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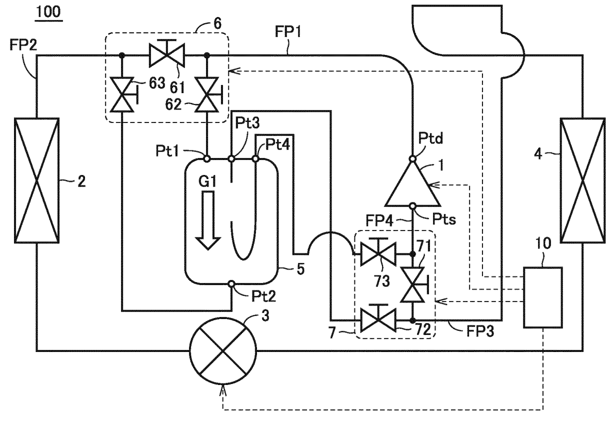
(54) REFRIGERATION CYCLE DEVICE

(57) In a refrigeration cycle apparatus (100), refrigerant circulates in order of a compressor (1), a first heat exchanger (2), a decompressor (3), and a second heat exchanger (4). The refrigeration cycle apparatus (100) has a refrigerant container (5), a first switch unit (6), a second switch unit (7), and a controller (10). When a first condition meaning that an amount of refrigerant in liquid state stored in the refrigerant container (5) is excessive is satisfied, the controller (10) controls the first switch unit (6) to guide the refrigerant from the compressor (1) to the first heat exchanger (2) through the refrigerant container (5) and controls the second switch unit (7) to guide the refrigerant from the second heat exchanger (4) to the compressor not through the refrigerant container (5). When the first condition is not satisfied, the controller (10) controls the first switch unit (6) to guide the refrigerant from the compressor (1) to the first heat exchanger (2) not through the refrigerant container (5) and controls the second switch unit (7) to guide the refrigerant from the refrigerant container (5) to the compressor (1).

FIG.1



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a refrigeration cycle apparatus having a function of preventing refrigerant in liquid state (liquid refrigerant) from being sucked into a compressor.

BACKGROUND ART

[0002] A conventional refrigeration cycle apparatus having a function of preventing liquid refrigerant from being sucked into a compressor (liquid back) has been known. For example, Japanese Patent Laying-Open No. 2010-19439 (PTL 1) discloses a refrigeration cycle apparatus capable of switching refrigerant that is to flow into a refrigerant accumulator, depending on the elapsed time from activation of the compressor. In this refrigeration cycle apparatus, refrigerant in the gas-liquid two-phase state of low temperature and low pressure flows into the refrigerant accumulator through low-pressure-side flow path switch means upon activation of the compressor, and refrigerant in gas state (gas refrigerant) separated from the gas-liquid two-phase refrigerant is sucked into the compressor and liquid refrigerant separated therefrom is stored in the refrigerant accumulator.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: Japanese Patent Laying-Open No. 2010-19439

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] Depending on the time for which the refrigeration cycle apparatus is stopped, a relatively large amount of liquid refrigerant may be stored in the refrigerant container as a result of cooling and resultant liquefaction of the gas refrigerant. If the compressor is activated under this condition, liquid back may occur. Occurrence of the liquid back causes deterioration of the lubrication performance of lubricating oil stored in the compressor, which leads to an increased possibility of failure of the compressor. Moreover, depending on the amount of the lubricating oil stored in the compressor, the performance of the compressor may be deteriorated. For the refrigeration cycle apparatus disclosed in PTL 1, however, no consideration is given to reduction of the amount of liquid refrigerant in the refrigerant container upon activation of the compressor, and no consideration is given to adjustment of the amount of the lubricating oil during operation of the compressor.

[0005] The present disclosure is made to solve the problems as described above, and an object of the present disclosure is to improve the stability of the refrigeration cycle apparatus.

SOLUTION TO PROBLEM

[0006] In a refrigeration cycle apparatus according to the present disclosure, refrigerant circulates in order of a compressor, a first heat exchanger, a decompressor, and a second heat exchanger. The refrigeration cycle apparatus has a refrigerant container, a first switch unit, a second switch unit, and a controller. The refrigerant container is configured to store the refrigerant in liquid state. The controller is configured to control the first switch unit and the second switch unit. When a first condition meaning that an amount of the refrigerant in liquid state stored in the refrigerant container is excessive is satisfied, the controller is configured to control the first switch unit to guide the refrigerant from the compressor to the first heat exchanger through the refrigerant container and control the second switch unit to guide the refrigerant from the second heat exchanger to the compressor not through the refrigerant container. When the first condition is not satisfied, the controller is configured to control the first switch unit to guide the refrigerant from the compressor to the first heat exchanger not through the refrigerant container and control the second switch unit to guide the refrigerant from the refrigerant container to the compressor.

ADVANTAGEOUS EFFECTS OF INVENTION

[0007] In the refrigeration cycle apparatus according to the present disclosure, when the first condition meaning that the amount of refrigerant in liquid state stored in the refrigerant container is excessive is satisfied, refrigerant is guided from the compressor to the first heat exchanger through the refrigerant container and refrigerant is guided from the second heat exchanger to the compressor not through the refrigerant container and, when the first condition is not satisfied, refrigerant is guided from the compressor to the first heat exchanger not through the refrigerant container and refrigerant is guided from the refrigerant container to the compressor. Accordingly, the stability of the refrigeration cycle apparatus can be improved.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

Fig. 1 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to Embodiment 1.
Fig. 2 is a functional block diagram showing a configuration of a controller in Fig. 1.
Fig. 3 is a functional block diagram showing a flow of refrigerant when the operation mode of the refrig-

eration cycle apparatus in Fig. 1 is a refrigerant discharge mode.

Fig. 4 is a functional block diagram showing a flow of refrigerant when the operation mode of the refrigeration cycle apparatus in Fig. 1 is a normal mode.

Fig. 5 is a flowchart showing a flow of a process performed by the controller in Fig. 1.

Fig. 6 is a functional block diagram showing a flow of refrigerant when the operation mode of a refrigeration cycle apparatus according to a modification of Embodiment 1 is the refrigerant discharge mode.

Fig. 7 is a functional block diagram showing a flow of refrigerant when the operation mode of the refrigeration cycle apparatus according to the modification of Embodiment 1 is the normal mode.

Fig. 8 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to Embodiment 2.

Fig. 9 is a flowchart showing a flow of a process of switching the operation mode performed by a controller in Fig. 8.

Fig. 10 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to a modification of Embodiment 2.

Fig. 11 is a flowchart showing a flow of a process of switching the operation mode performed by a controller in Fig. 10.

Fig. 12 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to Embodiment 3, together with a flow of refrigerant in an oil retrieval mode.

Fig. 13 is a flowchart showing a flow of a process of switching the operation mode performed by a controller in Fig. 12.

Fig. 14 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to Modification 1 of Embodiment 3, together with a flow of refrigerant in the oil retrieval mode.

Fig. 15 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to Modification 2 of Embodiment 3, together with a flow of refrigerant in the oil retrieval mode.

Fig. 16 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to Modification 3 of Embodiment 3, together with a flow of refrigerant in the oil retrieval mode.

Fig. 17 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to Modification 4 of Embodiment 3, together with a flow of refrigerant in the oil retrieval mode.

DESCRIPTION OF EMBODIMENTS

[0009] Embodiments of the present disclosure are hereinafter described in detail with reference to the drawings. In the drawings, the same or corresponding parts are denoted by the same reference characters, and a description thereof is not herein repeated in principle.

Embodiment 1

[0010] Fig. 1 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 100 according to Embodiment 1. In refrigeration cycle apparatus 100, refrigerant is circulated. Refrigeration cycle apparatus 100 may be a refrigerating machine, an air conditioner, or a showcase, for example.

[0011] As shown in Fig. 1, the refrigeration cycle apparatus includes a compressor 1, a condenser 2 (first heat exchanger), an expansion valve 3 (decompressor), an evaporator 4 (second heat exchanger), an accumulator 5 (refrigerant container), a switch unit 6 (first switch unit), a switch unit 7 (second switch unit), and a controller 10. In refrigeration cycle apparatus 100, refrigerant circulates in the order of compressor 1, condenser 2, expansion valve 3, and evaporator 4. In compressor 1, refrigeration oil (lubricating oil) for lubricating a compression mechanism is enclosed. Compressor 1 discharges the refrigeration oil together with refrigerant. Accumulator 5 stores liquid refrigerant and the refrigeration oil. An arrow G1 within accumulator 5 indicates the direction of gravity.

[0012] Controller 10 controls the drive frequency of compressor 1 to control the amount of refrigerant discharged per unit time from compressor 1. Controller 10 controls the opening degree of expansion valve 3. Controller 10 controls compressor 1 and expansion valve 3 in such a manner that the degree of subcooling of refrigerant discharged from condenser 2 and the degree of superheat of refrigerant discharged from evaporator 4, for example, meet respective target values.

[0013] Controller 10 switches the operation mode of refrigeration cycle apparatus 100. The operation mode includes a refrigerant discharge mode and a normal mode. The refrigerant discharge mode is an operation mode in which the amount of liquid refrigerant stored in accumulator 5 is reduced to increase the amount of refrigerant circulating in refrigeration cycle apparatus 100. The normal mode is an operation mode in which accumulator 5 is caused to store liquid refrigerant and gas refrigerant is caused to flow out from accumulator 5 into compressor 1, to thereby prevent liquid back.

[0014] Accumulator 5 includes a port Pt1 (first port), a port Pt2 (second port), a port Pt3 (third port), and a port Pt4 (fourth port). Port Pt2 is formed in the bottom of accumulator 5. Ports Pt1, Pt3, and Pt4 are formed in the top of accumulator 5. The height of port Pt2 is lower than the height of each of port Pt1, port Pt3, and port Pt4. Therefore, flow of liquid refrigerant from port Pt2 can be facilitated, and flow of liquid refrigerant from ports Pt1, Pt3, and Pt4 can be suppressed.

[0015] Switch unit 6 includes an on-off valve 61 (first valve), an on-off valve 62 (second valve), and an on-off valve 63 (third valve). On-off valve 61 is connected between a discharge port Ptd of compressor 1 and condenser 2. On-off valve 62 is connected between port Pt1 and a flow path FP1 (first flow path) from discharge port

Ptd to on-off valve 61. On-off valve 63 is connected between port Pt2 and a flow path FP2 (second flow path) from on-off valve 61 to condenser 2.

[0016] Switch unit 7 includes an on-off valve 71 (fourth valve), an on-off valve 72 (fifth valve), and an on-off valve 73 (sixth valve). On-off valve 71 is connected between evaporator 4 and a suction port Pts of compressor 1. On-off valve 72 is connected between port Pt3 and a flow path FP3 (third flow path) from evaporator 4 to on-off valve 71. On-off valve 73 is connected between port Pt4 and a flow path FP4 (fourth flow path) from on-off valve 71 to suction port Pts.

[0017] Fig. 2 is a functional block diagram showing a configuration of controller 10 in Fig. 1. As shown in Fig. 2, controller 10 includes circuitry 11, a memory 12, and an input/output unit 13. Circuitry 11 may be dedicated hardware or a CPU (Central Processing Unit) that executes a program stored in memory 12. When circuitry 11 is dedicated hardware, circuitry 11 is a single circuit, a composite circuit, a programmed processor, a parallel-programmed processor, an ASIC (Application Specific Integrated Circuit), an FPGA (Field Programmable Gate Array), or a combination thereof, for example. When circuitry 11 is a CPU, the functions of controller 10 are implemented by software, firmware, or a combination of software and firmware. The software or firmware is written as a program, and stored in memory 12. Circuitry 11 reads and executes a program stored in memory 12. Memory 12 includes a non-volatile or volatile semiconductor memory (for example, RAM (Random Access Memory), ROM (Read Only Memory), flash memory, EPROM (Erasable Programmable Read Only Memory), or EEPROM (Electrically Erasable Programmable Read Only Memory)), and a magnetic disc, a flexible disc, an optical disc, a compact disc, a mini disc, or a DVD (Digital Versatile Disc). The CPU is also called central processing unit, processing unit, arithmetic unit, microprocessor, microcomputer, processor, or DSP (Digital Signal Processor).

[0018] Input/output unit 13 receives operation from a user, and outputs a result of processing to the user. Input/output unit 13 includes a mouse, a keyboard, a touch panel, a display, and a speaker, for example.

[0019] Fig. 3 is a functional block diagram showing a flow of refrigerant when the operation mode of refrigeration cycle apparatus 100 in Fig. 1 is the refrigerant discharge mode. As shown in Fig. 3, controller 10 controls switch unit 6 to direct refrigerant from compressor 1 to condenser 2 through accumulator 5. Controller 10 controls switch unit 7 to direct refrigerant from evaporator 4 to compressor 1 not through accumulator 5. Controller 10 closes on-off valve 61 and opens on-off valves 62, 63. Controller 10 opens on-off valve 71, and closes on-off valves 72, 73.

[0020] Fig. 4 is a functional block diagram showing a flow of refrigerant when the operation mode of refrigeration cycle apparatus 100 in Fig. 1 is the normal mode. As shown in Fig. 4, controller 10 controls switch unit 6 to direct refrigerant from compressor 1 to condenser 2 not through accumulator 5. Controller 10 controls switch unit 7 to direct refrigerant from evaporator 4 to compressor 1 through accumulator 5. Controller 10 opens on-off valve 61 and closes on-off valves 62, 63. Controller 10 closes on-off valve 71 and opens on-off valves 72, 73.

[0021] Depending on the time for which refrigeration cycle apparatus 100 is stopped, a relatively large amount of liquid refrigerant may be stored in accumulator 5 as a result of cooling and resultant liquefaction of gas refrigerant. If the normal mode is started under this condition, liquid back may occur. Occurrence of the liquid back causes deterioration of the lubrication performance of refrigeration oil, which leads to an increased possibility of failure of compressor 1.

[0022] In refrigeration cycle apparatus 100, therefore, the refrigerant discharge mode is performed when a refrigerant discharge condition (first condition) that the elapsed time from activation of compressor 1 is shorter than a reference time is satisfied, and the normal mode is performed after elapse of the reference time from the activation of compressor 1. During the reference time from activation of compressor 1, liquid refrigerant in accumulator 5 is prevented from being sucked directly into compressor 1. The amount of liquid refrigerant stored in accumulator 5 is reduced during execution of the refrigerant discharge mode, and therefore, the amount of liquid refrigerant stored in accumulator 5, at the time when the normal mode, which is performed after elapse of the reference time, is started, can be reduced to the extent that prevents the liquid refrigerant from flowing out from accumulator 5. Consequently, liquid back in the normal mode can be suppressed.

[0023] Fig. 5 is a flowchart showing a flow of a process performed by controller 10 in Fig. 1. The process shown in Fig. 5 is followed, for each sampling time, by a main routine (not shown) that exercises overall management of refrigeration cycle apparatus 100. In the following, step is abbreviated simply as S.

[0024] As shown in Fig. 5, controller 10 determines in S101 whether or not the elapsed time from activation of compressor 1 is shorter than a reference time. When the elapsed time from activation of compressor 1 is shorter than the reference time (YES in S101), controller 10 sets the operation mode into the refrigerant discharge mode in S102, and returns the process back to the main routine. When the elapsed time from activation of compressor 1 is longer than or equal to the reference time (NO in S101), controller 10 sets the operation mode into the normal mode in S103, and thereafter returns the process back to the main routine. The reference time in S101 may be determined appropriately through a real-machine experiment or simulation.

[0025] Refrigeration cycle apparatus 100 is described above as the one in which each of switch units 6, 7 has three on-off valves. The configuration of the first switch unit and the second switch unit, however, is not limited to the configuration of switch units 6, 7. The functions of each of the first switch unit and the second switch unit may also be implemented by a four-way valve.

[0026] Fig. 6 is a functional block diagram showing a flow of refrigerant when the operation mode of a refrigeration cycle apparatus 100A according to a modification of Embodiment 1 is the refrigerant discharge mode. The configuration of refrigeration cycle apparatus 100A corresponds to the configuration of refrigeration cycle apparatus 100 in Fig. 1 in which switch units 6 and 7 are replaced with a four-way valve 6A (first four-way valve) and a four-way valve 7A (second four-way valve), respectively. These refrigeration cycle apparatuses are similar to each other in other respects, and therefore, the description thereof is not herein repeated.

[0027] As shown in Fig. 6, four-way valve 6A causes discharge port Ptd and port Pt1 to communicate with each other and causes port Pt2 and condenser 2 to communicate with each other. Four-way valve 7A causes port Pt3 and port Pt4 to communicate with each other and causes evaporator 4 and suction port Pts to communicate with each other.

[0028] Fig. 7 is a functional block diagram showing a flow of refrigerant when the operation mode of refrigeration cycle apparatus 100A according to the modification of Embodiment 1 is the normal mode. As shown in Fig. 7, four-way valve 6A causes discharge port Ptd and condenser 2 to communicate with each other and causes port Pt1 and port Pt2 to communicate with each other. Four-way valve 7A causes port Pt3 and evaporator 4 to communicate with each other and causes port Pt4 and suction port Pts to communicate with each other.

[0029] Accordingly, the refrigeration cycle apparatuses according to Embodiment 1 and the modification thereof enable the stability to be improved.

Embodiment 2

[0030] In connection with Embodiment 1, the above description is given of the configuration in which the refrigerant discharge mode is carried out when the refrigerant discharge condition that the elapsed time from activation of the compressor is shorter than a reference time is satisfied, in consideration of the fact that an excessive amount of liquid refrigerant may be stored in the refrigerant container when the compressor is activated. The refrigerant discharge condition is a condition indicative of a high possibility of occurrence of liquid back, and is not limited to the condition that the elapsed time from activation of the compressor is shorter than a reference time. In connection with Embodiment 2, a description is given below of a configuration in which the operation mode is switched between the refrigerant discharge mode and the normal mode, in consideration of the height of the surface of liquid stored in the refrigerant container, or the density of lubricating oil for the compressor in liquid stored in the refrigerant container.

[0031] Fig. 8 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 200 according to Embodiment 2. The configuration of refrigeration cycle apparatus 200 corresponds to the configuration of refrigeration cycle apparatus 100 in Fig. 1 to which a liquid surface sensor 80 is added and in which controller 10 is replaced with a controller 20. These refrigeration cycle apparatuses are similar to each other in other respects, and therefore, the description thereof is not herein repeated.

[0032] As shown in Fig. 8, liquid surface sensor 80 detects height H1 of the surface of liquid stored in accumulator 5, and outputs the detected height to controller 20. Controller 20 switches the operation mode of refrigeration cycle apparatus 200 depending on height H1. Controller 20 controls compressor 1 and expansion valve 3 in a similar manner to the manner in which controller 10 in Fig. 1 controls them. Controller 20 controls switch units 6, 7 in a similar manner to the manner in which controller 10 controls them, in each of the refrigerant discharge mode and the normal mode.

[0033] Fig. 9 is a flowchart showing a flow of a process of switching the operation mode that is performed by controller 20 in Fig. 8. The process shown in Fig. 9 is followed, for each sampling time, by a main routine (not shown) that exercises overall management of refrigeration cycle apparatus 200.

[0034] As shown in Fig. 9, controller 20 determines, in S201, whether or not a condition (first condition) that height H1 is higher than reference height Hth1 (first reference height) is satisfied. When height H1 is higher than reference height Hth1 (YES in S201), controller 20 sets the operation mode into the refrigerant discharge mode in S202, and returns the process back to the main routine. When height H1 is lower than or equal to reference height Hth1 (NO in S201), controller 20 sets the operation mode into the normal mode in S203, and returns the process back to the main routine. Reference height Hth1 may be determined appropriately through a real-machine experiment or simulation.

[0035] Fig. 10 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 200A according to a modification of Embodiment 2. The configuration of refrigeration cycle apparatus 200A corresponds to the configuration of the apparatus shown in Fig. 8 in which liquid surface sensor 80 and controller 20 are replaced with a density sensor 81 and a controller 20A, respectively. These refrigeration cycle apparatuses are similar to each other in other respects, and therefore, the description thereof is not herein repeated.

[0036] As shown in Fig. 10, density sensor 81 outputs, to controller 20A, density D1 of refrigeration oil in liquid stored in accumulator 5. Controller 20A switches the operation mode of refrigeration cycle apparatus 200A depending on density D1.

[0037] Fig. 11 is a flowchart showing a flow of a process of switching the operation mode that is performed by controller 20A in Fig. 10. The process shown in Fig. 11 is followed, for each sampling time, by a main routine (not shown) that exercises overall management of refrigeration cycle apparatus 200A.

[0038] As shown in Fig. 11, controller 20A determines, in S211, whether or not a condition (first condition) that density D1 is smaller than reference density Dth1 is satisfied. When density D1 is smaller than reference density Dth1 (first reference density) (YES in S211), controller 20A sets the operation mode into the refrigerant discharge mode in S212, and returns the process back to the main routine. When density D1 is larger than or equal to reference density Dth1 (NO in S211), controller 20A sets the operation mode into the normal mode in S213, and returns the process back to the main routine. Reference density Dth1 may be determined appropriately through a real-machine experiment or simulation.

[0039] In refrigeration cycle apparatus 200A, the normal mode is performed based on the fact that the amount of liquid refrigerant stored in accumulator 5 is relatively small when density D1 is large, even if the height of the liquid surface in accumulator 5 is relatively high. Consequently, liquid back can be suppressed and deficiency of refrigeration oil in compressor 1 can be avoided, and therefore, the reliability of compressor 1 can be improved.

[0040] In refrigeration cycle apparatuses 200, 200A, the refrigerant discharge mode may also be performed, as in Embodiment 1, when the elapsed time from activation of compressor 1 is shorter than a reference time. The refrigerant discharge condition may include more than one of the conditions in S101 of Fig. 5, S201 of Fig. 9, and S211 of Fig. 11, or include an additional condition(s).

[0041] Accordingly, the refrigeration cycle apparatuses according to Embodiment 2 and the modification thereof enable the stability to be improved.

Embodiment 3

[0042] In connection with Embodiment 3, a description is given below of a configuration in which the operation mode is switched, when the refrigerant discharge condition is not satisfied, between the normal mode and an oil retrieval mode of retrieving lubricating oil stored in the refrigerant container into the compressor, in order to appropriately maintain the amount of lubricating oil stored in the compressor.

[0043] Fig. 12 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 300 according to Embodiment 3 together with a flow of refrigerant in the oil retrieval mode. The configuration of refrigeration cycle apparatus 300 corresponds to the configuration of refrigeration cycle apparatus 100 in Fig. 1 in which controller 10 is replaced with a controller 30. These apparatuses are similar to each other in other respects, and therefore, the description thereof is not herein repeated. Controller 30 performs the refrigerant discharge mode when the refrigerant discharge condition is satisfied. Controller 30 performs the oil retrieval mode when the refrigerant discharge condition is not satisfied and an oil retrieval condition (second condition) meaning that the amount of refrigeration oil stored in compressor 1 is excessive is satisfied. Controller 30 performs the normal mode when the refrigerant discharge condition is not satisfied and the oil retrieval condition is not satisfied. Controller 30 controls switch units 6, 7 in a similar manner to the manner in which they are controlled in Embodiments 1 and 2, in each of the refrigerant discharge mode and the normal mode.

[0044] As shown in Fig. 12, controller 30 opens on-off valves 61 and 62 and closes on-off valve 63 in the oil retrieval mode. Controller 30 opens on-off valves 71 and 73 and closes on-off valve 72. A part of refrigerant discharged from compressor 1 flows toward condenser 2 not through accumulator 5, and the remainder of the refrigerant is sucked into compressor 1 through accumulator 5. Accumulator 5 also stores refrigeration oil discharged together with refrigerant from compressor 1. The amount of refrigeration oil circulating in refrigeration cycle apparatus 300 can be reduced and the amount of refrigeration oil stored in compressor 1 can be reduced to be closer to an appropriate amount, and therefore, deterioration of the performance of refrigeration cycle apparatus 300 can be suppressed.

[0045] Fig. 13 is a flowchart showing a flow of a process of switching the operation mode that is performed by controller 30 in Fig. 12. The process shown in Fig. 13 is followed, for each sampling time, by a main routine (not shown) that exercises overall management of refrigeration cycle apparatus 300.

[0046] As shown in Fig. 13, controller 30 determines in S301 whether or not the refrigerant discharge condition is satisfied. The refrigerant discharge condition may include more than one of the conditions in S101 of Fig. 5, S201 of Fig. 9, and S211 of Fig. 11, or include an additional condition(s). When the refrigerant discharge condition is satisfied (YES in S301), controller 30 sets the operation mode into the refrigerant discharge mode in S302, and returns the process back to the main routine. When the refrigerant discharge condition is not satisfied (NO in S301), controller 30 determines, in S303, whether or not the oil retrieval condition is satisfied. The oil retrieval condition may be a condition that the amount of change per sampling time (unit time) of the drive frequency of compressor 1 is less than a reference amount, for example. The reference amount may be determine appropriately through a real-machine experiment or simulation.

[0047] When the oil retrieval condition is satisfied (YES in S303), controller 30 sets the operation mode into the oil retrieval mode in S304, and returns the process back to the main routine. When the oil retrieval condition is not satisfied (NO in S303), controller 30 sets the operation mode into the normal mode in S305, and returns the process back to the main routine.

[0048] The oil retrieval condition is not limited to the condition that the amount of change, per sampling time, of the drive frequency of compressor 1 is less than a reference amount. The oil retrieval condition may for example be a condition that the temperature of refrigerant discharged from compressor 1 (discharge temperature) is higher than a reference temperature, a condition that the height of the surface of liquid stored in compressor 1 is higher than a reference height (second reference height), a condition that the density of refrigeration oil in liquid stored in compressor is larger than a reference density (second reference density), or a condition that the height of the surface of liquid stored in accumulator 5 is lower than a reference height (third reference height). The oil retrieval condition may include more than one of these conditions, or include an additional condition(s).

[0049] Fig. 14 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 300A according to Modification 1 of Embodiment 3, together with a flow of refrigerant in the oil retrieval mode. The configuration of refrigeration cycle apparatus 300A corresponds to the configuration of refrigeration cycle apparatus 300 in Fig. 12 to which a temperature sensor 90 is added and in which controller 30 is replaced with a controller 30A. These refrigeration cycle apparatuses are similar to each other in other respects, and therefore, the description thereof is not herein repeated. As shown in Fig. 14, temperature sensor 90 outputs discharge temperature Ts to controller 30A. The oil retrieval condition for refrigeration cycle apparatus 300A includes a condition that discharge temperature Ts is higher than reference temperature Tth. Reference temperature Tth may be determined appropriately through a real-machine experiment or simulation.

[0050] Fig. 15 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 300B according to Modification 2 of Embodiment 3, together with a flow of refrigerant in the oil retrieval mode. The configuration of refrigeration cycle apparatus 300B corresponds to the configuration of refrigeration cycle apparatus 300 in Fig. 12 to which a liquid surface sensor 91 is added and in which controller 30 is replaced with a controller 30B. These refrigeration cycle apparatuses are similar to each other in other respects, and therefore, the description thereof is not herein repeated. As shown in Fig. 15, liquid surface sensor 91 outputs, to controller 30B, height H2 of the surface of liquid stored in compressor 1. The oil retrieval condition for refrigeration cycle apparatus 300B includes a condition that height H2 is higher than reference height Hth2. Reference height Hth2 may be determined appropriately through a real-machine experiment or simulation.

[0051] Fig. 16 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 300C according to Modification 3 of Embodiment 3, together with a flow of refrigerant in the oil retrieval mode. The configuration of refrigeration cycle apparatus 300C corresponds to the configuration of refrigeration cycle apparatus 300 in Fig. 12 to which a density sensor 92 is added and in which controller 30 is replaced with a controller 30C. These refrigeration cycle apparatuses are similar to each other in other respects, and therefore, the description thereof is not herein repeated. As shown in Fig. 16, density sensor 92 outputs, to controller 30C, density D2 of refrigeration oil in liquid stored in compressor 1. The oil retrieval condition for refrigeration cycle apparatus 300C includes a condition that density D2 is larger than reference density Dth2. Reference density Dth2 may be determined appropriately through a real-machine experiment or simulation.

[0052] Fig. 17 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 300D according to Modification 4 of Embodiment 3, together with a flow of refrigerant in the oil retrieval mode. The configuration of refrigeration cycle apparatus 300D corresponds to the configuration of refrigeration cycle apparatus 300 in Fig. 12 to which a liquid surface sensor 93 is added and in which controller 30 is replaced with a controller 30D. These refrigeration cycle apparatuses are similar to each other in other respects, and therefore, the description thereof is not herein repeated. As shown in Fig. 17, liquid surface sensor 93 outputs, to controller 30D, height H3 of the surface of liquid stored in accumulator 5. The oil retrieval condition for refrigeration cycle apparatus 300D includes a condition that height H3 is lower than reference height Hth3. Reference height Hth3 may be determined appropriately through a real-machine experiment or simulation.

[0053] Accordingly, the refrigeration cycle apparatuses according to Embodiment 3 and Modifications 1 to 4 enable the stability to be improved.

[0054] The embodiments disclosed herein are also intended to be implemented in an appropriate combination within the range where they are consistent with each other.

[0055] It should be construed that the embodiments disclosed herein are given by way of illustration in all respects, not by way of limitation. It is intended that the scope of the present disclosure is defined by claims, not by the description above, and encompasses all modifications and variations equivalent in meaning and scope to the claims.

REFERENCE SIGNS LIST

[0056] 1 compressor; 2 condenser; 3 expansion valve; 4 evaporator; 5 accumulator; 6, 7 switch unit; 6A, 7A four-way valve; 10, 20, 20A, 30, 30A, 30B, 30C, 30D controller; 11 circuitry; 12 memory; 13 input/output unit; 61-63, 71-73 on-off valve; 80, 91, 93 liquid surface sensor; 81, 92 density sensor; 90 temperature sensor; 100, 100A, 200, 200A, 300, 300A-300D refrigeration cycle apparatus; FP1-FP4 flow path; Pt1-Pt4 port; Ptd discharge port; Pts suction port

Claims

1. A refrigeration cycle apparatus in which refrigerant circulates in order of a compressor, a first heat exchanger, a decompressor, and a second heat exchanger, the refrigeration cycle apparatus comprising:

a refrigerant container configured to store the refrigerant in liquid state;
a first switch unit and a second switch unit; and a controller configured to control the first switch unit and the second switch unit,
when a first condition is satisfied, the controller being configured to control the first switch unit to guide the refrigerant from the compressor to the first heat exchanger through the refrigerant container and to control the second switch unit to guide the refrigerant from the second heat exchanger to the compressor not through the refrigerant container, the first condition meaning that an amount of the refrigerant in liquid state stored in the refrigerant container is excessive,
when the first condition is not satisfied, the controller being configured to control the first switch unit to guide the refrigerant from the compressor to the first heat exchanger not through the refrigerant container and to control the second switch unit to guide the refrigerant from the refrigerant container to the compressor.

2. The refrigeration cycle apparatus according to claim 1, wherein the first condition includes a condition that an elapsed time from activation of the compressor is shorter than a reference time.

3. The refrigeration cycle apparatus according to claim 1, wherein the first condition includes a condition that a height of a surface of liquid stored in the refrigerant container is higher than a first reference height.

4. The refrigeration cycle apparatus according to claim 1, wherein the first condition includes a condition that a density of lubricating oil for the compressor in liquid stored in the refrigerant container is smaller than a first reference density.

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

the refrigerant container includes a first port, a second port, a third port, and a fourth port,
the first switch unit includes a first four-way valve,
the second switch unit includes a second four-way valve,
when the first condition is satisfied, the controller is configured to control the first four-way valve to cause a discharge port of the compressor and the first port to communicate with each other and cause the second port and the first heat exchanger to communicate with each other, and control the second four-way valve to cause the third port and the fourth port to communicate with each other and cause the second heat exchanger and a suction port of the compressor to communicate with each other, and
when the first condition is not satisfied, the controller is configured to control the first four-way valve to cause the discharge port and the first heat exchanger to communicate with each other and cause the first port and the second port to communicate with each other, and control the second four-way valve to cause the third port and the second heat exchanger to communicate with each other and cause the fourth port and the suction port to communicate with each other.

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

the refrigerant container includes a first port, a second port, a third port, and a fourth port,
the first switch unit includes a first valve, a second valve, and a third valve,
the first valve is connected between a discharge port of the compressor and the first heat exchanger,
the second valve is connected between the first port and a first flow path from the discharge port to the first valve,
the second switch unit includes a fourth valve, a fifth valve, and a sixth valve,
the third valve is connected between the second port and a second flow path from the first valve to the first heat exchanger,
the fourth valve is connected between the second heat exchanger and a suction port of the compressor,
the fifth valve is connected between the third port and a third flow path from the second heat exchanger to the fourth valve,
the sixth valve is connected between the fourth port and a fourth flow path from the fourth valve to the suction port,
when the first condition is satisfied, the controller is configured to close the first valve, open the second valve and the third valve, open the fourth valve, and close the fifth valve and the sixth valve, and
when the first condition is not satisfied, the controller is configured to open the first valve and open the sixth valve.

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

when the first condition is not satisfied and a second condition meaning that an amount of lubricating oil stored in the compressor is excessive is satisfied, the controller is configured to open the first valve and the second valve, close the third valve, open the fourth valve, close the fifth valve, and open the sixth valve, and

when the first condition is not satisfied and the second condition is not satisfied, the controller is configured to open the first valve, close the second valve and the third valve, close the fourth valve, and open the fifth valve and the sixth valve.

8. The refrigeration cycle apparatus according to claim 7, wherein the second condition includes a condition that an amount of change, per unit time, of a drive frequency of the compressor is smaller than a reference amount.

9. The refrigeration cycle apparatus according to claim 7, wherein the second condition includes a condition that a temperature of the refrigerant discharged from the compressor is higher than a reference temperature.

10. The refrigeration cycle apparatus according to claim 7, wherein the second condition includes a condition that a height of a surface of liquid stored in the compressor is higher than a second reference height.

11. The refrigeration cycle apparatus according to claim 7, wherein the second condition includes a condition that a density of lubricating oil for the compressor in liquid stored in the compressor is larger than a second reference density.

12. The refrigeration cycle apparatus according to claim 7, wherein the second condition includes a condition that a height of a surface of liquid stored in the refrigerant container is lower than a third reference height.

13. The refrigeration cycle apparatus according to any one of claims 5 to 12, wherein a height of the second port is lower than a height of each of the first port, the third port, and the fourth port.

FIG.1

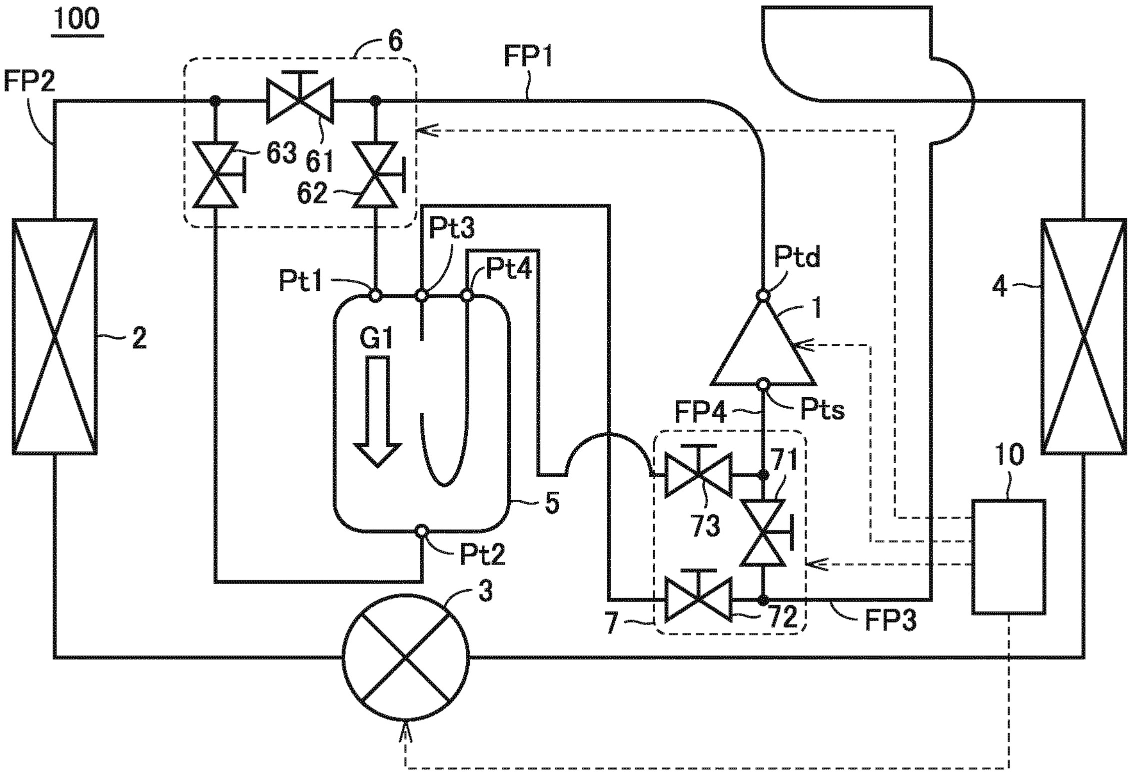

100
6
FP1
FP2
63
61
62
Pt3
Pt1
Pt4
Ptd
1
4
2
G1
FP4
Pts
71
10
5
73
Pt2
3
7
72
FP3

FIG.2

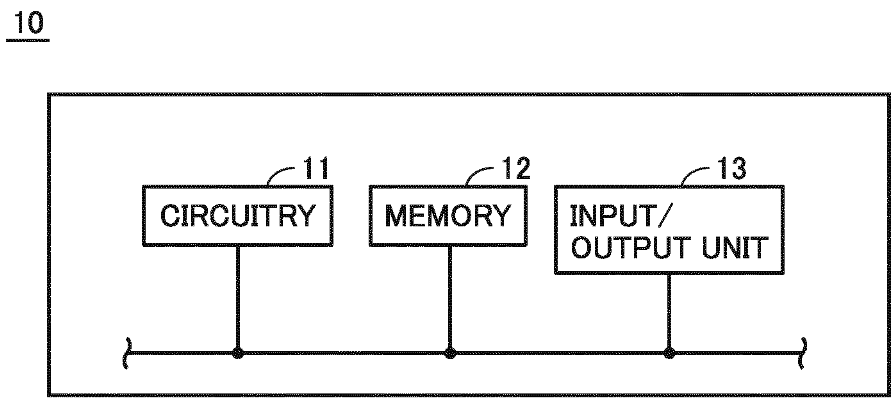

10
11
12
13
CIRCUITRY
MEMORY
INPUT/
OUTPUT UNIT

FIG.3

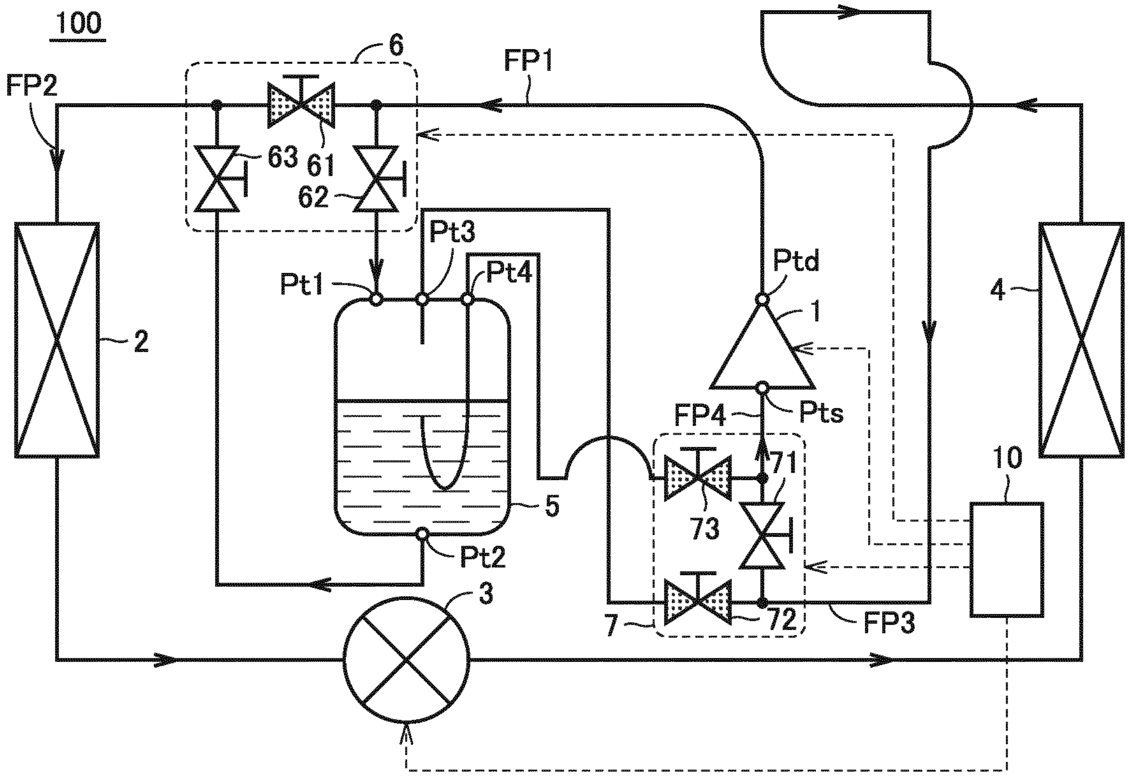

100
6
FP1
FP2
63
61
62
Pt3
Ptd
Pt4
Pt1
1
2
4
FP4
Pts
71
10
73
5
Pt2
3
7
72
FP3

FIG.4

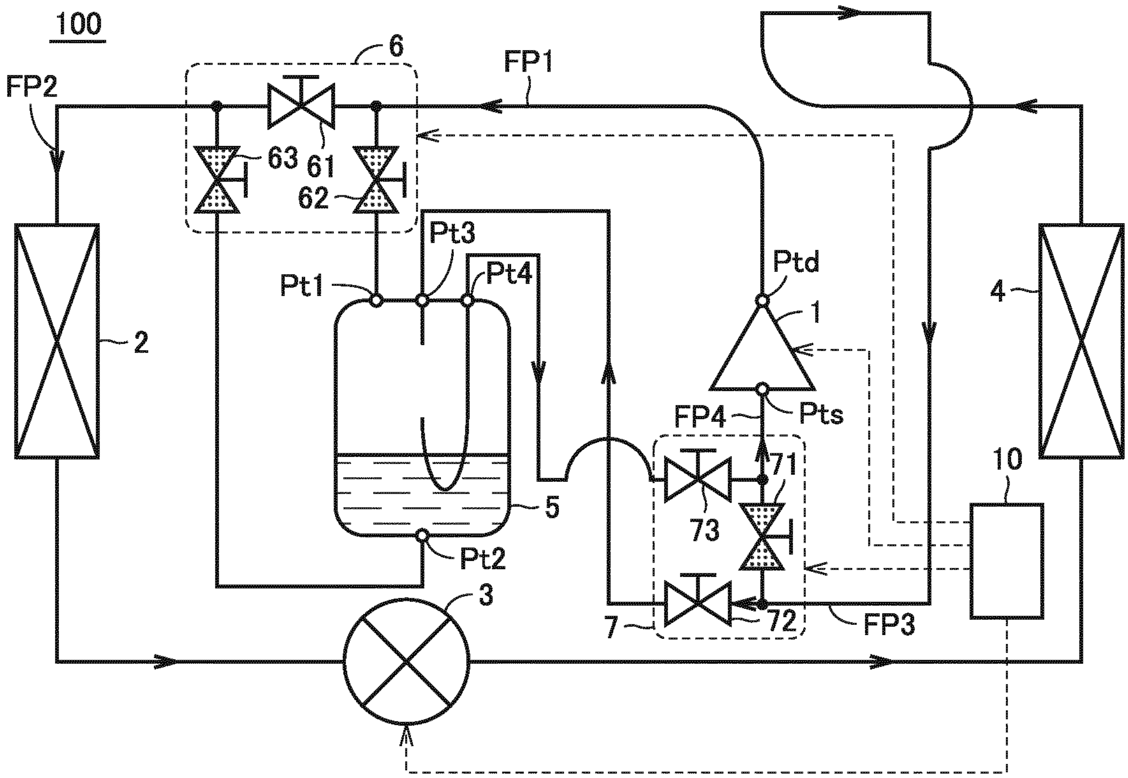

100
6
FP1
FP2
63
61
62
Pt3
Ptd
Pt4
Pt1
1
2
4
FP4
Pts
71
10
73
5
Pt2
3
7
72
FP3

FIG.5

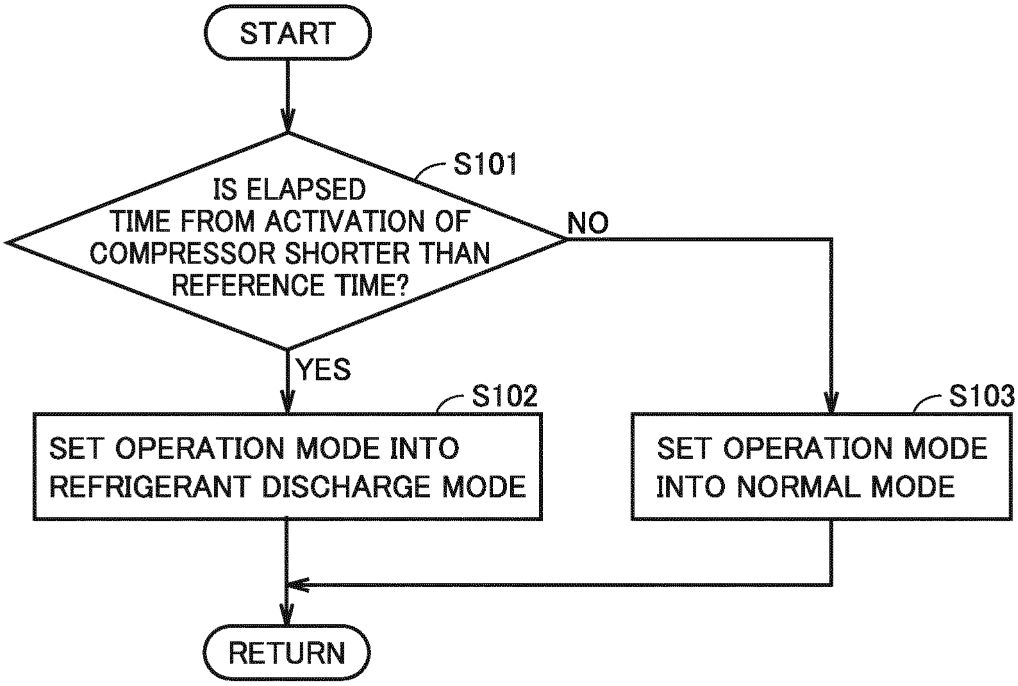

START
IS ELAPSED TIME FROM ACTIVATION OF COMPRESSOR SHORTER THAN REFERENCE TIME?
S101
NO
YES
S102
SET OPERATION MODE INTO REFRIGERANT DISCHARGE MODE
S103
SET OPERATION MODE INTO NORMAL MODE
RETURN

FIG.6

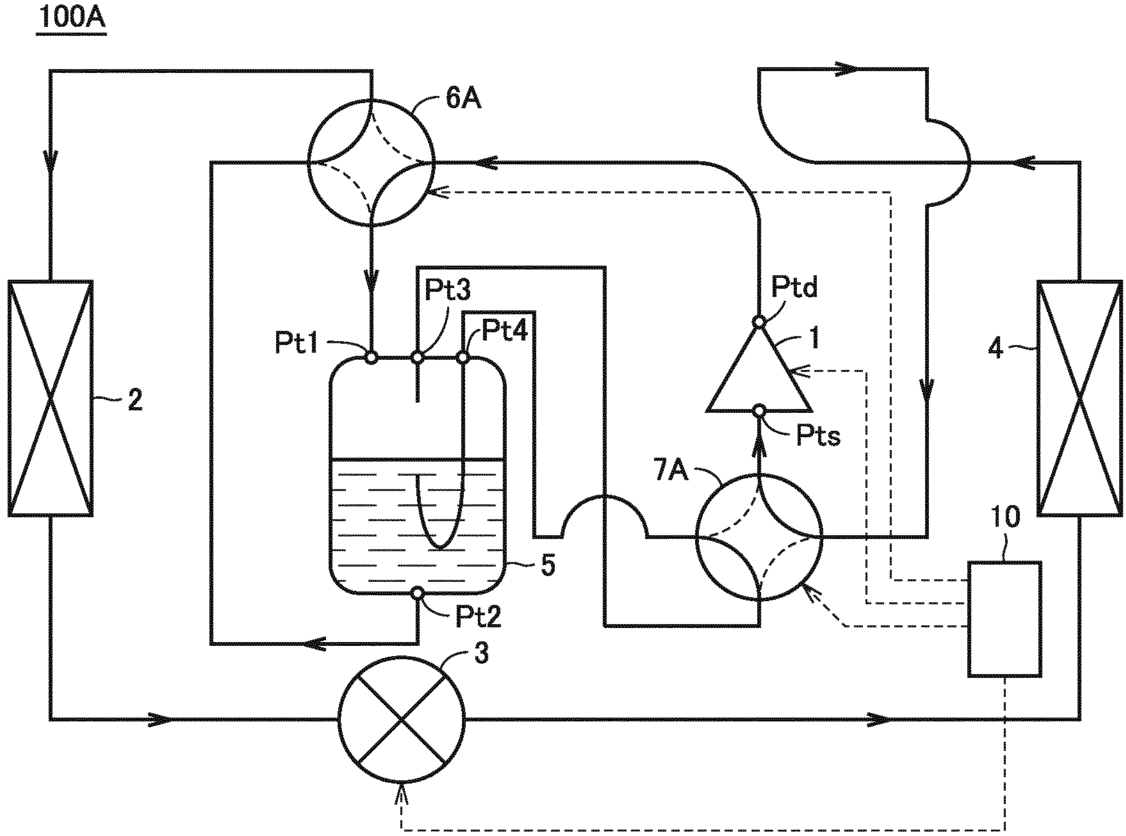

100A
6A
Pt3
Ptd
Pt1
Pt4
1
4
2
Pts
7A
10
5
Pt2
3

FIG.7

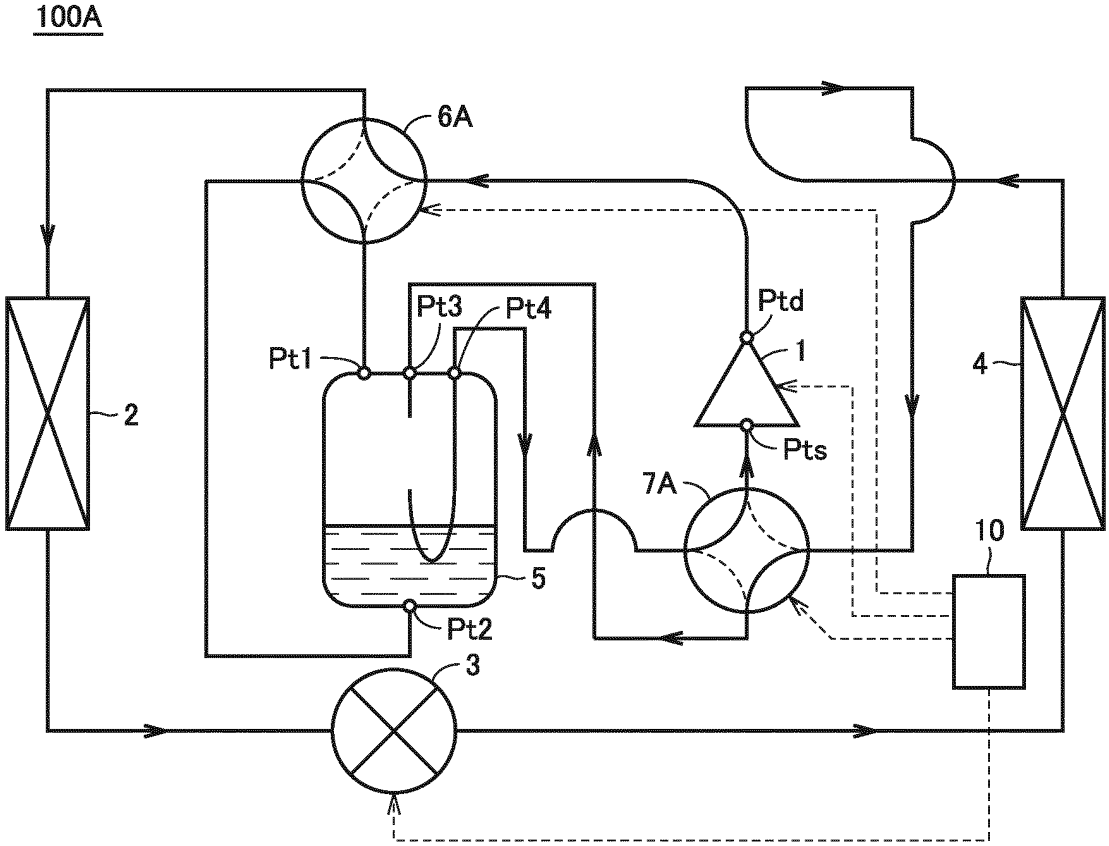

100A
6A
Ptd
1
Pt3
Pt4
Pt1
2
4
Pts
7A
10
5
Pt2
3

FIG.8

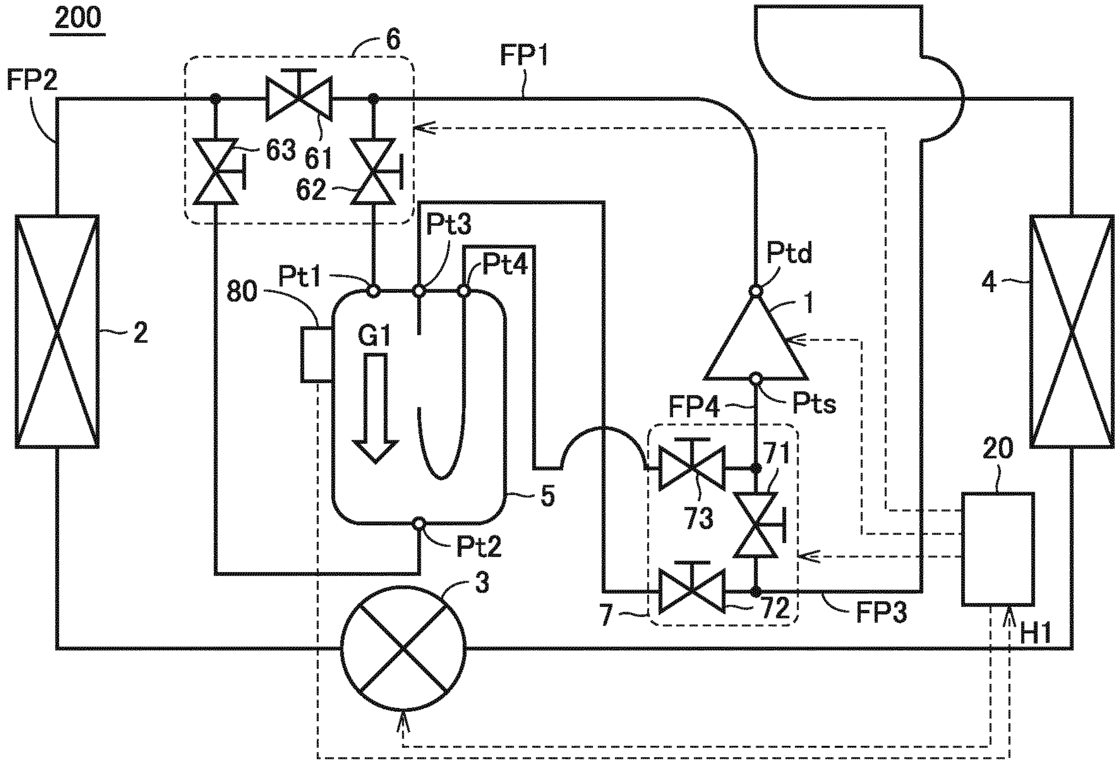

200
6
FP1
FP2
63
61
62
Pt3
Pt4
Ptd
1
80
Pt1
G1
2
4
FP4
Pts
71
20
73
5
Pt2
3
7
72
FP3
H1

FIG.9

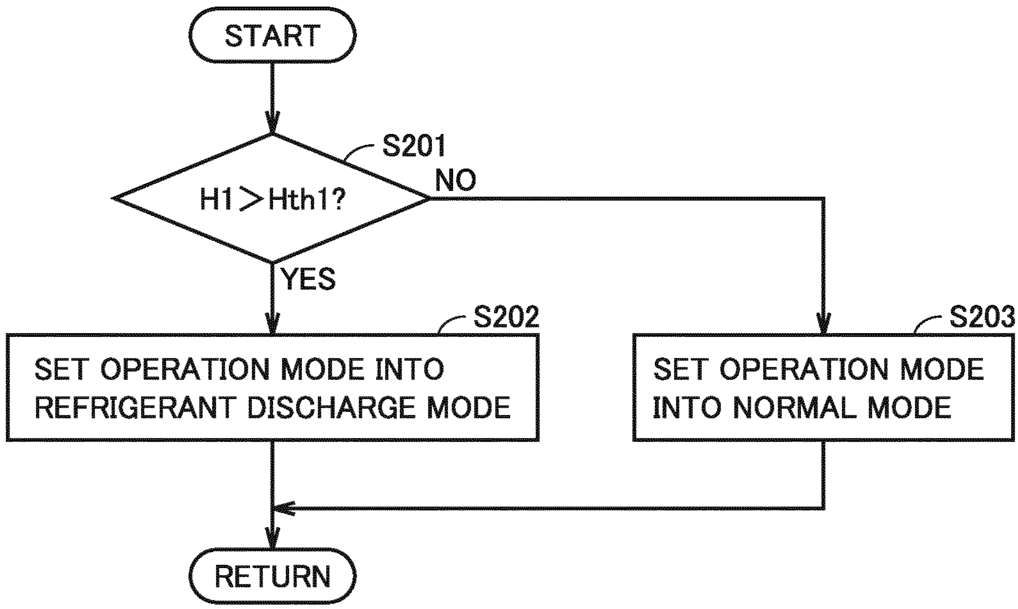

START
S201
H1>Hth1?
NO
YES
S202
SET OPERATION MODE INTO REFRIGERANT DISCHARGE MODE
S203
SET OPERATION MODE INTO NORMAL MODE
RETURN

FIG.10

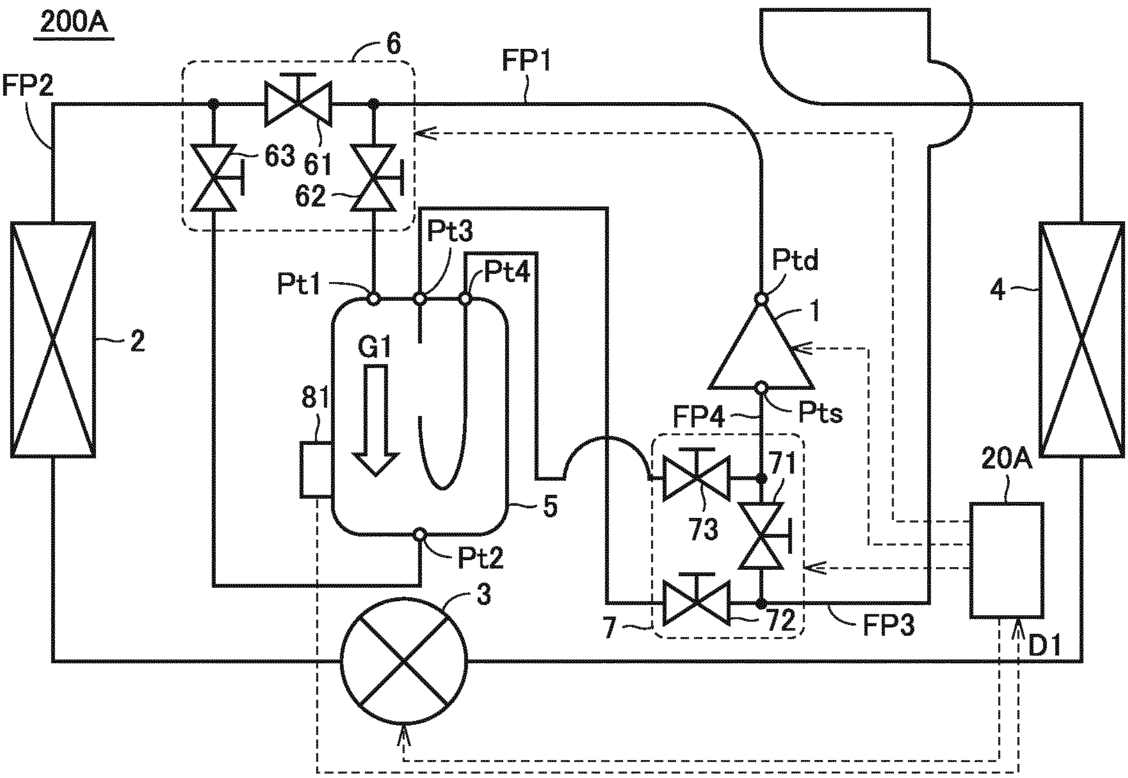

200A
6
FP1
FP2
63
61
62
Pt3
Ptd
Pt4
Pt1
1
4
2
G1
81
FP4
Pts
71
20A
73
5
Pt2
3
7
72
FP3
D1

FIG.11

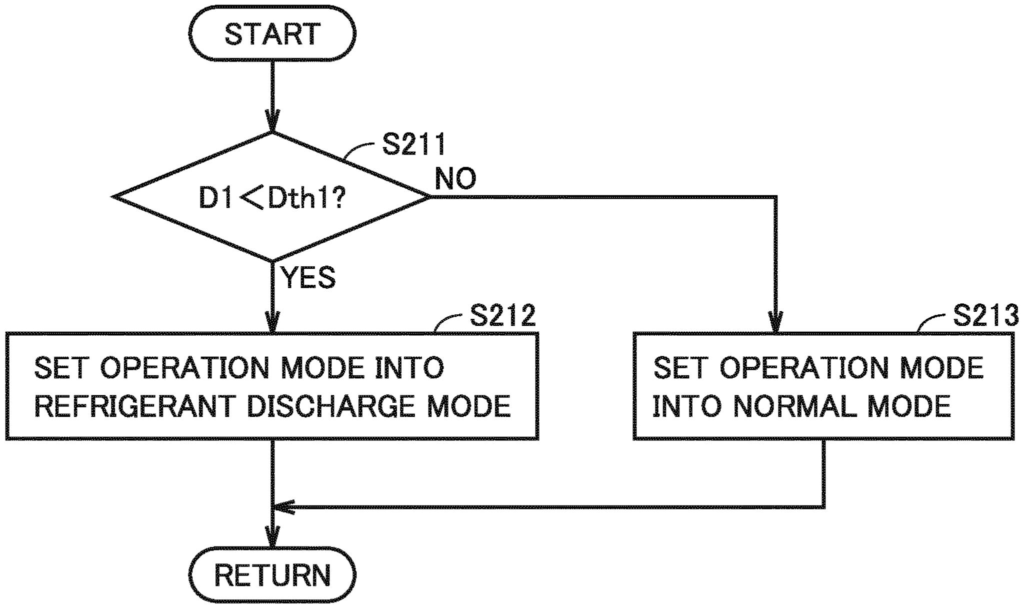

START
S211
D1<Dth1?
NO
YES
S212
SET OPERATION MODE INTO REFRIGERANT DISCHARGE MODE
S213
SET OPERATION MODE INTO NORMAL MODE
RETURN

FIG.12

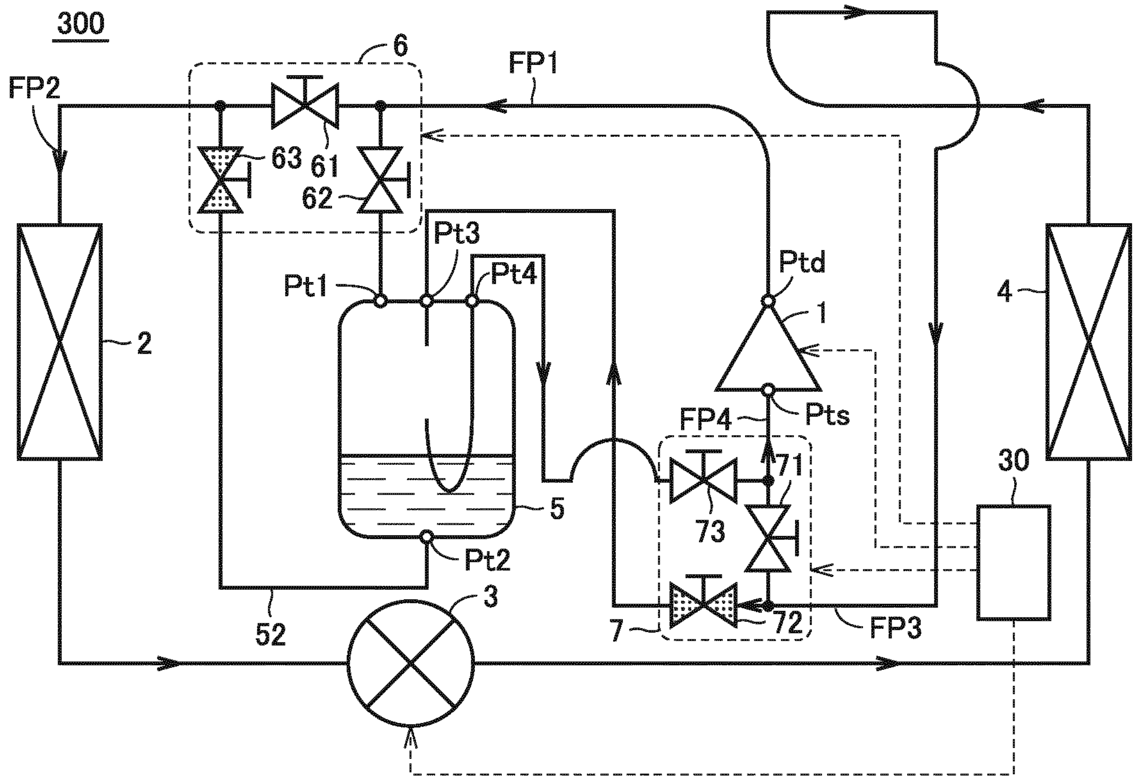

300
FP2
6
FP1
63
61
62
Pt3
Pt4
Pt1
Ptd
1
4
2
Pts
FP4
71
30
73
5
Pt2
3
52
7
72
FP3

FIG.13

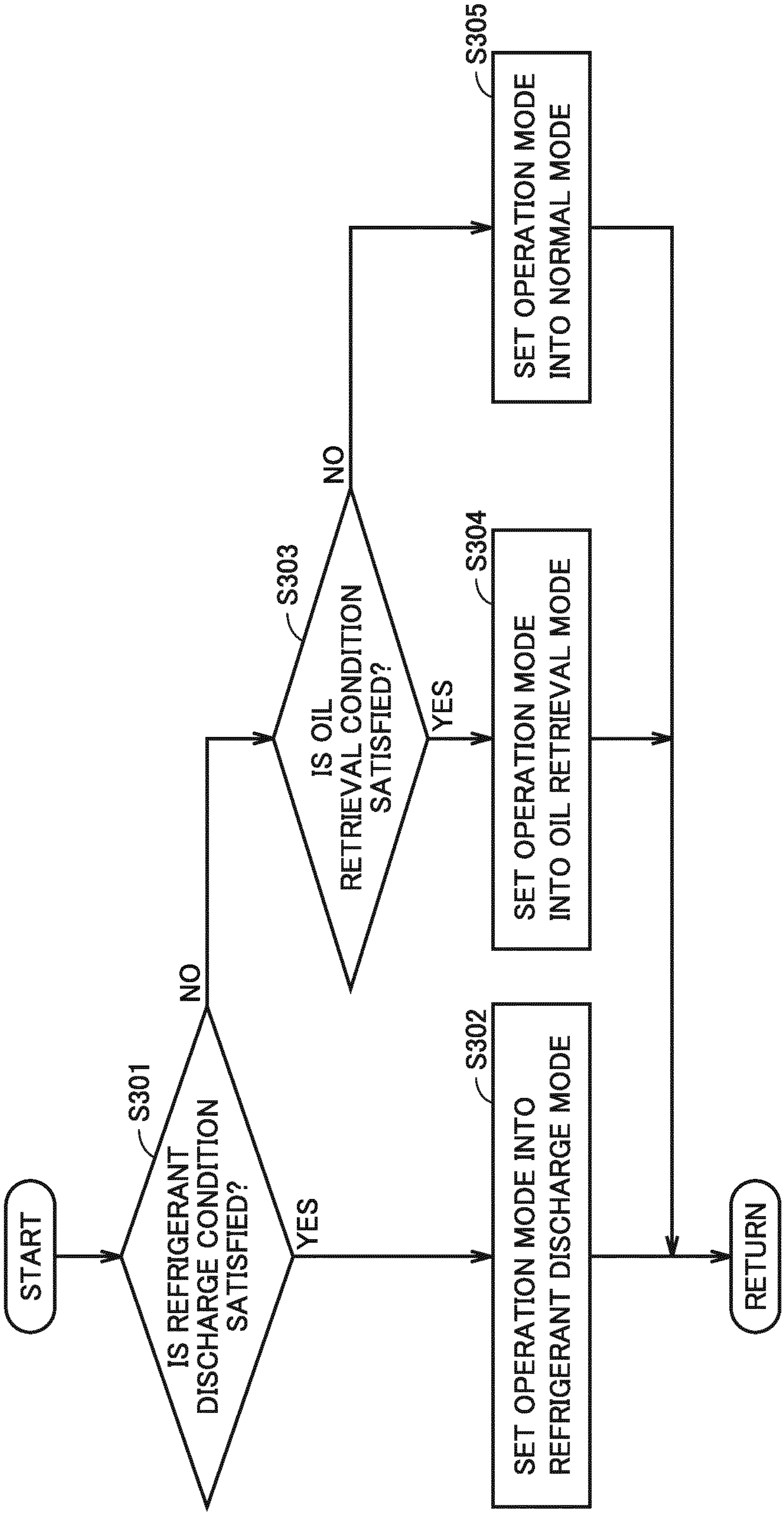

START
S301
IS REFRIGERANT DISCHARGE CONDITION SATISFIED?
YES
NO
S302
SET OPERATION MODE INTO REFRIGERANT DISCHARGE MODE
S303
IS OIL RETRIEVAL CONDITION SATISFIED?
YES
NO
S304
SET OPERATION MODE INTO OIL RETRIEVAL MODE
S305
SET OPERATION MODE INTO NORMAL MODE
RETURN

FIG.14

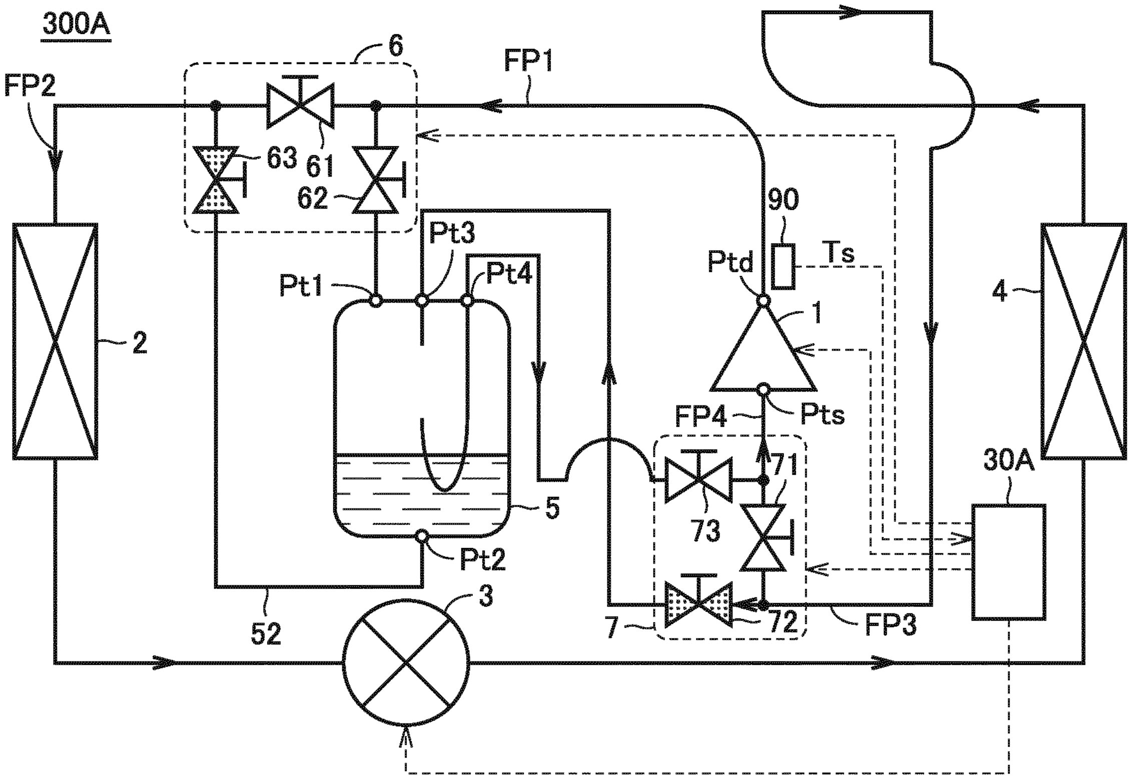

300A
6
FP1
FP2
63
61
62
90
Pt3
Ptd
Ts
Pt1
Pt4
4
2
1
FP4
Pts
30A
71
73
5
Pt2
3
72
52
7
FP3

FIG.15

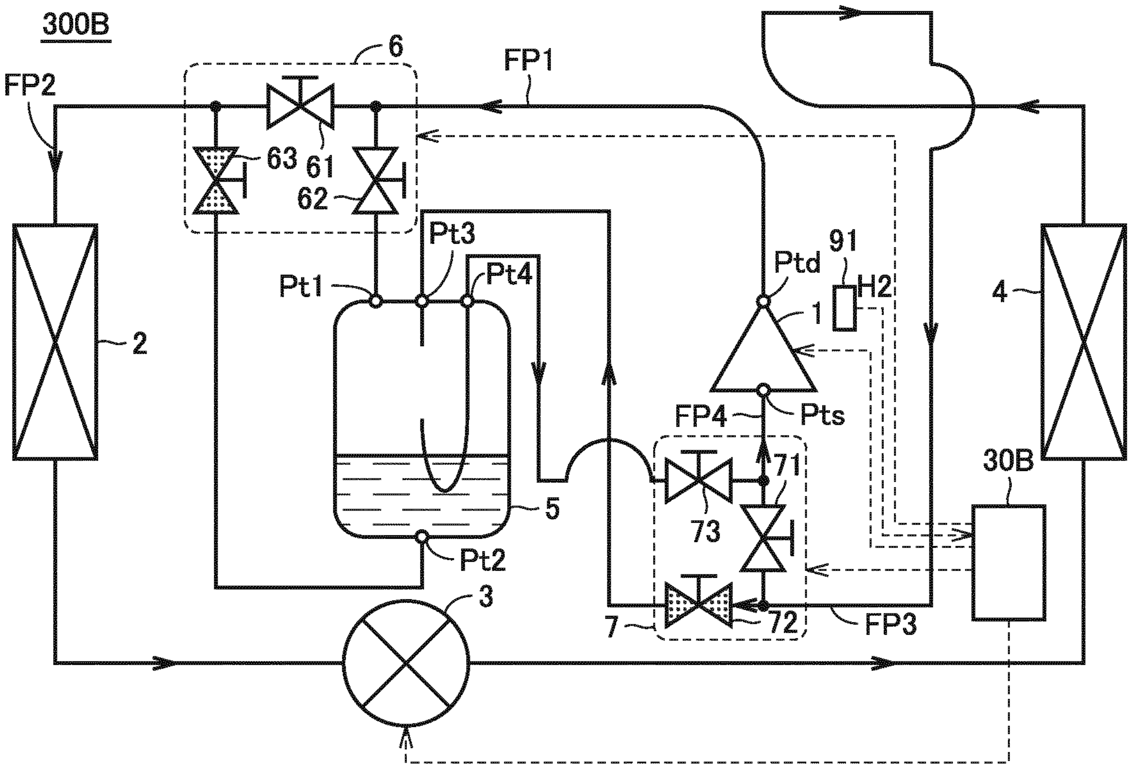
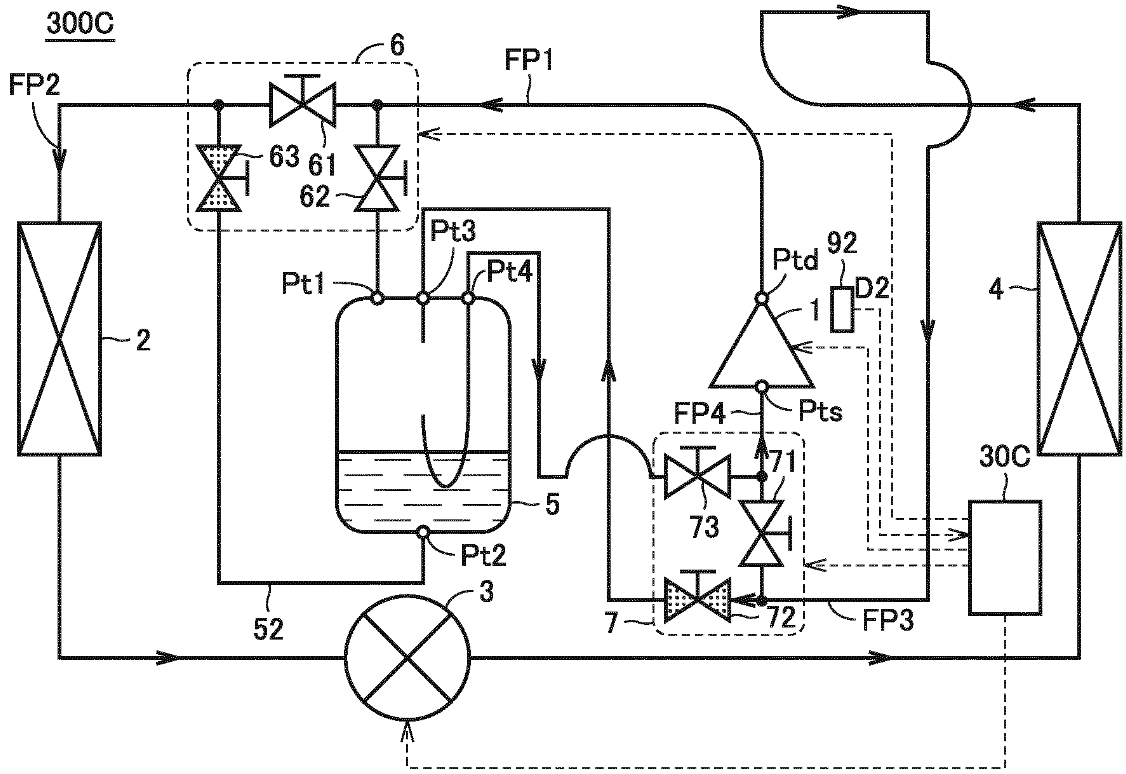

300B
6
FP1
FP2
63
61
62
Pt3
91
Ptd
H2
Pt1
Pt4
4
2
1
FP4
Pts
30B
71
73
5
Pt2
3
72
7
FP3

FIG.16


300C
6
FP1
FP2
63
61
62
Pt3
Pt4
Pt1
Ptd
92
D2
4
2
1
FP4
Pts
71
30C
73
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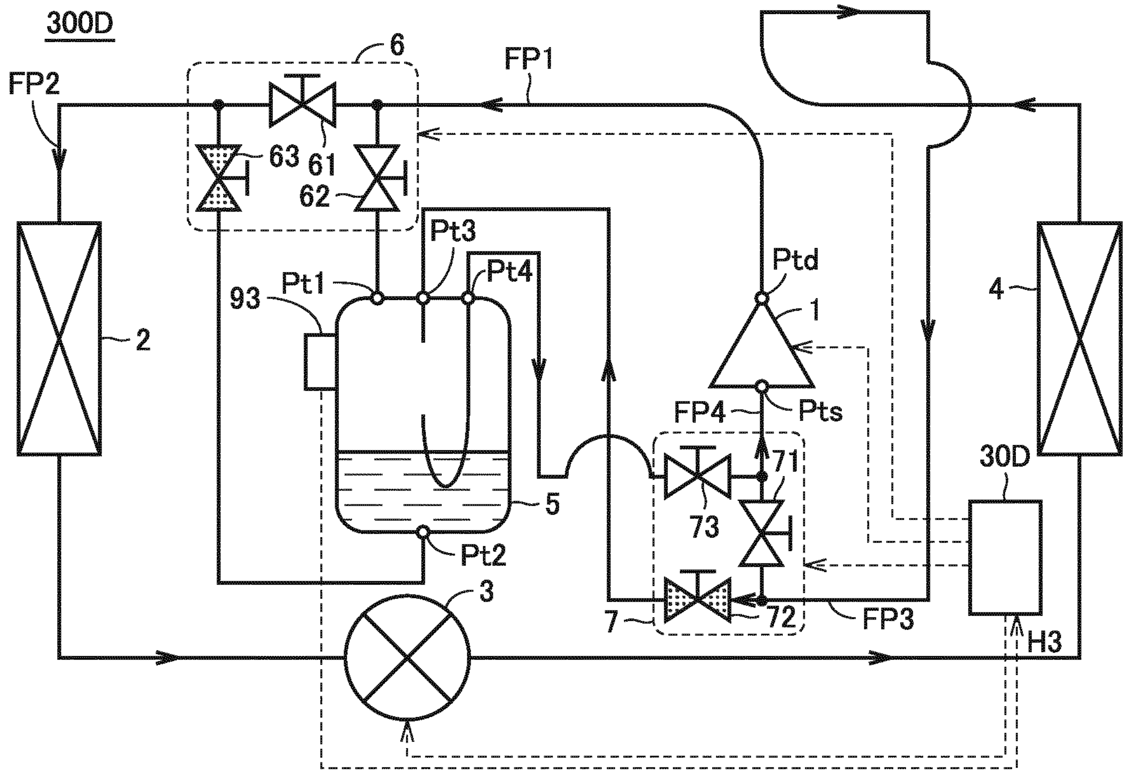
Pt2
3
52
7
72
FP3

FIG.17


300D
6
FP1
FP2
63
61
62
Pt3
93
Pt1
Pt4
Ptd
4
2
1
FP4
Pts
71
30D
73
5
Pt2
3
7
72
FP3
H3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/000498

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F25B41/04(2006.01)i, F25B43/00(2006.01)i, F25B1/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl. F25B41/04, F25B43/00, F25B1/00, F25B13/00

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 4-217754 A (HITACHI, LTD.) 07 August 1992, paragraphs [0016], [0026], fig. 1	1-13
A	JP 7-301459 A (KUBOTA CORP.) 14 November 1995, paragraphs [0003], [0026], [0029], [0036], [0037], [0053], fig. 1, 2, 6	1-13
A	JP 2010-19439 A (MITSUBISHI ELECTRIC CORP.) 28 January 2010, paragraphs [0009], [0011], [0012], fig. 1	1-13

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

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12.02.2020	25.02.2020

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/000498

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
JP 4-217754 A	07.08.1992	(Family: none)	
JP 7-301459 A	14.11.1995	(Family: none)	
JP 2010-19439 A	28.01.2010	(Family: none)	

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

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Patent documents cited in the description

- JP 2010019439 A **[0002] [0003]**