



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

(43) Date of publication:
15.01.2020 Bulletin 2020/03

(51) Int Cl.:
F25B 47/02 (2006.01)

(21) Application number: **17899458.8**

(86) International application number:
PCT/JP2017/009793

(22) Date of filing: **10.03.2017**

(87) International publication number:
WO 2018/163422 (13.09.2018 Gazette 2018/37)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(71) Applicant: **Mitsubishi Electric Corporation**
Chiyoda-ku
Tokyo 100-8310 (JP)

(72) Inventors:
• **YANACHI, Satoru**
Tokyo 100-8310 (JP)
• **MINAMISAKO, Hirokazu**
Tokyo 100-8310 (JP)

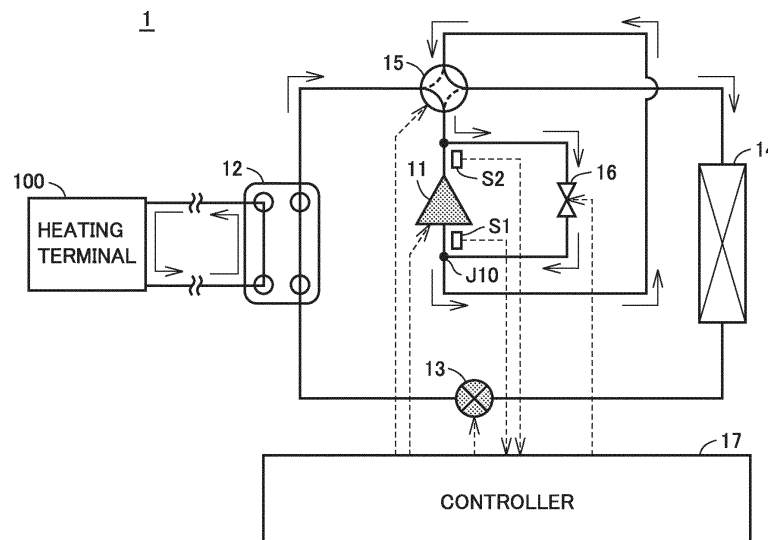
(74) Representative: **Mewburn Ellis LLP**
City Tower
40 Basinghall Street
London EC2V 5DE (GB)

(54) **REFRIGERATION CYCLE DEVICE**

(57) A refrigeration cycle apparatus (1) according to the present invention includes an on-off valve (16) and a controller (17). The on-off valve (16) is connected in parallel with a compressor (11) between a discharge port and a suction port of the compressor (11). The controller (17) controls the on-off valve (16) to be opened and closed, and switches an operation mode. The operation mode includes a heating mode, a defrosting mode, and

a pressure equalization mode. The on-off valve (16) is opened in the pressure equalization mode. In the pressure equalization mode, the on-off valve (16) that is opened is greater in flow path resistance than a four-way valve (15). The controller (17) switches the operation mode in order of the heating mode, the pressure equalization mode, and the defrosting mode.

FIG.4



Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigeration cycle apparatus in which the circulation direction of refrigerant is switched such that a heat exchanger that has been functioning as an evaporator in a heating mode is caused to function as a condenser, thereby defrosting the heat exchanger.

BACKGROUND ART

[0002] Conventionally, there is a known refrigeration cycle apparatus in which the circulation direction of refrigerant is switched such that a heat exchanger that has been functioning as an evaporator in a heating mode is caused to function as a condenser, thereby defrosting the heat exchanger. For example, Japanese Patent Laying-Open No. 2011-174662 (PTL 1) discloses an air heat source heat pump water heater/air-conditioner, in which a pump down operation for collecting refrigerant in a receiver is performed before a refrigerant circuit is switched by a four-way valve from a heating cycle to a cooling cycle, to thereby start a defrosting operation.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: Japanese Patent Laying-Open No. 2011-174662

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] When the circulation direction of refrigerant in a heating mode is switched by a flow path switching device such as a four-way valve in order to start a defrosting mode, the first heat exchanger connected to a discharge port of a compressor and functioning as a condenser in a heating mode is connected to a suction port of the compressor. On the other hand, the second heat exchanger connected to the suction port of the compressor and functioning as an evaporator in the heating mode is connected to the discharge port of the compressor in the defrosting mode. In the heating mode, the first heat exchanger connected to the discharge port (high pressure side) of the compressor is higher in pressure than the second heat exchanger connected to the suction port (low pressure side) of the compressor. Immediately after the circulation direction of the refrigerant is switched by a four-way valve in order to start a defrosting mode, a differential pressure in the heating mode remains between the first heat exchanger and the second heat exchanger. When the defrosting mode is started to cause the compressor to operate in the state where the differential pressure remains,

a large amount of refrigerant may be moved from the first heat exchanger to the second heat exchanger.

[0005] When the amount of refrigerant remaining in the first heat exchanger decreases, the pressure and the temperature in the first heat exchanger decreases. Such a temperature decrease in the first heat exchanger may lead to, for example, dew condensation in the refrigeration cycle apparatus, or damage to a pipe by solidification of a heat medium such as water conveying heat to a heating terminal as a result of heat exchange with refrigerant in the first heat exchanger. Consequently, it may become difficult to stabilize the operation of the refrigeration cycle apparatus.

[0006] The present invention has been made to solve the above-described problems. An object of the present invention is to suppress a temperature decrease at the start of a defrosting mode in a heat exchanger that has been functioning as a condenser in a heating mode.

SOLUTION TO PROBLEM

[0007] A refrigeration cycle apparatus according to the present invention is configured to operate in an operation mode including a heating mode and a defrosting mode. In the heating mode, refrigerant circulates sequentially through a compressor, a flow path switching device, a first heat exchanger, an expansion valve, and a second heat exchanger. In the defrosting mode, the refrigerant circulates sequentially through the compressor, the flow path switching device, the second heat exchanger, the expansion valve, and the first heat exchanger. The refrigeration cycle apparatus includes a flow regulating valve and a controller. The flow regulating valve is connected in parallel with the compressor between a discharge port of the compressor and a suction port of the compressor. The controller is configured to control a degree of opening of the flow regulating valve. The controller is configured to switch the operation mode. The operation mode further includes a pressure equalization mode. In the pressure equalization mode, the flow regulating valve is opened. In the pressure equalization mode, a flow path resistance of the flow regulating valve is greater than a flow path resistance of the flow path switching device. The flow path resistance of the flow regulating valve is in proportion to the degree of opening of the flow regulating valve. The controller is configured to switch the operation mode in order of the heating mode, the pressure equalization mode and the defrosting mode.

ADVANTAGEOUS EFFECTS OF INVENTION

[0008] In the refrigeration cycle apparatus according to the present invention, when the operation mode is switched from the heating mode to the defrosting mode, the operation mode is switched in order of the heating mode, the pressure equalization mode, and the defrosting mode. In the pressure equalization mode, the flow

regulating valve is opened, so that refrigerant on the high pressure side flows through the flow regulating valve to the low voltage side. The differential pressure between the pressure of the refrigerant on the high pressure side and the pressure of the refrigerant on the low voltage side is smaller at the end of the pressure equalization mode (at the start of the defrosting mode) than at the start of the pressure equalization mode (at the end of the heating mode). Furthermore, in the pressure equalization mode, the flow path resistance in proportion to the degree of opening of the flow regulating valve is greater than the flow path resistance of the flow path switching device. Thus, the amount of refrigerant flowing out of the first heat exchanger in the pressure equalization mode can be reduced. In the pressure equalization mode, while reducing the amount of refrigerant flowing out of the first heat exchanger, the differential pressure between the pressure of the refrigerant on the high pressure side and the pressure of the refrigerant on the low pressure side can be set to be smaller at the start of the defrosting mode than at the end of the heating mode. Furthermore, the pressure equalization mode is adopted before the defrosting mode, so that the differential pressure between the pressure of the refrigerant on the high pressure side and the pressure of the refrigerant on the low pressure side is set to be smaller at the start of the defrosting mode than at the end of the heating mode. Thereby, the amount of refrigerant flowing out of the first heat exchanger at the start of the defrosting mode can be reduced. Accordingly, a temperature decrease in the first heat exchanger at the start of the defrosting mode can be suppressed. As a result, the refrigeration cycle apparatus can be stably operated.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

Fig. 1 is a diagram showing the function configuration of a refrigeration cycle apparatus according to the first embodiment, together with the flow of refrigerant in a heating mode.

Fig. 2 is a diagram showing the function configuration of the refrigeration cycle apparatus in Fig. 1, together with the flow of refrigerant in a defrosting mode.

Fig. 3 is a flowchart for illustrating the flow of a process performed by a controller in Fig. 1 when a defrosting start condition is satisfied in the heating mode.

Fig. 4 is a diagram showing the function configuration of the refrigeration cycle apparatus in Fig. 1, together with the flow of refrigerant in a pressure equalization mode.

Fig. 5 is a flowchart illustrating the flow of a process performed by the controller in Fig. 1 in the pressure equalization mode.

Fig. 6 is a flowchart illustrating the flow of a process performed by the controller in Fig. 1 in the defrosting

mode.

Fig. 7 is an enlarged view of a connection portion and therearound shown in Fig. 4, the connection portion being provided between: a flow path connecting a suction port of a compressor and a four-way valve; and a flow path through which refrigerant from an on-off valve flows.

Fig. 8 is a diagram showing the function configuration of a refrigeration cycle apparatus according to the second embodiment, together with the flow of refrigerant at the start of a defrosting mode.

Fig. 9 is a flowchart illustrating the flow of a process performed by a controller in Fig. 8 in the defrosting mode.

Fig. 10 is a flowchart illustrating the flow of a process performed by a controller of a refrigeration cycle apparatus according to the third embodiment when a defrosting start condition is satisfied in a heating mode.

Fig. 11 is a diagram showing the function configuration of the refrigeration cycle apparatus according to the third embodiment, together with the flow of refrigerant in a pump down mode.

Fig. 12 is a flowchart illustrating the flow of a process performed by a controller in Fig. 11 in a pump down mode.

Fig. 13 is a diagram showing the function configuration of a refrigeration cycle apparatus according to the first modification of the third embodiment, together with the flow of refrigerant in the pump down mode.

Fig. 14 is a flowchart illustrating an example of a process performed when the defrosting start condition is satisfied in a refrigeration cycle apparatus according to the second modification of the third embodiment.

Fig. 15 is a flowchart illustrating another example of the process performed when the defrosting start condition is satisfied in the refrigeration cycle apparatus according to the second modification of the third embodiment.

Fig. 16 is a diagram showing the function configuration of a refrigeration cycle apparatus according to the fourth embodiment, together with the flow of refrigerant in a pressure equalization mode.

Fig. 17 is a diagram showing the function configuration of a refrigeration cycle apparatus according to a modification of the fourth embodiment, together with the flow of refrigerant in the pressure equalization mode.

Fig. 18 is a diagram showing the function configuration of a refrigeration cycle apparatus according to the fifth embodiment, together with the flow of refrigerant in the pressure equalization mode.

DESCRIPTION OF EMBODIMENTS

[0010] Embodiments of the present invention will be hereinafter described in detail with reference to the ac-

companying drawings, in which the same or corresponding components will be designated by the same reference characters, and the description thereof will not basically be repeated.

First Embodiment

[0011] Fig. 1 is a diagram showing the function configuration of a refrigeration cycle apparatus 1 according to the first embodiment, together with the flow of refrigerant in a heating mode. The operation mode of refrigeration cycle apparatus 1 includes a heating mode and a defrosting mode. As shown in Fig. 1, refrigeration cycle apparatus 1 includes a compressor 11, a heat exchanger 12, an expansion valve 13, a heat exchanger 14, a four-way valve 15, an on-off valve 16, and a controller 17. In the heating mode, the refrigerant circulates sequentially through compressor 11, four-way valve 15, heat exchanger 12, expansion valve 13, and heat exchanger 14. On-off valve 16 corresponds to a flow regulating valve of the present invention.

[0012] Compressor 11 adiabatically compresses refrigerant of gas (gas refrigerant) of low pressure and discharges gas refrigerant of high pressure.

[0013] In the heating mode, four-way valve 15 serves to connect the discharge port of compressor 11 and heat exchanger 12, and also connect heat exchanger 14 and the suction port of compressor 11. In the heating mode, four-way valve 15 forms a flow path such that the refrigerant circulates sequentially through compressor 11, four-way valve 15, heat exchanger 12, expansion valve 13, and heat exchanger 14.

[0014] Heat exchanger 12 functions as a condenser in the heating mode. The gas refrigerant from compressor 11 emits condensation heat and condenses in heat exchanger 12, and then, turns into refrigerant of liquid (liquid refrigerant). In heat exchanger 12, heat exchange is performed between the refrigerant and a heat medium that conveys heat to a heating terminal 100. Examples of the heat medium may be water or brine (salt water).

[0015] By expansion valve 13, the liquid refrigerant is adiabatically expanded and decompressed, and then, caused to flow out as moist vapor in a gas-liquid two-phase state. As expansion valve 13, an electronic controlled-type expansion valve (linear expansion valve: LEV) can be used, for example.

[0016] Heat exchanger 14 is disposed outdoors and functions as an evaporator in a heating mode. The moist vapor from expansion valve 13 is evaporated as a result of absorption of vaporization heat from the outside air in heat exchanger 14.

[0017] On-off valve 16 is connected in parallel with compressor 11 between the discharge port and the suction port of compressor 11. The flow path resistance of on-off valve 16 is greater than the flow path resistance of four-way valve 15. The flow path resistance of the on-off valve represents a flow path resistance at the time when the on-off valve is opened (the degree of opening

shows the fully-opened state). In other words, when on-off valve 16 is opened, the Cv value of on-off valve 16 is smaller than the Cv value of four-way valve 15. In the heating mode, on-off valve 16 is closed.

[0018] Controller 17 switches the operation mode of refrigeration cycle apparatus 1. Controller 17 controls the driving frequency of compressor 11 to control the amount of refrigerant discharged from compressor 11 per unit time. Controller 17 controls four-way valve 15 to switch the circulation direction of the refrigerant. Controller 17 controls the degree of opening of expansion valve 13. Controller 17 controls on-off valve 16 to be opened and closed. Controller 17 obtains the pressure of the refrigerant at the suction port (suction pressure) of compressor 11 and the pressure of the refrigerant at the discharge port (discharge pressure) of compressor 11 from pressure sensors S1 and S2, respectively. Then, controller 17 calculates the differential pressure between the discharge pressure and the suction pressure.

[0019] In the heating mode, frost may be formed on heat exchanger 14 disposed outdoors and functioning as an evaporator. When frost is formed on heat exchanger 14, the heat exchange efficiency of heat exchanger 14 functioning as an evaporator deteriorates, so that the performance of refrigeration cycle apparatus 1 deteriorates. In refrigeration cycle apparatus 1, when frost is formed on heat exchanger 14, the heating mode is interrupted, and the defrosting mode for removing the frost formed on heat exchanger 14 is started.

[0020] Fig. 2 is a diagram showing the function configuration of refrigeration cycle apparatus 1 in Fig. 1, together with the flow of refrigerant in the defrosting mode. As shown in Fig. 2, in the defrosting mode, four-way valve 15 serves to connect the discharge port of compressor 11 and heat exchanger 14, and also connect heat exchanger 12 and the suction port of compressor 11. In the defrosting mode, four-way valve 15 forms a flow path such that refrigerant circulates sequentially through compressor 11, four-way valve 15, heat exchanger 14, expansion valve 13, and heat exchanger 12. In the defrosting mode, heat exchanger 14 functions as a condenser. In heat exchanger 14, the condensation heat emitted during liquefaction of the refrigerant dissolves the frost formed on heat exchanger 14, thereby removing the frost.

[0021] In the defrosting mode, heat exchanger 12 connected to the high pressure side in the heating mode is connected to the low pressure side. On the other hand, heat exchanger 14 connected to the low pressure side in the heating mode is connected to the high pressure side. In the heating mode, the pressure in heat exchanger 12 connected to the high pressure side is higher than the pressure in heat exchanger 14 connected to the low pressure side. Immediately after the defrosting mode is started, the differential pressure in the heating mode remains between heat exchanger 12 and heat exchanger 14. When the defrosting mode is started to cause compressor 11 to operate in the state where the differential pressure remains, a large amount of refrigerant may be

moved from heat exchanger 12 to heat exchanger 14.

[0022] When the amount of refrigerant remaining in heat exchanger 12 decreases, the pressure and the temperature in heat exchanger 12 decrease. Such a temperature decrease in heat exchanger 12 may lead to, for example, dew condensation in refrigeration cycle apparatus 1, or damage to a pipe by solidification of a heat medium such as water. As a result, it may become difficult to stabilize the operation of refrigeration cycle apparatus 1.

[0023] Thus, in refrigeration cycle apparatus 1, when the defrosting start condition is satisfied in the heating mode, the operation mode is switched in order of the heating mode, the pressure equalization mode, and the defrosting mode. In the pressure equalization mode, on-off valve 16 is opened while maintaining the connected state in the heating mode, so that the differential pressure between the pressure of the refrigerant on the high pressure side and the pressure of the refrigerant on the low pressure side is set to be smaller at the start of the defrosting mode than at the end of the heating mode. Since the flow path resistance of on-off valve 16 is greater than the flow path resistance of four-way valve 15, the amount of refrigerant flowing out of heat exchanger 12 in the pressure equalization mode can be reduced. In the pressure equalization mode, while reducing the amount of refrigerant flowing out of heat exchanger 12, the differential pressure between the pressure on the high pressure side and the pressure on the low pressure side can be set to be smaller at the start of the defrosting mode than at the end of the heating mode. Furthermore, the pressure equalization mode is adopted before the defrosting mode, so that the differential pressure between the pressure of the refrigerant on the high pressure side and the pressure of the refrigerant on the low pressure side is set to be smaller at the start of the defrosting mode than at the end of the heating mode. Thereby, the amount of refrigerant flowing out of heat exchanger 12 at the start of the defrosting mode can be reduced. Accordingly, a temperature decrease in heat exchanger 12 at the start of the defrosting mode can be suppressed. As a result, refrigeration cycle apparatus 1 can be stably operated.

[0024] Fig. 3 is a flowchart illustrating the flow of the process in which controller 17 in Fig. 1 switches the operation mode of refrigeration cycle apparatus 1. In the following, a step will be simply referred to as S. The process shown in Fig. 3 is performed through a main routine (not shown) through which refrigeration cycle apparatus 1 is comprehensively controlled.

[0025] As shown in Fig. 3, controller 17 determines in S10 whether the termination condition for refrigeration cycle apparatus 1 is satisfied or not. The termination condition for refrigeration cycle apparatus 1 may be the condition that the termination operation has been performed by a user, or the condition that the termination time set by the user has arrived. When the termination condition is satisfied (YES in S10), controller 17 returns the process to a main routine. When the termination condition is not

satisfied (NO in S10), controller 17 causes the process to proceed to S20. Controller 17 adopts a heating mode in S20. When the defrosting start condition is satisfied in the heating mode, controller 17 causes the process to proceed to S200. Examples of the defrosting start condition may be the condition that the temperature in heat exchanger 14 is lower than a reference temperature, or the condition that the amount of frost formed (amount of formed frost) on heat exchanger 14 has exceeded a reference amount. The amount of formed frost can be calculated from the temperature in heat exchanger 14 and the humidity around heat exchanger 14.

[0026] After adopting the pressure equalization mode in S200, controller 17 causes the process to proceed to S300. After adopting the defrosting mode in S300, controller 17 returns the process to S10. Controller 17 switches the operation mode in order of the heating mode (S20), the pressure equalization mode (S200), and the defrosting mode (S300).

[0027] Fig. 4 is a diagram showing the function configuration of refrigeration cycle apparatus 1 in Fig. 1, together with the flow of refrigerant in the pressure equalization mode. As shown in Fig. 4, in the pressure equalization mode, controller 17 stops compressor 11, closes expansion valve 13, and opens on-off valve 16. In the pressure equalization mode, four-way valve 15 serves to maintain the connection between the discharge port of compressor 11 and heat exchanger 12 in the heating mode, and also, maintain the connection between heat exchanger 14 and the suction port of compressor 11 in the heating mode. Since expansion valve 13 is closed, the refrigerant is prevented from flowing from heat exchanger 12 with high pressure refrigerant through expansion valve 13 to heat exchanger 14 with low pressure refrigerant.

[0028] Since on-off valve 16 is opened, the refrigerant flows from heat exchanger 12 through on-off valve 16 into heat exchanger 14. The flow path resistance of on-off valve 16 is higher than the flow path resistance of four-way valve 15. Accordingly, the amount of refrigerant flowing out of heat exchanger 12 in the pressure equalization mode is smaller than the amount of refrigerant flowing out of heat exchanger 12 when the defrosting mode is started without adopting the pressure equalization mode. In the pressure equalization mode, while reducing the amount of refrigerant flowing out of heat exchanger 12, the differential pressure between the pressure on the high pressure side and the pressure on the low pressure side can be set to be smaller at the start of the defrosting mode than at the end of the heating mode. As a result, it becomes possible to suppress a temperature decrease in heat exchanger 12 at the start of the defrosting mode adopted after the pressure equalization mode.

[0029] Fig. 5 is a flowchart illustrating the flow of a process performed by controller 17 in Fig. 1 in the pressure equalization mode. The process shown in Fig. 5 is the same as the process performed in S200 in Fig. 3.

[0030] As shown in Fig. 5, controller 17 stops compres-

sor 11 in S201, and then, causes the process to proceed to S202. Controller 17 closes expansion valve 13 in S202, and then, causes the process to proceed to S203. Controller 17 opens on-off valve 16 in S203, and then, causes the process to proceed to S204. In S204, controller 17 determines whether the differential pressure between the discharge pressure and the suction pressure is smaller than a reference differential pressure or not. When the differential pressure between the discharge pressure and the suction pressure is smaller than the reference differential pressure (YES in S204), controller 17 determines that the differential pressure between the pressure of the refrigerant on the high pressure side and the pressure of the refrigerant on the low pressure side is sufficiently decreased. Then, controller 17 returns the process to a main routine. When the differential pressure between the discharge pressure and the suction pressure is equal to or greater than the reference differential pressure (NO in S204), controller 17 causes the process to proceed to S205. In S205, controller 17 determines whether or not the reference time period has elapsed since on-off valve 16 was opened. When the reference time period has elapsed since on-off valve 16 was opened (YES in S205), controller 17 determines that pressure equalization between the refrigerant on the high pressure side and the refrigerant on the low pressure side has been sufficiently achieved. Then, controller 17 returns the process to the main routine. When the reference time period has not elapsed since on-off valve 16 was opened (NO in S205), controller 17 waits for a prescribed time period in S206, and then, returns the process to S204. The reference differential pressure in S204 and the reference time period in S205 can be calculated as appropriate by a real machine experiment or through a simulation.

[0031] Fig. 6 is a flowchart illustrating the flow of the process performed by controller 17 in Fig. 1 in the defrosting mode. The process shown in Fig. 6 is the same as the process performed in S300 in Fig. 3.

[0032] As shown in Fig. 6, controller 17 switches four-way valve 15 in S301, and then, causes the process to proceed to S302. In S302, controller 17 closes on-off valve 16, and then, causes the process to proceed to S303. In S303, controller 17 opens expansion valve 13 to an appropriate degree of opening, and then, causes the process to proceed to S304. In S304, controller 17 starts compressor 11, and then, causes the process to proceed to S305. In S305, controller 17 determines whether a defrosting termination condition is satisfied or not. When the defrosting termination condition is satisfied (YES in S305), controller 17 returns the process to a main routine. When the defrosting termination condition is not satisfied (NO in S305), controller 17 waits for a prescribed time period in S306, and then, returns the process to S305. The defrosting termination condition includes, for example, the condition that the temperature in heat exchanger 14 has become equal to or higher than the reference temperature, or the condition that the reference time period has elapsed since the defrosting mode was

started.

[0033] Again referring to Fig. 4, in refrigeration cycle apparatus 1, heat exchanger 12 is lower in height than four-way valve 15. Furthermore, the height of a connection portion J10 between: the flow path connecting the suction port of compressor 11 and four-way valve 15; and the flow path through which the refrigerant from on-off valve 16 flows is lower than the height of four-way valve 15. Thus, the refrigerant is less likely to flow from heat exchanger 12 to four-way valve 15. Also, the refrigerant is less likely to flow from connection portion J10 to four-way valve 15. As a result, the amount of refrigerant flowing out of heat exchanger 12 in the pressure equalization mode can be further reduced.

[0034] Fig. 7 is an enlarged view of connection portion J10 and therearound shown in Fig. 4, connection portion J10 being provided between: a flow path RP1 connecting the suction port of compressor 11 and four-way valve 15; and a flow path RP2 through which the refrigerant from on-off valve 16 flows. As shown in Fig. 7, in refrigeration cycle apparatus 1, an angle α_1 formed between flow paths RP1 and RP2 is greater than 0 degree and less than 180 degrees. Accordingly, the refrigerant flowing through flow path RP2 collides with the inner wall of flow path RP1 in connection portion J10 between flow paths RP1 and RP2. The refrigerant from on-off valve 16 is less likely to merge into flow path RP1, to thereby decrease the amount of refrigerant per unit time that flows through on-off valve 16 in the pressure equalization mode. As a result, it becomes possible to further reduce the amount of the refrigerant flowing out of heat exchanger 12 in the pressure equalization mode.

[0035] Furthermore, in refrigeration cycle apparatus 1, flow path RP2 is narrower than flow path RP1 as shown in Fig. 7. Specifically, flow path RP1 has a cross section that is orthogonal to the flowing direction of the refrigerant flowing through flow path RP1 and flow path RP2 has a cross section that is orthogonal to the flowing direction of the refrigerant that flows through flow path RP2. The area of the cross section of flow path RP2 through which the refrigerant flows is smaller than the area of the cross section of flow path RP1 through which the refrigerant flows. The amount of refrigerant flowing per unit time through on-off valve 16 in the pressure equalization mode can be reduced as compared with the case where flow path RP2 is equal in thickness to flow path RP1. As a result, the amount of refrigerant flowing out of heat exchanger 12 can be further reduced. Furthermore, the manufacturing cost of refrigeration cycle apparatus 1 can be suppressed as compared with the case where flow path RP2 is equal in thickness to flow path RP1.

[0036] As described above, according to the refrigeration cycle apparatus of the first embodiment, the pressure equalization mode is adopted before the defrosting mode, which can suppress a temperature decrease at the start of the defrosting mode in the heat exchanger that has been functioning as a condenser in the heating mode. As a result, the refrigeration cycle apparatus can

be stably operated.

Second Embodiment

[0037] The first embodiment has been described with regard to the case where the on-off valve that is opened in the pressure equalization mode is closed before the compressor is started in the defrosting mode. The second embodiment will be described below with regard to the case where the on-off valve is closed after the compressor is started in the defrosting mode.

[0038] In the second embodiment, the compressor is operated while the on-off valve is kept opened for a certain time period after the start of the defrosting mode. While the on-off valve is kept opened, a part of the refrigerant that is discharged from the compressor is returned through the on-off valve to the suction port of the compressor. In this case, the refrigerant from the heat exchanger that has been functioning as a condenser in the heating mode is less likely to be suctioned into the compressor by the amount of the refrigerant that has been returned to the suction port of the compressor through the on-off valve. As a result, the amount of refrigerant flowing out of the heat exchanger at the start of the defrosting mode can be further reduced.

[0039] The second embodiment is different in the process flow in the defrosting mode from the first embodiment. Except for the above, the second embodiment is the same as the first embodiment. Specifically, Figs. 2 and 6 of the first embodiment are replaced with Figs. 8 and 9, respectively, of the second embodiment. Since the configurations other than the above are the same, the description thereof will not be repeated.

[0040] Fig. 8 is a diagram showing the function configuration of a refrigeration cycle apparatus 2 according to the second embodiment, together with the flow of refrigerant at the start of the defrosting mode. As shown in Fig. 8, on-off valve 16 is opened at the start of the defrosting mode of refrigeration cycle apparatus 2. While the on-off valve is opened, a part of the refrigerant that has been discharged from compressor 11 is returned through on-off valve 16 into the suction port of compressor 11.

[0041] Fig. 9 is a flowchart illustrating the flow of the process performed by controller 17 in Fig. 8 in the defrosting mode. As shown in Fig. 8, controller 17 switches four-way valve 15 in S311, and then, causes the process to proceed to S312. In S312, controller 17 opens expansion valve 13 to an appropriate degree of opening, and then, causes the process to proceed to S313. In S313, controller 17 starts compressor 11 and causes the process to proceed to S314. In S314, controller 17 determines whether the defrosting termination condition is satisfied or not. When the defrosting termination condition is satisfied (YES in S314), controller 17 causes the process to proceed to S315. In S315, controller 17 determines whether on-off valve 16 is opened or not. When on-off valve 16 is closed (NO in S315), controller 17 returns the process to a main routine. When on-off valve 16 is

opened (YES in S315), controller 17 closes on-off valve 16 in S316, and then, returns the process to a main routine.

[0042] When the defrosting termination condition is not satisfied (NO in S314), controller 17 causes the process to proceed to S317. In S317, controller 17 determines whether the suction pressure exceeds the reference pressure or not. When the suction pressure exceeds the reference pressure (YES in S317), controller 17 determines that the suction pressure has sufficiently increased. Thus, controller 17 closes on-off valve 16 in S319 and waits for a prescribed time period in S320. Then, controller 17 returns the process to S314. When the suction pressure is equal to or less than the reference pressure (NO in S317), controller 17 causes the process to proceed to S318. In S318, controller 17 determines whether the reference time period has elapsed or not since compressor 11 was started. When the reference time period has elapsed since compressor 11 was started (YES in S318), controller 17 determines that a time period sufficient to increase the suction pressure has elapsed. Thus, controller 17 closes on-off valve 16 in S319. Then, after controller 17 waits for a prescribed time period in S320, it returns the process to S314. When the reference time period has not elapsed since compressor 11 was started (NO in S318), the controller returns the process to S314. The reference pressure in S317 and the reference time period in S318 can be calculated as appropriate by a real machine experiment or through a simulation.

[0043] As described above, also in the refrigeration cycle apparatus according to the second embodiment, the pressure equalization mode is adopted before the defrosting mode, which can suppress a temperature decrease at the start of the defrosting mode in the heat exchanger that has been functioning as a condenser in the heating mode. As a result, the refrigeration cycle apparatus can be stably operated.

[0044] In the second embodiment, the compressor is operated while the on-off valve is kept opened for a certain time period after the start of the defrosting mode. Thereby, it becomes possible to further suppress a temperature decrease at the start of the defrosting mode in the heat exchanger that has been functioning as a condenser in the heating mode. As a result, the refrigeration cycle apparatus can be further stably operated.

Third Embodiment

[0045] The first embodiment has been described with regard to the case where the pressure equalization mode is adopted after the heating mode when the defrosting start condition is satisfied. The third embodiment will be hereinafter described with regard to the case where, when the defrosting start condition is satisfied, the heating mode is adopted, which is followed by the pump down mode, which is followed by the pressure equalization mode. In the pump down mode, the amount of refrigerant inside the heat exchanger that has been functioning as

a condenser in the heating mode is increased. The pump down mode is adopted before the pressure equalization mode, so that the amount of refrigerant inside the heat exchanger at the start of the pressure equalization mode becomes greater than that in the first embodiment. Thus, it becomes possible to further suppress a temperature decrease at the start of the defrosting mode in the heat exchanger. As a result, the refrigeration cycle apparatus can be further stably operated.

[0046] The third embodiment is different from the first embodiment in that a pump down mode is added to the operation mode. In other words, Fig. 3 in the first embodiment is replaced with Fig. 10 in the second embodiment. Since the features other than the above are the same, the description thereof will not be repeated.

[0047] Fig. 10 is a flowchart illustrating the flow of the process in which a controller of a refrigeration cycle apparatus according to the third embodiment switches the operation mode of the refrigeration cycle apparatus. As shown in Fig. 10, when the defrosting start condition is satisfied in the heating mode (S20), the controller adopts the pump down mode in S100. Then, in the same manner as in the first embodiment, the controller adopts the pressure equalization mode in S200, and adopts the defrosting mode in S300. When the defrosting start condition is satisfied, the controller switches the operation mode in order of the heating mode, the pump down mode, the pressure equalization mode, and the defrosting mode.

[0048] Fig. 11 is a diagram showing the function configuration of a refrigeration cycle apparatus 3 according to the third embodiment, together with the flow of refrigerant in the pump down mode. As shown in Fig. 11, in the pump down mode, controller 17 causes compressor 11 to operate, closes expansion valve 13, and closes on-off valve 16. In the pump down mode, four-way valve 15 serves to maintain the connection between the discharge port of compressor 11 and heat exchanger 12, and also maintain the connection between heat exchanger 14 and the suction port of compressor 11. Since compressor 11 is operated while expansion valve 13 is closed, the refrigerant discharged from compressor 11 is stored in heat exchanger 12. While the pump down mode is adopted, the amount of refrigerant inside heat exchanger 12 increases. The amount of refrigerant inside heat exchanger 12 at the start of the pressure equalization mode is greater than that in the first embodiment in which the pump down mode is not adopted. At the start of the defrosting mode adopted after the pressure equalization mode, the amount of refrigerant remaining inside heat exchanger 12 is greater than that in the first embodiment. Accordingly, a temperature decrease in heat exchanger 12 can be suppressed as compared with the first embodiment.

[0049] Fig. 12 is a flowchart illustrating the flow of the process performed by controller 17 in Fig. 11 in the pump down mode. The process shown in Fig. 12 is the same as the process performed in S100 in Fig. 10.

[0050] As shown in Fig. 12, controller 17 closes expansion valve 13 in S101, and then, causes the process to

proceed to S102. Controller 17 determines in S102 whether the suction pressure is smaller than the reference pressure or not. When the suction pressure is smaller than the reference pressure (YES in S102), controller 17 determines that the amount of refrigerant suctioned into compressor 11 has decreased due to a sufficient amount of refrigerant stored in heat exchanger 12, and then, returns the process to a main routine. When the suction pressure is equal to or greater than the reference pressure (NO in S102), controller 17 causes the process to proceed to S103. In S103, controller 17 determines whether the reference time period has elapsed or not since expansion valve 13 was closed. When the reference time period has elapsed since expansion valve 13 was closed (YES in S103), controller 17 determines that a time period sufficient to increase the amount of refrigerant inside heat exchanger 12 has elapsed, and then, returns the process to a main routine. When the reference time period has not elapsed since expansion valve 13 was closed (NO in S103), controller 17 waits for a prescribed time period in S104, and then, returns the process to S102.

First Modification of Third Embodiment

[0051] There is a conceivable situation in which the amount of refrigerant that flows into heat exchanger 12 in the pump down mode exceeds the capacity of heat exchanger 12. In preparation for such a situation, it is desirable that a refrigerant storage portion 30 is connected between heat exchanger 12 and expansion valve 13, as in a refrigeration cycle apparatus 3A shown in Fig. 13. When the amount of refrigerant flowing into heat exchanger 12 exceeds the capacity of heat exchanger 12, the refrigerant that has flowed out of heat exchanger 12 is stored in refrigerant storage portion 30. Thus, the amount of refrigerant existing on the high pressure side at the end of the pump down mode can be greater than that in the third embodiment. As a result, a temperature decrease at the start of the defrosting mode in heat exchanger 12 can be further suppressed.

Second Modification of Third Embodiment

[0052] As the amount of the frost formed (amount of formed frost) on the heat exchanger that has been functioning as an evaporator in the heating mode is increased, the heat capacity of the heat exchanger in the defrosting mode is increased. As the heat capacity of the heat exchanger that is to be defrosted is increased, the amount of the refrigerant that flows into the heat exchanger at the start of the defrosting mode is increased. Thus, as the amount of formed frost is increased, the amount of refrigerant flowing out, at the start of the defrosting mode, from the heat exchanger that has been functioning as a condenser in the heating mode is increased. In contrast, when the amount of formed frost is relatively small, the amount of refrigerant flowing out, at the start of the de-

frosting mode, from the heat exchanger that has been functioning as a condenser in the heating mode is decreased. When the amount of formed frost is relatively small, it is desirable to shorten the time period of the pump down mode in order to shorten the downtime of the heating mode. For example, as in the process shown in Fig. 14, when the amount of formed frost is smaller than the reference amount (YES in S30), the reference time period in S103 in Fig. 12 may be shortened by a prescribed proportion (S40). By performing the process as shown in Fig. 14, the time period of the pump down mode (S200) can be shortened. Since the time period from when the defrosting start condition is satisfied until when the defrosting mode ends can be shortened, the downtime of the heating mode can be shortened.

[0053] Alternatively, it may be determined depending on the amount of formed frost whether to adopt the pump down mode or not. For example, as in the process shown in Fig. 15, when the amount of formed frost is smaller than the reference amount (YES in S30), the pressure equalization mode (S200) may be adopted without adopting the pump down mode. By performing the process as shown in Fig. 15, an unnecessary pump down mode can be avoided. As a result, the downtime of the heating mode can be shortened.

[0054] As described above, also in the refrigeration cycle apparatus according to each of the third embodiment, the first modification and the second modification, by adopting a pressure equalization mode before a defrosting mode, it becomes possible to suppress a temperature decrease in the heat exchanger that has been functioning as a condenser in the heating mode at the start of the defrosting mode. As a result, the refrigeration cycle apparatus can be stably operated.

[0055] In the refrigeration cycle apparatus according to each of the third embodiment, the first modification and the second modification, by adopting the pump down mode before the pressure equalization mode, the amount of refrigerant inside the heat exchanger that has been functioning as a condenser in the heating mode is increased before the pressure equalization mode is adopted. Thus, a temperature decrease at the start of the defrosting mode in the heat exchanger can be further suppressed. As a result, the refrigeration cycle apparatus can be further stably operated.

Fourth Embodiment

[0056] There may be some flow path switching devices such as a four-way valve that cannot switch the connection state of the refrigeration cycle apparatus unless the differential pressure between the pressure of the refrigerant on the high pressure side and the pressure of the refrigerant on the low pressure side is equal to or greater than the reference differential pressure. The fourth embodiment will be described below with regard to the case where the differential pressure is maintained to be equal to or greater than the reference differential pressure in

order to ensure the operation of the flow path switching device.

[0057] The fourth embodiment is different from the first embodiment in the following points. Specifically, in the fourth embodiment, the four-way valve can be operated when the differential pressure between the pressure of the refrigerant on the high pressure side and the pressure of the refrigerant on the low pressure side is equal to or greater than the reference differential pressure, and also, a differential pressure regulating valve for maintaining the differential pressure to be equal to or greater than the reference differential pressure is provided. Since the configurations other than the above are the same, the description thereof will not be repeated.

[0058] Fig. 16 is a diagram showing the function configuration of a refrigeration cycle apparatus 4 according to the fourth embodiment, together with the flow of refrigerant in the pressure equalization mode. As shown in Fig. 16, in refrigeration cycle apparatus 4, four-way valve 15 of refrigeration cycle apparatus 1 shown in Fig. 4 is replaced with a four-way valve 154. Four-way valve 154 can be operated when the differential pressure between the pressure of the refrigerant on the high pressure side and the pressure of the refrigerant on the low pressure side is equal to or greater than the reference differential pressure. Also, refrigeration cycle apparatus 4 further includes a differential pressure regulating valve 40 in addition to the configuration of refrigeration cycle apparatus 1 shown in Fig. 4. Differential pressure regulating valve 40 is connected in series to on-off valve 16 between the discharge port and the suction port of compressor 11. Differential pressure regulating valve 40 serves as a mechanical valve for maintaining the pressure difference between both ends of differential pressure regulating valve 40 to be equal to or greater than the reference differential pressure.

[0059] In refrigeration cycle apparatus 4, the differential pressure between the pressure of the refrigerant on the high pressure side and the pressure of the refrigerant on the low pressure side is maintained by differential pressure regulating valve 40 to be equal to or greater than the reference differential pressure. Thus, it becomes possible to prevent occurrence of the situation where four-way valve 154 is not operated because the differential pressure is smaller than the reference differential pressure.

Modification of Fourth Embodiment

[0060] The configuration capable of setting the differential pressure between the pressure of the refrigerant on the high pressure side and the pressure of the refrigerant on the low pressure side to be equal to or greater than the reference differential pressure is not limited to a differential pressure regulating valve. For example, as in refrigeration cycle apparatus 4A shown in Fig. 17, a valve 41 for which the degree of opening can be adjusted in a stepwise manner in its opened state may be em-

played in place of on-off valve 16. Thereby, the degree of opening of valve 41 may be adjusted by controller 17 such that the differential pressure between the pressure of the refrigerant on the high pressure side and the pressure of the refrigerant on the low pressure side becomes equal to or greater than the reference differential pressure.

[0061] As described above, also in the refrigeration cycle apparatus according to each of the fourth embodiment and the modification, by adopting the pressure equalization mode before the defrosting mode, it becomes possible to suppress a temperature decrease in the heat exchanger that has been functioning as a condenser in the heating mode at the start of the defrosting mode. As a result, the refrigeration cycle apparatus can be stably operated.

[0062] According to the refrigeration cycle apparatus of each of the fourth embodiment and the modification, it becomes possible to prevent occurrence of the situation where the flow path switching device cannot be operated because the differential pressure between the pressure of the refrigerant on the high pressure side and the pressure of the refrigerant on the low pressure side is smaller than the reference differential pressure. As a result, the refrigeration cycle apparatus can be further stably operated.

Fifth Embodiment

[0063] The fifth embodiment will be hereinafter described with regard to the case where a gas-liquid separator is connected between the on-off valve and the suction port of the compressor. The refrigerant flowing out, in the pressure equalization mode, from the heat exchanger that has been functioning as a condenser in the heating mode is stored in the gas-liquid separator in the pressure equalization mode. At the start of the defrosting mode, the refrigerant from the gas-liquid separator is also supplied in addition to the refrigerant from the heat exchanger that has been functioning as a condenser in the heating mode. Thus, the amount of the refrigerant flowing out of the heat exchanger at the start of the defrosting mode can be reduced as compared with that in the first embodiment.

[0064] Even when the flow path resistance of the on-off valve is set to be smaller than that in the first embodiment to thereby increase the amount of refrigerant flowing out of the heat exchanger that has been functioning as a condenser in the heating mode, the refrigerant from the heat exchanger is stored in the gas-liquid separator in the pressure equalization mode. Since the refrigerant from the gas-liquid separator is also added to the refrigerant suctioned into the compressor at the start of the defrosting mode, a temperature decrease in the heat exchanger that has been functioning as a condenser in the heating mode can be suppressed to the same degree as that in the first embodiment. As the flow path resistance of the on-off valve is set to be smaller than that in the first

embodiment, the time period required for the pressure equalization mode can be shorter than that in the first embodiment. As a result, the downtime of the heating operation can be shortened.

[0065] Fig. 18 is a diagram showing the function configuration of a refrigeration cycle apparatus 5 according to the fifth embodiment, together with the flow of refrigerant in the pressure equalization mode. As shown in Fig. 18, refrigeration cycle apparatus 5 includes an on-off valve 165 in place of on-off valve 16 of refrigeration cycle apparatus 1 shown in Fig. 4. In the state where on-off valve 165 is opened, the flow path resistance of on-off valve 165 is greater than the flow path resistance of four-way valve 15 and smaller than the flow path resistance of on-off valve 16 in the state where on-off valve 16 is opened. Also, refrigeration cycle apparatus 5 further includes a gas-liquid separator 50 in addition to the configuration of refrigeration cycle apparatus 1 shown in Fig. 4. Gas-liquid separator 50 is connected between on-off valve 16 and the suction port of compressor 11. Gas-liquid separator 50 includes a discharge port LS1 through which the stored liquid refrigerant is discharged. Discharge port LS1 is connected to a junction point J2 of the flow path that connects the suction port of compressor 11 and four-way valve 15. Discharge port LS1 is located lower in height than junction point J2.

[0066] The refrigerant that has flowed out of heat exchanger 12 in the pressure equalization mode passes through on-off valve 16, and after that, the refrigerant is stored in gas-liquid separator 50. The liquid refrigerant stored in gas-liquid separator 50 is discharged through discharge port LS1 and merges at junction point J2 into the refrigerant that flows toward heat exchanger 14.

[0067] In the pressure equalization mode, the refrigerant from heat exchanger 12 passes through on-off valve 16, and then, the refrigerant is stored in gas-liquid separator 50. At the start of the defrosting mode, the refrigerant from gas-liquid separator 50 is also supplied in addition to the refrigerant from heat exchanger 12. Accordingly, the amount of the refrigerant flowing out of heat exchanger 12 at the start of the defrosting mode can be reduced. Furthermore, since the flow path resistance of on-off valve 165 is smaller than the flow path resistance of on-off valve 16 in the first embodiment, the time period required for the pressure equalization mode can be shorter than that in the first embodiment. Furthermore, since discharge port LS1 is located lower in height than junction point J2, the amount of refrigerant discharged from gas-liquid separator 50 can be reduced. As a result, the amount of refrigerant that flows from the high pressure side toward the low pressure side can be further reduced.

[0068] As described above, also in the refrigeration cycle apparatus according to the fifth embodiment, by adopting the pressure equalization mode before the defrosting mode, it becomes possible to suppress a temperature decrease at the start of the defrosting mode in the heat exchanger that has been functioning as a condenser in the heating mode. As a result, the refrigeration

cycle apparatus can be stably operated.

[0069] In the refrigeration cycle apparatus according to the fifth embodiment, the refrigerant from the heat exchanger that has been functioning as a condenser in the heating mode is stored in the gas-liquid separator, so that it becomes possible to reduce the amount of the refrigerant flowing out, at the start of the defrosting mode, from the heat exchanger that has been functioning as a condenser in the heating mode. Furthermore, since the flow path resistance of the on-off valve can be set to be smaller than that in the first embodiment, the time period required for the pressure equalization mode can be shorter than that in the first embodiment.

[0070] The embodiments disclosed herein are also intended to be implemented in combination as appropriate within a consistent scope. It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The scope of the present invention is defined by the terms of the claims, rather than the description above, and is intended to include any modifications within the meaning and scope equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0071] 1, 2, 3A, 4, 4A, 5 refrigeration cycle apparatus, 11 compressor, 12, 14 heat exchanger, 13 expansion valve, 15, 154 four-way valve, 16, 165 on-off valve, 17 controller, 30 refrigerant storage portion, 40 differential pressure regulating valve, 41 valve, 50 gas-liquid separator, 100 heating terminal, LS1 discharge port, RP1, RP2 flow path, S1, S2 pressure sensor.

Claims

1. A refrigeration cycle apparatus configured to operate in an operation mode including a heating mode and a defrosting mode,
in the heating mode, refrigerant circulating sequentially through a compressor, a flow path switching device, a first heat exchanger, an expansion valve, and a second heat exchanger, and
in the defrosting mode, the refrigerant circulating sequentially through the compressor, the flow path switching device, the second heat exchanger, the expansion valve, and the first heat exchanger,
the refrigeration cycle apparatus comprising:

a flow regulating valve connected in parallel with the compressor between a discharge port of the compressor and a suction port of the compressor; and

a controller configured to control a degree of opening of the flow regulating valve and switch the operation mode, wherein

the operation mode further includes a pressure

equalization mode,

in the pressure equalization mode,

the flow regulating valve is opened, and
a flow path resistance of the flow regulating valve is greater than a flow path resistance of the flow path switching device, the flow path resistance of the flow regulating valve being in proportion to the degree of opening, and

the controller is configured to switch the operation mode in order of the heating mode, the pressure equalization mode and the defrosting mode.

2. The refrigeration cycle apparatus according to claim 1, wherein
the flow path switching device is configured to switch a connection state of the refrigeration cycle apparatus between a first connection state and a second connection state, and
the controller is configured to

in the heating mode, set the connection state to the first connection state, cause the compressor to operate, open the expansion valve, and close the flow regulating valve,

in the pressure equalization mode, maintain the connection state at the first connection state, stop the compressor, close the expansion valve, and increase the degree of opening, and
in the defrosting mode, set the connection state to the second connection state, cause the compressor to operate, open the expansion valve, and close the flow regulating valve.

3. The refrigeration cycle apparatus according to claim 2, wherein the controller is configured to close the flow regulating valve before start of the compressor in the defrosting mode.

4. The refrigeration cycle apparatus according to claim 2, wherein the controller is configured to close the flow regulating valve after start of the compressor in the defrosting mode.

5. The refrigeration cycle apparatus according to any one of claims 2 to 4, wherein
the operation mode further includes a pump down mode in which an amount of the refrigerant inside the first heat exchanger is increased, and
the controller is configured to

switch the operation mode in order of the heating mode, the pump down mode, the pressure equalization mode, and the defrosting mode, and

in the pump down mode, maintain the connection state at the first connection state, cause the

- compressor to operate, close the expansion valve, and close the flow regulating valve.
6. The refrigeration cycle apparatus according to claim 5, wherein the controller is configured to adjust an operation time of the pump down mode in accordance with an amount of formed frost on the second heat exchanger in the heating mode. 5
 7. The refrigeration cycle apparatus according to any one of claims 2 to 4, wherein the operation mode further includes a pump down mode in which an amount of the refrigerant inside the first heat exchanger is increased, and the controller is configured to 10

switch the operation mode in order of the heating mode, the pump down mode, the pressure equalization mode, and the defrosting mode when an amount of formed frost on the second heat exchanger in the heating mode is greater than a reference amount, 20

switch the operation mode in order of the heating mode, the pressure equalization mode and the defrosting mode when the amount of formed frost in the heating mode is smaller than the reference amount, and 25

in the pump down mode, maintain the connection state at the first connection state, cause the compressor to operate, close the expansion valve, and close the flow regulating valve. 30
 8. The refrigeration cycle apparatus according to any one of claims 5 to 7, further comprising a refrigerant storage portion connected between the first heat exchanger and the expansion valve. 35
 9. The refrigeration cycle apparatus according to any one of claims 2 to 8, wherein the flow path switching device is capable of switching the connection state when a differential pressure between a pressure of the refrigerant from the discharge port to the expansion valve and a pressure of the refrigerant from the expansion valve to the suction port is equal to or greater than a reference differential pressure, 40

the refrigeration cycle apparatus further comprises a differential pressure regulating valve connected in series to the flow regulating valve between the discharge port and the suction port, and 45

the differential pressure regulating valve is configured to maintain the differential pressure to be equal to or greater than the reference differential pressure. 50
 10. The refrigeration cycle apparatus according to any one of claims 2 to 8, wherein the flow path switching device is capable of switching the connection state when a differential pressure be- 55

tween a pressure of the refrigerant from the discharge port to the expansion valve and a pressure of the refrigerant from the expansion valve to the suction port is equal to or greater than a reference differential pressure, and 60

the controller is configured to adjust the degree of opening such that the differential pressure is equal to or greater than the reference differential pressure in the pressure equalization mode. 65
 11. The refrigeration cycle apparatus according to any one of claims 1 to 10, further comprising a gas-liquid separator connected between the flow regulating valve and the suction port, wherein the gas-liquid separator has a liquid discharge port through which a liquid of the refrigerant stored is discharged, and the liquid discharge port is connected to a flow path that connects the suction port and the flow path switching device. 70
 12. The refrigeration cycle apparatus according to claim 11, wherein the liquid discharge port is lower in height than a junction point at which the liquid from the liquid discharge port merges into the flow path. 75
 13. The refrigeration cycle apparatus according to claim 1, wherein the first heat exchanger is lower in height than the flow path switching device, a connection portion between a first flow path and a second flow path is lower in height than the flow path switching device, the first flow path connects the suction port and the flow path switching device, and the second flow path is connected to the first flow path and allows the refrigerant from the flow regulating valve to flow therethrough. 80
 14. The refrigeration cycle apparatus according to claim 1, wherein an angle formed between a first flow path and a second flow path is greater than 0 degree and less than 180 degrees in a connection portion between the first flow path and the second flow path, the first flow path connects the suction port and the flow path switching device, and the second flow path is connected to the first flow path and allows the refrigerant from the flow regulating valve to flow therethrough. 85
 15. The refrigeration cycle apparatus according to claim 1, wherein a first flow path has a cross section that is orthogonal to a flowing direction of the refrigerant that flows through the first flow path connected to the flow regulating valve, a second flow path has a cross section that is or- 90

thogonal to a flowing direction of the refrigerant that flows through the second flow path connected to the suction port, and

an area of the cross section of the first flow path through which the refrigerant flows is smaller than an area of the cross section of the second flow path through which the refrigerant flows.

10

15

20

25

30

35

40

45

50

55

FIG.1

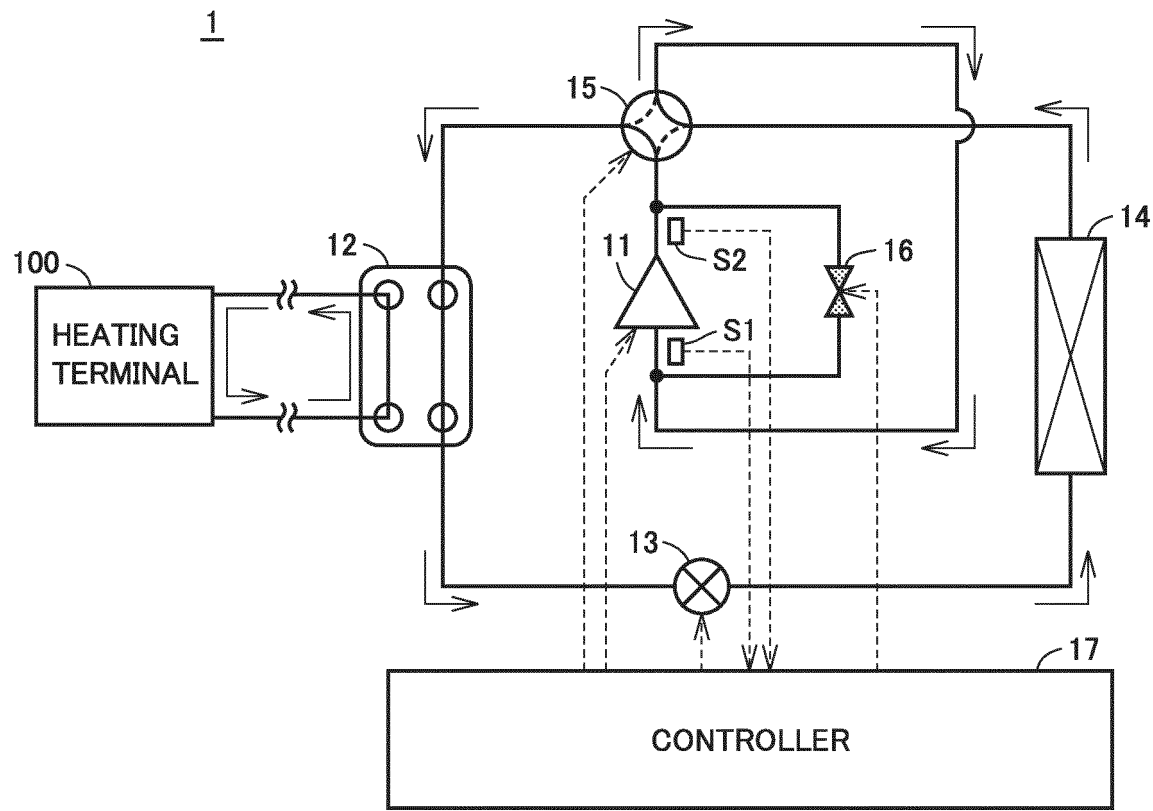


FIG.2

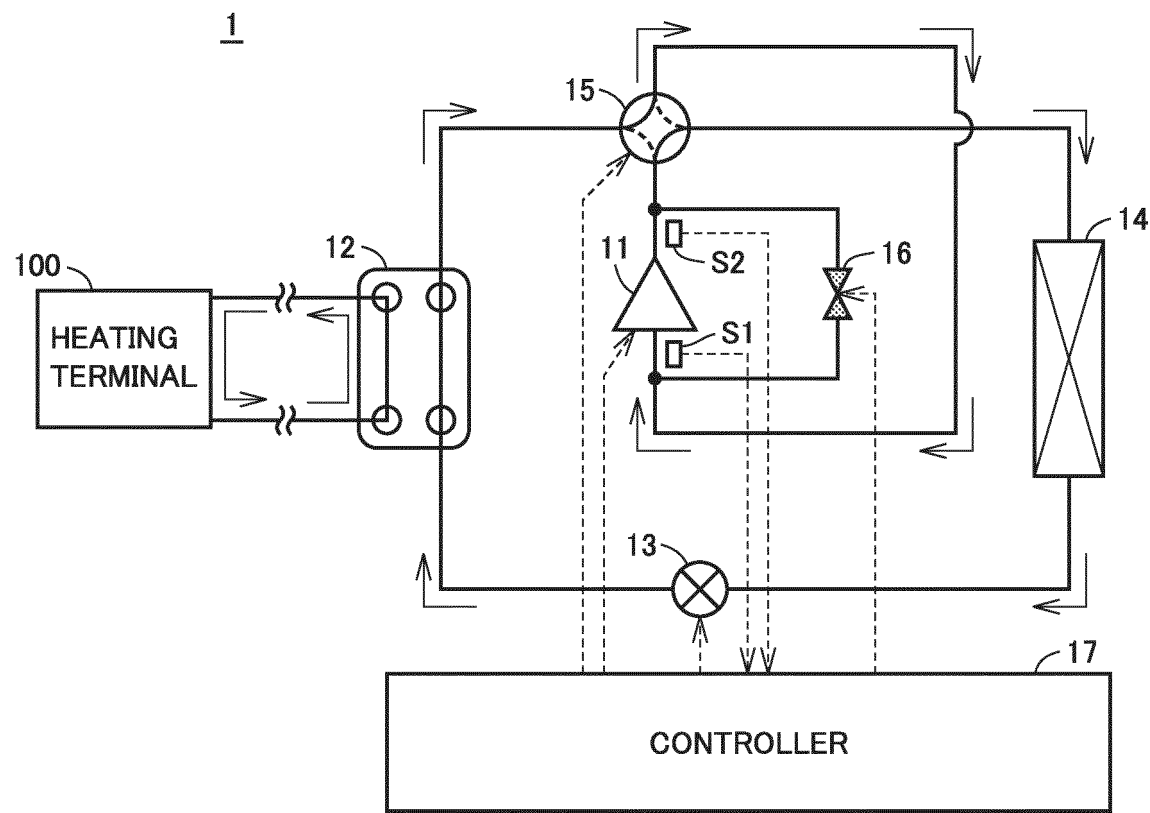


FIG.3

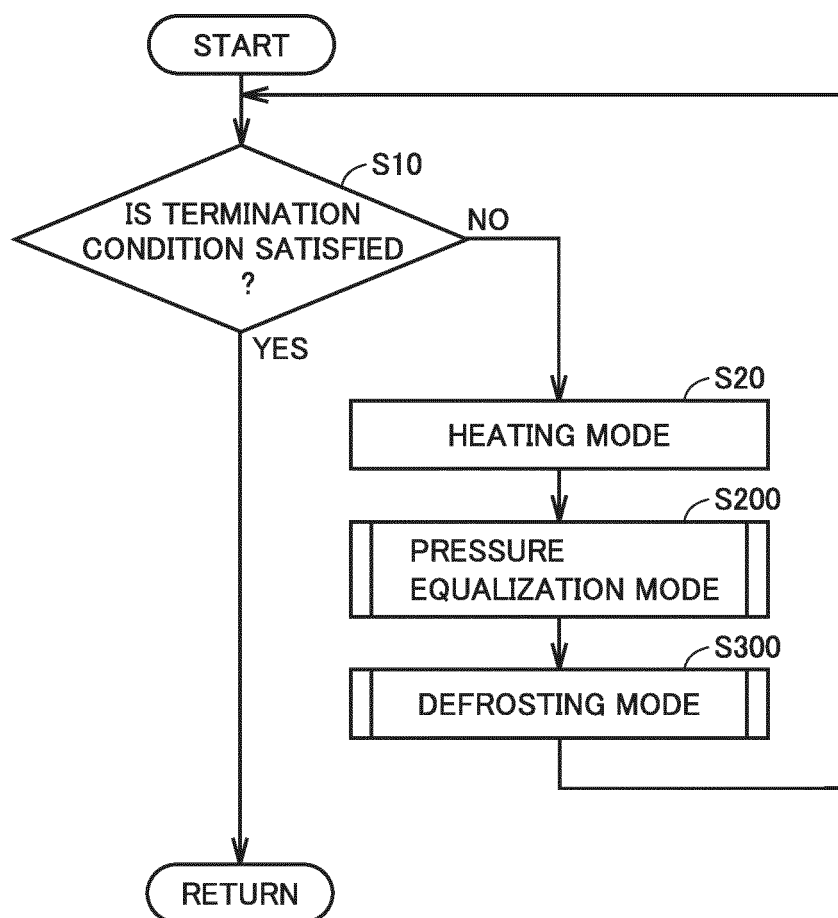


FIG.4

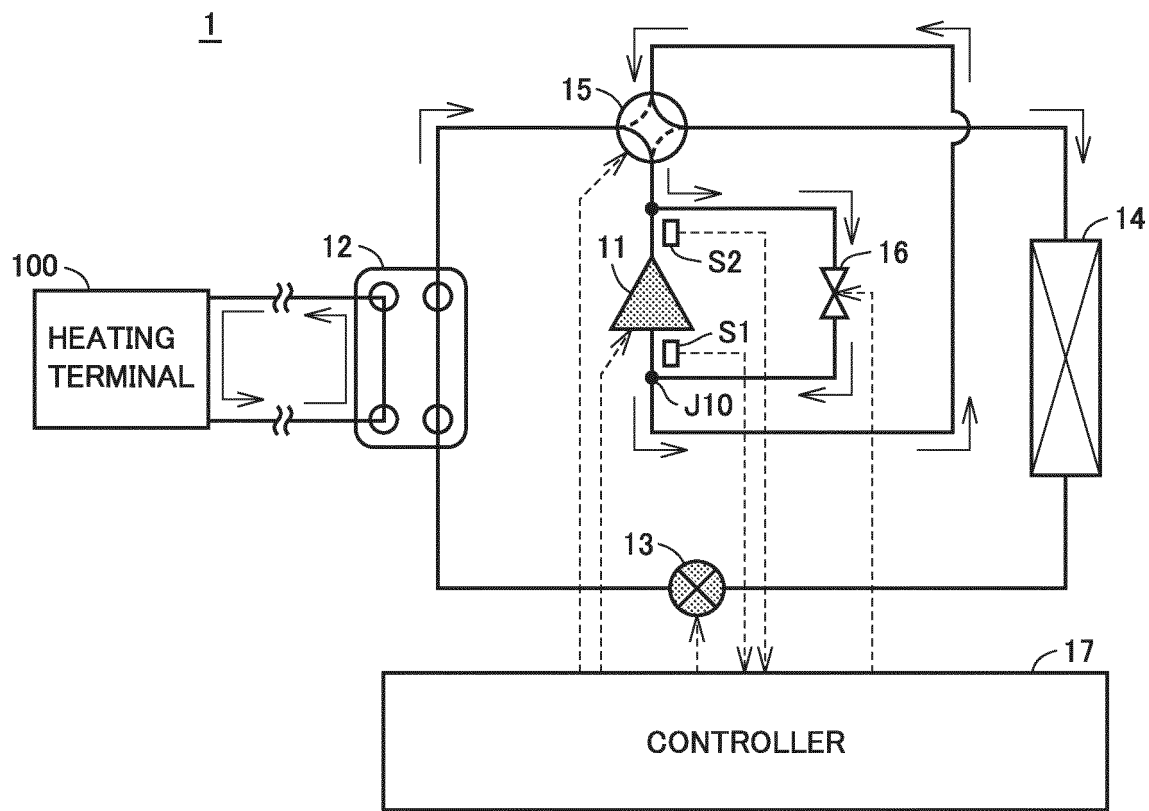


FIG.5

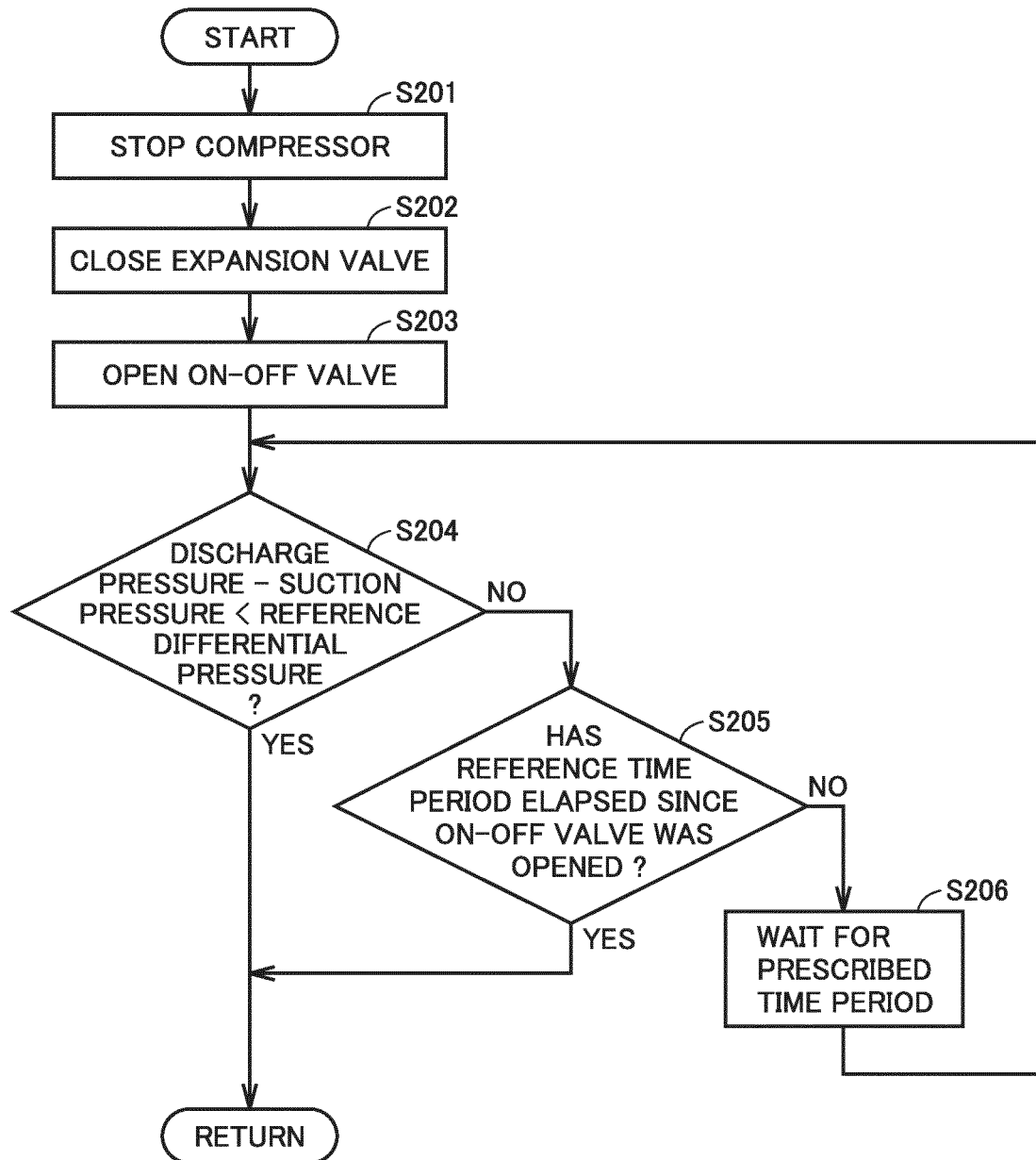


FIG.6

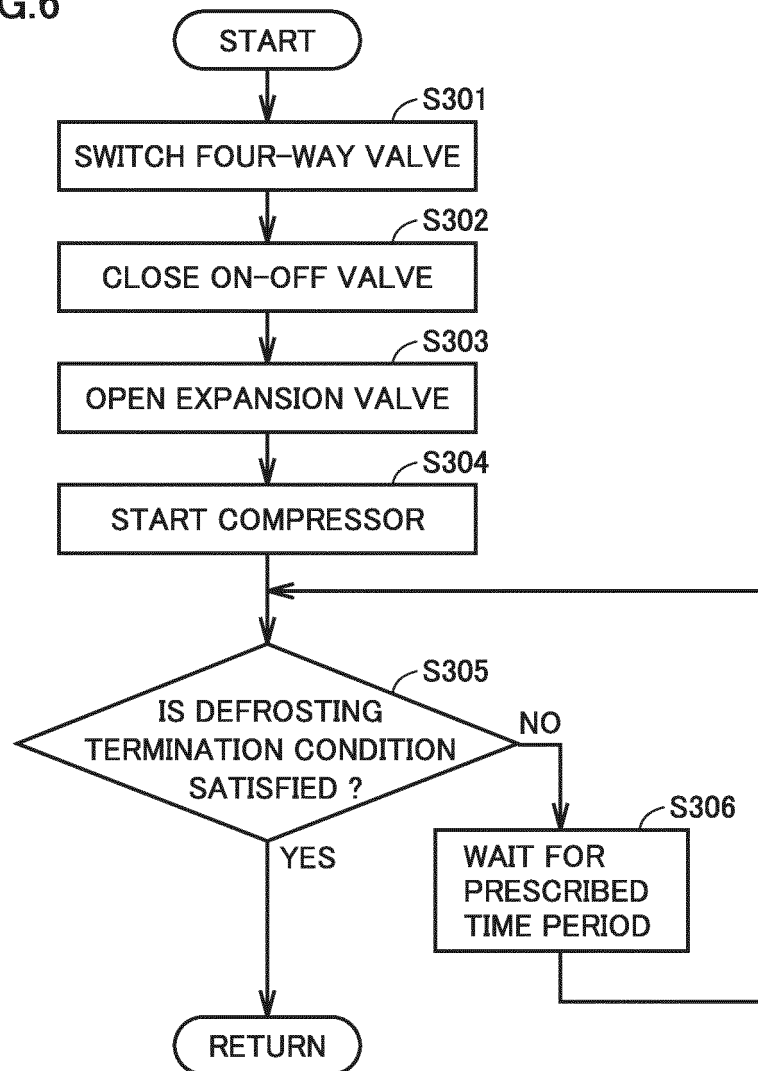


FIG. 7

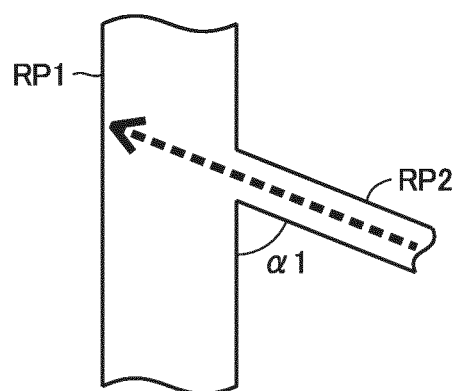


FIG.8

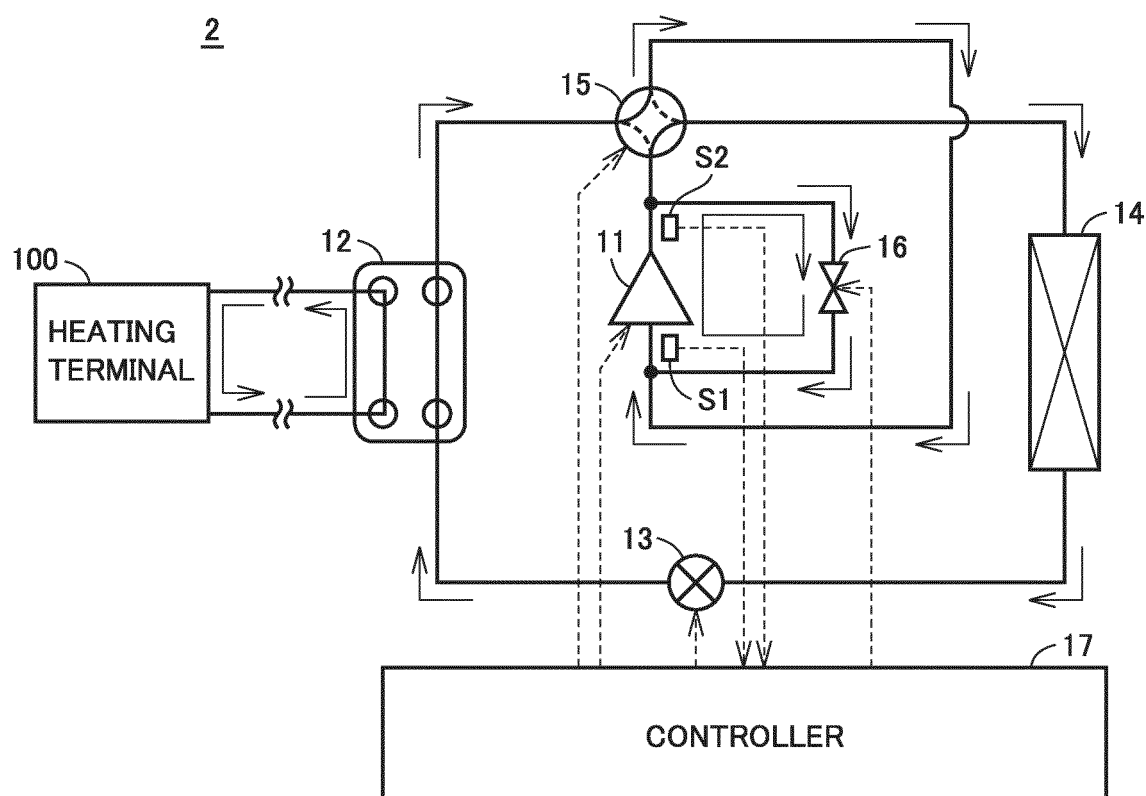


FIG.9

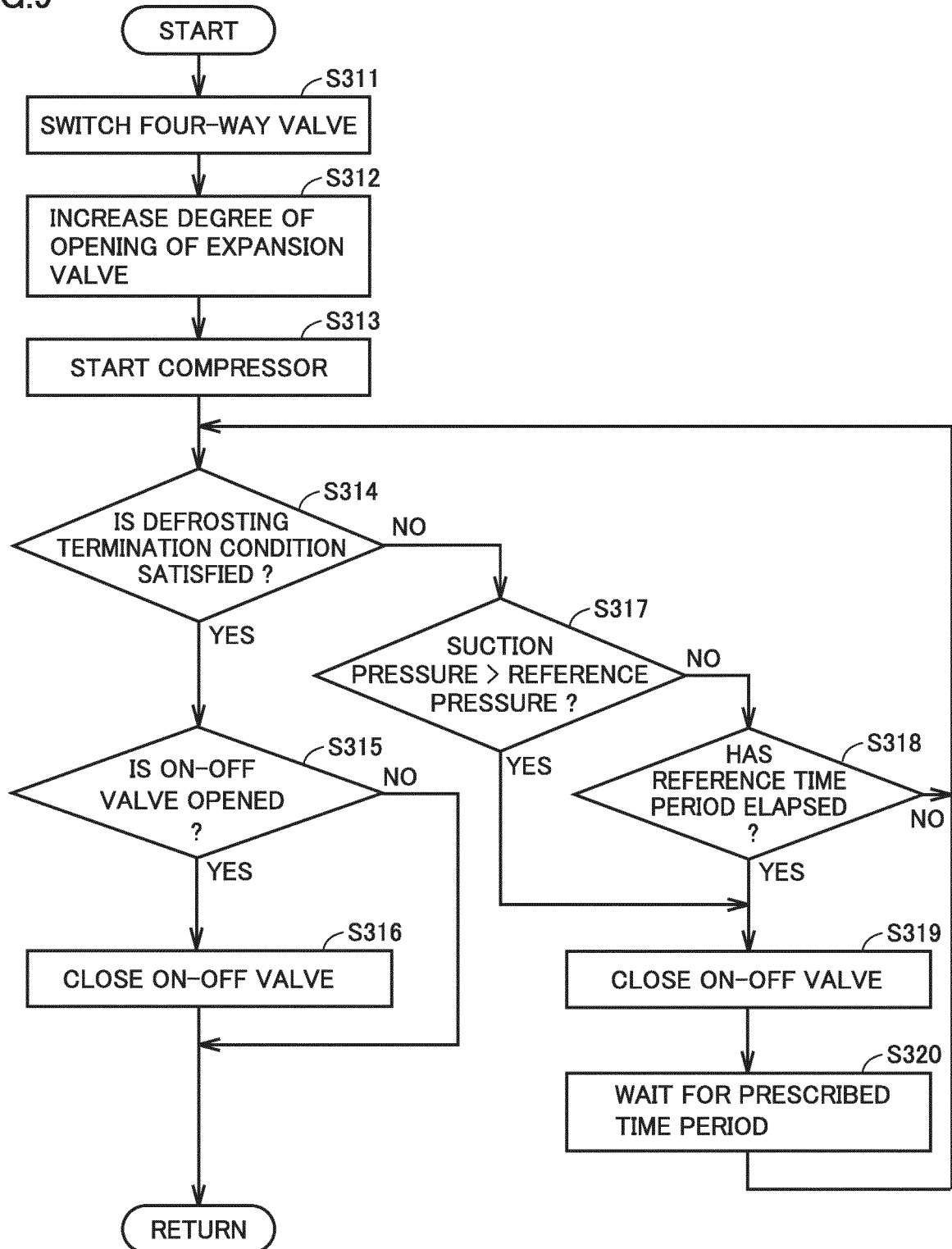


FIG.10

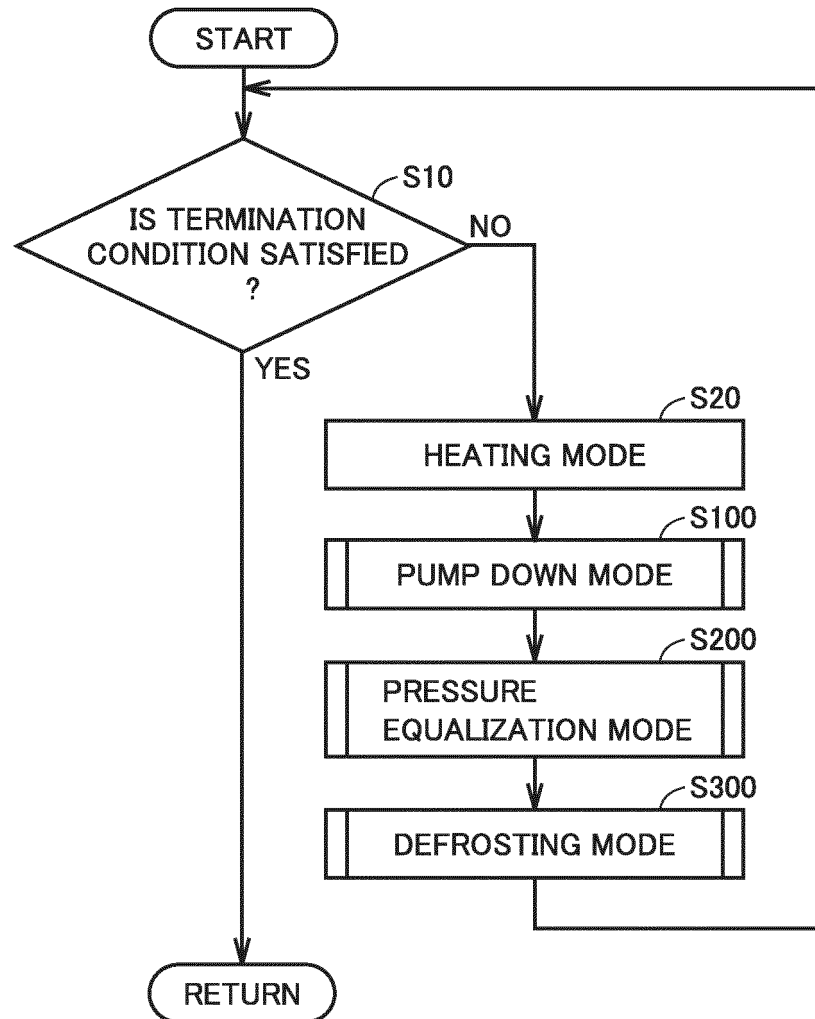


FIG.11

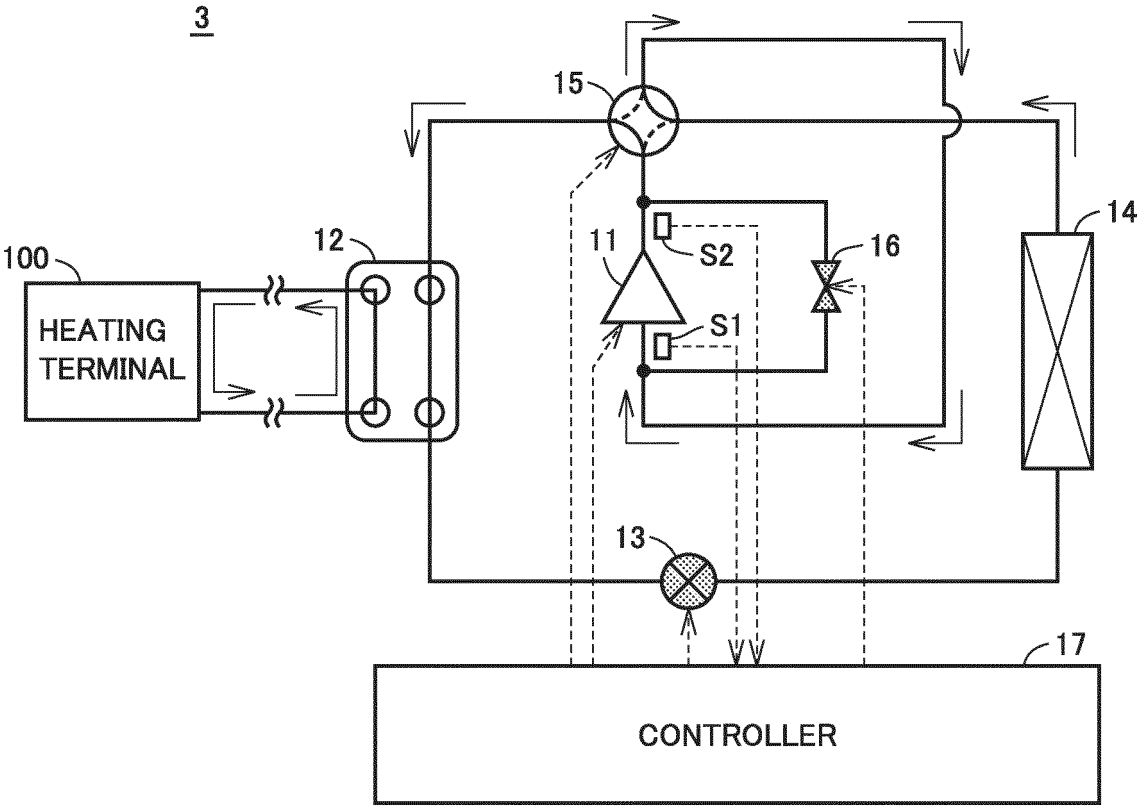


FIG.12

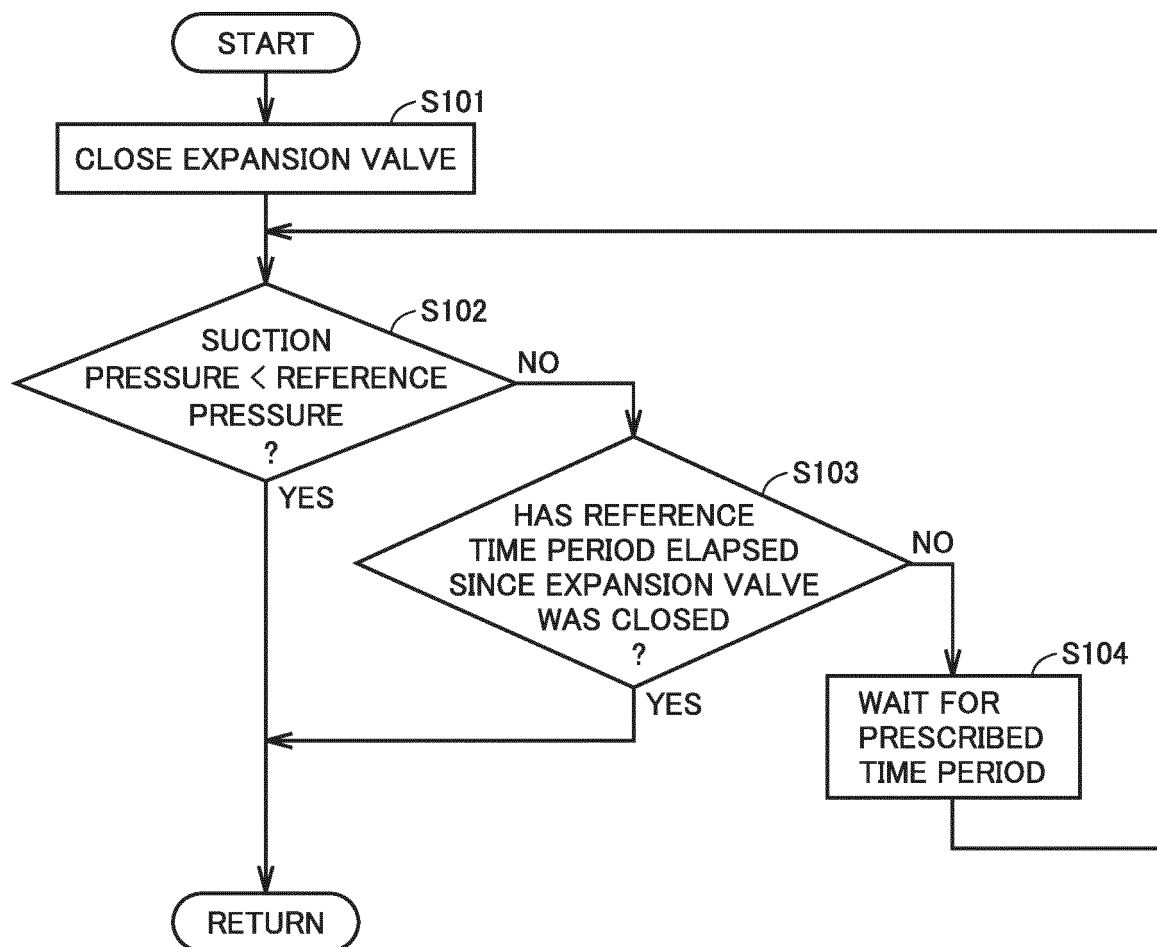


FIG.13

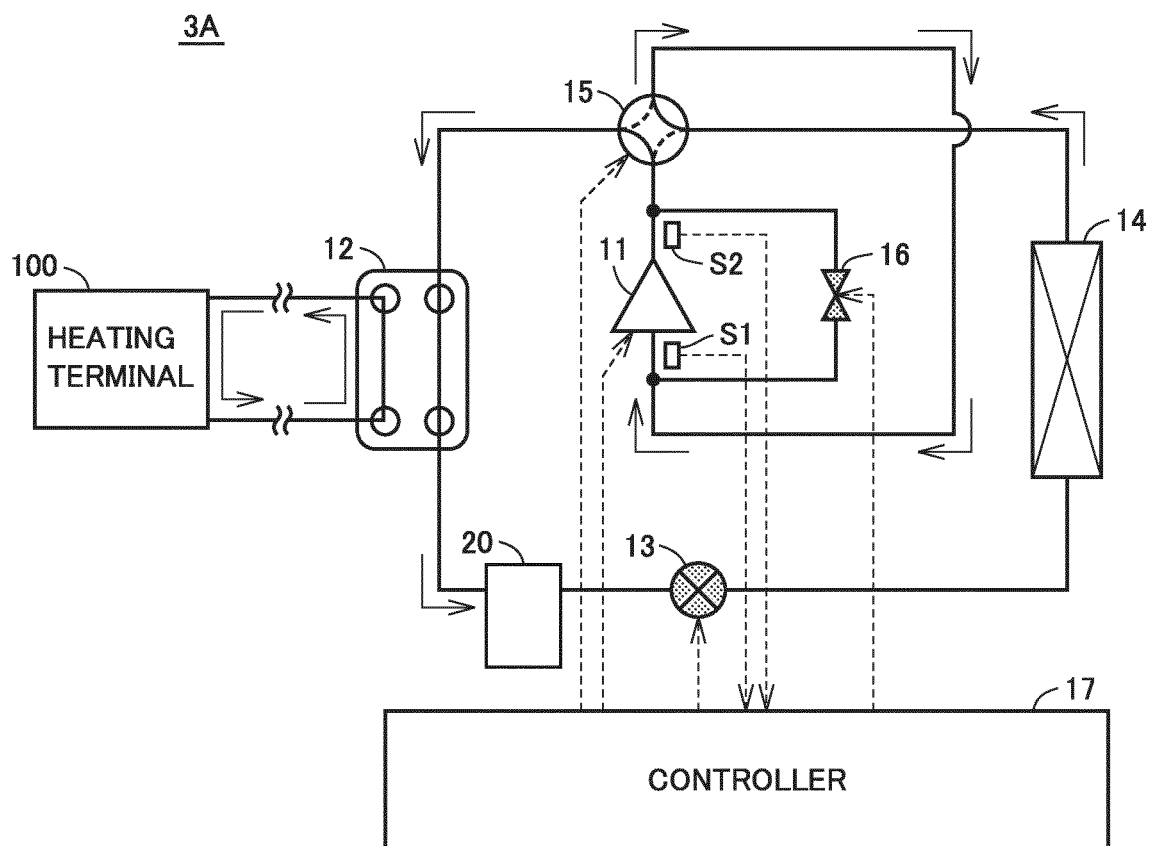


FIG.14

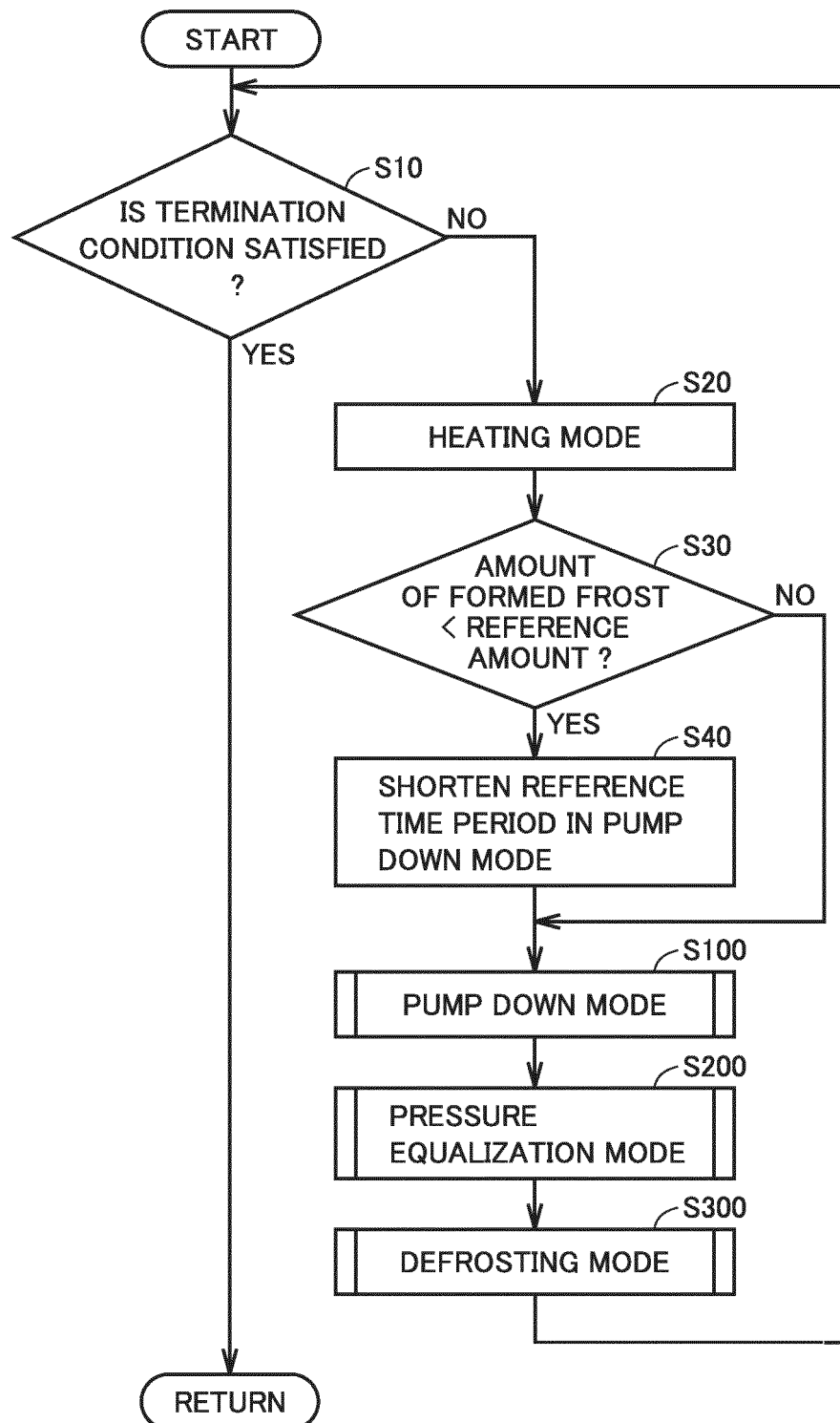


FIG.15

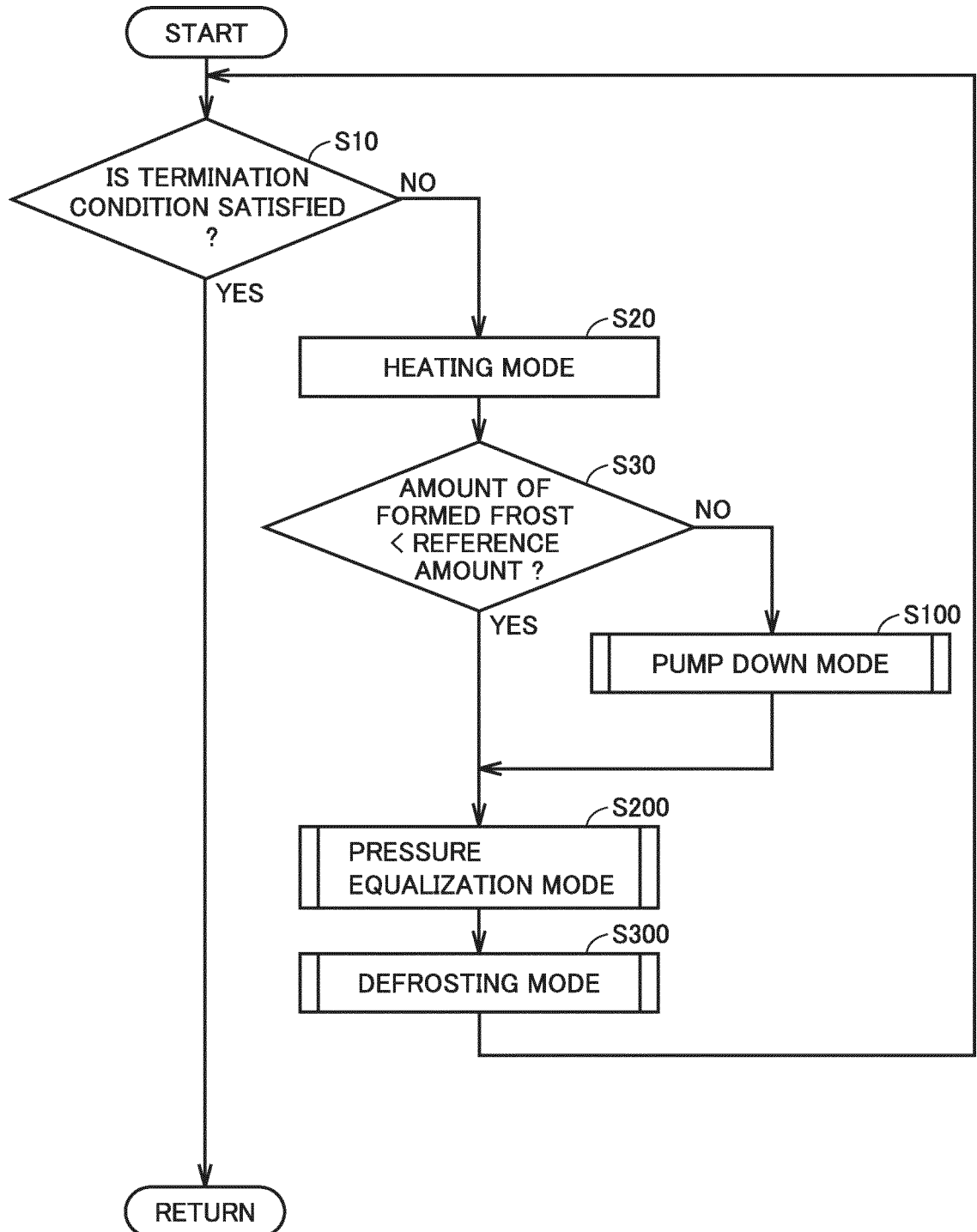


FIG.16

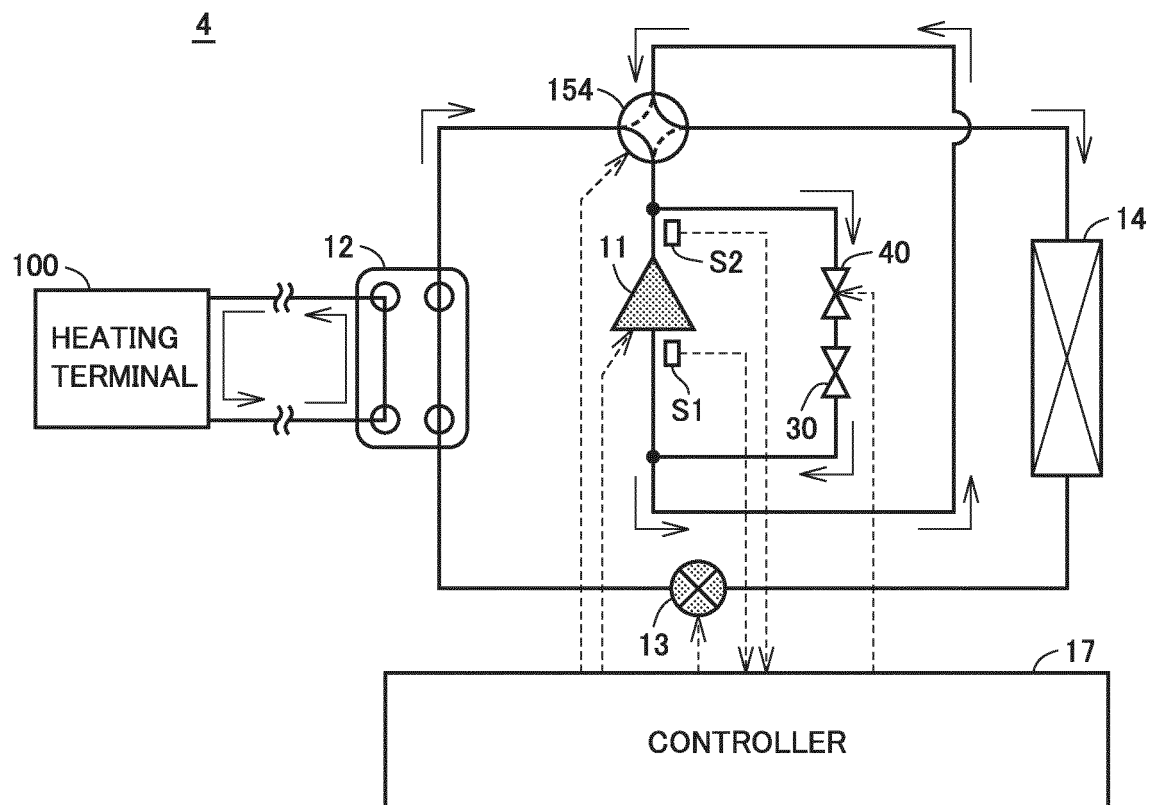


FIG.17

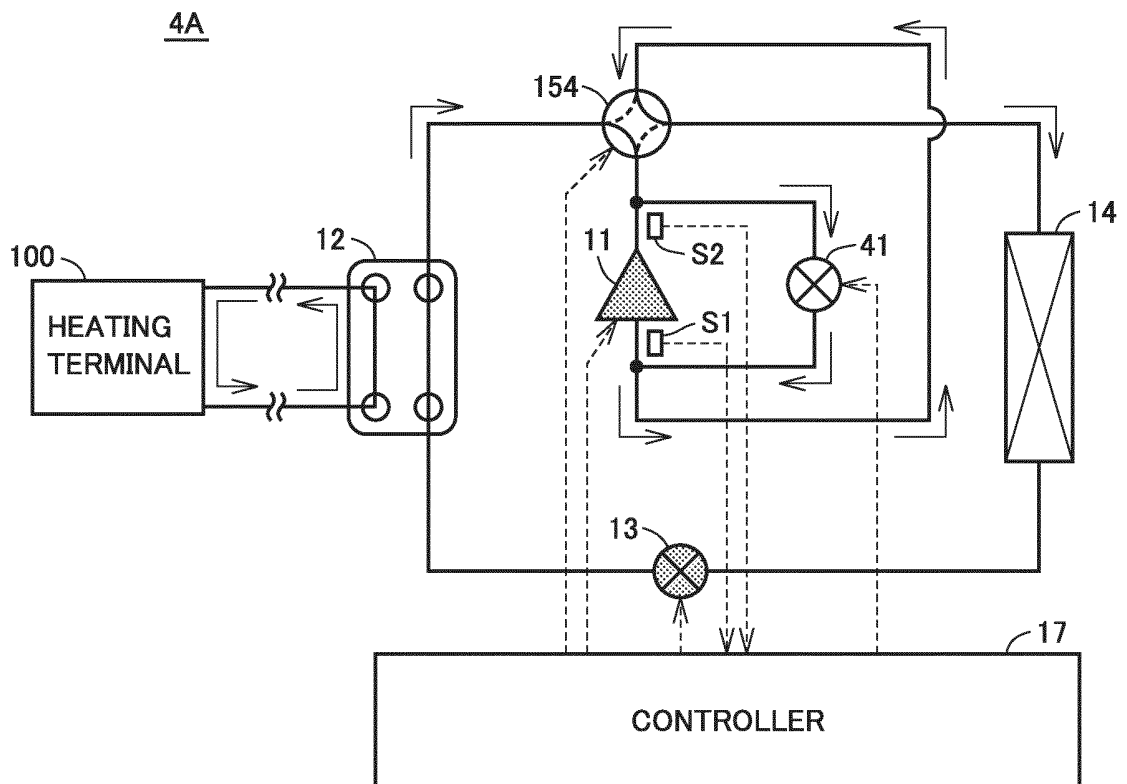
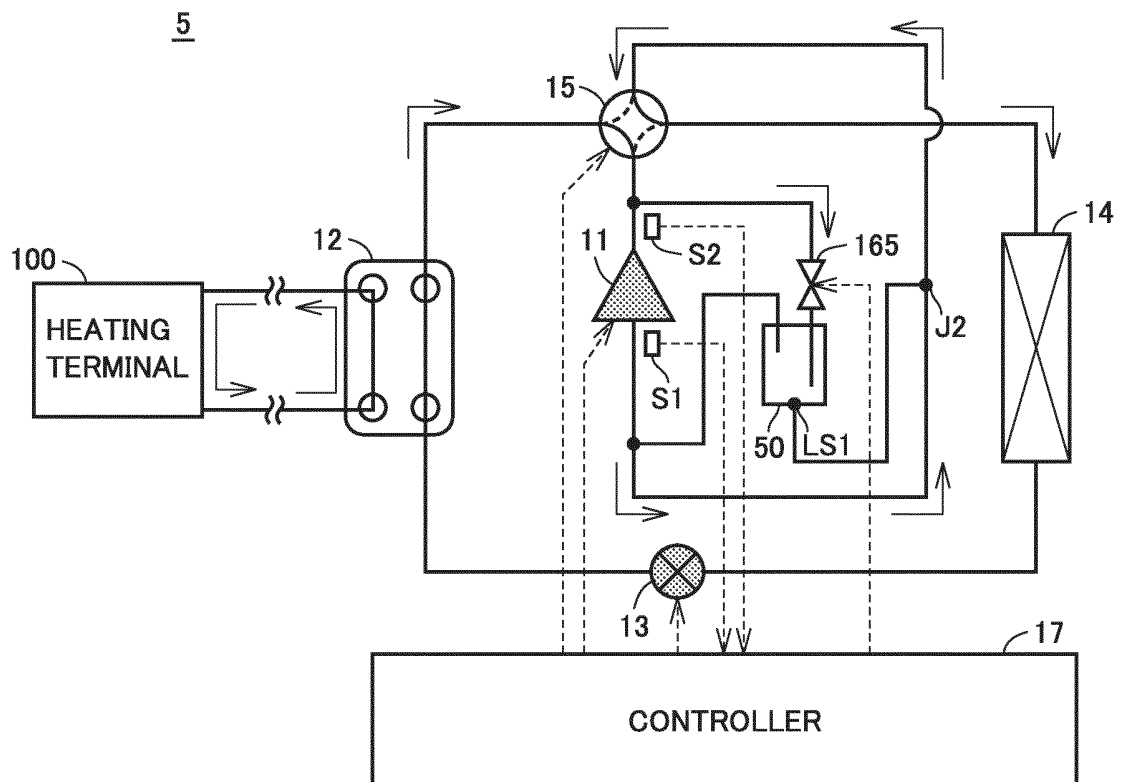


FIG.18



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/009793

A. CLASSIFICATION OF SUBJECT MATTER

F25B47/02(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)

F25B47/02

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 1996-2017

Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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 2015-68611 A (Daikin Industries, Ltd.), 13 April 2015 (13.04.2015), paragraphs [0046], [0061] to [0080]; fig. 1 to 5 (Family: none)	1-3, 5, 8, 14-15 4, 6-7, 9-13
Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 17841/1993(Laid-open No. 73667/1994) (Yanmar Diesel Engine Co., Ltd.), 18 October 1994 (18.10.1994), paragraphs [0003], [0007], [0014]; fig. 1 (Family: none)	1-3, 5, 8, 14-15 4, 6-7, 9-13

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
19 May 2017 (19.05.17)Date of mailing of the international search report
30 May 2017 (30.05.17)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/JP2017/009793

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2005-283041 A (Daikin Industries, Ltd.), 13 October 2005 (13.10.2005), paragraphs [0102] to [0107]; fig. 9 (Family: none)	1-3, 5, 8, 14-15 4, 6-7, 9-13
Y A	JP 2002-122361 A (Sanyo Electric Co., Ltd.), 26 April 2002 (26.04.2002), paragraph [0025]; fig. 2 (Family: none)	2-3, 5, 8 4, 6-7, 9-13
Y A	JP 2011-174662 A (Mitsubishi Heavy Industries, Ltd.), 08 September 2011 (08.09.2011), paragraphs [0030], [0036]; fig. 1 (Family: none)	5, 8 4, 6-7, 9-13
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 25956/1982 (Laid-open No. 129471/1983) (General Aircon Co., Ltd.), 01 September 1983 (01.09.1983), specification, page 3, line 14 to page 7, line 20; fig. 2, 3 (Family: none)	1-15
A	WO 2012/042573 A1 (Mitsubishi Electric Corp.), 05 April 2012 (05.04.2012), paragraphs [0017], [0024] to [0025]; fig. 1 to 3 & US 2013/0152613 A1 paragraphs [0034], [0041] to [0042]; fig. 1 to 3 & EP 2623887 A1 & CN 103154637 A	13

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2011174662 A [0002] [0003]