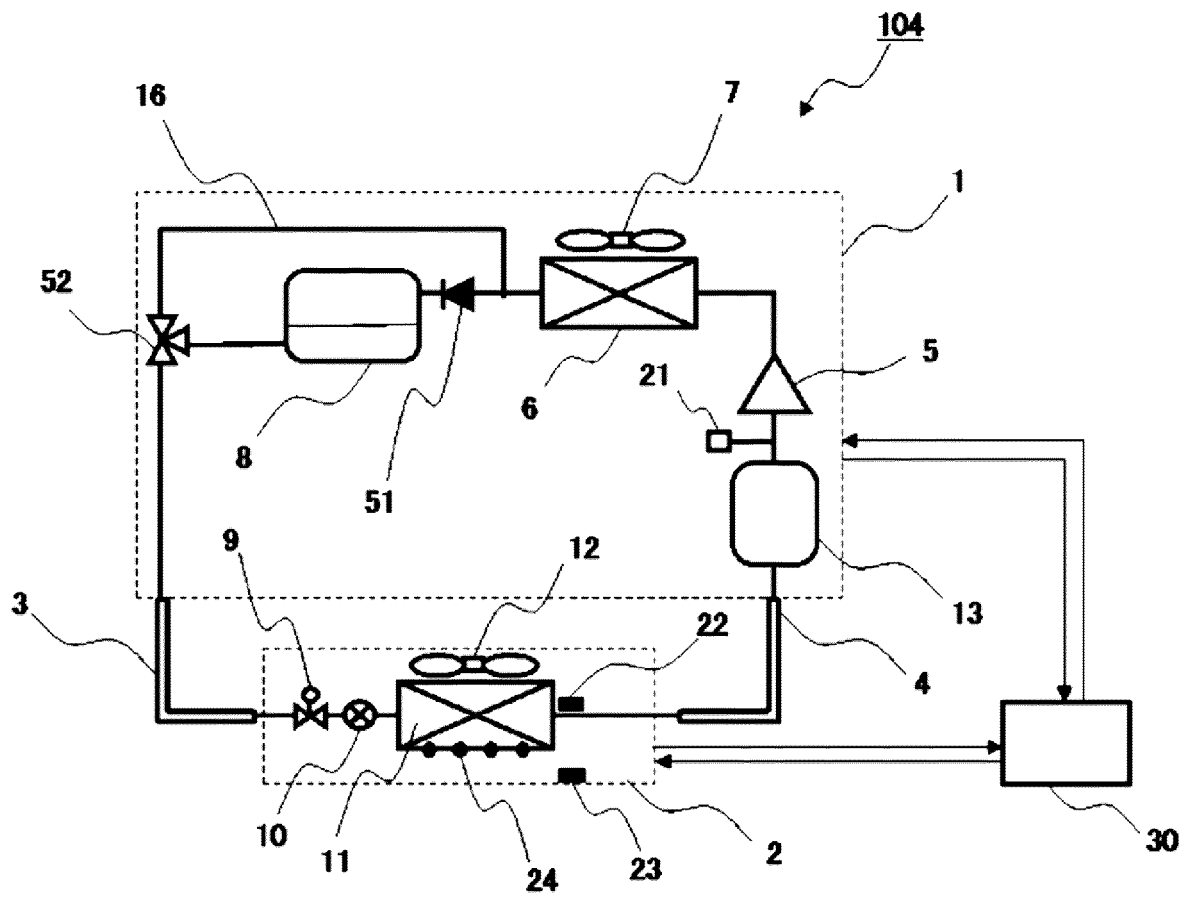


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/006991

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. F25B1/00(2006.01)i
FI: F25B1/00 385Z

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, F25B47/02

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.
A	JP 6-63692 B2 (SANYO ELECTRIC CO., LTD.) 22 August 1994 (1994-08-22), entire text, all drawings	1-7
A	JP 2017-166730 A (DENSO CORP.) 21 September 2017 (2017-09-21), entire text, all drawings	1-7
A	JP 2014-119145 A (SHARP CORP.) 30 June 2014 (2014-06-30), entire text, all drawings	1-7



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search

12.03.2021

Date of mailing of the international search report

13.04.2021

Name and mailing address of the ISA/

Japan Patent Office

3-4-3, Kasumigaseki, Chiyoda-ku,

Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2021/006991

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
JP 6-63692 B2	22.08.1994	(Family: none)	
JP 2017-166730 A	21.09.2017	(Family: none)	
JP 2014-119145 A	30.06.2014	(Family: none)	

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2017166730 A [0004]