



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

(43) Date of publication:
25.08.2021 Bulletin 2021/34

(51) Int Cl.:
F24F 11/41 (2018.01) F25B 47/02 (2006.01)

(21) Application number: **18937404.4**

(86) International application number:
PCT/JP2018/039035

(22) Date of filing: **19.10.2018**

(87) International publication number:
WO 2020/079835 (23.04.2020 Gazette 2020/17)

(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:
KH MA MD TN

(72) Inventors:
• **SATO, Tsuyoshi**
Tokyo 100-8310 (JP)
• **NISHIYAMA, Takumi**
Tokyo 100-8310 (JP)
• **ITO, Daisuke**
Tokyo 100-8310 (JP)

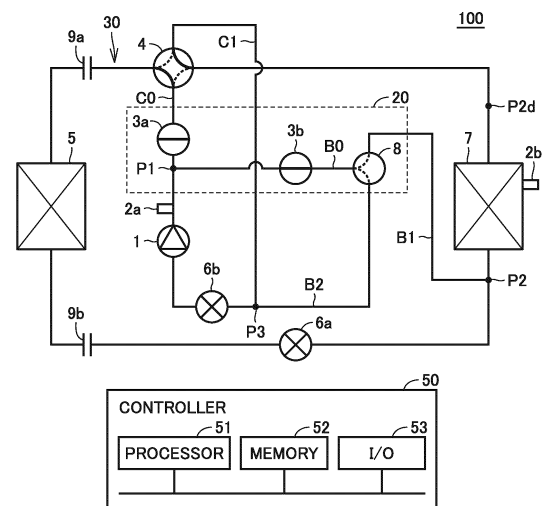
(71) Applicant: **Mitsubishi Electric Corporation**
Tokyo 100-8310 (JP)

(74) Representative: **Pfenning, Meinig & Partner mbB**
Patent- und Rechtsanwälte
Joachimsthaler Straße 10-12
10719 Berlin (DE)

(54) **AIR CONDITIONER**

(57) An air conditioning apparatus (100) includes: a main circuit (30); a first bypass flow path (B1) configured to communicate a pipe at a first expansion valve (6a) side of a second heat exchanger (7) with a pipe at a discharge side of a compressor (1); a second bypass flow path (B2) configured to communicate a pipe at a suction side of the compressor (1) with the pipe at the discharge side of the compressor (1); and a first flow path selection device (20) configured to selectively flow the refrigerant discharged from the compressor (1) to at least one of a first heat exchanger (5), the first bypass flow path (B1), and the second bypass flow path (B2). During a heating operation, the first flow path selection device (20) is configured to select at least the first heat exchanger (5). During a defrosting operation, the first flow path selection device (20) is configured to select at least the first bypass flow path (B1) after selecting at least the second bypass flow path (B2). With such a configuration, there can be provided an air conditioning apparatus that allows defrosting in a short time.

FIG.1



Description

TECHNICAL FIELD

[0001] The present invention relates to an air conditioning apparatus.

BACKGROUND ART

[0002] There has been conventionally known a refrigeration cycle apparatus including a bypass circuit that connects the discharge side of a compressor and the inlet side of an outdoor heat exchanger (PTL 1: Japanese Patent Laying-Open No. 2009-145032). The refrigeration cycle apparatus can perform defrosting quickly by flowing refrigerant discharged from the compressor to the outdoor heat exchanger through the bypass circuit, when frost forms on the outdoor heat exchanger.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: Japanese Patent Laying-Open No. 2009-145032

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] The refrigeration cycle apparatus described in Japanese Patent Laying-Open No. 2009-145032 above can achieve the shorter defrosting time by flowing the refrigerant to the outdoor heat exchanger through the bypass flow path that connects the discharge side of the compressor and the inlet side of the outdoor heat exchanger. However, when refrigerant having a low discharge temperature (e.g., R290, which is one type of hydrocarbon (HC) refrigerant) is contained in a refrigerant circuit, a temperature difference between the refrigerant and the outdoor heat exchanger is small and an amount of heat exchange per unit time decreases. Therefore, the time required for defrosting cannot be shortened.

[0005] The present invention has been made to solve the above-described problem, and an object of the present invention is to provide an air conditioning apparatus that can perform defrosting in a short time, regardless of used refrigerant.

SOLUTION TO PROBLEM

[0006] An air conditioning apparatus according to the present disclosure includes: a main circuit in which refrigerant circulates in the order of a compressor, a first heat exchanger, a first expansion valve, and a second heat exchanger in a heating operation; a first bypass flow path configured to communicate a pipe at the first expansion valve side of the second heat exchanger with a pipe

at a discharge side of the compressor; a second bypass flow path configured to communicate a pipe at a suction side of the compressor with the pipe at the discharge side of the compressor; and a first flow path selection device configured to selectively flow the refrigerant discharged from the compressor to at least one of the first heat exchanger, the first bypass flow path, and the second bypass flow path. During the heating operation, the first flow path selection device is configured to select at least the first heat exchanger. During a defrosting operation, the first flow path selection device is configured to select at least the first bypass flow path after selecting at least the second bypass flow path.

ADVANTAGEOUS EFFECTS OF INVENTION

[0007] According to the present invention, the temperature of the refrigerant is made higher than that during normal heating, and then, the refrigerant is introduced through the bypass flow path into the frosted heat exchanger. Therefore, the defrosting time is reduced.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

Fig. 1 is a schematic configuration diagram showing a configuration of an air conditioning apparatus 100 according to a first embodiment.

Fig. 2 is a flowchart for illustrating an operation of each component during a defrosting operation in the first embodiment.

Fig. 3 shows a state of each component in each processing of the flowchart shown in Fig. 2.

Fig. 4 shows a flow of refrigerant during heating (S100, S101, S106) in the first embodiment.

Fig. 5 shows a flow of the refrigerant in a first stage (S102, S103) during defrosting in the first embodiment.

Fig. 6 shows a flow of the refrigerant in a second stage (S104, S105) during defrosting in the first embodiment.

Fig. 7 is a p-h diagram showing a state of refrigerant in a comparative example in which general defrosting is performed, the general defrosting being defrosting during which a flow of the refrigerant is reversed in a cooling operation direction.

Fig. 8 is a p-h diagram showing a state of the refrigerant during the defrosting operation in the first embodiment.

Fig. 9 shows both a temperature distribution of the refrigerant in a second heat exchanger 7 during the defrosting operation in the comparative example and a temperature distribution of the refrigerant in second heat exchanger 7 during the defrosting operation in the first embodiment.

Fig. 10 shows a difference between the comparative example and the first embodiment in terms of the

time from determination of frost formation to start of the defrosting operation.

Fig. 11 shows a difference between the comparative example and the first embodiment in terms of the time from end of defrosting to return to heating.

Fig. 12 is a schematic configuration diagram showing a configuration of an air conditioning apparatus 200 according to a second embodiment.

Fig. 13 is a flowchart for illustrating an operation of each component during a defrosting operation in the second embodiment.

Fig. 14 shows a state of each component in each processing of the flowchart shown in Fig. 13.

Fig. 15 shows a flow of refrigerant during heating (S200, S201, S208) in the second embodiment.

Fig. 16 shows a flow of the refrigerant in a first stage (S202, S203) during defrosting in the second embodiment.

Fig. 17 shows a flow of the refrigerant in a second stage (S204, S205) during defrosting in the second embodiment.

Fig. 18 shows a flow of the refrigerant in a third stage (S206, S207) during defrosting in the second embodiment.

Fig. 19 is a p-h diagram showing a state of the refrigerant when distribution of the refrigerant to a second bypass flow path B2 starts just before the end of defrosting in the second embodiment.

Fig. 20 is a p-h diagram showing a state of the refrigerant when a certain time period elapses after distribution of the refrigerant to second bypass flow path B2 starts in the second embodiment.

Fig. 21 shows a temporal change in discharge temperature of the refrigerant from start of defrosting to return to heating in the comparative example in which defrosting is performed by a cooling operation.

Fig. 22 shows a temporal change in discharge temperature of the refrigerant from start of defrosting to return to heating in the second embodiment.

Fig. 23 is a schematic configuration diagram showing a configuration of an air conditioning apparatus 300 according to a third embodiment.

Fig. 24 is a flowchart for illustrating an operation of each component during a defrosting operation for a first heat exchange unit 7a in the third embodiment.

Fig. 25 shows a state of each component in each processing of the flowchart shown in Fig. 24.

Fig. 26 shows a flow of refrigerant during heating (S300, S301, S306) in the third embodiment.

Fig. 27 shows a flow of the refrigerant in a first stage (S302, S303) during the defrosting operation for first heat exchange unit 7a.

Fig. 28 shows a flow of the refrigerant in a second stage (S304, S305) during the defrosting operation for first heat exchange unit 7a.

Fig. 29 is a flowchart for illustrating an operation of each component during a defrosting operation for a second heat exchange unit 7b in the third embodi-

ment.

Fig. 30 shows a state of each component in each processing of the flowchart shown in Fig. 29.

Fig. 31 shows a flow of the refrigerant in a first stage (S302A, S303A) during the defrosting operation for second heat exchange unit 7b.

Fig. 32 shows a flow of the refrigerant in a second stage (S304A, S305A) during the defrosting operation for second heat exchange unit 7b.

Fig. 33 is a flowchart for illustrating an example process of performing defrosting for first heat exchange unit 7a more preferentially than second heat exchange unit 7b in the third embodiment.

DESCRIPTION OF EMBODIMENTS

[0009] Embodiments of the present invention will be described in detail hereinafter with reference to the drawings. A plurality of embodiments will be described hereinafter. However, it is originally intended to combine as appropriate the features described in the embodiments. In the drawings, the same or corresponding portions are denoted by the same reference characters, and description thereof will not be repeated.

First Embodiment

[0010] Fig. 1 is a schematic configuration diagram showing a configuration of an air conditioning apparatus 100 according to a first embodiment.

[0011] Referring to Fig. 1, air conditioning apparatus 100 includes a main circuit 30, a first bypass flow path B1, a second bypass flow path B2, and a first flow path selection device 20.

[0012] Air conditioning apparatus 100 further includes a compressor 1, a four-way valve 4, an extension pipe 9a, a first heat exchanger 5, an extension pipe 9b, a first expansion valve 6a, and a second heat exchanger 7. Normally, first heat exchanger 5 is an indoor heat exchanger arranged indoors, and second heat exchanger 7 is an outdoor heat exchanger arranged outdoors.

[0013] In main circuit 30, refrigerant circulates in the order of compressor 1, four-way valve 4, extension pipe 9a, first heat exchanger 5, extension pipe 9b, first expansion valve 6a, second heat exchanger 7, and four-way valve 4, and returns to compressor 1 during a heating operation.

[0014] First bypass flow path B1 communicates a point P2 of a pipe at the first expansion valve 6a side of second heat exchanger 7 with a point P1 of a pipe at the discharge side of compressor 1.

[0015] Second bypass flow path B2 communicates a point P3 of a pipe at the suction side of compressor 1 with point P1 of the pipe at the discharge side of compressor 1.

[0016] First flow path selection device 20 is configured to selectively flow the refrigerant discharged from compressor 1 to at least one of first heat exchanger 5, first

bypass flow path B1 and second bypass flow path B2. In the first embodiment, first flow path selection device 20 is configured to selectively flow the refrigerant discharged from compressor 1 to one of first heat exchanger 5, first bypass flow path B1 and second bypass flow path B2.

[0017] Air conditioning apparatus 100 further includes a second expansion valve 6b. In Fig. 1, second expansion valve 6b is arranged between second bypass flow path B2 and the pipe at the suction side of compressor 1. Second expansion valve 6b may be provided partway through second bypass flow path B2.

[0018] First flow path selection device 20 shown in Fig. 1 includes a solenoid valve 3a provided in a pipe C0 between point P1 of the pipe at the discharge side of compressor 1 and first heat exchanger 5, a solenoid valve 3b provided in a branch pipe B0 that branches off from main circuit 30, branch pipe B0 being shared by first bypass flow path B1 and second bypass flow path B2, and a flow path switching valve 8 that connects branch pipe B0 to one of first bypass flow path B1 and second bypass flow path B2.

[0019] By branch pipe B0 and bypass flow path B1, point P1 between the discharge side of compressor 1 and solenoid valve 3a is connected to point P2 between first expansion valve 6a and the inlet side of second heat exchanger 7. By branch pipe B0 and bypass flow path B2, point P3 between four-way valve 4 and second expansion valve 6b is connected to point P1.

[0020] Although not shown, a fan for blowing the air is provided at the air outlet side or the air inlet side of each of first heat exchanger 5 and second heat exchanger 7. A line flow fan, a propeller fan, a turbo fan, a sirocco fan or the like can be used as each fan. Furthermore, a plurality of fans may be provided for one heat exchanger. Furthermore, the configuration shown in Fig. 1 is a minimum configuration that can perform cooling and heating operations, and devices such as a gas-liquid separator, a receiver and an accumulator may be added to main circuit 30.

[0021] Air conditioning apparatus 100 further includes a controller 50 and temperature sensors 2a and 2b. Temperature sensor 2a detects a temperature of the refrigerant discharged from compressor 1. Temperature sensor 2b detects a surface temperature of second heat exchanger 7 at a position close to the point P2d side, which is a refrigerant outlet of second heat exchanger 7 during the heating operation. Controller 50 controls compressor 1, four-way valve 4, first expansion valve 6a, flow path selection device 20, second expansion valve 6b, and the not-shown fans, based on the temperatures detected by temperature sensors 2a and 2b and an instruction from a user.

[0022] Controller 50 includes a processor 51, a memory 52 and an input and output interface 53. Memory 52 is configured to include, for example, a read only memory (ROM), a random access memory (RAM) and a flash memory. An operating system, an application program

and various types of data are stored in the flash memory.

[0023] Controller 50 shown in Fig. 1 is implemented by processor 51 executing the operating system and the application program stored in memory 52. When the application program is executed, various types of data stored in memory 52 are referenced.

[0024] In the first embodiment, a type of the refrigerant contained in the air conditioning apparatus is not particularly limited. For example, hydrofluorocarbon (HFC) refrigerant, hydrofluoroolefin (HFO) refrigerant, hydrocarbon (HC) refrigerant, non-azeotropic mixed refrigerant or the like may be contained.

[0025] In air conditioning apparatus 100 configured as shown in Fig. 1, frost forms on second heat exchanger 7 arranged outdoors during the heating operation. A defrosting operation is performed to melt the frost. A flow of the refrigerant is switched by first flow path selection device 20 between the heating operation and the defrosting operation.

[0026] During the heating operation, first flow path selection device 20 selects at least first heat exchanger 5. As a result, the high-temperature and high-pressure refrigerant discharged from compressor 1 releases heat and condenses in first heat exchanger 5.

[0027] During the defrosting operation, first flow path selection device 20 selects at least first bypass flow path B1 after selecting at least second bypass flow path B2. As a result, the refrigerant flowing through second bypass flow path B2 and increasing in temperature flows through first bypass flow path B1 into second heat exchanger 7, and defrosting is performed.

[0028] Next, the operation of air conditioning apparatus 100 according to the first embodiment configured as mentioned above will be described. Fig. 2 is a flowchart for illustrating an operation of each component during the defrosting operation in the first embodiment. Fig. 3 shows a state of each component in each processing of the flowchart shown in Fig. 2.

[0029] When the heating operation is started, in step S100, controller 50 controls solenoid valves 3a and 3b and flow path switching valve 8 such that solenoid valve 3a enters an open state, solenoid valve 3b enters a closed state, and flow path switching valve 8 selects second bypass flow path B2.

[0030] Fig. 4 shows a flow of the refrigerant during heating (S100, S101, S106) in the first embodiment. As shown in Fig. 4, the refrigerant is discharged from compressor 1, circulates in the order of four-way valve 4, first heat exchanger 5, first expansion valve 6a, second heat exchanger 7, four-way valve 4, and second expansion valve 6b, and returns to compressor 1.

[0031] Referring again to Figs. 2 and 3, in step S101, controller 50 obtains information for determining whether or not frost forms on second heat exchanger 7, and determines whether or not frost forms on second heat exchanger 7. Specifically, controller 50 obtains a detection result by temperature sensor 2b, and determines whether or not the surface temperature of second heat exchanger

7 is equal to or less than a predetermined first threshold value (e.g., -3°C), based on the detection result. When the surface temperature of second heat exchanger 7 is equal to or less than the first threshold value, controller 50 determines that frost forms on second heat exchanger 7.

[0032] When it is determined that frost does not form in step S101 (NO in S101), the process is temporarily returned to the main routine and the processing in S100 and S101 is repeated again. When it is determined that frost forms in step S101 (YES in S101), the process proceeds to step S102.

[0033] In step S102, controller 50 sets solenoid valve 3a in the closed state and solenoid valve 3b in the open state. Selection by flow path switching valve 8 is maintained at second bypass flow path B2.

[0034] Fig. 5 shows a flow of the refrigerant in a first stage (S102, S103) during defrosting in the first embodiment. As shown in Fig. 5, in step S102, the refrigerant discharged from compressor 1 flows through second bypass flow path B2, is decompressed in second expansion valve 6b, and is again suctioned into compressor 1. Since solenoid valve 3a is in the closed state, a part of the refrigerant retained in first heat exchanger 5 and second heat exchanger 7 is suctioned out along a path shown by a broken arrow, and is increased in temperature in a loop shown by a solid arrow.

[0035] In step S102, controller 50 sets expansion valve 6a in a fully open state. The reason for this is to allow the refrigerant remaining in the main circuit to quickly flow to the loop shown by the solid arrow including second bypass flow path B2 at the time of switching to the defrosting operation. In addition, controller 50 sets a degree of opening of second expansion valve 6b to be the same as a degree of opening of first expansion valve 6a during the heating operation before entering the defrosting operation. One reason for this is to prevent a state in which a pressure difference between before second expansion valve 6b and after second expansion valve 6b becomes smaller and thus a discharge pressure and a discharge temperature of the refrigerant do not increase when the degree of opening of second expansion valve 6b is too large. Another reason for this is to prevent a state in which an amount of the refrigerant flowing into the suction side of compressor 1 becomes excessively smaller when the degree of opening of second expansion valve 6b is too small.

[0036] Referring again to Figs. 2 and 3, in step S103, controller 50 obtains information for determining whether or not the discharge temperature of the refrigerant reaches a target value, and determines whether or not the discharge temperature of the refrigerant reaches the target value. Specifically, controller 50 obtains a detection result by temperature sensor 2a, and determines whether or not the temperature of the refrigerant discharged from compressor 1 reaches a predetermined second threshold value T2 (e.g., 100°C), based on the detection result.

[0037] While the processing in steps S102 and S103

is repeated, a density of the suctioned refrigerant may decrease over time. In this case, a mass flow rate of the refrigerant suctioned into compressor 1 decreases, and thus, the discharge temperature of the refrigerant may be less likely to increase over time. Therefore, when the increase in discharge temperature of the refrigerant at a certain time interval (e.g., for five seconds) is less than a predetermined third threshold value (e.g., 10°C) in step S103, control for increasing an operation frequency of compressor 1 may be performed. Alternatively, when the temperature of the refrigerant discharged from compressor 1 is less than the predetermined second threshold value (e.g., 100°C) after a certain time period (e.g., 60 seconds) elapses from the start of step S102, the process may proceed to step S104.

[0038] Next, in step S104, controller 50 switches selection by flow path switching valve 8 from second bypass flow path B2 to first bypass flow path B1.

[0039] Fig. 6 shows a flow of the refrigerant in a second stage (S104, S105) during defrosting in the first embodiment. As shown by an arrow in Fig. 6, in step S104, the high-temperature and high-pressure refrigerant discharged from compressor 1 flows through first bypass flow path B1 and is introduced into second heat exchanger 7. Defrosting for second heat exchanger 7 is thus performed. The refrigerant flowing out of second heat exchanger 7 is decompressed in second expansion valve 6b and is again suctioned into compressor 1.

[0040] The operation frequency of compressor 1 in step S104 is desirably set at a frequency higher than that during the normal heating operation. The reason for this is to prevent a state in which the flow rate of the refrigerant becomes smaller and an amount of heat used for defrosting becomes smaller due to the defrosting operation in an overheated gas region, unlike the general defrosting operation during which the refrigerant is reversely circulated in a cooling direction.

[0041] Referring again to Fig. 2, in step S105, controller 50 determines whether or not to end defrosting. Specifically, controller 50 determines whether or not the surface temperature of second heat exchanger 7 is equal to or more than a predetermined third threshold value (e.g., 0°C), based on a detection signal output from temperature sensor 2b. When the surface temperature of second heat exchanger 7 is less than the third threshold value (NO in S105), controller 50 determines to continue defrosting for second heat exchanger 7, and returns the process to step S104. In contrast, when the surface temperature of second heat exchanger 7 is equal to or more than the third threshold value (YES in S105), controller 50 determines to end defrosting for second heat exchanger 7, and moves the process to step S106.

[0042] In step S106, controller 50 sets solenoid valve 3a in the open state and solenoid valve 3b in the closed state. At this time, the refrigerant flows as shown in Fig. 4, and the regular heating operation is thus performed.

[0043] As described above, during the defrosting operation, first flow path selection device 20 selects second

bypass flow path B2 and does not select first bypass flow path B1 and first heat exchanger 5 (Fig. 5, S102, S103), and then, selects first bypass flow path B1 and does not select second bypass flow path B2 and first heat exchanger 5 (Fig. 6, S104, S105).

[0044] Next, an effect obtained by air conditioning apparatus 100 according to the first embodiment will be described.

[0045] When controller 50 determines that the detection result by temperature sensor 2b is equal to or less than the predetermined first threshold value and frost forms on second heat exchanger 7, controller 50 controls solenoid valve 3a, solenoid valve 3b and flow path switching valve 8 such that a total amount of the refrigerant flows to second bypass flow path B2. Then, when the detection result by temperature sensor 2a becomes equal to or more than the preset second threshold value, controller 50 controls flow path switching valve 8 such that the total amount of the refrigerant flows through first bypass flow path B1 to second heat exchanger 7, to thereby perform defrosting for second heat exchanger 7.

[0046] By flowing the refrigerant to second bypass flow path B2, the temperature of the refrigerant increases in the loop shown by the solid arrow in Fig. 5. Therefore, the discharge temperature of the refrigerant can be made higher than that during the normal heating operation.

[0047] By increasing the discharge temperature of the refrigerant, the refrigerant having a temperature higher than normal can be flown to second heat exchanger 7 when flow path switching valve 8 is switched to first bypass flow path B1.

[0048] Fig. 7 is a p-h diagram showing a state of refrigerant in a comparative example in which general defrosting is performed, the general defrosting being defrosting during which a flow of the refrigerant is reversed in a cooling operation direction. Fig. 8 is a p-h diagram showing a state of the refrigerant during the defrosting operation in the first embodiment. Enthalpy is higher during the defrosting operation in the present embodiment shown in Fig. 8, as compared with general defrosting during which the flow of the refrigerant is reversed in the cooling operation direction, and thus, the defrosting operation is performed in a more overheated gas region.

[0049] Fig. 9 shows both a temperature distribution of the refrigerant in second heat exchanger 7 during the defrosting operation in the comparative example and a temperature distribution of the refrigerant in second heat exchanger 7 during the defrosting operation in the first embodiment. A temperature difference between the refrigerant and second heat exchanger 7 is larger and an amount of heat exchange per unit time is larger during the defrosting operation in the first embodiment shown by Ta' to Tb' in Fig. 9 than during the defrosting operation in the comparative example shown by Ta to Tb in Fig. 9. Therefore, defrosting can be performed in a short time.

[0050] The above-described effect of being able to perform defrosting in a short time by increasing the discharge temperature of the refrigerant is obtained regardless of

the type of the refrigerant contained in the air conditioning apparatus, such as HFC refrigerant, HFO refrigerant, HC refrigerant, or non-azeotropic mixed refrigerant. Therefore, by using refrigerant having a low global warming potential (GWP) (e.g., R290 (GWP: 3), which is one type of HC refrigerant), a GWP total amount value in the refrigeration cycle can be reduced.

[0051] When the non-azeotropic mixed refrigerant is contained in the air conditioning apparatus, frost is likely to form on the refrigerant inlet side during heating of the outdoor heat exchanger. However, in the present embodiment, high-pressure and high-temperature refrigerant gas can be flown to the inlet side during heating of second heat exchanger 7 through first bypass flow path B1, and thus, the temperature difference between the refrigerant and second heat exchanger 7 becomes large at the heating inlet side of second heat exchanger 7 and the amount of heat exchange per unit time increases. Therefore, defrosting can be performed in a short time.

[0052] As compared with general defrosting during which the flow of the refrigerant is reversed in the cooling operation direction, defrosting is performed in a more overheated gas region. Therefore, suction SH increases and liquid back to compressor 1 is less likely to occur. Thus, the reliability of compressor 1 can be improved (Fig. 7, Fig. 8).

[0053] In addition, as compared with general defrosting during which the flow of the refrigerant is reversed in the cooling operation direction, the refrigerant does not flow through extension pipe 9a, extension pipe 9b and indoor first heat exchanger 5 during the defrosting operation. Therefore, a heat release loss can be reduced.

[0054] In addition, the defrosting operation can be performed without flowing the refrigerant through indoor first heat exchanger 5. Therefore, a decrease in room temperature during the defrosting operation can be reduced.

[0055] In the first embodiment, when it is determined that the detection result by temperature sensor 2b becomes equal to or less than the preset first threshold value and frost forms on outdoor second heat exchanger 7, and thus, the defrosting operation is started, solenoid valve 3a is closed to thereby stop the inflow of the refrigerant into main circuit 30, and at the same time, solenoid valve 3b is opened to thereby flow the total amount of the refrigerant to second bypass flow path B2, and then, flow path switching valve 8 is switched to select first bypass flow path B1, to thereby flow the total amount of the refrigerant to second heat exchanger 7. Therefore, switching of four-way valve 4 at the time of the defrosting operation is unnecessary.

[0056] Fig. 10 shows a difference between the comparative example and the first embodiment in terms of the time from determination of frost formation to start of the defrosting operation. In the present embodiment, it is unnecessary to stop compressor 1 for a time period from time t1 to time t2 in order to produce a pressure state required for switching of four-way valve 4. Therefore, as shown in Fig. 10, the time to start of defrosting

can be made shorter by $\Delta T1$ than that in the comparative example.

[0057] When the detection result by temperature sensor 2a becomes equal to or more than the preset second threshold value, and thus, defrosting for outdoor second heat exchanger 7 ends and the operation returns to the heating operation, solenoid valve 3b is closed and solenoid valve 3a is opened to thereby change the flow of the refrigerant from first bypass flow path B1 to main circuit 30. Therefore, switching of four-way valve 4 at the time of return to the heating operation is unnecessary.

[0058] Fig. 11 shows a difference between the comparative example and the first embodiment in terms of the time from end of defrosting to return to heating. In the present embodiment, it is unnecessary to stop compressor 1 for a time period from time t11 to time t12 in order to produce a pressure state required for switching of four-way valve 4. Therefore, as shown in Fig. 11, the time to return to the heating operation can be made shorter by $\Delta T2$ than that in the comparative example.

Second Embodiment

[0059] Fig. 12 is a schematic configuration diagram showing a configuration of an air conditioning apparatus 200 according to a second embodiment.

[0060] Referring to Fig. 2, air conditioning apparatus 200 includes main circuit 30, first bypass flow path B1, second bypass flow path B2, and a first flow path selection device 20A.

[0061] Air conditioning apparatus 200 further includes compressor 1, four-way valve 4, extension pipe 9a, first heat exchanger 5, extension pipe 9b, first expansion valve 6a, and second heat exchanger 7. Normally, first heat exchanger 5 is an indoor heat exchanger arranged indoors, and second heat exchanger 7 is an outdoor heat exchanger arranged outdoors.

[0062] In main circuit 30, refrigerant circulates in the order of compressor 1, four-way valve 4, extension pipe 9a, first heat exchanger 5, extension pipe 9b, first expansion valve 6a, second heat exchanger 7, and four-way valve 4, and returns to compressor 1 during a heating operation.

[0063] First bypass flow path B1 communicates the pipe (point P2) at the first expansion valve 6a side of second heat exchanger 7 with the pipe (point P1) at the discharge side of compressor 1.

[0064] Second bypass flow path B2 communicates the pipe (point P4) at the suction side of compressor 1 with the pipe (point P1) at the discharge side of compressor 1.

[0065] First flow path selection device 20A is configured to selectively flow the refrigerant discharged from compressor 1 to at least one of first heat exchanger 5, first bypass flow path B1 and second bypass flow path B2. In the second embodiment, first flow path selection device 20A is configured to selectively flow the refrigerant discharged from compressor 1 to pipe C0 or branch pipe B0. First flow path selection device 20A is also configured

to be capable of distributing the refrigerant between first bypass flow path B1 and second bypass flow path B2 at an arbitrary ratio.

[0066] In the second embodiment, during a defrosting operation, first flow path selection device 20A selects second bypass flow path B2 and does not select first bypass flow path B1 and first heat exchanger 5 (Fig. 16), and then, selects first bypass flow path B1 and second bypass flow path B2 and does not select first heat exchanger 5 (Fig. 18).

[0067] Air conditioning apparatus 200 according to the second embodiment shown in Fig. 12 further includes a second expansion valve 6c, a third bypass flow path B3, a third expansion valve 6d, and a second flow path selection device.

[0068] Second expansion valve 6c is arranged partway through second bypass flow path B2. Third bypass flow path B3 is a flow path that branches off from a pipe C1 and extends to the suction side of compressor 1, pipe C1 being a pipe through which the refrigerant passing through second heat exchanger 7 flows during the heating operation. Third expansion valve 6d is arranged partway through third bypass flow path B3. A flow path switching valve 8b that selectively connects a pipe C2 or third bypass flow path B3 can be used as the second flow path selection device. Pipe C2 is a pipe that communicates pipe C1 with the suction side of compressor 1 not via third bypass flow path B3.

[0069] Although a basic configuration of air conditioning apparatus 200 according to the second embodiment is the same as that of air conditioning apparatus 100 according to the first embodiment, air conditioning apparatus 200 according to the second embodiment is different in the following first to fourth points from air conditioning apparatus 100 according to the first embodiment. First, main circuit 30 has flow path switching valve 8b and expansion valve 6b is removed. Secondly, flow path switching valve 8 that selects first bypass flow path B1 or second bypass flow path B2 is replaced by a flow rate adjusting valve 10. Thirdly, second expansion valve 6c is provided in second bypass flow path B2. Fourthly, third bypass flow path B3 having third expansion valve 6d is provided. Flow rate adjusting valve 10 is configured to be capable of freely adjusting an amount of the refrigerant distributed between first bypass flow path B1 and second bypass flow path B2. Although flow rate adjusting valve 10 may have any configuration, flow rate adjusting valve 10 may be configured such that an electronic expansion valve is provided in each of branch paths in two directions through which the refrigerant flows.

[0070] In Fig. 12, the same components as those of the first embodiment are denoted by the same reference characters. In addition, similarly to the first embodiment, a fan for blowing the air is provided at the air outlet side or the air inlet side of each of first heat exchanger 5 and second heat exchanger 7 (not shown). A line flow fan, a propeller fan, a turbo fan, a sirocco fan or the like can be used as each fan. Furthermore, a plurality of fans may

be provided for one heat exchanger. Furthermore, the configuration shown in Fig. 12 is a minimum configuration that can perform cooling and heating operations, and devices such as a gas-liquid separator, a receiver and an accumulator may be added to main circuit 30.

[0071] Air conditioning apparatus 200 further includes controller 50 and temperature sensors 2a and 2b. Temperature sensor 2a detects a temperature of the refrigerant discharged from compressor 1. Temperature sensor 2b detects a surface temperature of second heat exchanger 7 at a position close to the point P2d side, which is a refrigerant outlet of second heat exchanger 7 during the heating operation. Controller 50 controls compressor 1, four-way valve 4, first expansion valve 6a, flow path selection device 20, second expansion valve 6b, and the not-shown fans, based on the temperatures detected by temperature sensors 2a and 2b and an instruction from a user. Since a basic configuration of controller 50 is the same as that of the first embodiment, description will not be repeated.

[0072] In the second embodiment, a type of the refrigerant contained in the air conditioning apparatus is not particularly limited. For example, HFC refrigerant, HFO refrigerant, HC refrigerant, non-azeotropic mixed refrigerant or the like may be contained.

[0073] Next, the operation of air conditioning apparatus 200 according to the second embodiment configured as mentioned above will be described. Fig. 13 is a flowchart for illustrating an operation of each component during the defrosting operation in the second embodiment. Fig. 14 shows a state of each component in each processing of the flowchart shown in Fig. 13.

[0074] Determination of frost formation (S201), determination of arrival at the certain discharge temperature (S203) and determination of end of defrosting (S205) during the defrosting operation performed in the second embodiment are the same as determination of frost formation (S101), determination of arrival at the certain discharge temperature (S103) and determination of end of defrosting (S105) in the first embodiment. However, the second embodiment is different from the first embodiment in terms of processing with control of the valves (S200, S202, S204, S206, S207) and determination as to whether or not defrosting has progressed to a certain stage (S205).

[0075] When the heating operation is started, in step S200, controller 50 controls solenoid valves 3a and 3b and flow path switching valve 8b such that solenoid valve 3a enters an open state, solenoid valve 3b enters a closed state, and flow path switching valve 8b selects pipe C2.

[0076] Fig. 15 shows a flow of the refrigerant during heating (S200, S201, S208) in the second embodiment. As shown in Fig. 15, the refrigerant is discharged from compressor 1, circulates in the order of four-way valve 4, first heat exchanger 5, first expansion valve 6a, second heat exchanger 7, four-way valve 4, and flow path switching valve 8b, and returns to compressor 1.

[0077] Referring again to Figs. 13 and 14, in step S201, controller 50 obtains information for determining whether or not frost forms on second heat exchanger 7, and determines whether or not frost forms on second heat exchanger 7. Specifically, controller 50 obtains a detection result by temperature sensor 2b, and determines whether or not the surface temperature of second heat exchanger 7 is equal to or less than a predetermined first threshold value (e.g., -3°C), based on the detection result. When the surface temperature of second heat exchanger 7 is equal to or less than the first threshold value, controller 50 determines that frost forms on second heat exchanger 7.

[0078] When it is determined that frost does not form in step S201 (NO in S201), the process is temporarily returned to the main routine and the processing in S200 and S201 is repeated again. When it is determined that frost forms in step S201 (YES in S201), the process proceeds to step S202.

[0079] In step S202, controller 50 sets solenoid valve 3a in the closed state and solenoid valve 3b in the open state, and controls flow rate adjusting valve 10 such that a total amount of the refrigerant flows to second bypass flow path B2. In addition, controller 50 switches selection by flow path switching valve 8b from pipe C2 to the third bypass flow path, and sets expansion valve 6d in a fully open state.

[0080] Fig. 16 shows a flow of the refrigerant in a first stage (S202, S203) during defrosting in the second embodiment. As shown in Fig. 16, the refrigerant discharged from compressor 1 flows through second bypass flow path B2, is decompressed in second expansion valve 6c, and is again suctioned into compressor 1.

[0081] Since solenoid valve 3a is in the closed state and expansion valve 6d is in the open state, a part of the refrigerant retained in first heat exchanger 5 and second heat exchanger 7 is suctioned out along a path shown by a broken arrow, and is increased in temperature in a loop shown by a solid arrow.

[0082] In step S202, first expansion valve 6a and expansion valve 6d are set in the fully open state. The reason for this is to allow the refrigerant remaining in main circuit 30 to quickly flow to the loop shown by the solid arrow including second bypass flow path B2 at the time of switching to the defrosting operation. In addition, a degree of opening of second expansion valve 6c is set to be the same as a degree of opening of first expansion valve 6a during the heating operation before entering the defrosting operation. One reason for this is to prevent a state in which a pressure difference between before second expansion valve 6c and after second expansion valve 6c becomes smaller and thus a discharge pressure and a discharge temperature of the refrigerant do not increase when the degree of opening of second expansion valve 6c is too large. Another reason for this is to prevent a state in which an amount of the refrigerant flowing into the suction side of compressor 1 becomes excessively smaller when the degree of opening of second

expansion valve 6c is too small.

[0083] Referring again to Figs. 13 and 14, in step S203, controller 50 obtains information for determining whether or not the discharge temperature of the refrigerant reaches a target value, and determines whether or not the discharge temperature of the refrigerant reaches the target value. Specifically, controller 50 obtains a detection result by temperature sensor 2a, and determines whether or not the temperature of the refrigerant discharged from compressor 1 reaches a predetermined second threshold value T2 (e.g., 100°C), based on the detection result.

[0084] While the processing in steps S202 and S203 is repeated, a density of the suctioned refrigerant may decrease over time. In this case, a mass flow rate of the refrigerant suctioned into compressor 1 decreases, and thus, the discharge temperature of the refrigerant may be less likely to increase over time. Therefore, when the increase in discharge temperature of the refrigerant at a certain time interval (e.g., for five seconds) is less than a predetermined third threshold value (e.g., 10°C) in step S203, control for increasing an operation frequency of compressor 1 may be performed. Alternatively, when the temperature of the refrigerant discharged from compressor 1 is less than the predetermined second threshold value (e.g., 100°C) after a certain time period (e.g., 60 seconds) elapses from the start of step S202, the process may proceed to step S204.

[0085] Next, in step S204, controller 50 controls flow rate adjusting valve 10 such that the total amount of the refrigerant flows to first bypass flow path B1. At this time, selection by flow path switching valve 8b is maintained at third bypass flow path B3.

[0086] Fig. 17 shows a flow of the refrigerant in a second stage (S204, S205) during defrosting in the second embodiment. As shown in Fig. 17, the high-temperature and high-pressure refrigerant discharged from compressor 1 flows through first bypass flow path B1 and is introduced into second heat exchanger 7. Defrosting for second heat exchanger 7 is performed by the high-temperature and high-pressure refrigerant. The refrigerant flowing out of second heat exchanger 7 is decompressed in third expansion valve 6d and is again suctioned into compressor 1.

[0087] Next, in step S205, controller 50 determines whether or not defrosting has progressed to a certain stage. Specifically, controller 50 determines whether or not the surface temperature of second heat exchanger 7 is equal to or more than a predetermined fourth threshold value (e.g., -0.5°C), based on a detection signal output from temperature sensor 2b. When the surface temperature of second heat exchanger 7 is equal to or more than the fourth threshold value, controller 50 determines that defrosting for second heat exchanger 7 has progressed to a certain stage.

[0088] Next, in step S206, controller 50 controls flow rate adjusting valve 10 such that the refrigerant is distributed to first bypass flow path B1 and second bypass flow path B2.

[0089] Fig. 18 shows a flow of the refrigerant in a third stage (S206, S207) during defrosting in the second embodiment. As shown in Fig. 18, a part of the refrigerant discharged from compressor 1 flows through first bypass flow path B1 and is introduced into second heat exchanger 7, and defrosting for second heat exchanger 7 is continued. The refrigerant flowing out of second heat exchanger 7 is decompressed in third expansion valve 6d and is again suctioned into compressor 1. A part of the refrigerant discharged from compressor 1 flows through second bypass flow path B2, is decompressed in second expansion valve 6c, and is again suctioned into compressor 1.

[0090] Next, in step S207, controller 50 determines whether or not to end defrosting. Specifically, controller 50 determines whether or not the surface temperature of second heat exchanger 7 is equal to or more than a predetermined third threshold value (e.g., 0°C), based on a detection signal output from temperature sensor 2b. When the surface temperature of second heat exchanger 7 is equal to or more than the third threshold value, controller 50 determines to end defrosting for second heat exchanger 7.

[0091] When controller 50 determines to end defrosting (YES in S207), in step S208, controller 50 sets solenoid valve 3a in the open state and solenoid valve 3b in the closed state, and switches selection by flow path switching valve 8b from third bypass flow path B3 to pipe C2. As a result, the regular heating operation during which the refrigerant flows as shown in Fig. 15 is performed.

[0092] Although the defrosting time becomes somewhat longer, the processing in steps S204 and S205 may be omitted. Alternatively, the order of the processing in step S204 and the processing in step S206 may be changed.

[0093] Next, an effect produced by air conditioning apparatus 200 according to the second embodiment will be described.

[0094] Fig. 19 is a p-h diagram showing a state of the refrigerant when distribution of the refrigerant to second bypass flow path B2 starts just before the end of defrosting in the second embodiment. In accordance with an amount of distribution of the refrigerant at this time, a suction temperature Ts of compressor 1 starts to increase. Fig. 20 is a p-h diagram showing a state of the refrigerant when a certain time period elapses after distribution of the refrigerant to second bypass flow path B2 starts in the second embodiment. With an increase in a suction temperature Ts' after the certain time period elapses, a discharge temperature Td' also increases. As a result, the operation can return to the heating operation with discharge temperature Td' being high.

[0095] Fig. 21 shows a temporal change in discharge temperature of the refrigerant from start of defrosting to return to heating in the comparative example in which defrosting is performed by the cooling operation. In the comparative example, compressor 1 is temporarily

stopped and the four-way valve is switched for a time period from the end of defrosting at time t22 to time t23, and then, the operation of compressor 1 is resumed at time t24, and the discharge temperature reaches a target at time t25.

[0096] Fig. 22 shows a temporal change in discharge temperature of the refrigerant from start of defrosting to return to heating in the second embodiment. In the second embodiment, at time t32 when defrosting for second heat exchanger 7 has progressed to a certain stage before the end of defrosting, the refrigerant is distributed and flown to both first bypass flow path B1 and second bypass flow path B2, which makes it possible to increase the discharge temperature of the refrigerant while continuing defrosting. Therefore, the discharge temperature of the refrigerant does not decrease even after determination of end of defrosting is made at time t33, and the temperature of the refrigerant reaches the target discharge temperature at time t34.

[0097] Since it is unnecessary to stop compressor 1 and the discharge temperature of the refrigerant at the end of the defrosting operation is high, the time from start of defrosting to return to heating can be reduced from $\Delta T3$ to $\Delta T4$ as compared with the conventional art, and the quickly heating effect can be obtained at the time of return to the heating operation.

Third Embodiment

[0098] Fig. 23 is a schematic configuration diagram showing a configuration of an air conditioning apparatus 300 according to a third embodiment.

[0099] Referring to Fig. 23, air conditioning apparatus 300 includes main circuit 30, first bypass flow path B 1, second bypass flow path B2, and a first flow path selection device 20B.

[0100] Air conditioning apparatus 300 further includes compressor 1, four-way valve 4, extension pipe 9a, first heat exchanger 5, extension pipe 9b, first expansion valve 6a, and second heat exchanger 7. Normally, first heat exchanger 5 is an indoor heat exchanger arranged indoors, and second heat exchanger 7 is an outdoor heat exchanger arranged outdoors.

[0101] In main circuit 30, refrigerant circulates in the order of compressor 1, four-way valve 4, extension pipe 9a, first heat exchanger 5, extension pipe 9b, first expansion valve 6a, second heat exchanger 7, and four-way valve 4, and returns to compressor 1 during a heating operation.

[0102] First bypass flow path B1 communicates a pipe at the first expansion valve 6a side of one of a first heat exchange unit 7a and a second heat exchange unit 7b of second heat exchanger 7 with the pipe at the discharge side of compressor 1 through first flow path selection device 20B and a third flow path selection device 20C.

[0103] Second bypass flow path B2 communicates the pipe at the suction side of compressor 1 with the pipe at the discharge side of compressor 1 through first flow path

selection device 20B.

[0104] Air conditioning apparatus 100 further includes a second expansion valve 6e. In Fig. 23, second expansion valve 6e is provided partway through second bypass flow path B2.

[0105] In air conditioning apparatus 300 according to the third embodiment shown in Fig. 23, second heat exchanger 7 includes first heat exchange unit 7a and second heat exchange unit 7b. As to arrangement of first heat exchange unit 7a and second heat exchange unit 7b, two outdoor heat exchangers each having a small height may be arranged in a vertical direction, or one of two outdoor heat exchangers each having the small number of rows in a wind direction may be arranged in an upwind direction and the other may be arranged in a downwind direction.

[0106] Air conditioning apparatus 300 further includes third flow path selection device 20C configured to connect first bypass flow path B1 and first expansion valve 6a to one of first heat exchange unit 7a and second heat exchange unit 7b.

[0107] Second flow path selection device 20C includes solenoid valves 3c, 3d, 3e, and 3f. Solenoid valve 3c opens and closes a flow path that connects first expansion valve 6a and first heat exchange unit 7a. Solenoid valve 3d opens and closes a flow path that connects first expansion valve 6a and second heat exchange unit 7b. Solenoid valve 3e opens and closes a flow path that connects first bypass flow path B1 and first heat exchange unit 7a. Solenoid valve 3f opens and closes a flow path that connects first bypass flow path B1 and second heat exchange unit 7b.

[0108] First flow path selection device 20B is configured to selectively flow the refrigerant discharged from compressor 1 to at least one of first heat exchanger 5, first bypass flow path B1 and second bypass flow path B2. In the third embodiment, first flow path selection device 20B is configured to selectively flow the refrigerant discharged from compressor 1 to first heat exchanger 5 or branch pipe B0, and distribute and flow the refrigerant flowing through branch pipe B0 to first bypass flow path B1 and second bypass flow path B2.

[0109] Specifically, in the third embodiment, during a defrosting operation, first flow path selection device 20B distributes and flows the refrigerant to main circuit 30 and second bypass flow path B2 (Fig. 27, Fig. 31), and then, flows the refrigerant to one of first heat exchange unit 7a and second heat exchange unit 7b through main circuit 30 and flows the refrigerant to the other of first heat exchange unit 7a and second heat exchange unit 7b through first bypass flow path B1 (Fig. 28, Fig. 32).

[0110] During the defrosting operation, third flow path selection device 20C connects first bypass flow path B1 to one of first heat exchange unit 7a and second heat exchange unit 7b, and connects first expansion valve 6a to the other of first heat exchange unit 7a and second heat exchange unit 7b (Fig. 28, Fig. 32).

[0111] Although a basic configuration of air condition-

ing apparatus 300 according to the third embodiment is the same as that of air conditioning apparatus 100 according to the first embodiment, air conditioning apparatus 300 according to the third embodiment is different in the following points from air conditioning apparatus 100 according to the first embodiment. First, main circuit 30 has a flow rate adjusting valve 10b. Secondly, expansion valve 6b is removed. Thirdly, solenoid valve 3c and solenoid valve 3d are provided. Fourthly, first heat exchange unit 7a and second heat exchange unit 7b formed by dividing second heat exchanger 7 are provided. Fifthly, temperature sensors 2c and 2d are provided in first heat exchange unit 7a and second heat exchange unit 7b, respectively. Sixthly, expansion valves 6f and 6g are provided to correspond to first heat exchange unit 7a and second heat exchange unit 7b, respectively. Seventhly, solenoid valve 3e and solenoid valve 3f are provided at an outlet of first bypass flow path B1. Lastly, solenoid valve 6e is provided partway through second bypass flow path B2. The same components as those of the first embodiment are denoted by the same reference characters.

[0112] In addition, a fan for blowing the air is provided at the air outlet side or the air inlet side of each of first heat exchanger 5 and second heat exchanger 7 (not shown).

[0113] A line flow fan, a propeller fan, a turbo fan, a sirocco fan or the like can be used as each fan. Furthermore, a plurality of fans may be provided for one heat exchanger. Furthermore, first heat exchange unit 7a and second heat exchange unit 7b may be arranged to align in a horizontal direction, or may be arranged to align in a vertical direction. Furthermore, the above-described configuration is a minimum configuration that can perform cooling and heating operations, and a gas-liquid separator, a receiver, an accumulator or the like may be further added to main circuit 30.

[0114] Each of temperature sensor 2c provided in first heat exchange unit 7a and temperature sensor 2d provided in second heat exchange unit 7b is arranged at a position (point P10 side), which is the refrigerant outlet side during the heating operation.

[0115] Similarly to the first embodiment, a type of the refrigerant contained in the air conditioning apparatus is not limited. HFC refrigerant, HFO refrigerant, HC refrigerant, non-azeotropic mixed refrigerant or the like may be contained as the refrigerant.

[0116] Next, the operation of air conditioning apparatus 300 according to the third embodiment will be described.

[0117] Fig. 24 is a flowchart for illustrating an operation of each component during the defrosting operation for first heat exchange unit 7a in the third embodiment. Fig. 25 shows a state of each component in each processing of the flowchart shown in Fig. 24. Fig. 25 shows open and closed states of solenoid valves 3c, 3d, 3b, 3e, and 3f in each processing shown in Fig. 24, a flow direction of the refrigerant in flow path switching valve 8, and a distribution state of the refrigerant in flow rate adjusting

valve 10b.

[0118] Determination of frost formation (S301), determination of arrival at the certain discharge temperature (S303) and determination of end of defrosting (S305) in the flowchart shown in Fig. 24 are the same as S101, S103 and S105 in the first embodiment, respectively. However, the third embodiment is different from the first embodiment in terms of processing with control of the valves (S300, S302, S304, S306).

[0119] Control described with reference to Figs. 24 and 25 is control in the case of defrosting first heat exchange unit 7a after the heating operation, and the case of defrosting second heat exchange unit 7b will be described later with reference to Figs. 29 to 31.

[0120] When the heating operation is started, in step S300, controller 50 controls solenoid valves 3c, 3d, 3b, 3e, and 3f, flow path switching valve 8, and flow rate adjusting valve 10b such that solenoid valve 3c enters the open state, solenoid valve 3d enters the open state, solenoid valve 3b enters the closed state, solenoid valve 3e enters the closed state, solenoid valve 3f enters the closed state, flow path switching valve 8 selects first bypass flow path B1, and flow rate adjusting valve 10b flows a total amount of the refrigerant to main circuit 30.

[0121] Fig. 26 shows a flow of the refrigerant during heating (S300, S301, S306) in the third embodiment. As shown in Fig. 26, the refrigerant is discharged from compressor 1, circulates in the order of flow rate adjusting valve 10b, four-way valve 4, first heat exchanger 5, first expansion valve 6a, second heat exchanger 7, and four-way valve 4, and returns to compressor 1. In second heat exchanger 7, the refrigerant is divided into two paths by flow path selection device 20C, such that the refrigerant flows in parallel through a path including first heat exchange unit 7a and expansion valve 6f and a path including second heat exchange unit 7b and expansion valve 6g, and then, the flows of the refrigerant join at a point P10.

[0122] Referring again to Figs. 24 and 25, in step S301, controller 50 obtains information for determining whether or not frost forms on first heat exchange unit 7a, and determines whether or not frost forms on first heat exchange unit 7a. Specifically, controller 50 obtains a detection result by temperature sensor 2c, and determines whether or not a surface temperature of first heat exchange unit 7a is equal to or less than a predetermined first threshold value (e.g., -3°C), based on the detection result. When the surface temperature of first heat exchange unit 7a is equal to or less than the first threshold value, controller 50 determines that frost forms on first heat exchange unit 7a. When it is determined that frost forms, controller 50 moves the process to step S302. When it is determined that frost does not form, the processing in steps S302 to S306 is not performed and the processing in steps S300 and S301 is repeated again.

[0123] In step S302, controller 50 controls solenoid valves 3c and 3b, flow path switching valve 8, and flow rate adjusting valve 10 such that solenoid valve 3c enters

the closed state, solenoid valve 3b enters the open state, flow path switching valve 8 selects second bypass flow path B2, and flow rate adjusting valve 10 distributes the refrigerant to pipe C0 of main circuit 30 and second bypass flow path B2. As to solenoid valves 3e and 3f, the state in step S300 is maintained, i.e., solenoid valves 3e and 3f are both controlled to the closed state. As to solenoid valve 3d, the state in step S300 is maintained, i.e., solenoid valve 3d is controlled to the open state.

[0124] Fig. 27 shows a flow of the refrigerant in a first stage (S302, S303) during the defrosting operation for first heat exchange unit 7a. As shown in Fig. 27, one part of the refrigerant discharged from compressor 1 flows to main circuit 30 and second heat exchange unit 7b, to thereby continue the heating operation. The other part of the refrigerant flows through second bypass flow path B2, is decompressed in expansion valve 6e, and is again suctioned into compressor 1.

[0125] In step S302, a degree of opening of expansion valve 6e is set to be the same as a degree of opening of expansion valve 6a. The reason for this is to allow the refrigerant flowing through pipe C1 of main circuit 30 and the refrigerant flowing through second bypass flow path B2 to join at a point P11 at the same pressure.

[0126] Next, in step S303, controller 50 obtains information for determining whether or not the discharge temperature of the refrigerant reaches a target value, and determines whether or not the discharge temperature of the refrigerant reaches the target value. Specifically, controller 50 obtains a detection result by temperature sensor 2a, and determines whether or not the temperature of the refrigerant discharged from compressor 1 reaches a predetermined second threshold value T2 (e.g., 100°C), based on the detection result. When the discharge temperature of the refrigerant reaches second threshold value T2 in step S303, controller 50 moves the process to step S304.

[0127] In steps S302 and S303, a density of the refrigerant suctioned into compressor 1 may decrease over time. In this case, a mass flow rate of the refrigerant suctioned into compressor 1 decreases, and thus, the discharge temperature of the refrigerant may be less likely to increase over time. Therefore, when the increase in discharge temperature of the refrigerant at a certain time interval (e.g., five-second interval) is less than a predetermined third threshold value (e.g., 10°C) in step S303, control for increasing an operation frequency of compressor 1 may be performed. Alternatively, when the temperature of the refrigerant discharged from compressor 1 is less than the predetermined second threshold value (e.g., 100°C) after a certain time period (e.g., 60 seconds) elapses from the start of step S302, the process may proceed to step S304.

[0128] In step S304, controller 50 controls solenoid valve 3e and flow path switching valve 8 such that solenoid valve 3e enters the open state and flow path switching valve 8 selects first bypass flow path B1. As to solenoid valves 3b, 3c, 3d, and 3f and flow rate adjusting

valve 10b, the states in step S302 are maintained.

[0129] Fig. 28 shows a flow of the refrigerant in a second stage (S304, S305) during the defrosting operation for first heat exchange unit 7a. As shown in Fig. 28, a part of the high-temperature and high-pressure refrigerant discharged from compressor 1 flows through first bypass flow path B1 and is introduced into first heat exchange unit 7a. Defrosting for first heat exchange unit 7a is thus performed. The refrigerant flowing out of first heat exchange unit 7a is decompressed in expansion valve 6f.

[0130] In step S304, controller 50 sets a degree of opening of expansion valve 6f to be the same as the degree of opening of expansion valve 6a, and sets expansion valve 6g in the fully open state. The reason for this is to allow the refrigerant in main circuit 30 flowing through second heat exchange unit 7b and the refrigerant flowing through first heat exchange unit 7a and used for defrosting to have the same pressure and join at point P10.

[0131] Next, in step S305, controller 50 determines whether or not to end defrosting. Specifically, controller 50 determines whether or not the surface temperature of first heat exchange unit 7a is equal to or more than a predetermined third threshold value (e.g., 0°C), based on a detection signal output from temperature sensor 2c. When the surface temperature of first heat exchange unit 7a is equal to or more than the above-described third threshold value, controller 50 determines to end defrosting. When controller 50 determines to end defrosting, controller 50 moves the process to step S306.

[0132] In step S306, controller 50 controls solenoid valves 3c, 3d, 3b, and 3e and flow rate adjusting valve 10b such that solenoid valve 3c enters the open state, solenoid valve 3d enters the open state, solenoid valve 3b enters the closed state, solenoid valve 3e enters the closed state, and flow rate adjusting valve 10b flows the total amount of the refrigerant to main circuit 30. At this time, flow path switching valve 8 is maintained in the state in step S304. As a result, the refrigerant flows as shown in Fig. 26, and the regular heating operation is performed.

[0133] Next, the operation of performing the defrosting operation for second heat exchange unit 7b will be described.

[0134] Fig. 29 is a flowchart for illustrating an operation of each component during the defrosting operation for second heat exchange unit 7b in the third embodiment. Fig. 30 shows a state of each component in each processing of the flowchart shown in Fig. 29. Fig. 30 shows open and closed states of solenoid valves 3c, 3d, 3b, 3e, and 3f in each processing shown in Fig. 29, a flow direction of the refrigerant in flow path switching valve 8, and a distribution state of the refrigerant in flow rate adjusting valve 10b.

[0135] In the flowchart shown in Fig. 29, steps S301 to S305 in the flowchart shown in Fig. 24 are replaced by steps S301A to S305A.

[0136] When the heating operation is started, in step S300, controller 50 controls solenoid valves 3c, 3d, 3b,

3e, and 3f, flow path switching valve 8, and flow rate adjusting valve 10b such that solenoid valve 3c enters the open state, solenoid valve 3d enters the open state, solenoid valve 3b enters the closed state, solenoid valve 3e enters the closed state, solenoid valve 3f enters the closed state, flow path switching valve 8 selects first bypass flow path B1, and flow rate adjusting valve 10b flows a total amount of the refrigerant to main circuit 30. As a result, the refrigerant flows as shown in Fig. 26.

[0137] Next, in step S301A, controller 50 obtains information for determining whether or not frost forms on second heat exchange unit 7b, and determines whether or not frost forms on second heat exchange unit 7b. Specifically, controller 50 obtains a detection result by temperature sensor 2d, and determines whether or not a surface temperature of second heat exchange unit 7b is equal to or less than a predetermined first threshold value (e.g., -3°C), based on the detection result. When the surface temperature of second heat exchange unit 7b is equal to or less than the first threshold value, controller 50 determines that frost forms on second heat exchange unit 7b. In this case, controller 50 moves the process to step S302A.

[0138] In step S302A, controller 50 controls solenoid valves 3d and 3b, flow path switching valve 8, and flow rate adjusting valve 10 such that solenoid valve 3d enters the closed state, solenoid valve 3b enters the open state, flow path switching valve 8 selects second bypass flow path B2, and flow rate adjusting valve 10 distributes the refrigerant to pipe C0 of main circuit 30 and second bypass flow path B2. As to solenoid valves 3e and 3f, the state in step S300 is maintained, i.e., solenoid valves 3e and 3f are both controlled to the closed state. As to solenoid valve 3c, the state in step S300 is maintained, i.e., solenoid valve 3c is controlled to the open state.

[0139] Fig. 31 shows a flow of the refrigerant in a first stage (S302A, S303A) during the defrosting operation for second heat exchange unit 7b. As shown in Fig. 31, one part of the refrigerant discharged from compressor 1 flows to main circuit 30 and first heat exchange unit 7a, to thereby continue the heating operation. The other part of the refrigerant flows through second bypass flow path B2, is decompressed in expansion valve 6e, and is again suctioned into compressor 1.

[0140] In step S302A, the degree of opening of expansion valve 6e is set to be the same as the degree of opening of expansion valve 6a. The reason for this is to allow the refrigerant flowing through pipe C1 of main circuit 30 and the refrigerant flowing through second bypass flow path B2 to join at point P11 at the same pressure.

[0141] Next, in step S303A, controller 50 obtains information for determining whether or not the discharge temperature of the refrigerant reaches a target value, and determines whether or not the discharge temperature of the refrigerant reaches the target value. Specifically, controller 50 obtains a detection result by temperature sensor 2a, and determines whether or not the temperature of the refrigerant discharged from compressor 1 reaches

a predetermined second threshold value (e.g., 100°C), based on the detection result. When the discharge temperature of the refrigerant reaches the second threshold value in step S303A, controller 50 moves the process to step S304A.

[0142] In steps S302A and S303A, a density of the refrigerant suctioned into compressor 1 may decrease over time. In this case, a mass flow rate of the refrigerant suctioned into compressor 1 decreases, and thus, the discharge temperature of the refrigerant may be less likely to increase over time. Therefore, when the increase in discharge temperature of the refrigerant at a certain time interval (e.g., five-second interval) is less than a predetermined third threshold value (e.g., 10°C) in step S303A, control for increasing an operation frequency of compressor 1 may be performed. Alternatively, when the temperature of the refrigerant discharged from compressor 1 is less than the predetermined second threshold value (e.g., 100°C) after a certain time period (e.g., 60 seconds) elapses from the start of step S302A, the process may proceed to step S304A.

[0143] In step S304A, controller 50 controls solenoid valve 3f and flow path switching valve 8 such that solenoid valve 3f enters the open state and flow path switching valve 8 selects first bypass flow path B1. As to solenoid valves 3b, 3c, 3d, and 3e and flow rate adjusting valve 10b, the states in step S302A are maintained.

[0144] Fig. 32 shows a flow of the refrigerant in a second stage (S304A, S305A) during the defrosting operation for second heat exchange unit 7b. As shown in Fig. 32, a part of the high-temperature and high-pressure refrigerant discharged from compressor 1 flows through first bypass flow path B1 and is introduced into second heat exchange unit 7b. Defrosting for second heat exchange unit 7b is thus performed. The refrigerant flowing out of second heat exchange unit 7b is decompressed in expansion valve 6g.

[0145] In step S304A, controller 50 sets a degree of opening of expansion valve 6g to be the same as the degree of opening of expansion valve 6a, and sets solenoid valve 6f in the fully open state. The reason for this is to allow the refrigerant in main circuit 30 flowing through first heat exchange unit 7a and the refrigerant flowing through second heat exchange unit 7b and used for defrosting to have the same pressure and join at point P10.

[0146] Next, in step S305A, controller 50 determines whether or not to end defrosting. Specifically, controller 50 determines whether or not the surface temperature of second heat exchange unit 7b is equal to or more than a predetermined third threshold value (e.g., 0°C), based on a detection signal output from temperature sensor 2d. When the surface temperature of second heat exchange unit 7b is equal to or more than the above-described third threshold value, controller 50 determines to end defrosting. When controller 50 determines to end defrosting, controller 50 moves the process to step S306.

[0147] In step S306, controller 50 controls solenoid valves 3c, 3d, 3b, and 3e and flow rate adjusting valve

10b such that solenoid valve 3c enters the open state, solenoid valve 3d enters the open state, solenoid valve 3b enters the closed state, solenoid valve 3e enters the closed state, and flow rate adjusting valve 10b flows the total amount of the refrigerant to main circuit 30. As a result, the refrigerant flows as shown in Fig. 26, and the regular heating operation is performed.

[0148] As described above, in the third embodiment, when frost forms on only one of first heat exchange unit 7a and second heat exchange unit 7b, defrosting for the frosted heat exchange unit is performed by the processes in the flowcharts shown in Figs. 24 and 29. However, when frost forms on the two heat exchange units at the same time, defrosting is performed in accordance with a degree of priority described below.

[0149] First, when two heat exchange units each having a small height are arranged in a vertical direction of an outdoor unit, defrosting is performed more preferentially for the heat exchange unit arranged on the upstream side in the vertical direction. The reason for this is that if defrosting is performed in the reversed order, the heat exchange unit on the downstream side subjected to defrosting is splashed with water produced by defrosting for the heat exchange unit on the upstream side, which may cause refreezing on a surface of the heat exchange unit on the downstream side. When one of two heat exchange units each having the small number of rows in a wind direction is arranged on the upwind side and the other is arranged on the downwind side, defrosting is performed more preferentially for the heat exchange unit on the upwind side. The reason for this is that frost is more likely to form on the heat exchange unit on the upwind side than the heat exchange unit on the downwind side, and defrosting for the heat exchange unit on the downwind side is often unnecessary. In the following description, the heat exchange unit for which defrosting is performed preferentially corresponds to first heat exchange unit 7a.

[0150] Fig. 33 is a flowchart for illustrating an example process of performing defrosting for first heat exchange unit 7a more preferentially than second heat exchange unit 7b in the third embodiment. The numbers of the steps are the same as those of the steps in Figs. 24 and 29, and detailed description will not be repeated.

[0151] Referring to Fig. 33, first, in step S300, controller 50 flows the refrigerant to first heat exchange unit 7a and second heat exchange unit 7b in parallel, to thereby perform the normal heating operation. Then, in step S301, controller 50 determines whether or not frost forms on first heat exchange unit 7a.

[0152] When it is determined that frost forms in step S301 (YES in S301), in steps S302 and S303, controller 50 continues heating using second heat exchange unit 7b with a part of the refrigerant, and performs a refrigerant temperature increasing process of flowing and circulating the remaining refrigerant through second bypass flow path B2 to increase the temperature of the refrigerant.

[0153] Thereafter, in steps S304 and S305, controller

50 continues heating using second heat exchange unit 7b with a part of the refrigerant, and flows the remaining refrigerant to first heat exchange unit 7a through first bypass flow path B1 to perform defrosting for first heat exchange unit 7a.

[0154] When it is determined that frost does not form in step S301 and when the processing in steps S304 and S305 is performed and defrosting for first heat exchange unit 7a is completed, controller 50 determines whether or not frost forms on second heat exchange unit 7b in step S301A.

[0155] When it is determined that frost forms in step S301A (YES in S301A), in steps S302A and S303A, controller 50 continues heating using first heat exchange unit 7a with a part of the refrigerant, and performs the refrigerant temperature increasing process of flowing and circulating the remaining refrigerant through second bypass flow path B2 to increase the temperature of the refrigerant.

[0156] Thereafter, in steps S304A and S305A, controller 50 continues heating using first heat exchange unit 7a with a part of the refrigerant, and flows the remaining refrigerant to second heat exchange unit 7b through first bypass flow path B1 to perform defrosting for second heat exchange unit 7b.

[0157] When it is determined that frost does not form in step S301A and when the processing in steps S304A and S305A is performed and defrosting for second heat exchange unit 7b is completed, the process proceeds to step S306. In step S306, controller 50 changes the settings of the valves to flow the refrigerant to first heat exchange unit 7a and second heat exchange unit 7b in parallel to perform the normal heating operation.

[0158] Next, an effect of the air conditioning apparatus according to the third embodiment configured as mentioned above will be described.

[0159] In the third embodiment, during the defrosting operation, the refrigerant is distributed and flown to main circuit 30 and second bypass flow path B2, and then, is distributed and flown to main circuit 30 and first bypass flow path B1. Therefore, the heating operation can be continued even during the defrosting operation.

[0160] Since the heating operation can be continued even during the defrosting operation, a decrease in room temperature during the defrosting operation can be reduced, which leads to improvement in comfortability.

[0161] In the end, the effects of the air conditioning apparatuses according to the first to third embodiments will be summarized.

[0162] The air conditioning apparatus according to the present disclosure includes first bypass flow path B1 that connects the discharge side of compressor 1 and the heating inlet side of outdoor second heat exchanger 7, and second bypass flow path B2 that connects the discharge side of compressor 1 and the suction side of compressor 1. When the temperature of outdoor second heat exchanger 7 becomes equal to or less than the predetermined first threshold value, controller 50 controls flow

path selection device 20, 20A, 20B to flow the refrigerant to second bypass flow path B2 and then flow the refrigerant to outdoor second heat exchanger 7 through first bypass flow path B1 to thereby perform defrosting.

[0163] By flowing the refrigerant to second bypass flow path B2, the discharge temperature of the refrigerant in compressor 1 can be made higher than normal.

[0164] By increasing the discharge temperature of the refrigerant, the refrigerant having a temperature higher than that during the normal heating operation can be flown to outdoor second heat exchanger 7 when flow path selection device 20, 20A, 20B is switched to first bypass flow path B1.

[0165] Since the defrosting operation is performed with the temperature of the refrigerant being higher than normal, the temperature difference between the refrigerant and the frosted heat exchanger is large and the amount of heat exchange per unit time increases in the whole of outdoor second heat exchanger 7. Therefore, defrosting can be performed in a short time.

[0166] The above-described effect of being able to perform defrosting in a short time by increasing the discharge temperature of the refrigerant is obtained regardless of the type of the refrigerant contained in the air conditioning apparatus, such as HFC refrigerant, HFO refrigerant, HC refrigerant, or non-azeotropic mixed refrigerant. Particularly, by using refrigerant having a low GWP (e.g., R290 (GWP: 3), which is one type of HC refrigerant), a GWP total amount value in the cycle can be reduced.

[0167] When the non-azeotropic mixed refrigerant is contained in the air conditioning apparatus, frost is likely to form on the heating refrigerant inlet side of the outdoor heat exchanger. However, in the air conditioning apparatus according to the present embodiment, high-pressure and high-temperature refrigerant gas can be flown to the heating refrigerant inlet side of second heat exchanger 7 through first bypass flow path B1. Therefore, the temperature difference between the refrigerant and the frosted heat exchanger becomes large at the heating refrigerant inlet side of second heat exchanger 7 and the amount of heat exchange per unit time increases. Therefore, defrosting can be performed in a short time.

[0168] In the air conditioning apparatus according to the present embodiment, defrosting is performed in a more overheated gas region, as compared with general defrosting performed by switching to the cooling operation. Therefore, a degree of overheat (SH) of the refrigerant suctioned into compressor 1 increases and liquid back to compressor 1 is less likely to occur. Thus, the reliability of compressor 1 can be improved.

[0169] In addition, in the air conditioning apparatus according to the present embodiment, the refrigerant does not flow through extension pipes 9a and 9b, indoor first heat exchanger 5 and the like during the defrosting operation, as compared with the general defrosting operation performed by switching to the cooling operation. Therefore, a heat release loss can be reduced.

[0170] In addition, in the air conditioning apparatus ac-

cording to the present embodiment, the defrosting operation can be performed without flowing the refrigerant through indoor first heat exchanger 5, as compared with the general defrosting operation performed by switching to the cooling operation. Therefore, absorption of heat does not occur in first heat exchanger 5, and thus, a decrease in room temperature during the defrosting operation can be reduced.

[0171] In addition, in the air conditioning apparatus according to the present embodiment, when the defrosting operation is started, flow path selection device 20, 20A, 20B is controlled to stop the inflow of the refrigerant into main circuit 30 and flow the refrigerant to second bypass flow path B2 and then flow the refrigerant to outdoor second heat exchanger 7 through first bypass flow path B1. Therefore, switching of the four-way valve at the time of the defrosting operation is unnecessary, and it is unnecessary to stop the compressor in order to produce a pressure state required for switching of the four-way valve. Thus, the time to start of defrosting can be made shorter.

[0172] In addition, when the defrosting operation ends and the operation returns to the heating operation, flow path selection device 20, 20A, 20B is controlled to flow the total amount of the refrigerant to main circuit 30, which eliminates the need to switch the four-way valve at the time of return to the heating operation. Therefore, it is unnecessary to stop the compressor in order to produce a pressure state required for switching of the four-way valve. Thus, the time to return to the heating operation can be made shorter, as compared with the general defrosting operation performed by switching to the cooling operation.

[0173] 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 of the embodiments above, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0174] 1 compressor; 2a, 2b, 2c, 2d temperature sensor; 3a, 3b, 3c, 3d, 3e, 3f solenoid valve; 4 four-way valve; 5 first heat exchanger; 6a, 6b, 6c, 6d, 6e, 6f, 6g expansion valve; 7 second heat exchanger; 7a first heat exchange unit; 7b second heat exchange unit; 8 switching valve; 8b, 20, 20A, 20B, 20C selection device; 9a, 9b extension pipe; 10, 10b flow rate adjusting valve; 30 main circuit; 50 controller; 51 processor; 52 memory; 53 input and output interface; 100, 200, 300 air conditioning apparatus; B0 branch pipe; B1, B2, B3 flow path; C0, C1, C2 pipe.

Claims

1. An air conditioning apparatus comprising:

- a main circuit in which refrigerant circulates in the order of a compressor, a first heat exchanger, a first expansion valve, and a second heat exchanger in a heating operation;
 a first bypass flow path configured to communicate a pipe at the first expansion valve side of the second heat exchanger with a pipe at a discharge side of the compressor;
 a second bypass flow path configured to communicate a pipe at a suction side of the compressor with the pipe at the discharge side of the compressor; and
 a first flow path selection device configured to selectively flow the refrigerant discharged from the compressor to at least one of the first heat exchanger, the first bypass flow path, and the second bypass flow path,
 during the heating operation, the first flow path selection device being configured to select at least the first heat exchanger,
 during a defrosting operation, the first flow path selection device being configured to select at least the first bypass flow path after selecting at least the second bypass flow path.
2. The air conditioning apparatus according to claim 1, wherein
 during the defrosting operation, the first flow path selection device is configured to select the second bypass flow path and not to select the first bypass flow path and the first heat exchanger, and then, to select the first bypass flow path and not to select the second bypass flow path and the first heat exchanger.
3. The air conditioning apparatus according to claim 1 or 2, further comprising
 a second expansion valve arranged partway through the second bypass flow path or between the second bypass flow path and the pipe at the suction side of the compressor.
4. The air conditioning apparatus according to any one of claims 1 to 3, wherein
 the first flow path selection device includes:
 a first solenoid valve provided in a pipeline between the discharge side of the compressor and the first heat exchanger;
 a second solenoid valve provided in a branch pipe that branches off from the main circuit, the branch pipe being shared by the discharge side of the compressor and the first bypass flow path and the second bypass flow path; and
 a flow path switching valve configured to connect the branch pipe to one of the first bypass flow path and the second bypass flow path.
5. The air conditioning apparatus according to claim 1, wherein
 during the defrosting operation, the first flow path selection device is configured to select the second bypass flow path and not to select the first bypass flow path and the first heat exchanger, and then, to select the first bypass flow path and the second bypass flow path and not to select the first heat exchanger.
6. The air conditioning apparatus according to claim 1 or 5, further comprising:
 a second expansion valve arranged partway through the second bypass flow path;
 a third bypass flow path that branches off from a first pipe and extends to the suction side of the compressor, the first pipe being a pipe through which the refrigerant passing through the second heat exchanger flows during the heating operation;
 a third expansion valve arranged partway through the third bypass flow path; and
 a second flow path selection device, wherein the second flow path selection device is configured to selectively connect a second pipe or the third bypass flow path, the second pipe being configured to connect the first pipe to the suction side of the compressor not via the third bypass flow path.
7. The air conditioning apparatus according to claim 1, wherein
 the second heat exchanger includes a first heat exchange unit and a second heat exchange unit, and during the defrosting operation, the first flow path selection device is configured to distribute and flow the refrigerant to the main circuit and the second bypass flow path, and then, flow the refrigerant to the first heat exchange unit through the main circuit and flow the refrigerant to the second heat exchange unit through the first bypass flow path.
8. The air conditioning apparatus according to claim 7, further comprising
 a third flow path selection device configured to connect the first bypass flow path and the first expansion valve to one of the first heat exchange unit and the second heat exchange unit, wherein
 during the defrosting operation, the third flow path selection device is configured to connect the first bypass flow path to one of the first heat exchange unit and the second heat exchange unit, and connect the first expansion valve to the other of the first heat exchange unit and the second heat exchange unit.
9. The air conditioning apparatus according to any one of claims 1 to 8, wherein

the refrigerant is HC refrigerant.

10. The air conditioning apparatus according to any one of claims 1 to 8, wherein the refrigerant is non-azeotropic mixed refrigerant. 5

10

15

20

25

30

35

40

45

50

55

FIG.1

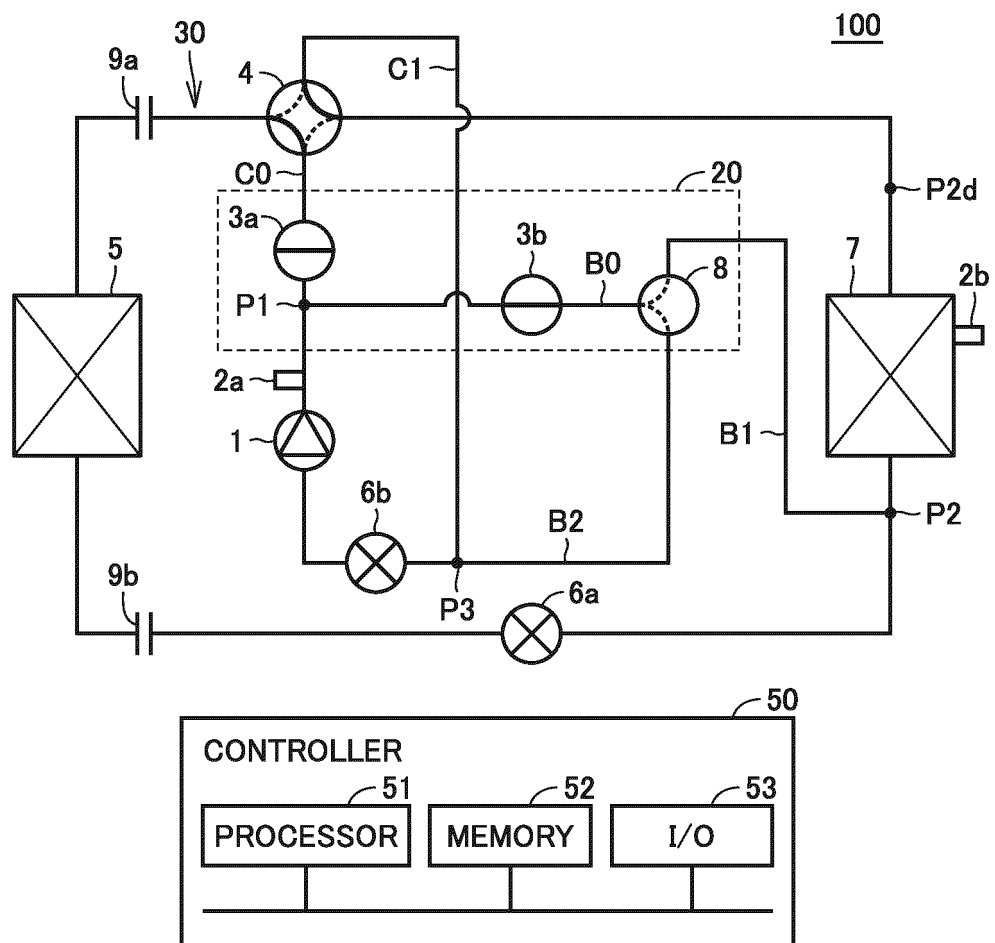


FIG.2

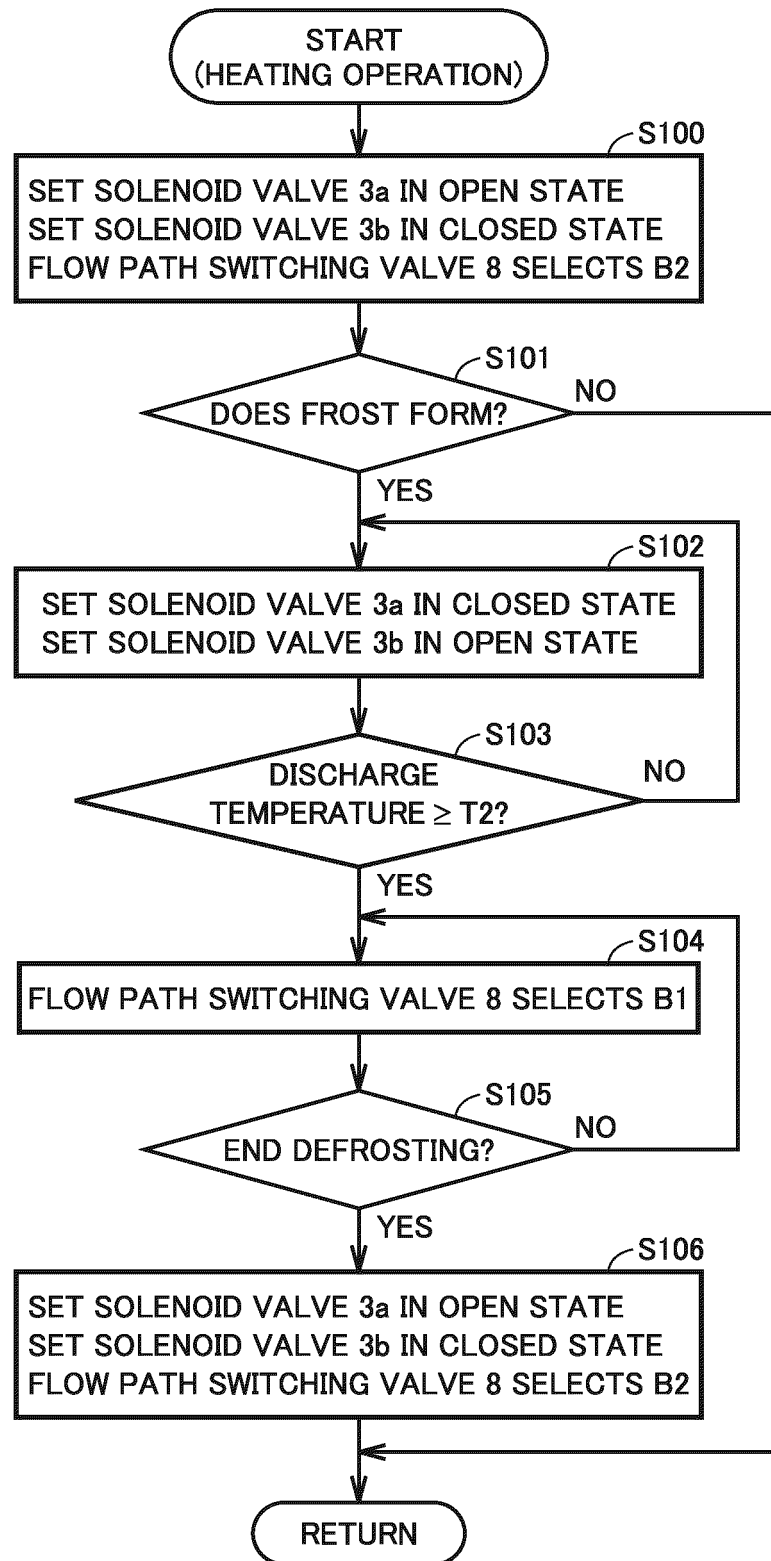


FIG.3

OPERATION STATE	PROCESSING	SOLENOID VALVE 3a	SOLENOID VALVE 3b	FLOW PATH SWITCHING VALVE 8
HEATING OPERATION	S100 S101	OPEN	CLOSED	BYPASS FLOW PATH B2
DEFROSTING OPERATION	S102 S103	CLOSED	OPEN	BYPASS FLOW PATH B2
	S104 S105	CLOSED	OPEN	BYPASS FLOW PATH B1
HEATING OPERATION	S106	OPEN	CLOSED	BYPASS FLOW PATH B2

FIG.4

HEATING OPERATION (S100,S101,S106)

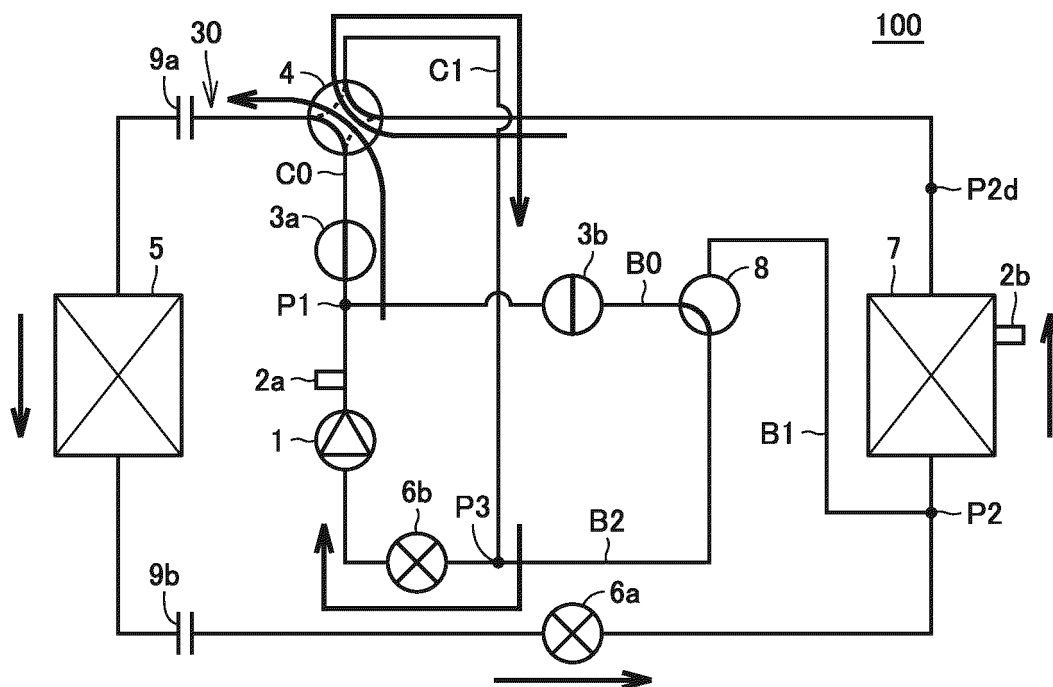


FIG.5

DEFROSTING OPERATION (S102,S103)

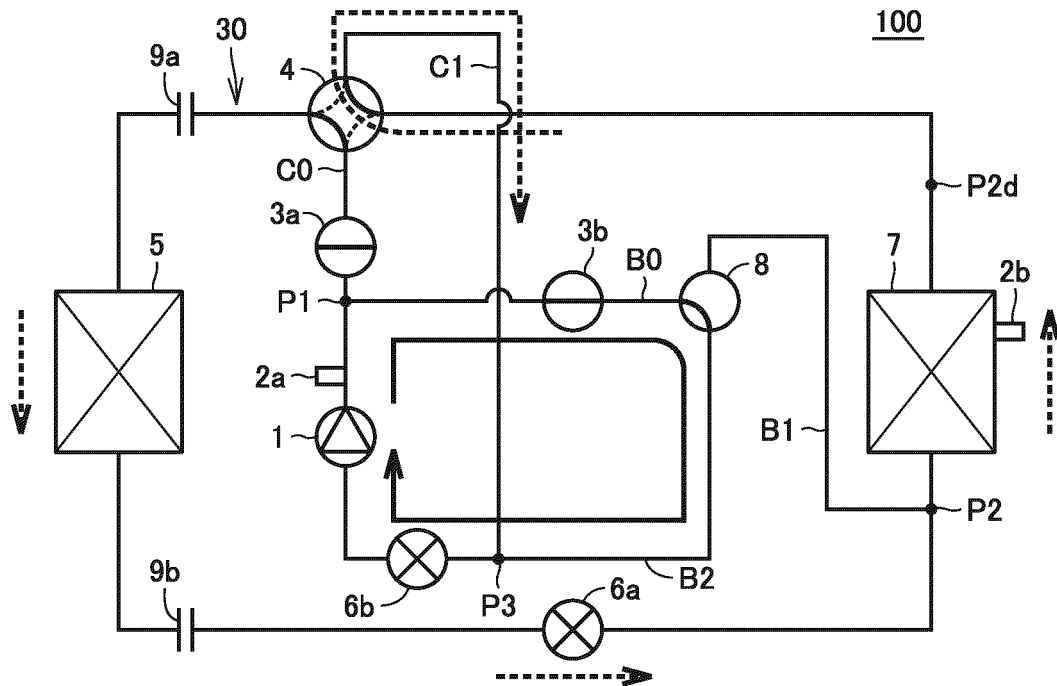


FIG.6

DEFROSTING OPERATION (S104,S105)

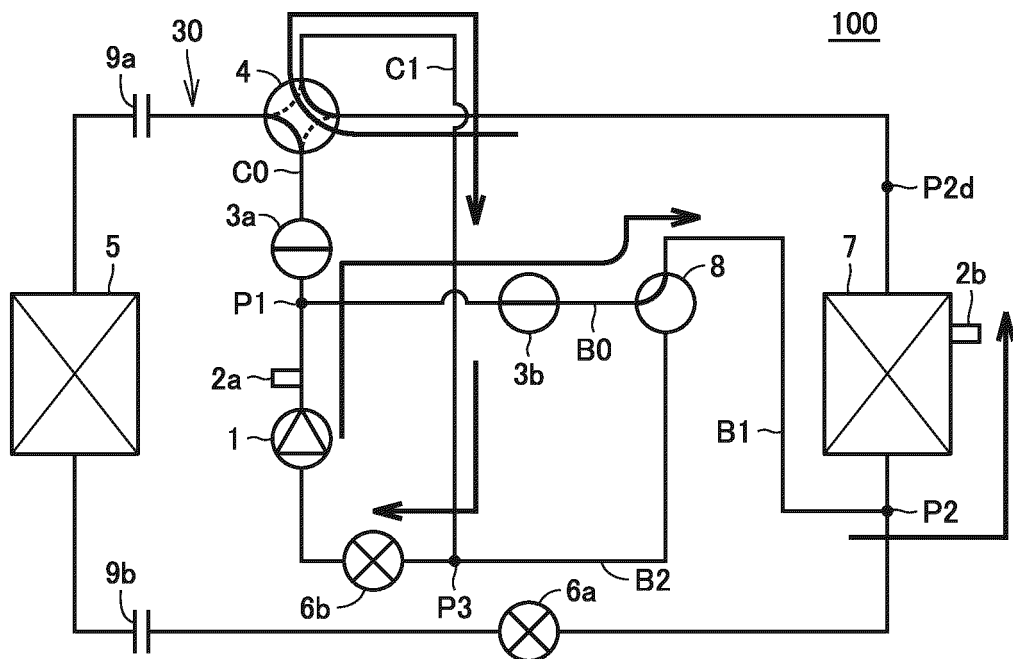


FIG.7

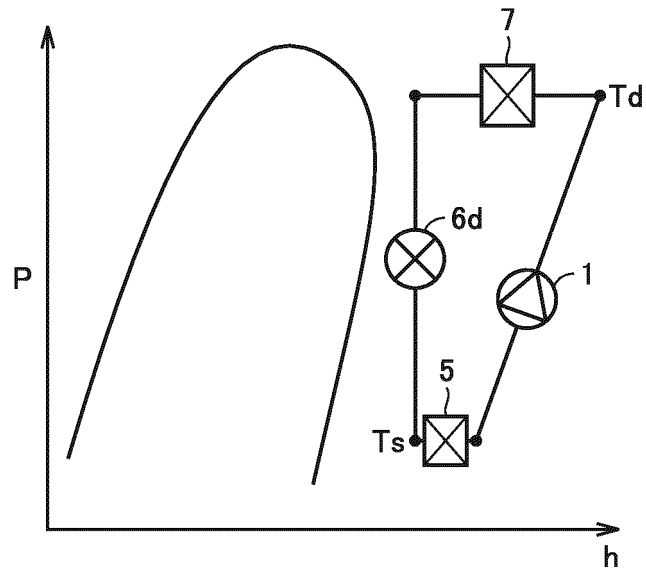


FIG.8

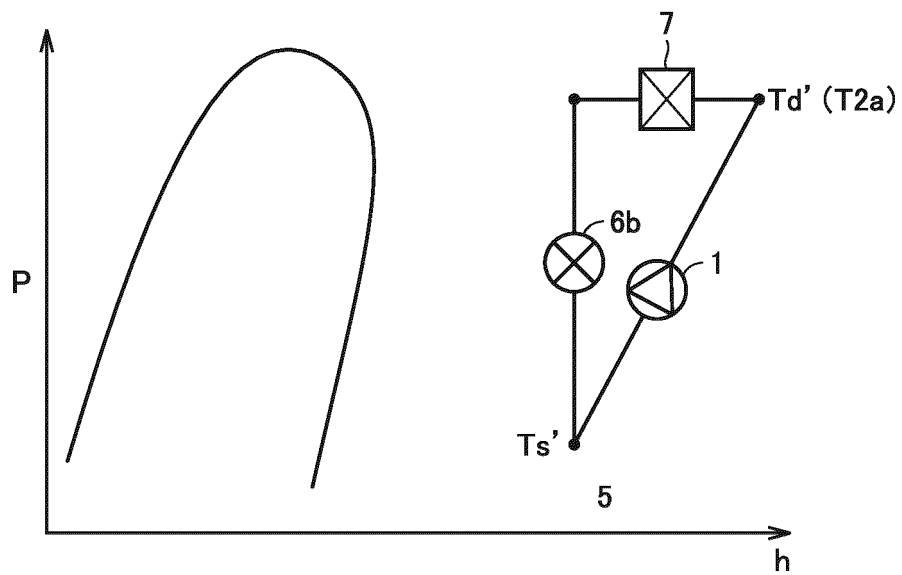


FIG.9

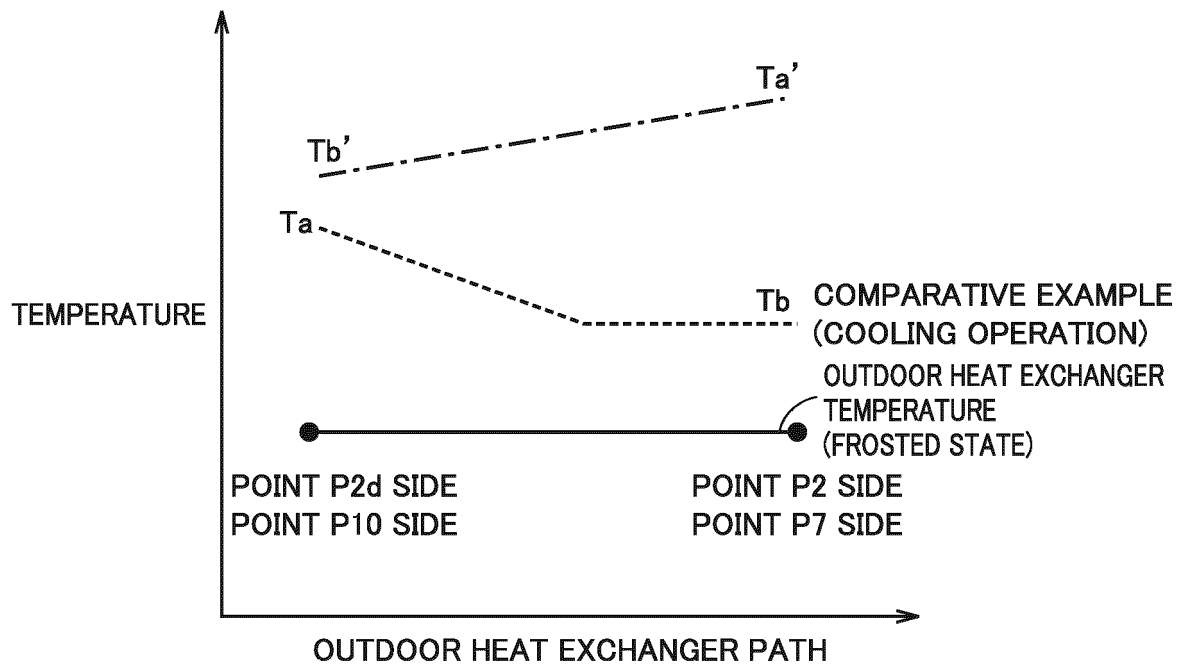


FIG.10

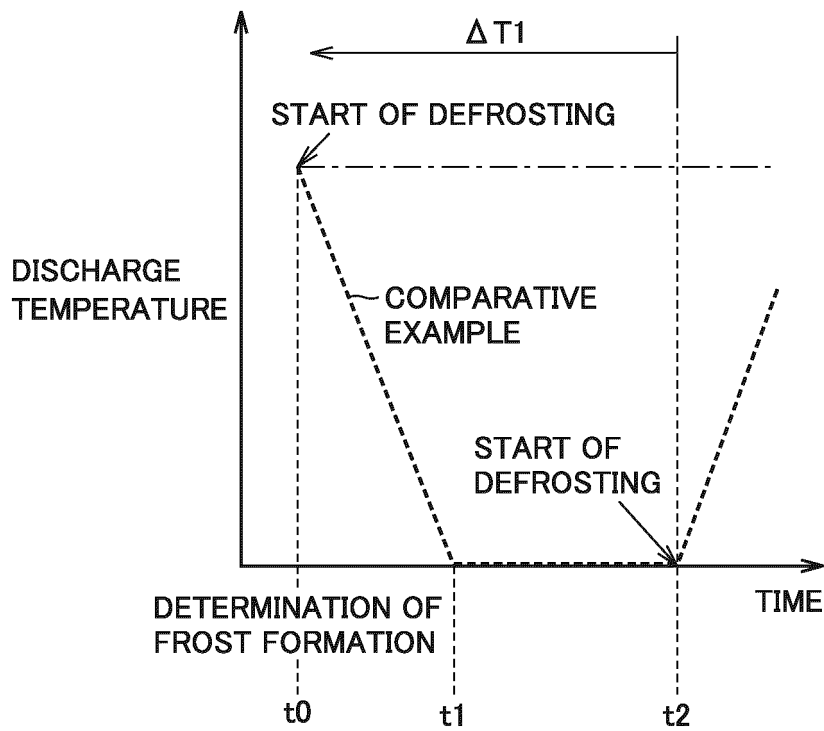


FIG.11

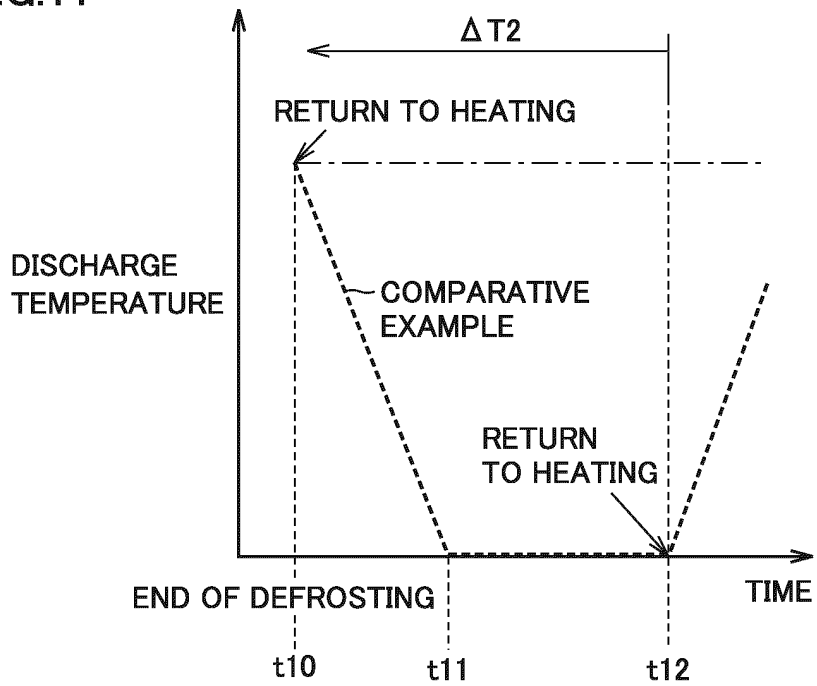


FIG.12

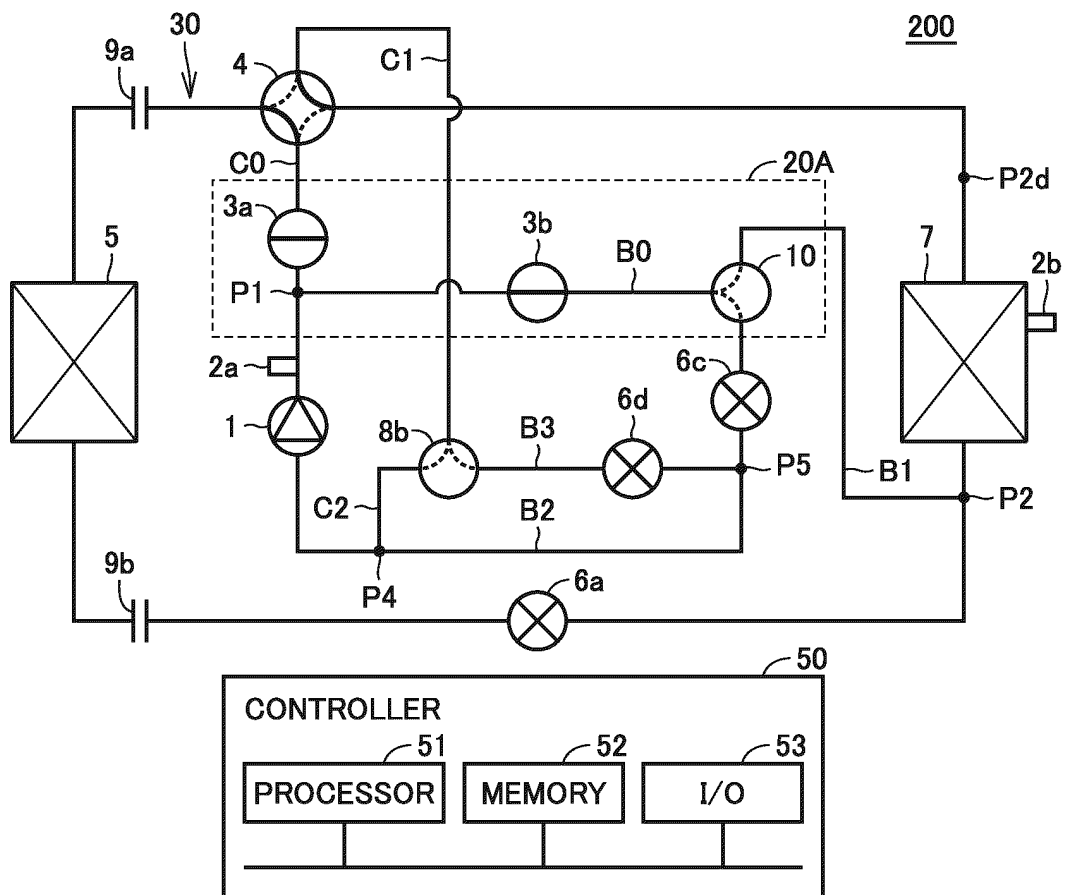


FIG.13

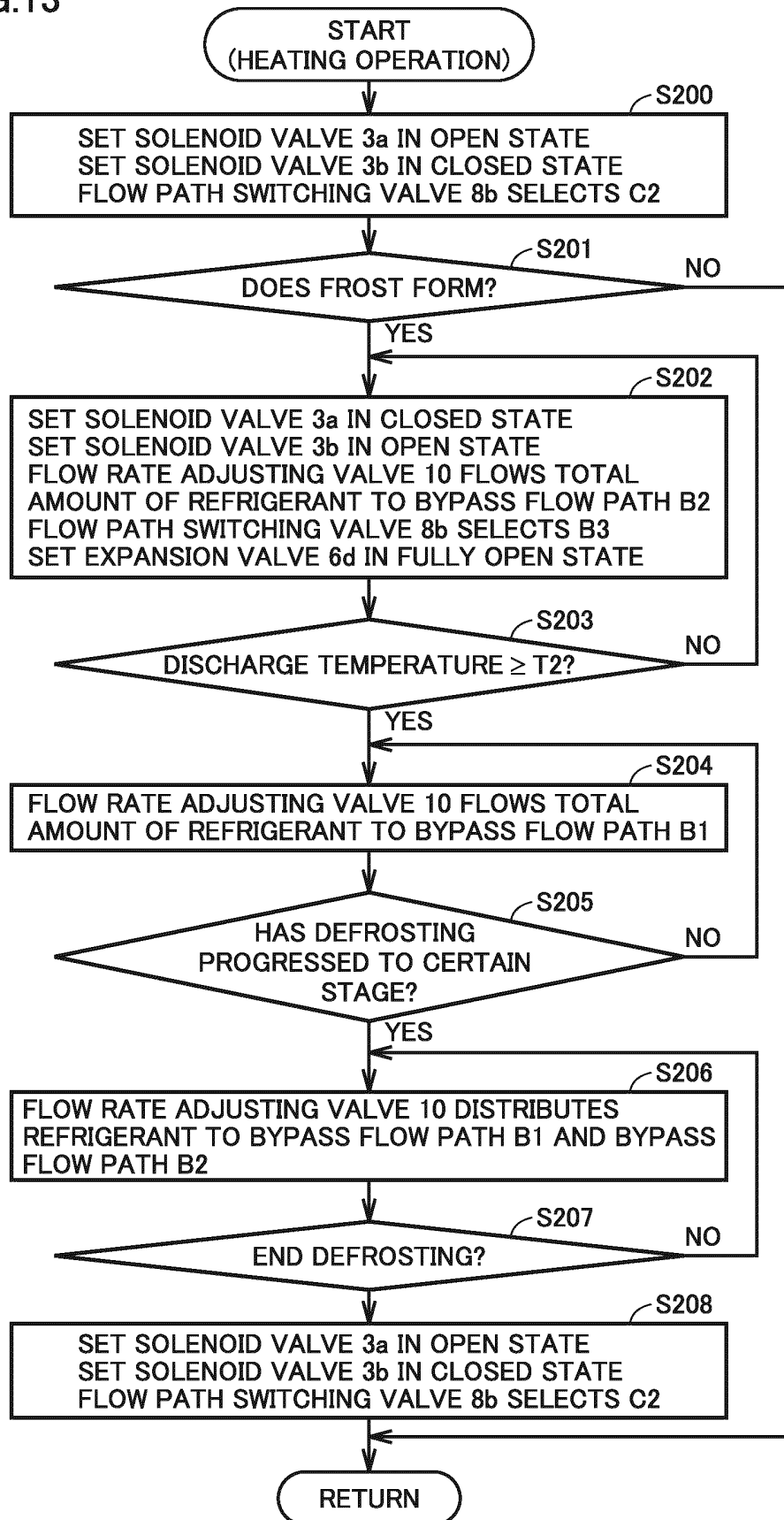


FIG. 14

OPERATION STATE	PROCESSING	SOLENOID VALVE 3a	SOLENOID VALVE 3b	FLOW PATH SWITCHING VALVE 8b	FLOW PATH WITCHINGVALVE 10
HEATING OPERATION	S200 S201	OPEN	CLOSED	PIPE C2	ARBITRARY STATE
DEFROSTING OPERATION	S202 S203	CLOSED	OPEN	BYPASS FLOW PATH B3	FLOW TOTAL AMOUNT OF REFRIGERANT TO BYPASS FLOW PATH B2
	S204 S205	CLOSED	OPEN	BYPASS FLOW PATH B3	FLOW TOTAL AMOUNT OF REFRIGERANT TO BYPASS FLOW PATH B1
	S206 S207	CLOSED	OPEN	BYPASS FLOW PATH B3	DISTRIBUTE REFRIGERANT TO BYPASS FLOW PATH B1 AND BYPASS FLOW PATH B2
HEATING OPERATION	S208	OPEN	CLOSED	PIPE C2	ARBITRARY STATE

FIG.15

HEATING OPERATION (S200,S201,S208)

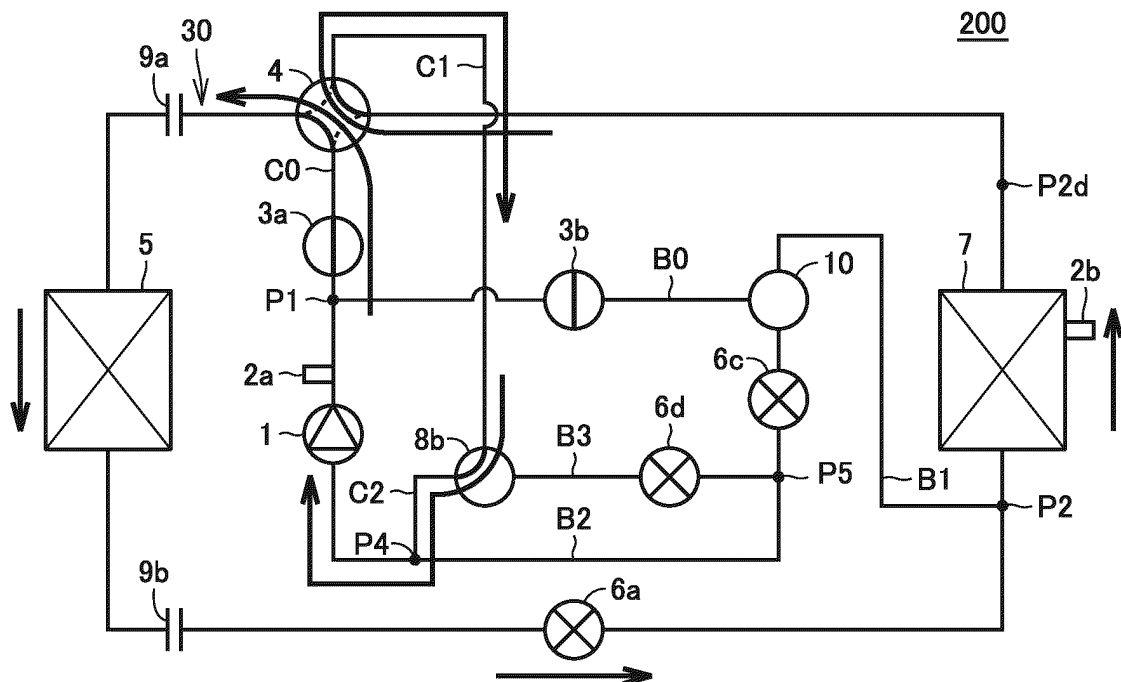


FIG.16

DEFROSTING OPERATION (S202,S203)

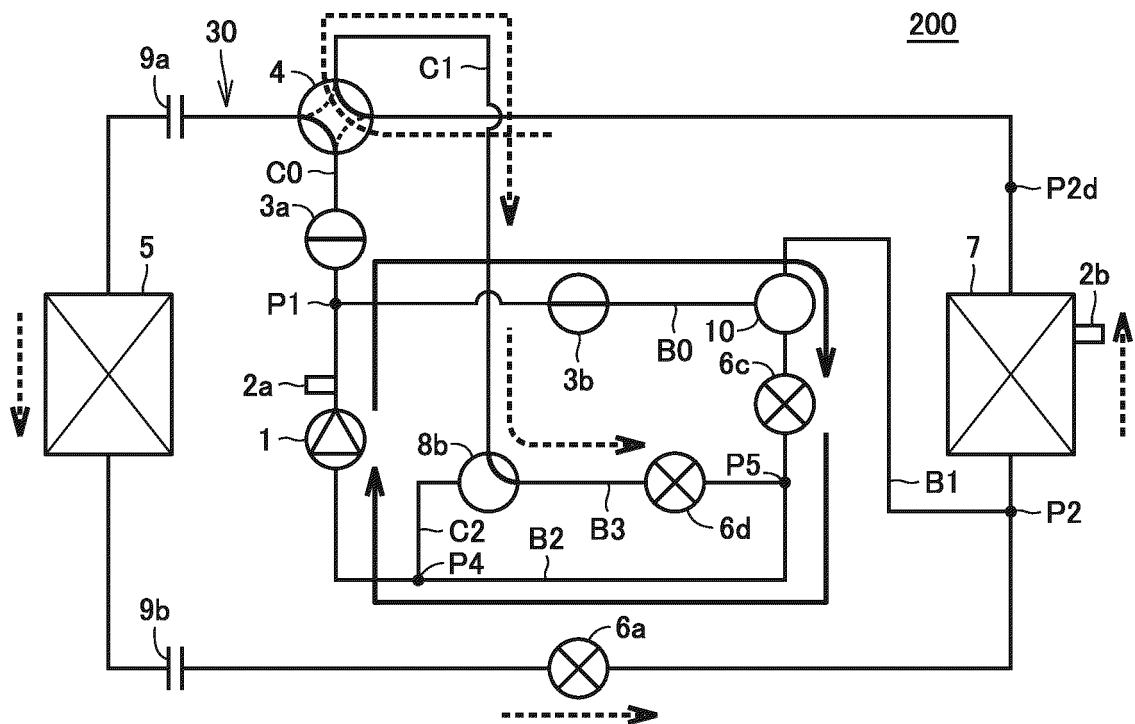


FIG.17

DEFROSTING OPERATION (S204,S205)

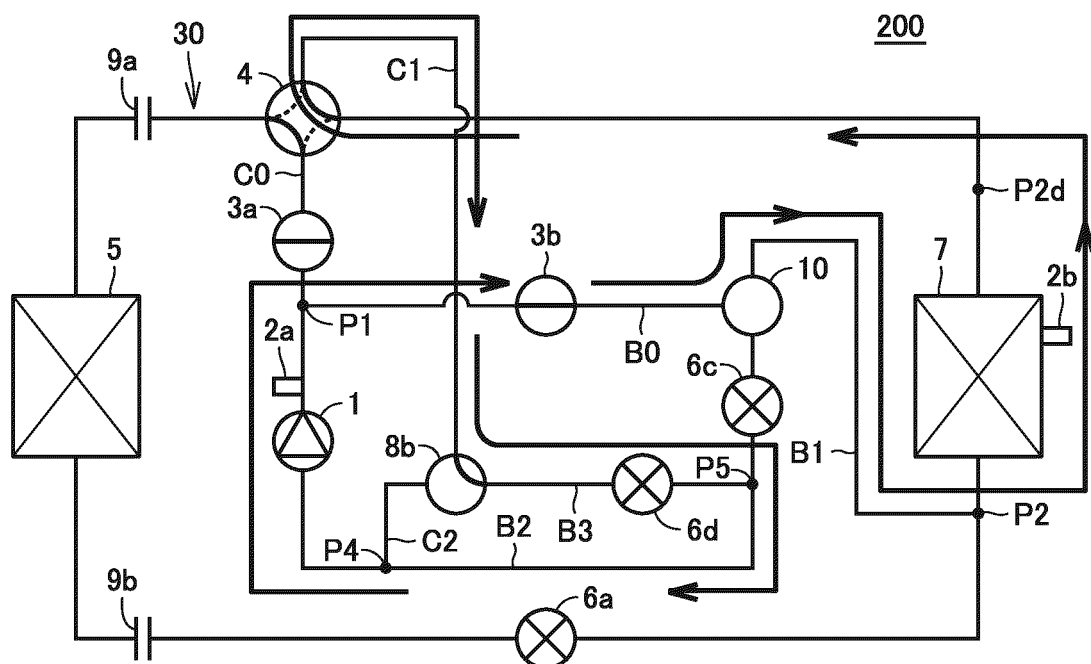


FIG.18

DEFROSTING OPERATION (S206,S207)

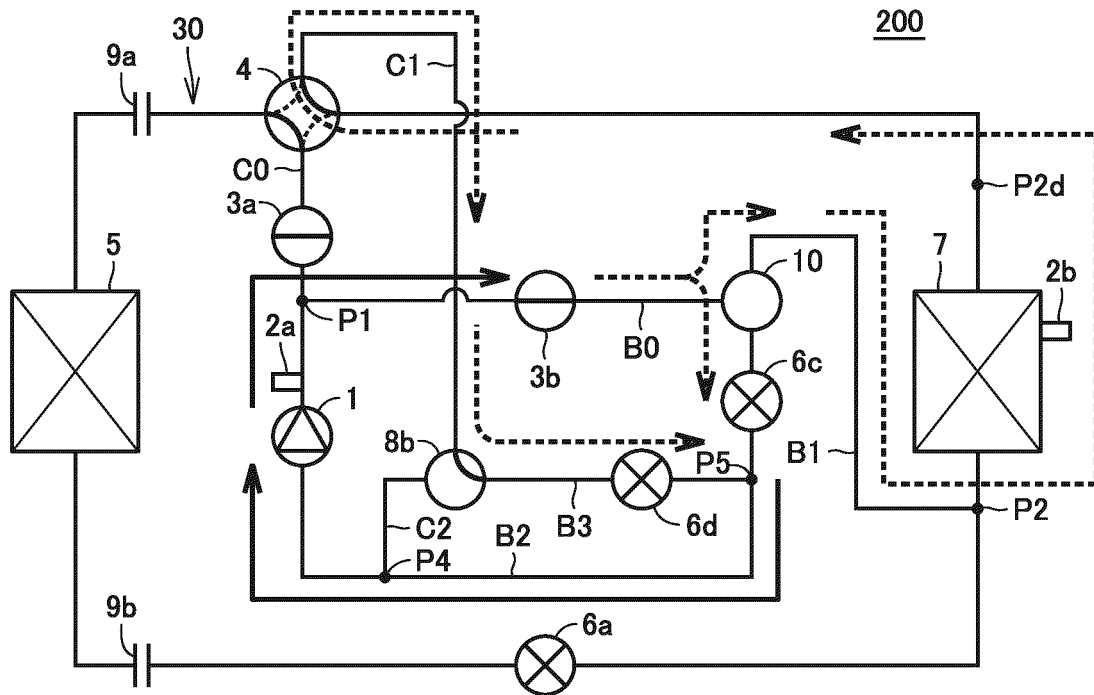


FIG.19

[DISTRIBUTION TO BYPASS FLOW PATH B2
STARTS JUST BEFORE END OF DEFROSTING]

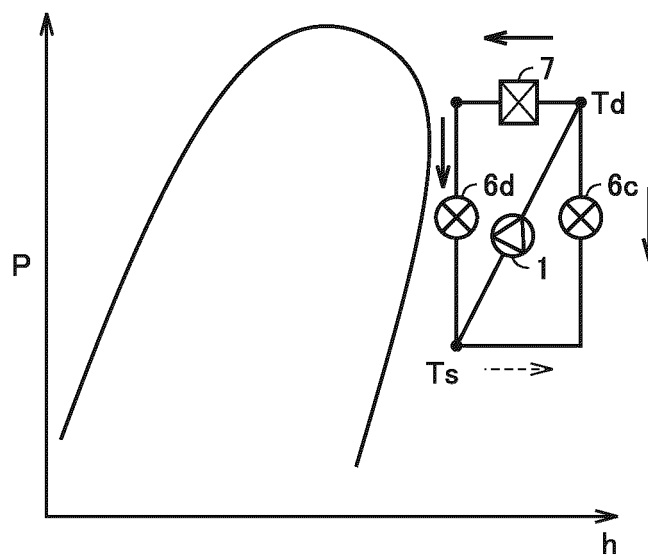


FIG.20

[CERTAIN TIME PERIOD ELAPSES AFTER DISTRIBUTION
TO BYPASS FLOW PATH B2 STARTS]

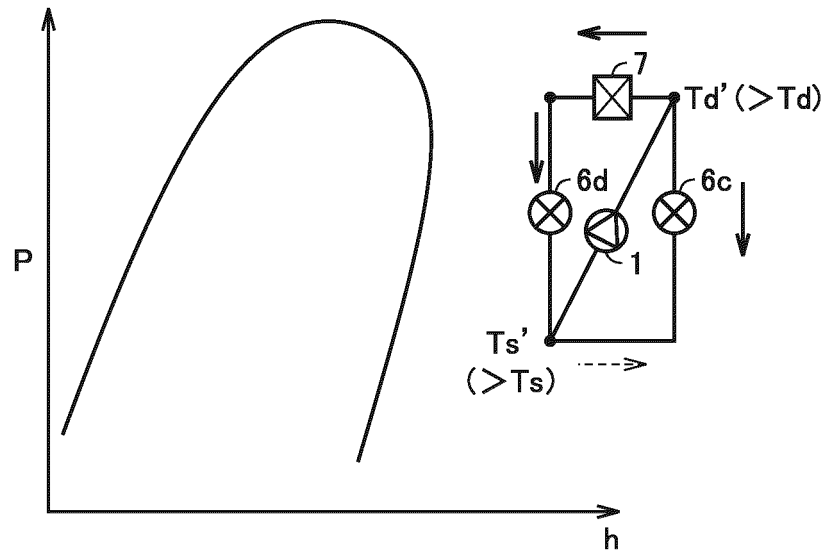


FIG.21

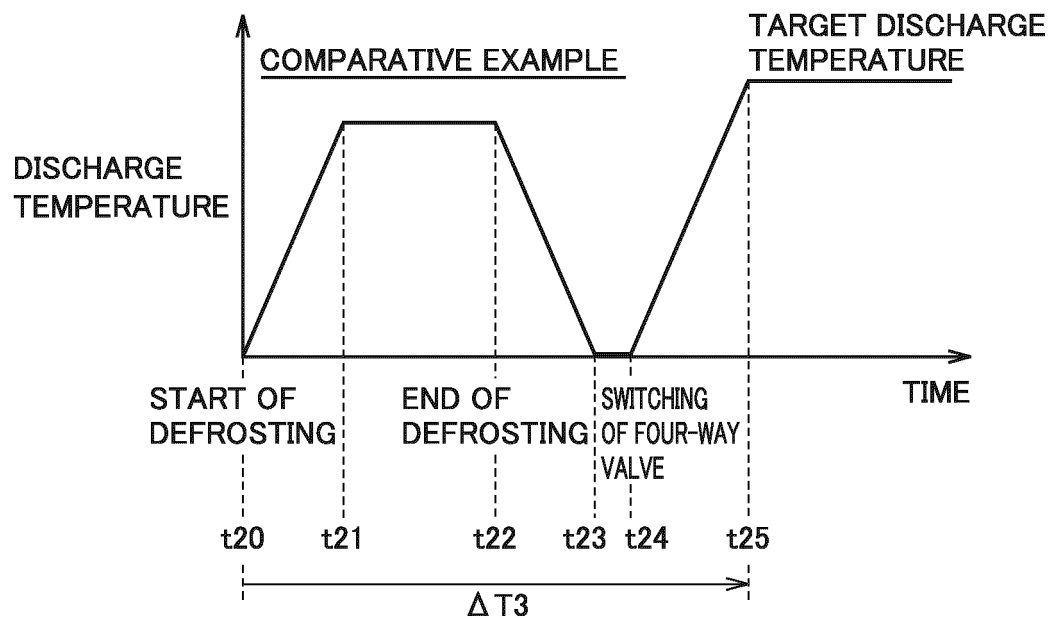


FIG.22

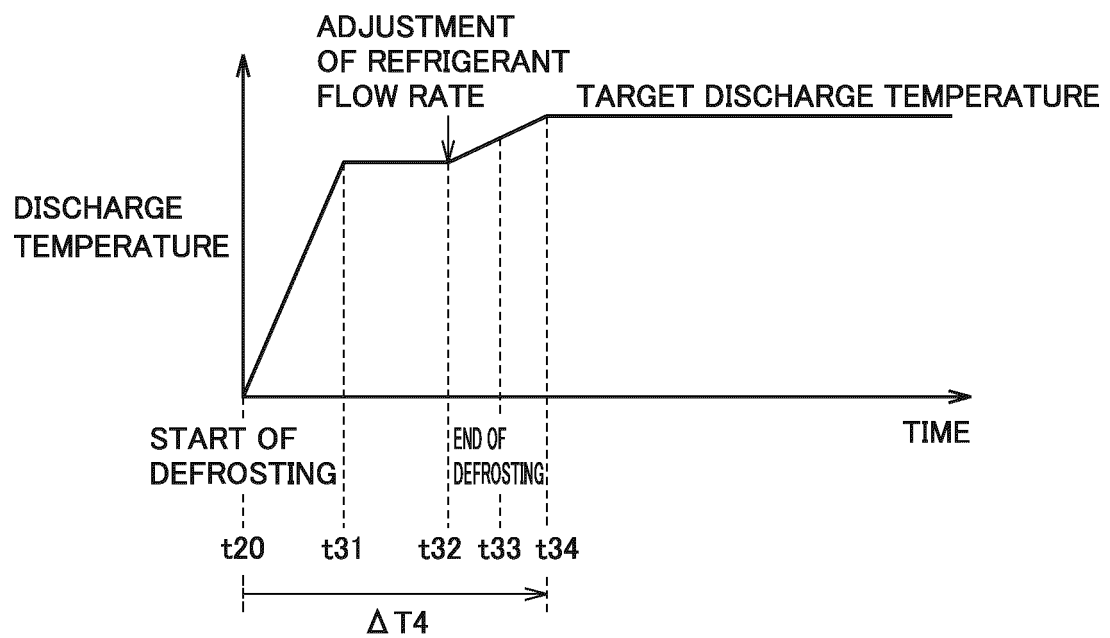


FIG.24

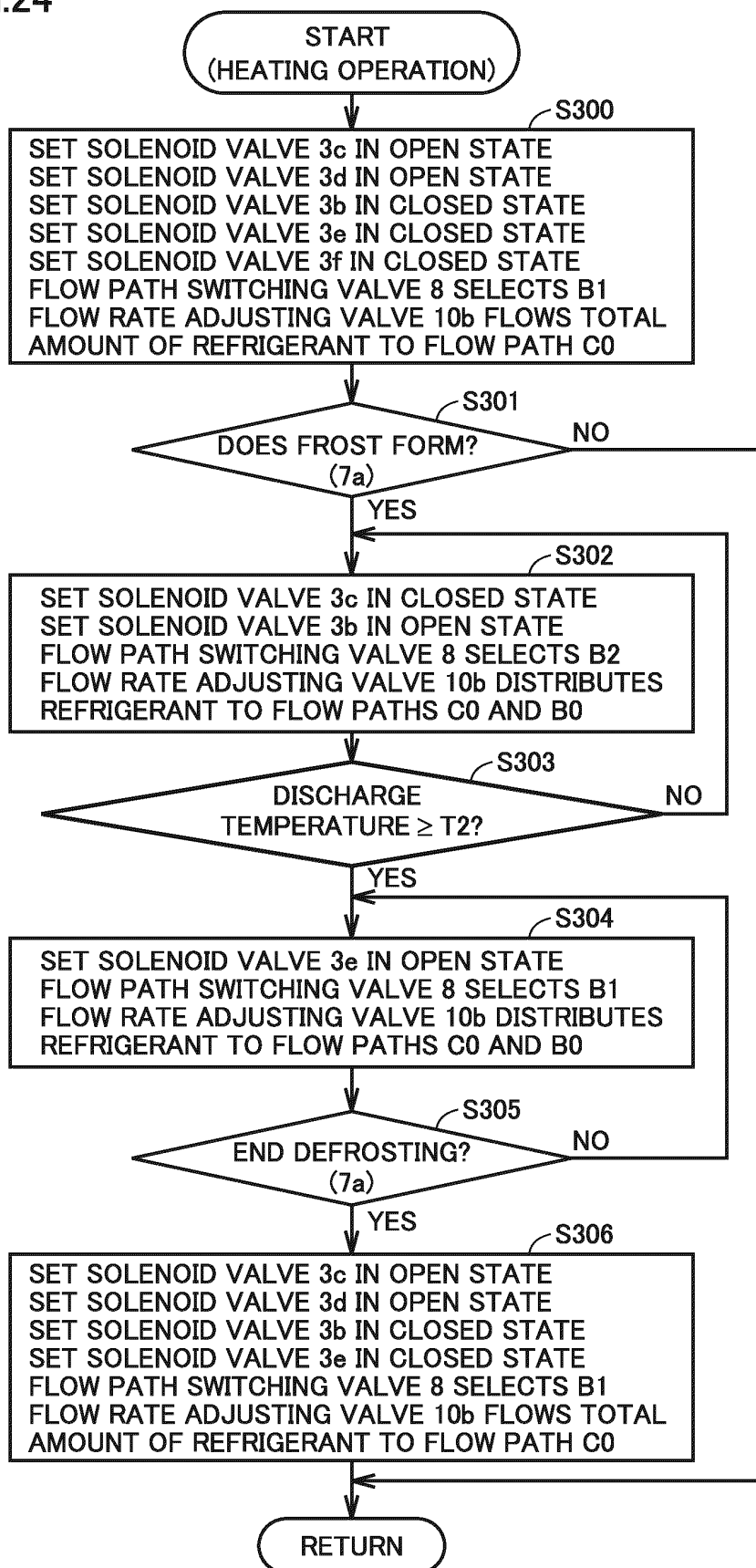


FIG.25

OPERATION STATE	PROCESSING	SOLENOID VALVE 3c	SOLENOID VALVE 3d	SOLENOID VALVE 3b	SOLENOID VALVE 3e	SOLENOID VALVE 3f	FLOW PATH SWITCHING VALVE 8	FLOW RATE ADJUSTING VALVE 10b
HEATING OPERATION	S300 S301	OPEN	OPEN	CLOSED	CLOSED	CLOSED	BYPASS FLOW PATH B1	FLOW TOTAL AMOUNT OF REFRIGERANT TO FLOW PATH C0
DEFROSTING OPERATION	S302 S303	CLOSED	OPEN	OPEN	CLOSED	CLOSED	BYPASS FLOW PATH B2	DISTRIBUTE REFRIGERANT TO FLOW PATHS C0 AND B0
	S304 S305	CLOSED	OPEN	OPEN	OPEN	CLOSED	BYPASS FLOW PATH B1	DISTRIBUTE REFRIGERANT TO FLOW PATHS C0 AND B0
HEATING OPERATION	S306	OPEN	OPEN	CLOSED	CLOSED	CLOSED	BYPASS FLOW PATH B1	FLOW TOTAL AMOUNT OF REFRIGERANT TO FLOW PATH C0

FIG.26

HEATING OPERATION (S300,S301,S306)

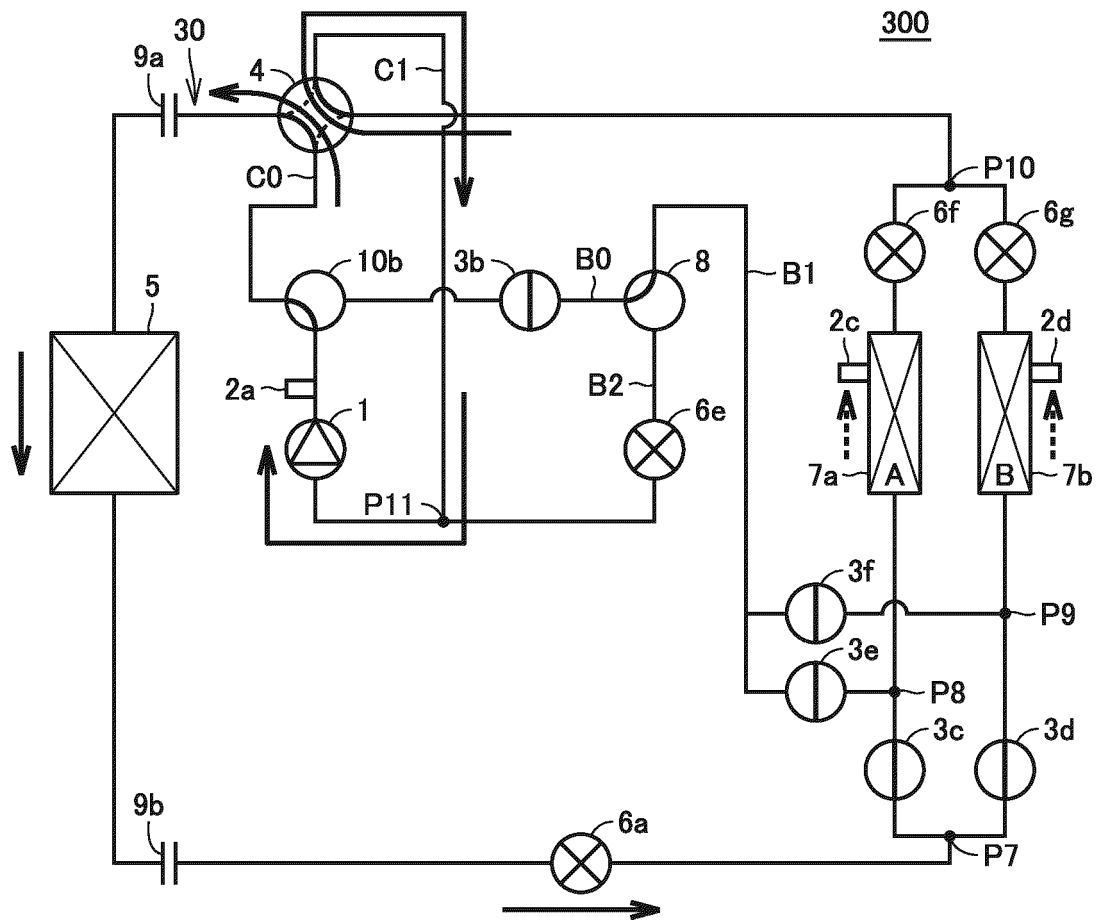


FIG.27

DEFROSTING OPERATION (S302,S303)

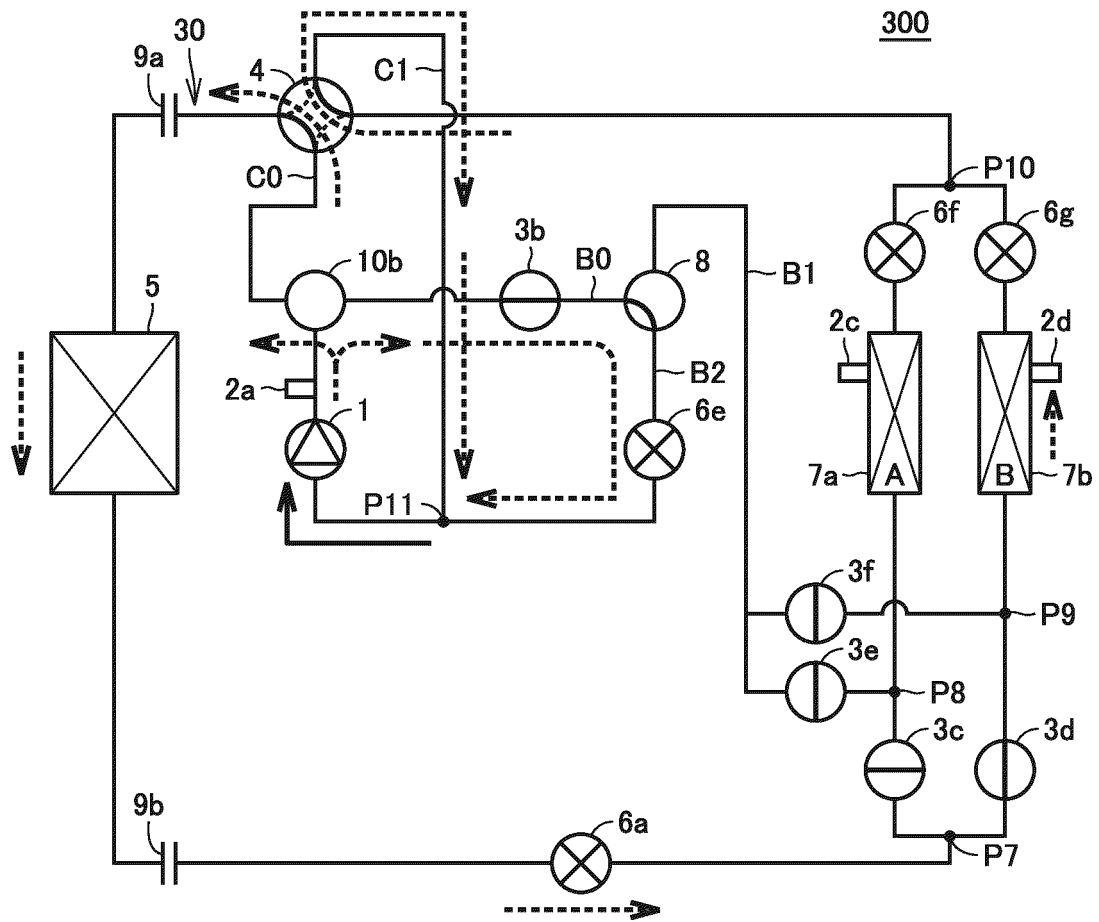


FIG.28

DEFROSTING OPERATION (S304,S305)

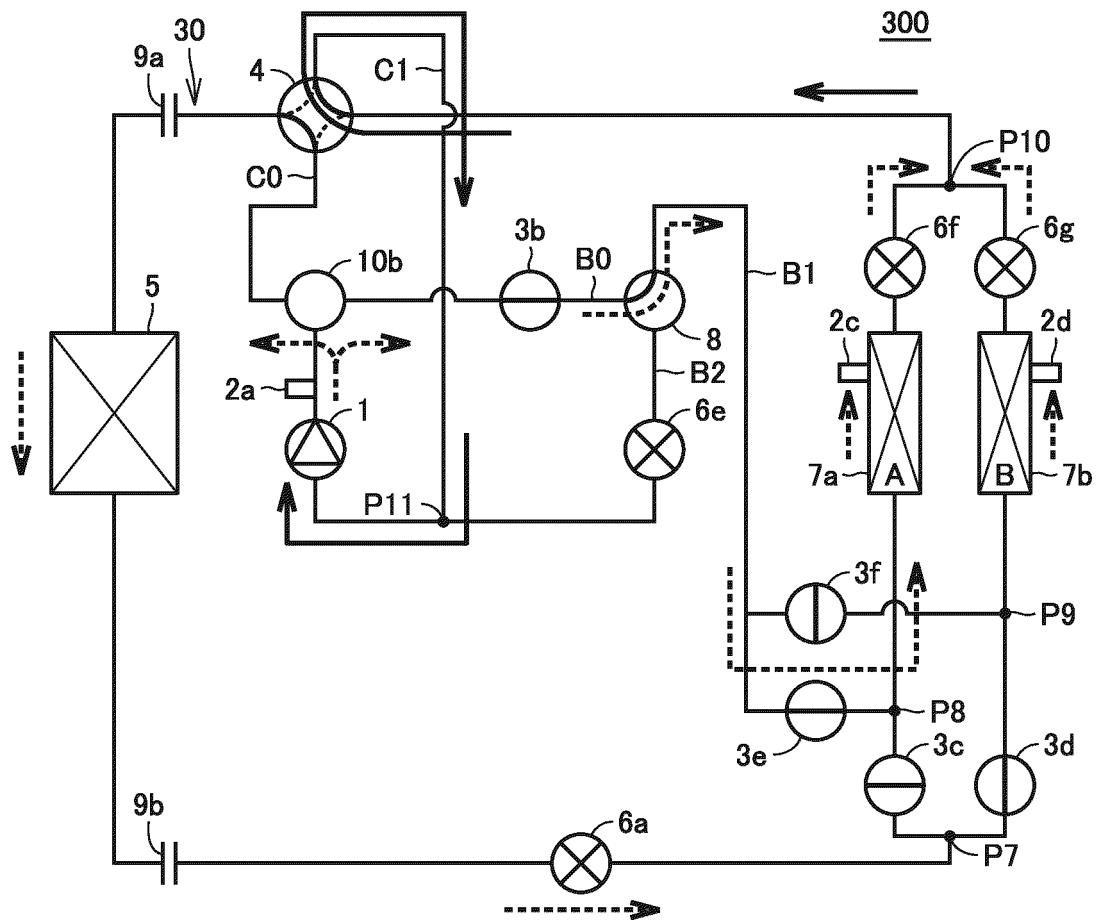


FIG.29

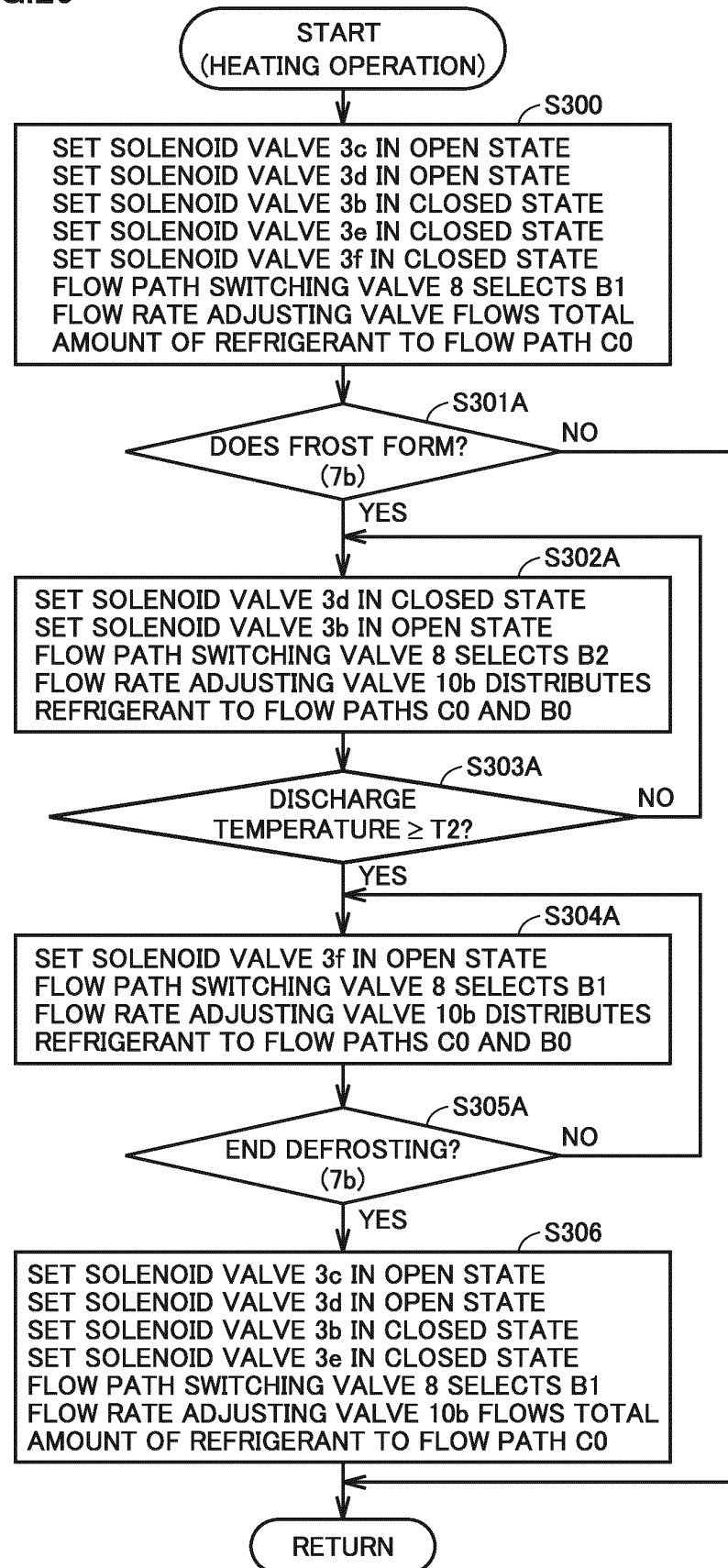


FIG.30

OPERATION STATE	PROCESSING	SOLENOID VALVE 3c	SOLENOID VALVE 3d	SOLENOID VALVE 3b	SOLENOID VALVE 3e	SOLENOID VALVE 3f	FLOW PATH SWITCHING VALVE 8	FLOW RATE ADJUSTING VALVE 10b
HEATING OPERATION	S300 S301A	OPEN	OPEN	CLOSED	CLOSED	CLOSED	BYPASS FLOW PATH B1	FLOW TOTAL AMOUNT OF REFRIGERANT TO FLOW PATH C0
DEFROSTING OPERATION	S302A S303A	OPEN	CLOSED	OPEN	CLOSED	CLOSED	BYPASS FLOW PATH B2	DISTRIBUTE REFRIGERANT TO FLOW PATHS C0 AND B0
	S304A S305A	OPEN	CLOSED	OPEN	CLOSED	OPEN	BYPASS FLOW PATH B1	DISTRIBUTE REFRIGERANT TO FLOW PATHS C0 AND B0
HEATING OPERATION	S306	OPEN	OPEN	CLOSED	CLOSED	CLOSED	BYPASS FLOW PATH B1	FLOW TOTAL AMOUNT OF REFRIGERANT TO FLOW PATH C0

FIG.31

DEFROSTING OPERATION (S302A,S303A)

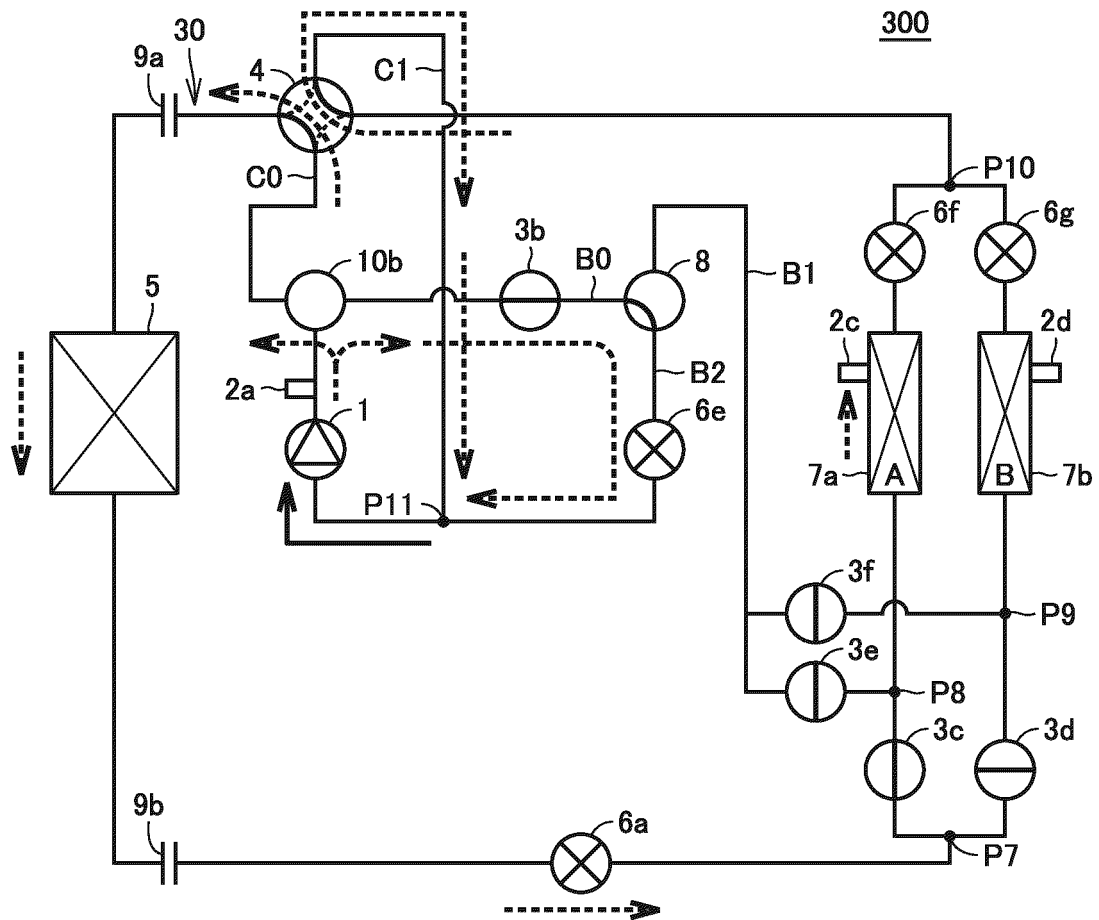


FIG.32

DEFROSTING OPERATION (S304A,S305A)

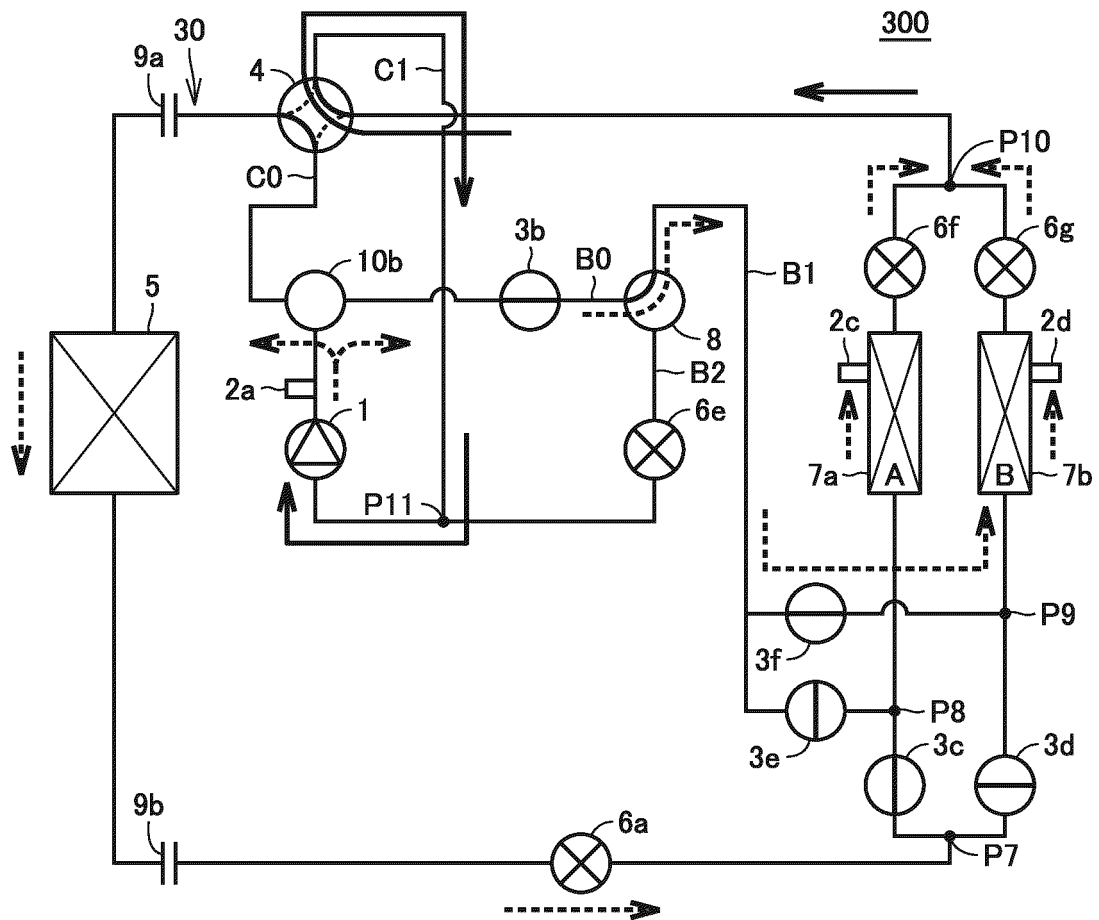
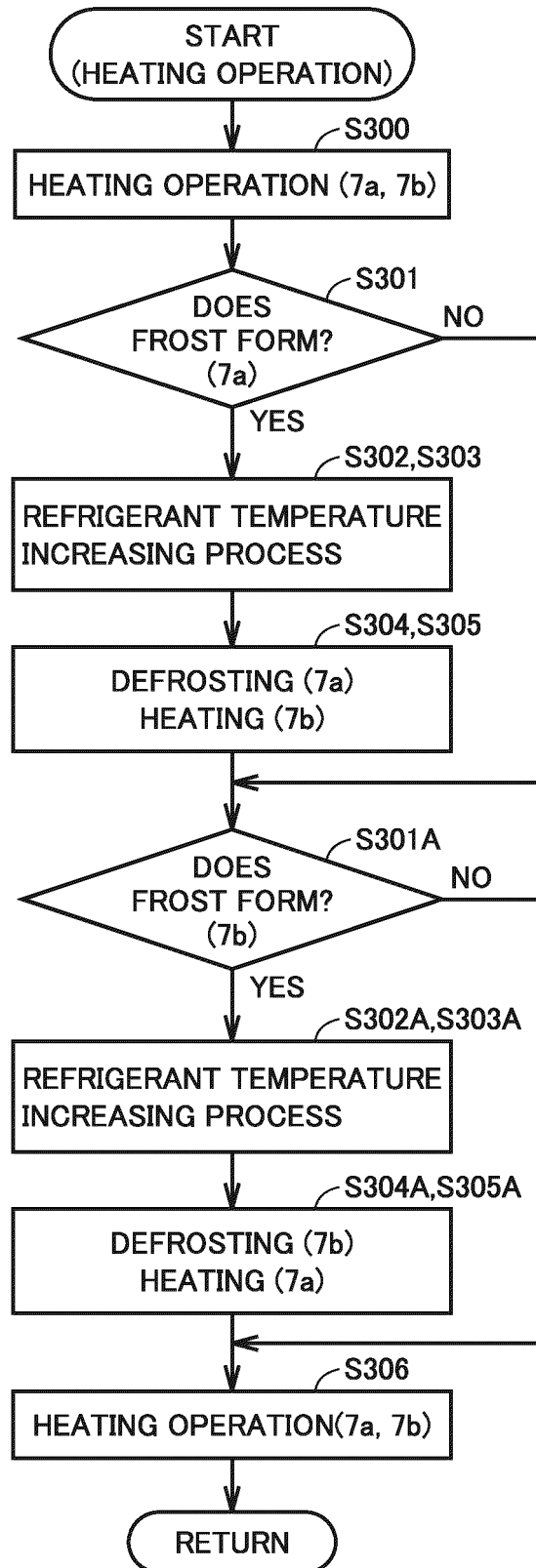


FIG.33



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/039035

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F24F11/41 (2018.01) i, 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)

Int.Cl. F24F11/41, 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 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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 2009-145032 A (PANASONIC CORP.) 02 July 2009, paragraphs [0006]-[0009], [0027]-[0049], fig. 1 & EP 1983277 A2, paragraphs [0002]-[0008], [0030]-[0049], fig. 1-2 & CN 101307964 A	1-10
Y	JP 11-2477 A (SANYO ELECTRIC CO., LTD.) 06 January 1999, paragraphs [0004]-[0005], [0014]-[0015], [0029]-[0033], [0041], fig. 7-12 (Family: none)	1-10



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
14 December 2018 (14.12.2018)Date of mailing of the international search report
25 December 2018 (25.12.2018)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/039035

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 55-041341 A (MITSUBISHI ELECTRIC CORP.) 24 March 1980, page 1, lower left column, line 19 to page 2, lower left column, line 19, fig. 1-2 (Family: none)	6, 9-10
Y	WO 2014/083650 A1 (MITSUBISHI ELECTRIC CORP.) 05 June 2014, paragraphs [0047]-[0062], fig. 5-6 & EP 2930450 A1, paragraphs [0077]-[0108], fig. 5-6	7-10
Y	JP 2001-59664 A (FUJITSU GENERAL LTD.) 06 March 2001, paragraphs [0013]-[0019], fig. 1-3 (Family: none)	7-10

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 2009145032 A [0002] [0003] [0004]