



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.09.2011 Bulletin 2011/36

(51) Int Cl.:
F24F 1/00 (2011.01)

(21) Application number: **11152696.8**

(22) Date of filing: **31.01.2011**

(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

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(30) Priority: **24.02.2010 JP 2010039419**

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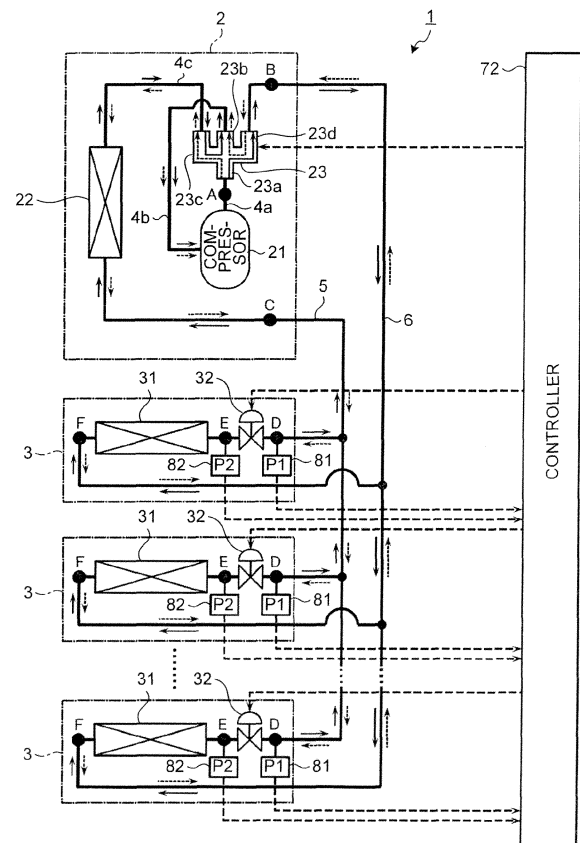
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(54) **Air conditioner**

(57) An air conditioner comprising: a set of outdoor unit 2 having a compressor 21 that compresses a refrigerant, an outdoor heat exchanger 22, and a four-way valve 23; and a plurality of indoor units 3 respectively having indoor heat exchangers 31 connected to the outdoor unit through a liquid refrigerant pipe 5 and a gas refrigerant pipe 6, in which the outdoor unit is arranged above the indoor units. The air conditioner further includes: on-off valves 32 respectively provided in the indoor units 3 on a side of the liquid refrigerant pipe 5; and a controller 72 that performs a defrost operation by switching the four-way valve 23, and the controller once controls the on-off valves 32 in a closing direction when the four-way valve 23 switches the defrost operation to a heating operation.

FIG.5



Description

No. 2008-209022

[Technical field]

[Summary of Invention]

[0001] The present invention relates to an air conditioner that includes a plurality of indoor units with respect to a set of outdoor unit and performs a cooling operation and a heating operation.

5 [Technical Problem]

[Background art]

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[0002] An outdoor unit of an air conditioner mainly includes a compressor, an outdoor heat exchanger, and a four-way valve. An indoor unit of the air conditioner mainly includes an indoor heat exchanger and an electronic expansion valve. In the air conditioner, at the time of a cooling operation (a cooling cycle), the outdoor heat exchanger gives heat to outdoor air and condenses a high temperature and high pressure gas refrigerant compressed by the compressor by switching the four-way valve, thereby forming a liquid refrigerant. While sending the condensed gas refrigerant through a liquid refrigerant pipe, an electronic expansion valve of the indoor unit expands the gas refrigerant to form a low temperature and low pressure gas-liquid refrigerant, the indoor heat exchanger draws heat from indoor air and evaporates the refrigerant to change it into a low temperature and low pressure gas refrigerant, and the gas refrigerant is again sent to the compressor through the gas refrigerant pipe. Meanwhile, in the air conditioner, at the time of a heating operation (a heating cycle), a high temperature and high pressure gas refrigerant compressed by the compressor is sent to the indoor heat exchanger through the gas refrigerant pipe by switching the four-way valve, heat is given to indoor air to condense the indoor air to form a liquid refrigerant. While sending the liquid refrigerant through the liquid refrigerant pipe, the electronic expansion valve of the outdoor unit expands the liquid refrigerant to form a low temperature and low pressure two-phase refrigerant, the outdoor heat exchanger draws heat from outdoor air and evaporates the refrigerant to form a low temperature and low pressure gas refrigerant, and the gas refrigerant is again sent to the compressor.

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[0003] Conventionally, in this type of air conditioners, a defrost operation is performed to prevent the outdoor heat exchanger from being frozen at the time of a heating operation. In the defrost operation, a refrigerant is sent in a cooling cycle direction, and a high temperature refrigerant is sent to the outdoor heat exchanger to increase the temperature of the outdoor heat exchanger, thereby eliminating frost of the outdoor heat exchanger (see, for example, Patent Literature 1).

[0005] When the air conditioner described above is used in an intermediate-rise building or a high-rise building, the outdoor unit is installed on a rooftop of the building, and the indoor units are provided in respective rooms in many cases. In this case, a liquid refrigerant is sent from above to below to the liquid refrigerant pipe at the time of a defrost operation, and a refrigerant pressure at the electronic expansion valve on a side of the outdoor heat exchanger becomes higher than a refrigerant pressure at the electronic expansion valve on a side of the indoor heat exchanger due to a pressure head difference. Therefore, immediately after the defrost operation is switched to a heating operation, because a state where the refrigerant pressure at the electronic expansion valve on the side of the outdoor heat exchanger being higher than the refrigerant pressure at the electronic expansion valve on the side of the indoor heat exchanger is continued, there is a concern that a liquid refrigerant in the liquid refrigerant pipe reversely flows into the indoor heat exchanger, the refrigerant stays in the indoor heat exchanger of the indoor unit, the refrigerant becomes deficient, a refrigerant pressure is reduced, and thus starting of the heating operation is delayed.

[0006] The present invention has been achieved to solve the above problems, and an object of the present invention is to provide an air conditioner capable of favorably starting a heating operation when a defrost operation is switched to the heating operation.

[Solution to Problem]

[0007] According to an aspect of the present invention, an air conditioner including a set of outdoor unit having a compressor that compresses a refrigerant, an outdoor heat exchanger, and a four-way valve; and a plurality of indoor units respectively having indoor heat exchangers connected to the outdoor unit through a liquid refrigerant pipe and a gas refrigerant pipe, and which the outdoor unit is arranged above the indoor units, includes: on-off valves respectively provided in the indoor units on a side of the liquid refrigerant pipe; and a controller that performs a defrost operation for circulating a refrigerant through the compressor, the outdoor heat exchanger, the liquid refrigerant pipe, the on-off valves, the indoor heat exchangers, and the gas refrigerant pipes in this order by switching the four-way valve, and the controller once controls the on-off valves in a closing direction when the four-way valve switches the defrost operation to a heating operation that is performed for circulating the refrigerant through the compressor, the gas refrigerant pipe, the indoor heat exchangers, the on-off valves, the liquid refrigerant pipe, and the outdoor heat exchanger

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in this order.

[0008] In this way, according to the air conditioner of the present embodiment, when the defrost operation is switched to the heating operation, the on-off valve is controlled in a closing direction. This control avoids a case that a liquid refrigerant in the liquid refrigerant pipe reversely flows into the indoor heat exchanger due to the pressure head difference. As a result, a case that the refrigerant stays in the indoor heat exchanger of the indoor unit and the refrigerant becomes deficient can be avoided, the refrigerant pressure is not reduced and therefore, it is possible to favorably start the heating operation when the defrost operation is switched to the heating operation.

[0009] Advantageously, in the air conditioner, the controller controls the on-off valves in a closing direction when the defrost operation is switched to the heating operation, and the controller controls the on-off valves in an opening direction after a predetermined time is elapsed.

[0010] According to the air conditioner of the present embodiment, the on-off valve is controlled in a closing direction and after a predetermined time is elapsed, the on-off valve is controlled in an opening direction. Therefore, the case that the liquid refrigerant in the liquid refrigerant pipe reversely flows into the indoor heat exchanger due to the pressure head difference is avoided for a predetermined time that is elapsed until the effect of the pressure rise of the liquid refrigerant caused by the pressure head difference ceases, the case that the refrigerant stays in the indoor heat exchanger of the indoor unit and the refrigerant becomes deficient is avoided, and the heating operation is started in a state where the refrigerant pressure is not reduced. As a result, it is possible to quickly and favorably start the heating operation when the defrost operation is switched to the heating operation.

[0011] Advantageously, the air conditioner further includes: a first indoor-refrigerant pressure detector that detects a refrigerant pressure in the liquid refrigerant pipe in the indoor unit at the on-off valve on a side of the outdoor heat exchanger; and a second indoor-refrigerant pressure detector that detects a refrigerant pressure in the liquid refrigerant pipe in the indoor unit at the on-off valve on a side of the indoor heat exchanger. The controller controls the on-off valves when a refrigerant pressure that is input from the first indoor-refrigerant pressure detector becomes equal to or lower than a refrigerant pressure that is input from the second indoor-refrigerant pressure detector after the controller controls the on-off valves in a closing direction when the defrost operation is switched to the heating operation.

[0012] According to the air conditioner of the present embodiment, the on-off valve is controlled in a closing direction and when the refrigerant pressure becomes equal to or lower than the refrigerant pressure, the on-off valve is controlled in an opening direction. Therefore, the case that the liquid refrigerant in the liquid refrigerant

pipe reversely flows into the indoor heat exchanger due to the pressure head difference is avoided, the case that the refrigerant stays in the indoor heat exchanger of the indoor unit and the refrigerant becomes deficient is avoided, and the heating operation is started in a state where the refrigerant pressure is not reduced. As a result, it is possible to favorably and quickly start the heating operation when the defrost operation is switched to the heating operation.

[0013] Further, according to the air conditioner of the present embodiment, because each of the indoor units includes the first indoor-refrigerant pressure detector and the second indoor-refrigerant pressure detector, the on-off valve can be controlled in an opening direction according to the pressure head difference in each of the indoor units. Therefore, it is possible to favorably and quickly start the heating operation in each of the indoor units when the defrost operation is switched to the heating operation.

[0014] Advantageously, the air conditioner further includes: an outdoor-refrigerant temperature detector that detects a refrigerant temperature of a liquid refrigerant in the liquid refrigerant pipe in the outdoor unit; and an outdoor-refrigerant pressure detector that detects a refrigerant pressure at a discharging position of the compressor in the outdoor unit. The controller calculates a saturated refrigerant pressure from a refrigerant temperature that is input from the outdoor-refrigerant temperature detector after the controller controls the on-off valves in a closing direction when the defrost operation is switched to the heating operation, the controller calculates an estimated refrigerant pressure in which a liquid refrigerant pressure of a level corresponding to a pressure head difference is added to the saturated refrigerant pressure, and the controller controls the on-off valves in an opening direction when the estimated refrigerant pressure becomes equal to or lower than a refrigerant pressure that is input from the outdoor-refrigerant pressure detector.

[0015] According to the air conditioner of the present embodiment, the refrigerant pressure in the liquid refrigerant pipe in the indoor unit at the on-off valve on the side of the outdoor heat exchanger is calculated as the estimated refrigerant pressure at the point based on the refrigerant temperature T1 that is input from the outdoor-refrigerant temperature detector, and the refrigerant pressure in the liquid refrigerant pipe in the indoor unit at the on-off valve on the side of the indoor heat exchanger corresponds to the refrigerant pressure that is input from the outdoor-refrigerant pressure detector, and the on-off valve is controlled in an opening direction when the calculated estimated refrigerant pressure becomes equal to or lower than the refrigerant pressure. Therefore, the case that the liquid refrigerant in the liquid refrigerant pipe reversely flows into the indoor heat exchanger due to the pressure head difference is avoided, the case that the refrigerant stays in the indoor heat exchanger of the indoor unit and the refrigerant becomes deficient is avoided.

ed, and the heating operation is started in a state where the refrigerant pressure is not reduced. As a result, it is possible to favorably and quickly start the heating operation when the defrost operation is switched to the heating operation.

[0016] Further, according to the air conditioner of the present embodiment, control is performed based on detection of the outdoor-refrigerant temperature detector and the outdoor-refrigerant pressure detector provided on the side of the outdoor unit. With this control, no detector is provided on the side of each of the indoor units. Therefore, the cost required for providing the detector in each of the indoor units can be reduced.

[0017] Advantageously, the air conditioner further includes an outdoor-refrigerant pressure detector that detects a refrigerant pressure at a discharging position of the compressor in the outdoor unit. The controller obtains in advance a saturated refrigerant pressure under a using restriction on an outdoor air temperature in the heating operation after the on-off valves are controlled in a closing direction when the defrost operation is switched to the heating operation, calculates an estimated refrigerant pressure in which a liquid refrigerant pressure of a level corresponding to a pressure head difference is added to the saturated refrigerant pressure, and controls the on-off valves in an opening direction when the estimated refrigerant pressure becomes equal to or lower than a refrigerant pressure that is input from the outdoor-refrigerant pressure detector.

[0018] According to the air conditioner of the present embodiment, the refrigerant pressure in the liquid refrigerant pipe in the indoor unit at the on-off valve on the side of the outdoor heat exchanger is calculated as the estimated refrigerant pressure at the point where the liquid refrigerant pressure of the level corresponding to the pressure head difference is added to the saturated refrigerant pressure under the using restriction on the outdoor air temperature in the heating operation, the refrigerant pressure in the liquid refrigerant pipe in the indoor unit at the on-off valve on the side of the indoor heat exchanger corresponds to the refrigerant pressure that is input from the outdoor-refrigerant pressure detector, and when the calculated estimated refrigerant pressure becomes equal to or lower than the input refrigerant pressure, the on-off valve is controlled in an opening direction. Therefore, the case that the liquid refrigerant in the liquid refrigerant pipe reversely flows into the indoor heat exchanger due to the pressure head difference is avoided, the case that the refrigerant stays in the indoor heat exchanger of the indoor unit and the refrigerant becomes deficient is avoided, and the heating operation is started in a state where the refrigerant pressure is not reduced. As a result, it is possible to favorably and quickly start the heating operation when the defrost operation is switched to the heating operation.

[0019] Further, according to the air conditioner of the present embodiment, control is performed based on detection of the outdoor-refrigerant pressure detector pro-

vided on the side of the outdoor unit. With this control, no detector is provided on the side of each of the indoor units. Therefore, the cost required for providing the detector in each of the indoor units can be reduced.

[0020] Advantageously, the air conditioner further includes: an outdoor-air temperature detector that is provided outside of a room and detects an outdoor air temperature; and an outdoor-refrigerant pressure detector that detects a refrigerant pressure at a discharging position of the compressor in the outdoor unit. The controller calculates a saturated refrigerant pressure from an outdoor air temperature that is input from the outdoor-air temperature detector after the controller controls the on-off valves in a closing direction when the defrost operation is switched to the heating operation, calculates an estimated refrigerant pressure in which a liquid refrigerant pressure of a level corresponding to a pressure head difference is added to the saturated refrigerant pressure, and controls the on-off valves in an opening direction when the estimated refrigerant pressure becomes equal to or lower than a refrigerant pressure that is input from the outdoor-refrigerant pressure detector.

[0021] According to the air conditioner of the present embodiment, the refrigerant pressure in the liquid refrigerant pipe in the indoor unit at the on-off valve on the side of the outdoor heat exchanger is calculated as the estimated refrigerant pressure at the point where the liquid refrigerant pressure of a level corresponding to the pressure head difference is added to the saturated refrigerant pressure corresponding to the outdoor air temperature, the refrigerant pressure in the liquid refrigerant pipe in the indoor unit at the on-off valve on the side of the indoor heat exchanger corresponds to the refrigerant pressure that is input from the outdoor-refrigerant pressure detector, and the on-off valve is controlled in an opening direction when the calculated estimated refrigerant pressure becomes equal to or lower than the input refrigerant pressure. Therefore, the case that the liquid refrigerant in the liquid refrigerant pipe reversely flows into the indoor heat exchanger due to the pressure head difference is avoided, the case that the refrigerant stays in the indoor heat exchanger of the indoor unit and the refrigerant becomes deficient is avoided, and the heating operation is started in a state where the refrigerant pressure is not reduced. As a result, it is possible to favorably and quickly start the heating operation when the defrost operation is switched to the heating operation.

[0022] According to the air conditioner of the present embodiment, control is performed based on detection of the outdoor-air temperature detector and the outdoor-refrigerant pressure detector provided outside of a room, and a detector for performing this control is not provided on the side of the indoor unit. Therefore, the cost required for providing the detector in each of the indoor units can be reduced.

[0023] Advantageously, in the air conditioner, the controller once closes the on-off valves when the defrost operation is switched to the heating operation.

[0024] According to this air conditioner, it is able to avoid the case that the liquid refrigerant in the liquid refrigerant pipe reversely flows into the indoor heat exchanger due to the pressure head difference.

[Advantageous Effects of Invention]

[0025] According to the present invention, it is possible to favorably start a heating operation when a defrost operation is switched to the heating operation.

[Brief Description of Drawings]

[0026]

[Fig. 1] Fig. 1 is a schematic diagram of an air conditioner according to a first embodiment of the present invention.

[Fig. 2] Fig. 2 is a configuration diagram of the air conditioner according to the first embodiment of the present invention.

[Fig. 3] Fig. 3 is an operation diagram of the air conditioner according to the first embodiment of the present invention at the time of a defrost operation.

[Fig. 4] Fig. 4 is a flowchart of control of the air conditioner according to the first embodiment of the present invention.

[Fig. 5] Fig. 5 is a configuration diagram of an air conditioner according to a second embodiment of the present invention.

[Fig. 6] Fig. 6 is a flowchart of control of the air conditioner according to the second embodiment of the present invention.

[Fig. 7] Fig. 7 is a configuration diagram of an air conditioner according to a third embodiment of the present invention.

[Fig. 8] Fig. 8 is a flowchart of control of the air conditioner according to the third embodiment of the present invention.

[Fig. 9] Fig. 9 is a configuration diagram of an air conditioner according to a fourth embodiment of the present invention.

[Fig. 10] Fig. 10 is a flowchart of control of the air conditioner according to the fourth embodiment of the present invention.

[Fig. 11] Fig. 11 is a configuration diagram of an air conditioner according to a fifth embodiment of the present invention.

[Fig. 12] Fig. 12 is a flowchart of control of the air conditioner according to the fifth embodiment of the present invention.

[Description of Embodiment]

[0027] Exemplary embodiments of the present invention will be explained below in detail with reference to the accompanying drawings. The present invention is not limited to the embodiments. In addition, constituent ele-

ments in the following embodiments include those that can be easily replaceable by persons skilled in the art or that are substantially equivalent.

5 [First embodiment]

[0028] Fig. 1 is a schematic diagram of an air conditioner according to a first embodiment of the present invention. As shown in Fig. 1, an air conditioner 1 includes a set of outdoor unit 2 and a plurality of indoor units 3. In many cases, the outdoor unit 2 is provided in a machine room 101 arranged on a rooftop or the top floor of an intermediate-rise or high-rise building 100. The indoor units 3 are provided in respective rooms 102. The indoor units 3 are connected to the outdoor unit 2. A pressure head difference H is generated between the outdoor unit 2 and the indoor unit 3 due to a difference in height therebetween. Fig. 1 depicts the pressure head difference H between the outdoor unit 2 and the indoor unit 3 provided at the lowest position.

[0029] Fig. 2 is a configuration diagram of the air conditioner according to the present embodiment. As shown in Fig. 2, the outdoor unit 2 includes a compressor 21, an outdoor heat exchanger 22, and a four-way valve 23. The compressor 21 sucks and compresses a gas refrigerant. The outdoor heat exchanger 22 functions as a condenser that condenses a high pressure gas refrigerant passing through the compressor 21 at the time of a cooling operation and of a defrost operation, and also functions as an evaporator that evaporates a low temperature liquid refrigerant at the time of a heating operation. The four-way valve 23 includes an introducing unit 23a connected to a discharging side of the compressor 21 through a refrigerant pipe 4a, a discharging unit 23b connected to a suction side of the compressor 21 through a refrigerant pipe 4b, and a first introducing/discharging unit 23c and a second introducing/discharging unit 23d, which are selectively switched between the side of the introducing unit 23a or the discharging units 23b. The four-way valve 23 selectively switches between destinations of supply of a gas refrigerant compressed by the compressor 21 at the time of the cooling operation, at the time of the defrost operation, and at the time of the heating operation.

[0030] The indoor unit 3 includes an indoor heat exchanger 31 and an on-off valve 32. The indoor heat exchanger 31 functions as an evaporator that evaporates a low temperature liquid refrigerant at the time of the cooling operation and of the defrost operation, and also functions as a condenser that condenses a high pressure gas refrigerant passing through the compressor 21 at the time of the heating operation. The on-off valve 32 is provided on the side of a liquid refrigerant pipe 5 connected to the indoor heat exchanger 31, and opens or closes the liquid refrigerant pipe 5, thereby making a refrigerant flow or stop. To adjust a flow rate of a refrigerant flowing into the liquid refrigerant pipe 5, an electronic expansion valve is used as the on-off valve 32 in many cases.

[0031] As for the four-way valve 23 of the outdoor unit 2, the first introducing/discharging unit 23c is connected to the outdoor heat exchanger 22 through a refrigerant pipe 4c. The outdoor heat exchanger 22 is connected to one end of the liquid refrigerant pipe 5. The liquid refrigerant pipe 5 extends to outside of the outdoor unit 2, branches into the respective indoor units 3, and the branched other ends are connected to the respective indoor heat exchangers 31. The on-off valve 32 is provided on each of the branched other ends of the liquid refrigerant pipe 5. Further, as for the four-way valve 23 of the outdoor unit 2, the second introducing/discharging unit 23d is connected to one end of a gas refrigerant pipe 6. The gas refrigerant pipe 6 extends to outside the outdoor unit 2, branches into the respective indoor units 3, and the branched other ends are connected to the indoor heat exchangers 31.

[0032] The air conditioner 1 circulates a refrigerant through the compressor 21, the outdoor heat exchanger 22, the liquid refrigerant pipe 5, the on-off valves 32, the indoor heat exchangers 31, and the gas refrigerant pipe 6 in this order by switching the four-way valve 23, as shown with arrows of broken lines in Fig. 2, and cools indoor air in the rooms 102 by the cooling operation, or prevents, by the defrost operation, the outdoor heat exchanger 22 from being frozen at the time of the heating operation. The air conditioner 1 circulates a refrigerant through the compressor 21, the gas refrigerant pipe 6, the indoor heat exchangers 31, the on-off valves 32, the liquid refrigerant pipe 5, and the outdoor heat exchanger 22 in this order by switching the four-way valve 23 as shown with arrows of solid lines in Fig. 2, and heats indoor air by the heating operation.

[0033] Fig. 3 is an operation diagram (a P-h line drawing) of the air conditioner according to the present embodiment at the time of the defrost operation. Symbols of points A to F in Fig. 3 correspond to positions of points A to F in Fig. 2. As shown in Fig. 3, at the time of the defrost operation, a refrigerant pressure at the point D, that is, in the liquid refrigerant pipe 5 in the indoor unit 3 at the on-off valve 32 on the side of the outdoor heat exchanger 22 is increased by the pressure head difference H, and this refrigerant pressure becomes higher than a refrigerant pressure at the point E, that is, in the liquid refrigerant pipe 5 in the indoor unit 3 at the on-off valve 32 on the side of the indoor heat exchanger 31. When the defrost operation is completed and immediately after the defrost operation is switched to the heating operation, the state where the refrigerant pressure at the point D is higher than the refrigerant pressure at the point E is maintained. Therefore, there is a concern that the liquid refrigerant in the liquid refrigerant pipe 5 reversely flows into the indoor heat exchanger 31, the refrigerant stays in the indoor heat exchanger 31 of the indoor unit 3, the refrigerant becomes deficient, a refrigerant pressure is reduced, and thus starting of the heating operation is delayed.

[0034] Therefore, the air conditioner 1 according to the

present embodiment includes a controller 71. The controller 71 includes a microcomputer. The controller 71 is connected to the four-way valve 23 and the on-off valves 32. The controller 71 has a storage unit (not shown) that includes a RAM, a ROM and the like and in which a program and data are stored. The data stored in the storage unit is time measuring information. More specifically, the time measuring information is obtained in advance by an experiment or the like by measuring a time that is elapsed until a refrigerant pressure at the point D becomes equal to or lower than a refrigerant pressure at the point E after the on-off valve 32 is once operated in its closing direction when the defrost operation is switched to the heating operation. The controller 71 controls the on-off valves 32 based on the switching operation of the four-way valve 23 according to the program and data stored in the storage unit.

[0035] Control performed by the controller 71 is described with reference to the flowchart in Fig. 4.

[0036] As shown in Fig. 4, the controller 71 first switches from the defrost operation to the heating operation (Step S1). Next, the controller 71 controls the on-off valve 32 in a closing direction based on the switching operation of the four-way valve 23 (Step S2). Next, the controller 71 measures a time that is elapsed after the controller 71 controls the on-off valve 32 in a closing direction (Step S3). Next, when a predetermined time is elapsed (YES at Step S4), the controller 71 controls the on-off valve 32 in an opening direction (Step S5). In the opening control of the on-off valve 32 at Step S5, an opening degree of the on-off valve 32 is set such that the temperature in the room 102 becomes equal to a value that is set in the indoor unit 3.

[0037] In this way, according to the air conditioner 1 of the present embodiment, when the defrost operation is switched to the heating operation, the on-off valve 32 is controlled in a closing direction. This control avoids a case that a liquid refrigerant in the liquid refrigerant pipe 5 reversely flows into the indoor heat exchanger 31 due to the pressure head difference H. As a result, a case that the refrigerant stays in the indoor heat exchanger 31 of the indoor unit 3 and the refrigerant becomes deficient can be avoided, the refrigerant pressure is not reduced and therefore, it is possible to favorably start the heating operation when the defrost operation is switched to the heating operation.

[0038] Further, according to the air conditioner 1 of the present embodiment, the on-off valve 32 is controlled in a closing direction and after a predetermined time is elapsed, the on-off valve 32 is controlled in an opening direction. Therefore, the case that the liquid refrigerant in the liquid refrigerant pipe 5 reversely flows into the indoor heat exchanger 31 due to the pressure head difference H is avoided for a predetermined time that is elapsed until the effect of the pressure rise of the liquid refrigerant caused by the pressure head difference H ceases, the case that the refrigerant stays in the indoor heat exchanger 31 of the indoor unit 3 and the refrigerant

becomes deficient is avoided, and the heating operation is started in a state where the refrigerant pressure is not reduced. As a result, it is possible to quickly and favorably start the heating operation when the defrost operation is switched to the heating operation.

[0039] In the air conditioner 1 according to the present embodiment, it is preferable that a predetermined time that is elapsed until the effect of the pressure rise of the liquid refrigerant caused by the pressure head difference H ceases is set for each of the indoor units 3. By setting the predetermined time in this manner, it is possible to control the on-off valve 32 in an opening direction according to the pressure head difference H in each of the indoor units 3, and therefore it is possible to favorably and quickly start the heating operation when the defrost operation is switched to the heating operation in each of the indoor units 3.

[0040] The control of the on-off valve 32 at Step S2 fully closes the liquid refrigerant pipe 5 by the on-off valve 32. This control can reliably avoid the case that the liquid refrigerant in the liquid refrigerant pipe 5 reversely flows into the indoor heat exchanger 31 due to the pressure head difference H. The control of the on-off valve 32 at Step S2 is not limited to the fully closing operation, and the liquid refrigerant pipe 5 can be closed about 90% by the on-off valve 32. With this arrangement, the heating operation can be started substantially at the same time when the effect of the pressure rise of the liquid refrigerant caused by the pressure head difference H ceases, and therefore it is possible to start the heating operation at a relatively early timing.

[Second embodiment]

[0041] Fig. 5 is a configuration diagram of an air conditioner according to a second embodiment of the present invention. In the present embodiment described below, constituent elements equivalent to those of the first embodiment described above are denoted with like reference numerals and explanations thereof will be omitted.

[0042] As shown in Fig. 5, the air conditioner 1 according to the present embodiment includes first indoor-refrigerant pressure detectors 81 each of which detects a refrigerant pressure P1 at the point D, that is, in the liquid refrigerant pipe 5 in the indoor unit 3 at the on-off valve 32 on the side of the outdoor heat exchanger 22.

[0043] Further, the air conditioner 1 includes second indoor-refrigerant pressure detectors 82 each of which detects a refrigerant pressure P2 at the point E, that is, in the liquid refrigerant pipe 5 in the indoor unit 3 at the on-off valve 32 on the side of the indoor heat exchanger 31.

[0044] The refrigerant pressure P1 detected by the first indoor-refrigerant pressure detector 81 and the refrigerant pressure P2 detected by the second indoor-refrigerant pressure detector 82 are input to a controller 72. The controller 72 includes a microcomputer. The controller 72 is connected to the first indoor-refrigerant pressure

detectors 81, the second indoor-refrigerant pressure detectors 82, the four-way valve 23, and the on-off valves 32. The controller 72 has a storage unit (not shown) that includes a RAM, a ROM and the like and in which a program and data are stored. The data stored in the storage unit is comparing information for comparing whether the refrigerant pressure P1 is equal to or lower than the refrigerant pressure P2 by the refrigerant pressure P1 that is input from the first indoor-refrigerant pressure detector 81 and the refrigerant pressure P2 that is input from the second indoor-refrigerant pressure detector 82. The controller 72 switches the four-way valve 23 and controls the on-off valves 32 based on inputs of the refrigerant pressure P1 and the refrigerant pressure P2, according to the program and the data stored in the storage unit.

[0045] Control performed by the controller 72 is described with reference to the flowchart in Fig. 6.

[0046] First, as shown in Fig. 6, the controller 72 switches the four-way valve 23 from the defrost operation to the heating operation (Step S11). Next, the controller 72 controls the on-off valve 32 in a closing direction based on the switching operation of the four-way valve 23 (Step S12). Next, the controller 72 inputs the refrigerant pressure P1 detected by the first indoor-refrigerant pressure detector 81 (Step S13). Next, the controller 72 inputs the refrigerant pressure P2 detected by the second indoor-refrigerant pressure detector 82 (Step S14). Next, when the refrigerant pressure P1 is equal to or lower than the refrigerant pressure P2 (YES at Step S15), the controller 72 controls the on-off valve 32 in an opening direction (Step S16). If the refrigerant pressure P1 is not equal to or lower than the refrigerant pressure P2 (NO at Step S15), the controller 72 repeats the control operations at Steps S13 to S15 until the refrigerant pressure P1 becomes equal to or lower than the refrigerant pressure P2. In the opening control of the on-off valve 32 at Step S16, an opening degree of the on-off valve 32 is set such that the temperature in the room 102 becomes equal to a value that is set in the indoor unit 3.

[0047] In this way, according to the air conditioner 1 of the present embodiment, when the defrost operation is switched to the heating operation, the on-off valve 32 is controlled in a closing direction. Accordingly, this control avoids the case that the liquid refrigerant in the liquid refrigerant pipe 5 reversely flows into the indoor heat exchanger 31 due to the pressure head difference H. As a result, the case that the refrigerant stays in the indoor heat exchanger 31 of the indoor unit 3 and the refrigerant becomes deficient can be avoided, the refrigerant pressure is not reduced and therefore, it is possible to favorably start the heating operation when the defrost operation is switched to the heating operation.

[0048] According to the air conditioner 1 of the present embodiment, the on-off valve 32 is controlled in a closing direction and when the refrigerant pressure P1 becomes equal to or lower than the refrigerant pressure P2, the on-off valve 32 is controlled in an opening direction. Therefore, the case that the liquid refrigerant in the liquid

refrigerant pipe 5 reversely flows into the indoor heat exchanger 31 due to the pressure head difference H is avoided, the case that the refrigerant stays in the indoor heat exchanger 31 of the indoor unit 3 and the refrigerant becomes deficient is avoided, and the heating operation is started in a state where the refrigerant pressure is not reduced. As a result, it is possible to favorably and quickly start the heating operation when the defrost operation is switched to the heating operations.

[0049] Further, according to the air conditioner 1 of the present embodiment, because each of the indoor units 3 includes the first indoor-refrigerant pressure detector 81 and the second indoor-refrigerant pressure detector 82, the on-off valve 32 can be controlled in an opening direction according to the pressure head difference H in each of the indoor units 3. Therefore, it is possible to favorably and quickly start the heating operation in each of the indoor units 3 when the defrost operation is switched to the heating operation.

[0050] The control of the on-off valve 32 at Step S12 fully closes the liquid refrigerant pipe 5 by the on-off valve 32. This control can reliably avoid the case that the liquid refrigerant in the liquid refrigerant pipe 5 reversely flows into the indoor heat exchanger 31 due to the pressure head difference H. The control of the on-off valve 32 at Step S12 is not limited to the fully closing operation, and the liquid refrigerant pipe 5 can be closed about 90% by the on-off valve 32. With this arrangement, the heating operation can be started substantially at the same time when the effect of the pressure rise of the liquid refrigerant caused by the pressure head difference H ceases, and therefore it is possible to start the heating operation at a relatively early timing.

[Third embodiment]

[0051] Fig. 7 is a configuration diagram of an air conditioner according to a third embodiment of the present invention. In the present embodiment described below, constituent elements equivalent to those of the first embodiment described above are denoted with like reference numerals and explanations thereof will be omitted.

[0052] As shown in Fig. 7, in the air conditioner 1 according to the present embodiment, the outdoor unit 2 includes an outdoor-refrigerant temperature detector 83 that detects a refrigerant temperature T1 of the liquid refrigerant in the liquid refrigerant pipe 5.

[0053] As for the air conditioner 1, an outdoor-refrigerant pressure detector 84 that detects a refrigerant pressure P3 at a discharging position of the compressor 21 is provided in the outdoor unit 2. The refrigerant pressure P3 corresponds to the refrigerant pressure at the point E, that is, in the liquid refrigerant pipe 5 in the indoor unit 3 at the on-off valve 32 on the side of the indoor heat exchanger 31.

[0054] The refrigerant temperature T1 detected by the outdoor-refrigerant temperature detector 83 and the refrigerant pressure P3 detected by the outdoor-refrigerant

pressure detector 84 are input to a controller 73. The controller 73 includes a microcomputer. The controller 73 is connected to the outdoor-refrigerant temperature detector 83, the outdoor-refrigerant pressure detector 84, the four-way valve 23, and the on-off valves 32. The controller 73 has a storage unit (not shown) that includes a RAM, a ROM and the like, and in which a program and data are stored. The data stored in the storage unit includes saturated-refrigerant-pressure calculating information for calculating a refrigerant pressure in a saturated state from the refrigerant temperature T1 that is input from the outdoor-refrigerant temperature detector 83, estimated-refrigerant-pressure calculating information for calculating an estimated refrigerant pressure P4 at the point D where a liquid refrigerant pressure of a level corresponding to the pressure head difference H is added to a saturated refrigerant pressure, and comparing information for comparing whether the estimated refrigerant pressure P4 is equal to or lower than the refrigerant pressure P3 by the estimated refrigerant pressure P4 and the refrigerant pressure P3 that is input from the outdoor-refrigerant pressure detector 84. The controller 73 switches the four-way valve 23 and controls the on-off valves 32 based on the inputs of the refrigerant temperature T1 and the refrigerant pressure P3, according to the program and the data stored in the storage unit.

[0055] Control performed by the controller 73 is described with reference to the flowchart in Fig. 8.

[0056] First, as shown in Fig. 8, the controller 73 switches the four-way valve 23 from the defrost operation to the heating operation (Step S21). Next, the controller 73 controls the on-off valve 32 in a closing direction based on the switching operation of the four-way valve 23 (Step S22). Next, the controller 73 inputs the refrigerant temperature T1 detected by the outdoor-refrigerant temperature detector 83 (Step S23). Next, the controller 73 calculates the saturated refrigerant pressure based on the refrigerant temperature T1, and calculates the estimated refrigerant pressure P4 at the point D where a liquid refrigerant pressure of a level corresponding to the pressure head difference H is added to the saturated refrigerant pressure (Step S24). Next, the controller 73 inputs the refrigerant pressure P3 detected by the outdoor-refrigerant pressure detector 84 (Step S25). Next, when the estimated refrigerant pressure P4 is equal to or lower than the refrigerant pressure P3 (YES at Step S26), the controller 73 controls the on-off valve 32 in an opening direction (Step S27). When the refrigerant pressure P4 is not equal to or lower than the refrigerant pressure P3 (NO at Step S26), the controller 73 repeats the control operations at Steps S23 to S26 until the refrigerant pressure P4 becomes equal to or lower than the refrigerant pressure P3. In the opening control of the on-off valve 32 at Step S27, an opening degree of the on-off valve 32 is set such that the temperature in the room 102 becomes equal to a value that is set in the indoor unit 3.

[0057] In this way, according to the air conditioner 1 of the present embodiment, when the defrost operation is

switched to the heating operation, the on-off valve 32 is controlled in a closing direction. Accordingly, this control avoids the case that the liquid refrigerant in the liquid refrigerant pipe 5 reversely flows into the indoor heat exchanger 31 due to the pressure head difference H. As a result, the case that the refrigerant stays in the indoor heat exchanger 31 of the indoor unit 3 and the refrigerant becomes deficient can be avoided, the refrigerant pressure is not reduced and therefore, it is possible to favorably start the heating operation when the defrost operation is switched to the heating operation.

[0058] According to the air conditioner 1 of the present embodiment, the refrigerant pressure in the liquid refrigerant pipe 5 in the indoor unit 3 at the on-off valve 32 on the side of the outdoor heat exchanger 22 is calculated as the estimated refrigerant pressure P4 at the point D based on the refrigerant temperature T1 that is input from the outdoor-refrigerant temperature detector 83, and the refrigerant pressure in the liquid refrigerant pipe 5 in the indoor unit 3 at the on-off valve 32 on the side of the indoor heat exchanger 31 corresponds to the refrigerant pressure P3 that is input from the outdoor-refrigerant pressure detector 84, and the on-off valve 32 is controlled in an opening direction when the calculated estimated refrigerant pressure P4 becomes equal to or lower than the refrigerant pressure P3. Therefore, the case that the liquid refrigerant in the liquid refrigerant pipe 5 reversely flows into the indoor heat exchanger 31 due to the pressure head difference H is avoided, the case that the refrigerant stays in the indoor heat exchanger 31 of the indoor unit 3 and the refrigerant becomes deficient is avoided, and the heating operation is started in a state where the refrigerant pressure is not reduced. As a result, it is possible to favorably and quickly start the heating operation when the defrost operation is switched to the heating operation.

[0059] Further, according to the air conditioner 1 of the present embodiment, control is performed based on detection of the outdoor-refrigerant temperature detector 83 and the outdoor-refrigerant pressure detector 84 provided on the side of the outdoor unit 2. With this control, no detector is provided on the side of each of the indoor units 3. Therefore, the cost required for providing the detector in each of the indoor units 3 can be reduced.

[0060] In the air conditioner 1 according to the present embodiment, it is preferable that the estimated refrigerant pressure P4 is calculated while adding the pressure head difference H of each of the indoor units 3 to the saturated refrigerant pressure. By calculating the estimated refrigerant pressure P4 in this manner, because the on-off valve 32 can be controlled in an opening direction according to the pressure head difference H of each of the indoor units 3, it is possible to favorably and quickly start the heating operation when the defrost operation is switched to the heating operation in each of the indoor units 3.

[0061] The control of the on-off valve 32 at Step S22 fully closes the liquid refrigerant pipe 5 by the on-off valve

32. This control can reliably avoid the case that the liquid refrigerant in the liquid refrigerant pipe 5 reversely flows into the indoor heat exchanger 31 due to the pressure head difference H. The control of the on-off valve 32 at Step S22 is not limited to the fully closing operation, and the liquid refrigerant pipe 5 can be closed about 90% by the on-off valve 32. With this arrangement, the heating operation can be started substantially at the same time when the effect of the pressure rise of the liquid refrigerant caused by the pressure head difference H ceases, and therefore it is possible to start the heating operation at a relatively early timing.

[Fourth embodiment]

[0062] Fig. 9 is a configuration diagram of an air conditioner according to a fourth embodiment of the present invention. In the present embodiment described below, constituent elements equivalent to those of the first embodiment described above are denoted with like reference numerals and explanations thereof will be omitted.

[0063] As shown in Fig. 9, according to the air conditioner 1 of the present embodiment, the outdoor-refrigerant pressure detector 84 that detects the refrigerant pressure P3 at the discharging position of the compressor 21 is provided in the outdoor unit 2. The refrigerant pressure P3 corresponds to the refrigerant pressure at the point E, that is, in the liquid refrigerant pipe 5 in the indoor unit 3 at the on-off valve 32 on the side of the indoor heat exchanger 31.

[0064] The refrigerant pressure P3 detected by the outdoor-refrigerant pressure detector 84 is input to a controller 74. The controller 74 includes a microcomputer. The controller 74 is connected to the outdoor-refrigerant pressure detector 84, the four-way valve 23, and the on-off valves 32. The controller 74 has a storage unit (not shown) that includes a RAM, a ROM and the like, and in which a program and data are stored. The data stored in the storage unit includes saturated-refrigerant-pressure obtaining information in which a saturated refrigerant pressure is obtained in advance under a using restriction on an outdoor air temperature in the heating operation, estimated-refrigerant-pressure calculating information for calculating an estimated refrigerant pressure P5 at the point D where the liquid refrigerant pressure of a level corresponding to the pressure head difference H is added to a saturated refrigerant pressure, and comparing information for comparing whether the estimated refrigerant pressure P5 is equal to or lower than the refrigerant pressure P3 by the estimated refrigerant pressure P5 and the refrigerant pressure P3 and that is input from the outdoor-refrigerant pressure detector 84. The controller 74 switches the four-way valve 23 and controls the on-off valves 32 based on the input of the refrigerant pressure P3, according to the program and the data stored in the storage unit.

[0065] According to the using restriction on the outdoor air temperature in the heating operation, because the

heating operation is not performed when the outdoor air temperature is relatively high, the use of the air conditioner 1 is restricted such that the heating operation is not performed at a predetermined outdoor air temperature that is set by the air conditioner 1. The predetermined outdoor air temperature is 24°C, for example. That is, when the outdoor air temperature is 24°C, the saturated refrigerant pressure is about 1.5 megapascals. When the head difference is 90 m, the estimated refrigerant pressure P5 becomes 2.4 megapascals because the pressure head difference H of 0.9 megapascal is applied.

[0066] Control performed by the controller 74 is described with reference to the flowchart in Fig. 10.

[0067] First, as shown in Fig. 10, the controller 74 switches the four-way valve 23 from the defrost operation to the heating operation (Step S31). Next, the controller 74 controls the on-off valve 32 in a closing direction based on the switching operation of the four-way valve 23 (Step S32). Next, the controller 74 calculates the estimated refrigerant pressure P5 at the point D where the liquid refrigerant pressure of a level corresponding to the pressure head difference H is added to a saturated refrigerant pressure under the using restriction on the outdoor air temperature in the heating operation (Step S33). Next, the controller 74 inputs the refrigerant pressure P3 detected by the outdoor-refrigerant pressure detector 84 (Step S34). Next, when the estimated refrigerant pressure P5 is equal to or lower than the refrigerant pressure P3 (YES at Step S35), the controller 74 controls the on-off valve 32 in an opening direction (Step S36). When the refrigerant pressure P5 is not equal to or lower than the refrigerant pressure P3 (NO at Step S35), the controller 74 repeats the control operations at Steps S34 to S35 until the refrigerant pressure P5 becomes equal to or lower than the refrigerant pressure P3. In the opening control of the on-off valve 32 at Step S36, an opening degree of the on-off valve 32 is set such that the temperature in the room 102 becomes equal to a value that is set in the indoor unit 3.

[0068] In this way, according to the air conditioner 1 of the present embodiment, when the defrost operation is switched to the heating operation, the on-off valve 32 is controlled in a closing direction. Accordingly, this control avoids the case that the liquid refrigerant in the liquid refrigerant pipe 5 reversely flows into the indoor heat exchanger 31 due to the pressure head difference H. As a result, the case that the refrigerant stays in the indoor heat exchanger 31 of the indoor unit 3 and the refrigerant becomes deficient can be avoided, the refrigerant pressure is not reduced and therefore, it is possible to favorably start the heating operation when the defrost operation is switched to the heating operation.

[0069] According to the air conditioner 1 of the present embodiment, the refrigerant pressure in the liquid refrigerant pipe 5 in the indoor unit 3 at the on-off valve 32 on the side of the outdoor heat exchanger 22 is calculated as the estimated refrigerant pressure P5 at the point D where the liquid refrigerant pressure of the level corre-

sponding to the pressure head difference H is added to the saturated refrigerant pressure under the using restriction on the outdoor air temperature in the heating operation, the refrigerant pressure in the liquid refrigerant pipe 5 in the indoor unit 3 at the on-off valve 32 on the side of the indoor heat exchanger 31 corresponds to the refrigerant pressure P3 that is input from the outdoor-refrigerant pressure detector 84, and when the calculated estimated refrigerant pressure P5 becomes equal to or lower than the input refrigerant pressure P3, the on-off valve 32 is controlled in an opening direction. Therefore, the case that the liquid refrigerant in the liquid refrigerant pipe 5 reversely flows into the indoor heat exchanger 31 due to the pressure head difference H is avoided, the case that the refrigerant stays in the indoor heat exchanger 31 of the indoor unit 3 and the refrigerant becomes deficient is avoided, and the heating operation is started in a state where the refrigerant pressure is not reduced. As a result, it is possible to favorably and quickly start the heating operation when the defrost operation is switched to the heating operation.

[0070] Further, according to the air conditioner 1 of the present embodiment, control is performed based on detection of the outdoor-refrigerant pressure detector 84 provided on the side of the outdoor unit 2. With this control, no detector is provided on the side of each of the indoor units 3. Therefore, the cost required for providing the detector in each of the indoor units 3 can be reduced.

[0071] In the air conditioner 1 according to the present embodiment, it is preferable that the estimated refrigerant pressure P5 is calculated while adding the pressure head difference H of each of the indoor units 3 to the saturated refrigerant pressure. By calculating the estimated refrigerant pressure P5 in this manner, the on-off valve 32 can be controlled in an opening direction according to the pressure head difference H of each of the indoor units 3, and it is possible to favorably and quickly start the heating operation when the defrost operation is switched to the heating operation in each of the indoor units 3.

[0072] The control of the on-off valve 32 at Step S32 fully closes the liquid refrigerant pipe 5 by the on-off valve 32. This control can reliably avoid the case that the liquid refrigerant in the liquid refrigerant pipe 5 reversely flows into the indoor heat exchanger 31 due to the pressure head difference H. The control of the on-off valve 32 at Step S32 is not limited to the fully closing operation, and the liquid refrigerant pipe 5 can be closed about 90% by the on-off valve 32. With this arrangement, the heating operation can be started substantially at the same time when the effect of the pressure rise of the liquid refrigerant caused by the pressure head difference H ceases, and therefore it is possible to start the heating operation at a relatively early timing.

[Fifth embodiment]

[0073] Fig. 11 is a configuration diagram of an air conditioner according to a fifth embodiment of the present

invention. In the present embodiment described below, constituent elements equivalent to those of the first embodiment described above are denoted with like reference numerals and explanations thereof will be omitted.

[0074] As shown in Fig. 11, the air conditioner 1 according to the present embodiment includes an outdoor-air temperature detector 85 that is provided outside of a room and detects an outdoor air temperature T2.

[0075] According to the air conditioner 1, the outdoor-refrigerant pressure detector 84 that detects a refrigerant pressure P3 at a discharging position of the compressor 21 is provided in the outdoor unit 2. The refrigerant pressure P3 corresponds to the refrigerant pressure at the point E, that is, in the liquid refrigerant pipe 5 in the indoor unit 3 at the on-off valve 32 on the side of the indoor heat exchanger 31.

[0076] The outdoor air temperature T2 detected by the outdoor-air temperature detector 85 and the refrigerant pressure P3 detected by the outdoor-refrigerant pressure detector 84 are input to a controller 75. The controller 75 includes a microcomputer. The controller 75 is connected to the outdoor-air temperature detector 85, the outdoor-refrigerant pressure detector 84, the four-way valve 23, and the on-off valves 32. The controller 75 has a storage unit (not shown) that includes a RAM, a ROM and the like, and in which a program and data are stored. The data stored in the storage unit includes saturated-refrigerant-pressure obtaining information for calculating a saturated refrigerant pressure corresponding to the outdoor air temperature, estimated-refrigerant-pressure calculating information for calculating an estimated refrigerant pressure P6 at the point D where the liquid refrigerant pressure of a level corresponding to the pressure head difference H is added to the saturated refrigerant pressure, and comparing information for comparing whether the estimated refrigerant pressure P6 is equal to or lower than the refrigerant pressure P3 by the estimated refrigerant pressure P6 and the refrigerant pressure P3 that is input from the outdoor-refrigerant pressure detector 84. The controller 75 switches the four-way valve 23 and controls the on-off valves 32 based on the inputs of the outdoor air temperature T2 and the refrigerant pressure P3, according to the program and the data stored in the storage unit.

[0077] Control performed by the controller 75 is described with reference to the flowchart in Fig. 12.

[0078] First, as shown in Fig. 12, the controller 75 switches the four-way valve 23 from the defrost operation to the heating operation (Step S41). Next, the controller 75 controls the on-off valve 32 in a closing direction based on the switching operation of the four-way valve 23 (Step S42). Next, the controller 75 inputs the outdoor air temperature T2 detected by the outdoor-air temperature detector 85 (Step S43). Next, the controller 75 calculates the saturated refrigerant pressure based on the outdoor air temperature T2, and calculates the estimated refrigerant pressure P6 at the point D where the liquid refrigerant pressure of a level corresponding to the pressure

head difference H is added to the saturated refrigerant pressure (Step S44). Next, the controller 75 inputs the refrigerant pressure P3 detected by the outdoor-refrigerant pressure detector 84 (Step S45). Next, when the estimated refrigerant pressure P6 is equal to or lower than the refrigerant pressure P3 (YES at Step S46), the controller 75 controls the on-off valve 32 in an opening direction (Step S47). When the refrigerant pressure P6 is not equal to or lower than the refrigerant pressure P3 (NO at Step S46), the controller 75 repeats the control operations at Steps S43 to S46 until the refrigerant pressure P6 becomes equal to or lower than the refrigerant pressure P3. In the opening control of the on-off valve 32 at Step S47, an opening degree of the on-off valve 32 is set such that the temperature in the room 102 becomes equal to a value that is set in the indoor unit 3.

[0079] In this way, according to the air conditioner 1 of the present embodiment, when the defrost operation is switched to the heating operation, the on-off valve 32 is controlled in a closing direction. Accordingly, this control avoids the case that the liquid refrigerant in the liquid refrigerant pipe 5 reversely flows into the indoor heat exchanger 31 due to the pressure head difference H. As a result, the case that the refrigerant stays in the indoor heat exchanger 31 of the indoor unit 3 and the refrigerant becomes deficient can be avoided, the refrigerant pressure is not reduced and therefore, it is possible to favorably start the heating operation when the defrost operation is switched to the heating operation.

[0080] According to the air conditioner 1 of the present embodiment, the refrigerant pressure in the liquid refrigerant pipe 5 in the indoor unit 3 at the on-off valve 32 on the side of the outdoor heat exchanger 22 is calculated as the estimated refrigerant pressure P6 at the point D where the liquid refrigerant pressure of a level corresponding to the pressure head difference H is added to the saturated refrigerant pressure corresponding to the outdoor air temperature T2, the refrigerant pressure in the liquid refrigerant pipe 5 in the indoor unit 3 at the on-off valve 32 on the side of the indoor heat exchanger 31 corresponds to the refrigerant pressure P3 that is input from the outdoor-refrigerant pressure detector 84, and the on-off valve 32 is controlled in an opening direction when the calculated estimated refrigerant pressure P6 becomes equal to or lower than the input refrigerant pressure P3. Therefore, the case that the liquid refrigerant in the liquid refrigerant pipe 5 reversely flows into the indoor heat exchanger 31 due to the pressure head difference H is avoided, the case that the refrigerant stays in the indoor heat exchanger 31 of the indoor unit 3 and the refrigerant becomes deficient is avoided, and the heating operation is started in a state where the refrigerant pressure is not reduced. As a result, it is possible to favorably and quickly start the heating operation when the defrost operation is switched to the heating operation.

[0081] Further, according to the air conditioner 1 of the present embodiment, control is performed based on detection of the outdoor-air temperature detector 85 and

the outdoor-refrigerant pressure detector 84 provided outside of a room, and a detector for performing this control is not provided on the side of the indoor unit 3. Therefore, the cost required for providing the detector in each of the indoor units 3 can be reduced.

[0082] In the air conditioner 1 according to the present embodiment, it is preferable to calculate the estimated refrigerant pressure P6 while adding the pressure head difference H to the saturated refrigerant pressure. By calculating the estimated refrigerant pressure P6 in this manner, the on-off valve 32 can be controlled in an opening direction in accordance of the pressure head difference H of each of the indoor units 3. Therefore, it is possible to favorably and quickly start the heating operation when the defrost operation is switched to the heating operation in each of the indoor units 3.

[0083] The control of the on-off valve 32 at Step S42 fully closes the liquid refrigerant pipe 5 by the on-off valve 32. This control can reliably avoid the case that the liquid refrigerant in the liquid refrigerant pipe 5 reversely flows into the indoor heat exchanger 31 due to the pressure head difference H. The control of the on-off valve 32 at Step S42 is not limited to the fully closing operation, and the liquid refrigerant pipe 5 can be closed about 90% by the on-off valve 32. With this arrangement, the heating operation can be started substantially at the same time when the effect of the pressure rise of the liquid refrigerant caused by the pressure head difference H ceases, and therefore it is possible to start the heating operation at a relatively early timing.

[Industrial Applicability]

[0084] As described above, the air conditioner according to the present invention is suitable for favorably starting a heating operation when a defrost operation is switched to the heating operation.

[Reference Signs List]

[0085]

1 air conditioner
2 outdoor unit
21 compressor
22 outdoor heat exchanger
23 four-way valve
23a introducing unit
23b discharging unit
23c first introducing/discharging unit
23d second introducing/discharging unit
3 indoor unit
31 indoor heat exchanger
32 on-off valve
4a, 4b, 4c refrigerant pipe
5 liquid refrigerant pipe
6 gas refrigerant pipe
71, 72, 73, 74, 75 controller

81 first indoor-refrigerant pressure detector
82 second indoor-refrigerant pressure detector
83 outdoor-refrigerant temperature detector
84 outdoor-refrigerant pressure detector
85 outdoor-air temperature detector
100 building
101 machine room
102 room
H pressure head difference
P1 refrigerant pressure
P2 refrigerant pressure
P3 refrigerant pressure
P4 estimated refrigerant pressure
P5 estimated refrigerant pressure
P6 estimated refrigerant pressure
T1 refrigerant temperature
T2 outdoor air temperature

20 Claims

1. An air conditioner (1) including a set of outdoor unit (2) having a compressor (21) that compresses a refrigerant, an outdoor heat exchanger (22), and a four-way valve (23); and a plurality of indoor units (3) respectively having indoor heat exchangers (31) connected to the outdoor unit (2) through a liquid refrigerant pipe (5) and a gas refrigerant pipe (6), in which the outdoor unit (2) is arranged above the indoor units (3), comprises:

on-off valves (32) respectively provided in the indoor units (3) on a side of the liquid refrigerant pipe (5); and

a controller (71; 72; 73; 74; 75) that performs a defrost operation for circulating a refrigerant through the compressor (21), the outdoor heat exchanger (22), the liquid refrigerant pipe (5), the on-off valves (32), the indoor heat exchangers (31), and the gas refrigerant pipes (6) in this order by switching the four-way valve (23), and the controller (71; 72; 73; 74; 75) once controls the on-off valves (32) in a closing direction when the four-way valve (23) switches the defrost operation to a heating operation that is performed for circulating the refrigerant through the compressor (21), the gas refrigerant pipe (6), the indoor heat exchangers (31), the on-off valves (32), the liquid refrigerant pipe (5), and the outdoor heat exchanger (22) in this order.

2. The air conditioner (1) of Claim 1, wherein the controller (71; 72; 73; 74; 75) controls the on-off valves (32) in a closing direction when the defrost operation is switched to the heating operation, and the controller (71; 72; 73; 74; 75) controls the on-off valves (32) in an opening direction after a predetermined time is elapsed.

3. The air conditioner (1) of Claim 1, further comprising:

a first indoor-refrigerant pressure detector (81) that detects a refrigerant pressure in the liquid refrigerant pipe (5) in the indoor unit (3) at the on-off valve (32) on a side of the outdoor heat exchanger (22); and
 a second indoor-refrigerant pressure detectors (82) that detects a refrigerant pressure in the liquid refrigerant pipe (5) in the indoor unit (3) at the on-off valve (32) on a side of the indoor heat exchanger (3); wherein
 the controller (71; 72; 73; 74; 75) controls the on-off valves (32) when a refrigerant pressure that is input from the first indoor-refrigerant pressure detector(81) becomes equal to or lower than a refrigerant pressure that is input from the second indoor-refrigerant pressure detector(82) after the controller (71; 72; 73; 74; 75) controls the on-off valves (32) in a closing direction when the defrost operation is switched to the heating operation.

4. The air conditioner (1) of Claim 1, further comprising:

an outdoor-refrigerant temperature detector(83) that detects a refrigerant temperature of a liquid refrigerant in the liquid refrigerant pipe (5) in the outdoor unit (2); and
 an outdoor-refrigerant pressure detector(84) that detects a refrigerant pressure at a discharging position of the compressor (21) in the outdoor unit (2); wherein
 the controller (71; 72; 73; 74; 75) calculates a saturated refrigerant pressure from a refrigerant temperature that is input from the outdoor-refrigerant temperature detector(83) after the controller (71; 72; 73; 74; 75) controls the on-off valves (32) in a closing direction when the defrost operation is switched to the heating operation, the controller (71; 72; 73; 74; 75) calculates an estimated refrigerant pressure in which a liquid refrigerant pressure of a level corresponding to a pressure head difference is added to the saturated refrigerant pressure, and the controller (71; 72; 73; 74; 75) controls the on-off valves (32) in an opening direction when the estimated refrigerant pressure becomes equal to or lower than a refrigerant pressure that is input from the outdoor-refrigerant pressure detector(84).

5. The air conditioner (1) of Claim 1, further comprising an outdoor-refrigerant pressure detector (84) that detects a refrigerant pressure at a discharging position of the compressor (21) in the outdoor unit (2); wherein
 the controller (71; 72; 73; 74; 75) obtains in advance a saturated refrigerant pressure under a using re-

striction on an outdoor air temperature in the heating operation after the on-off valves (32) are controlled in a closing direction when the defrost operation is switched to the heating operation, calculates an estimated refrigerant pressure in which a liquid refrigerant pressure of a level corresponding to a pressure head difference is added to the saturated refrigerant pressure, and controls the on-off valves (32) in an opening direction when the estimated refrigerant pressure becomes equal to or lower than a refrigerant pressure that is input from the outdoor-refrigerant pressure detector(84).

6. The air conditioner (1) of Claim 1, further comprising:

an outdoor-air temperature detector(85) that is provided outside of a room and detects an outdoor air temperature; and
 an outdoor-refrigerant pressure detector(84) that detects a refrigerant pressure at a discharging position of the compressor (21) in the outdoor unit (2); wherein
 the controller (71; 72; 73; 74; 75) calculates a saturated refrigerant pressure from an outdoor air temperature that is input from the outdoor-air temperature detector(85) after the controller (71; 72; 73; 74; 75) controls the on-off valves (32) in a closing direction when the defrost operation is switched to the heating operation, calculates an estimated refrigerant pressure in which a liquid refrigerant pressure of a level corresponding to a pressure head difference is added to the saturated refrigerant pressure, and controls the on-off valves (32) in an opening direction when the estimated refrigerant pressure becomes equal to or lower than a refrigerant pressure that is input from the outdoor-refrigerant pressure detector(84).

7. The air conditioner (1) of any one of Claims 1 to 6, wherein the controller (71; 72; 73; 74; 75) once closes the on-off valves (32) when the defrost operation is switched to the heating operation.

FIG.1

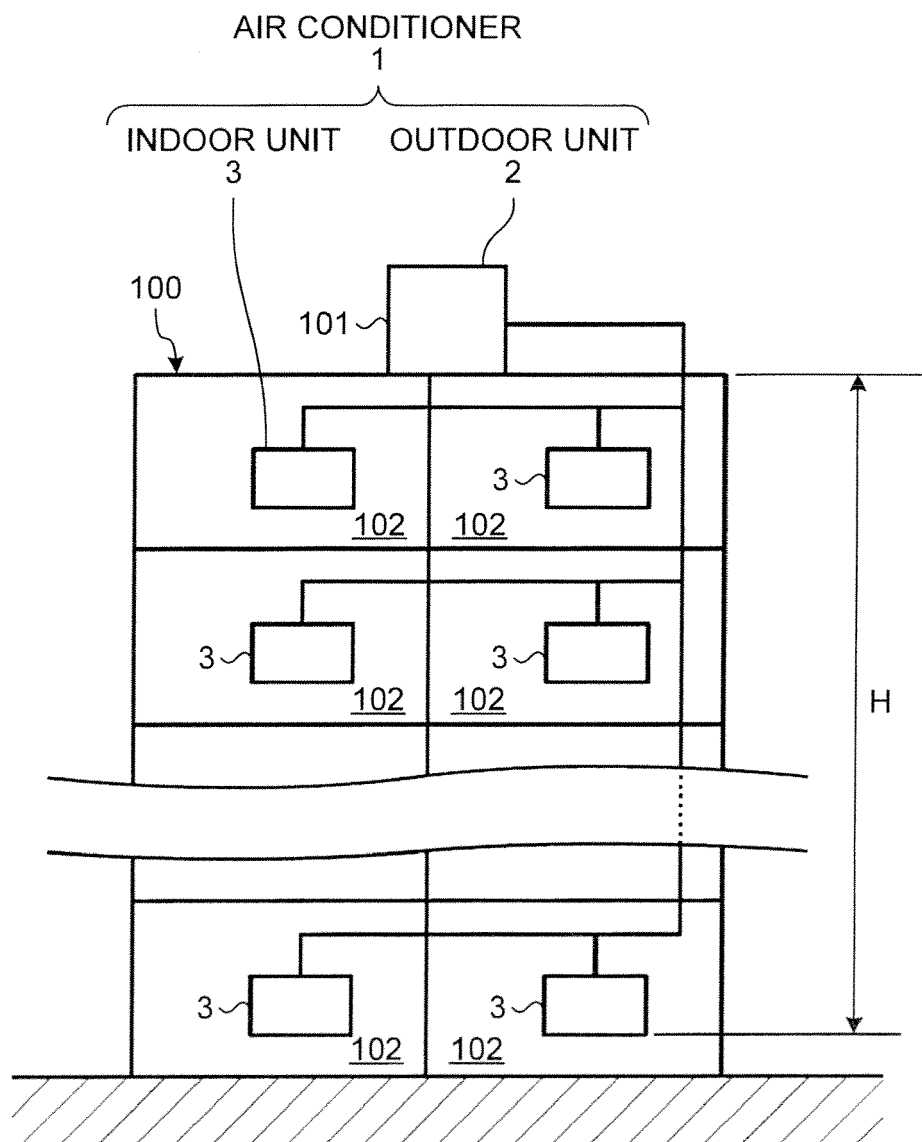


FIG.2

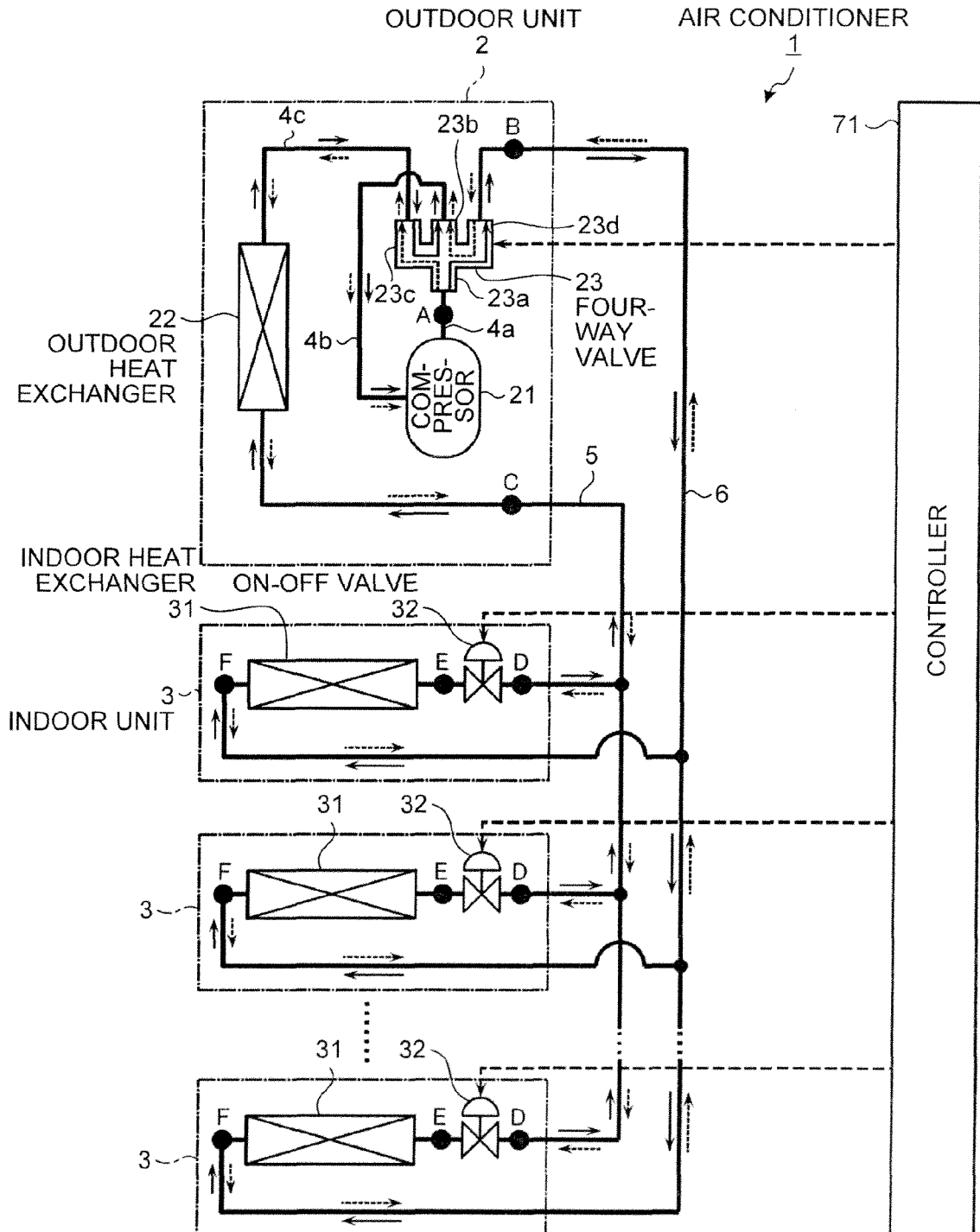


FIG.3

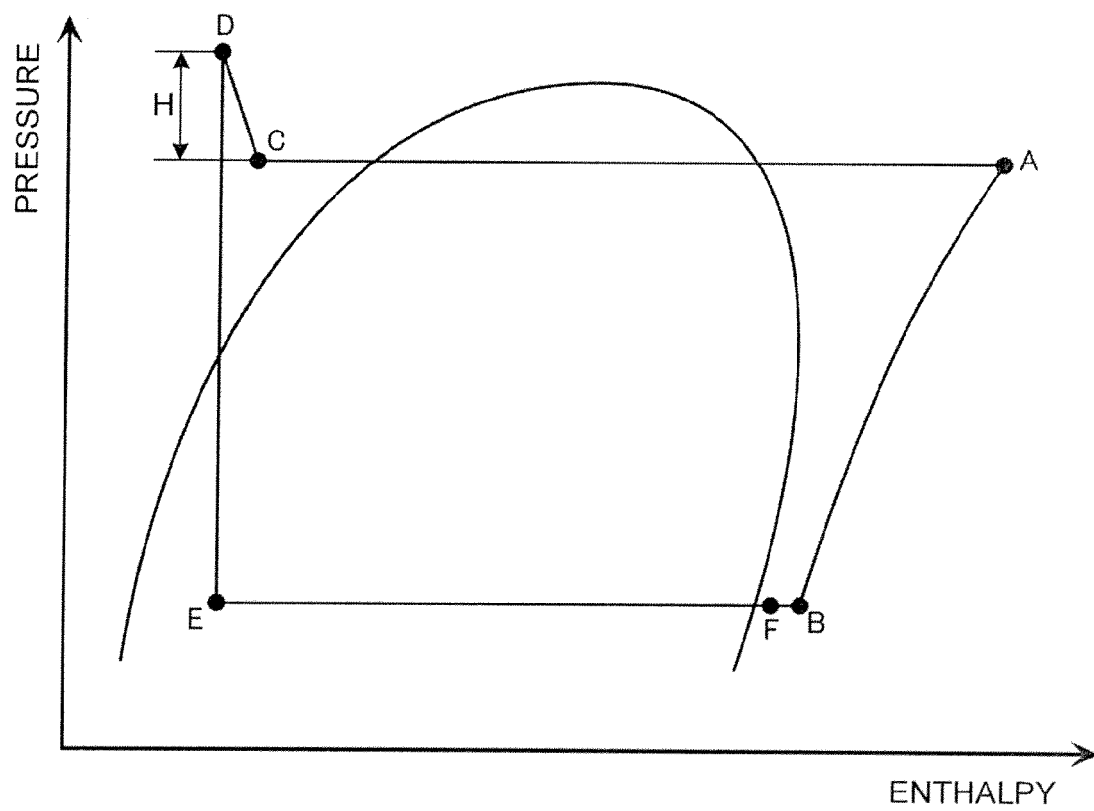


FIG.4

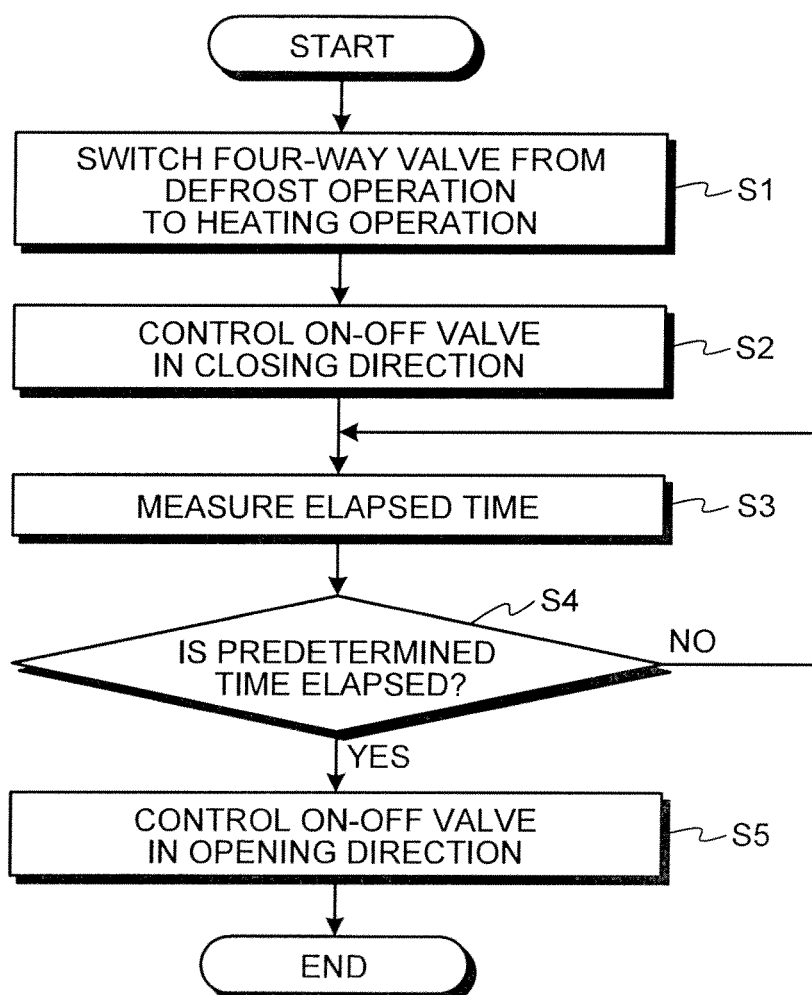


FIG.5

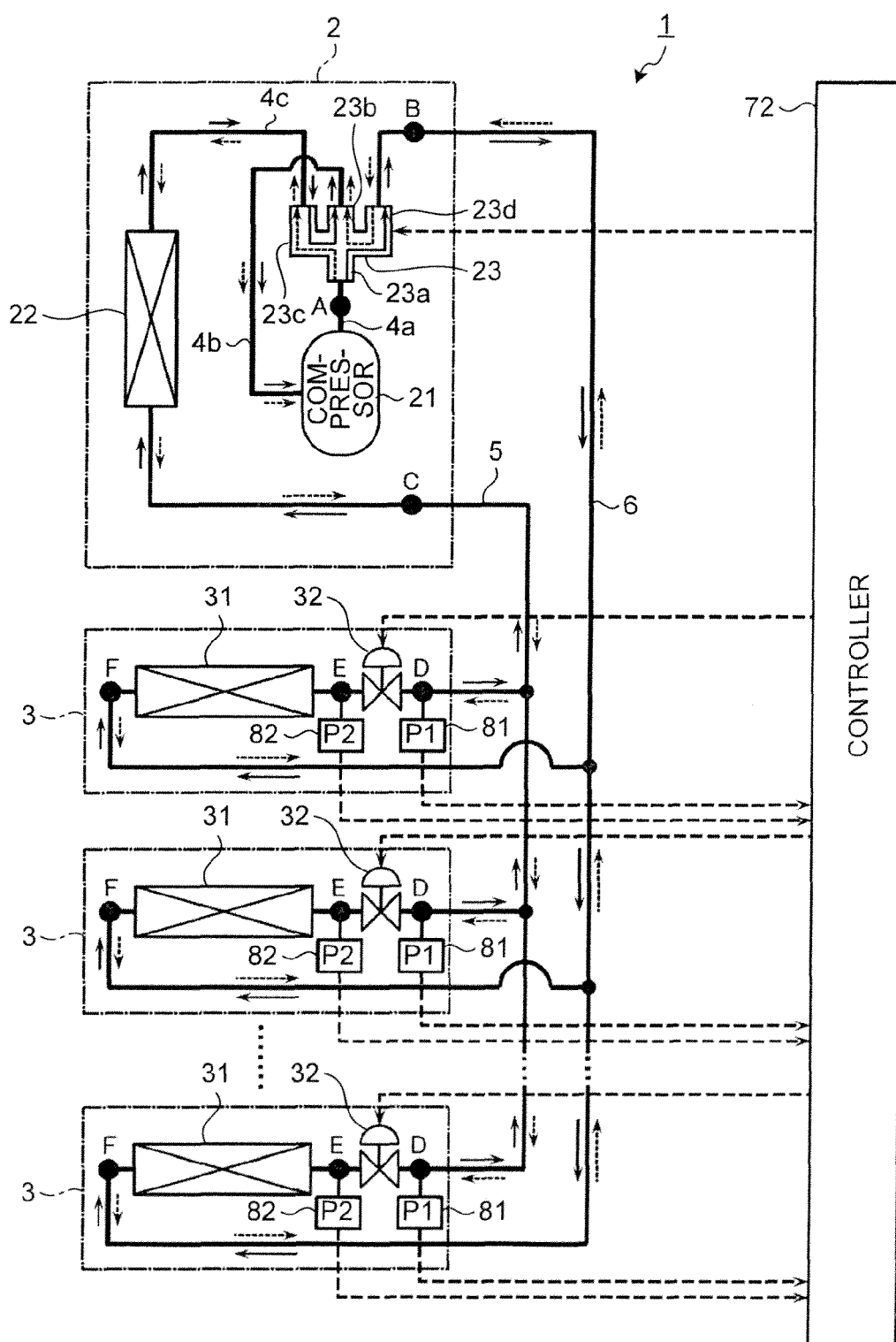


FIG.6

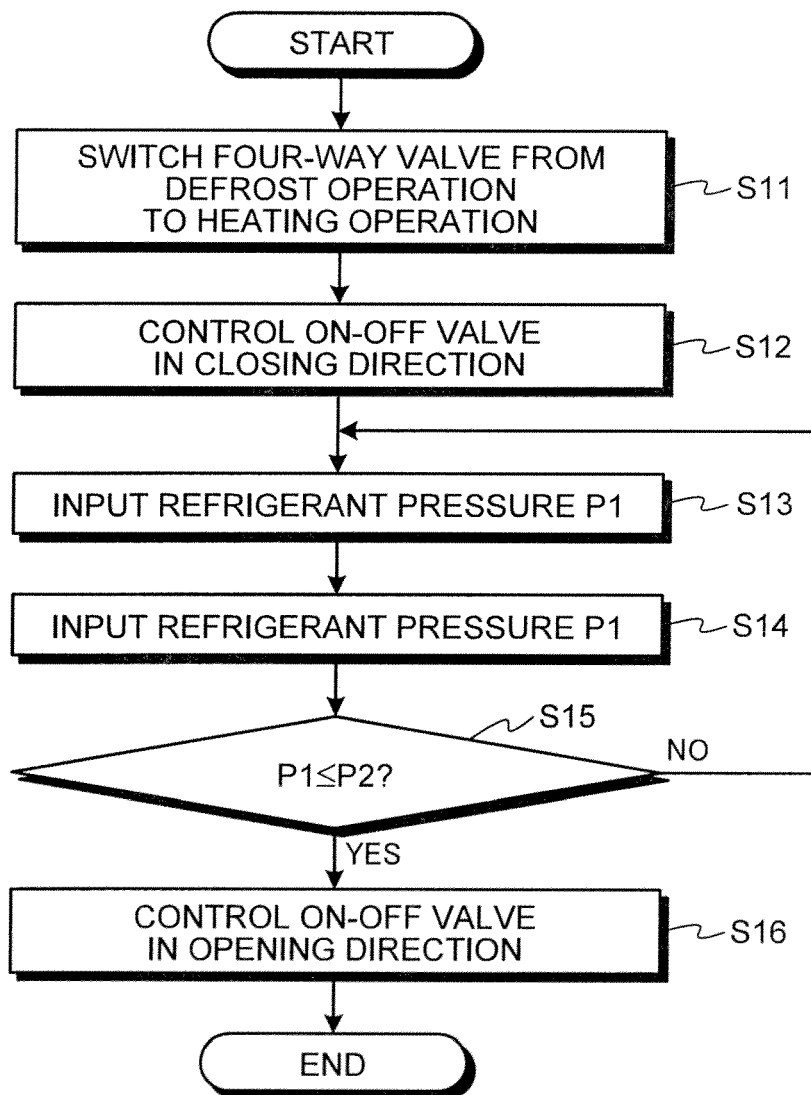


FIG.7

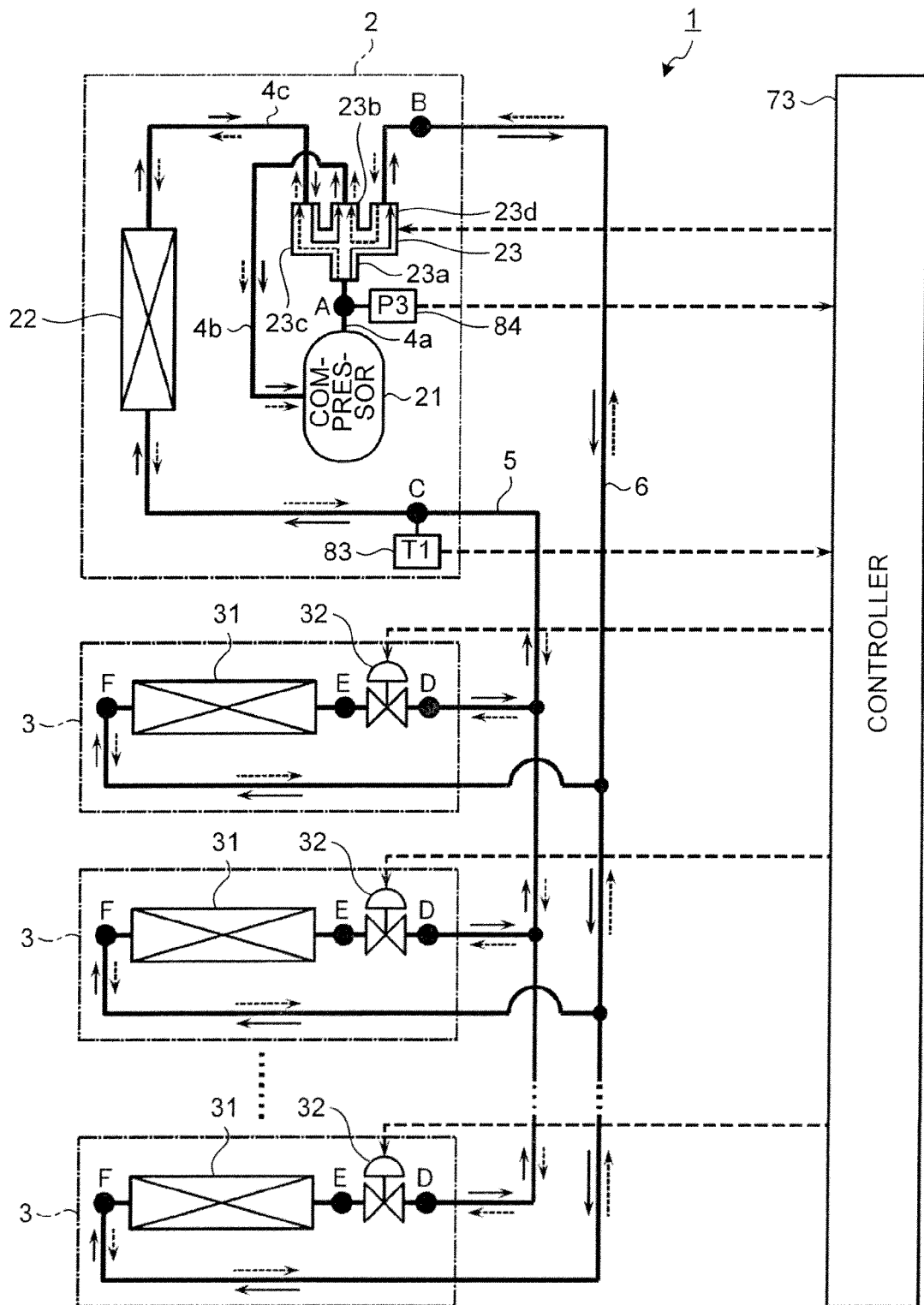


FIG.8

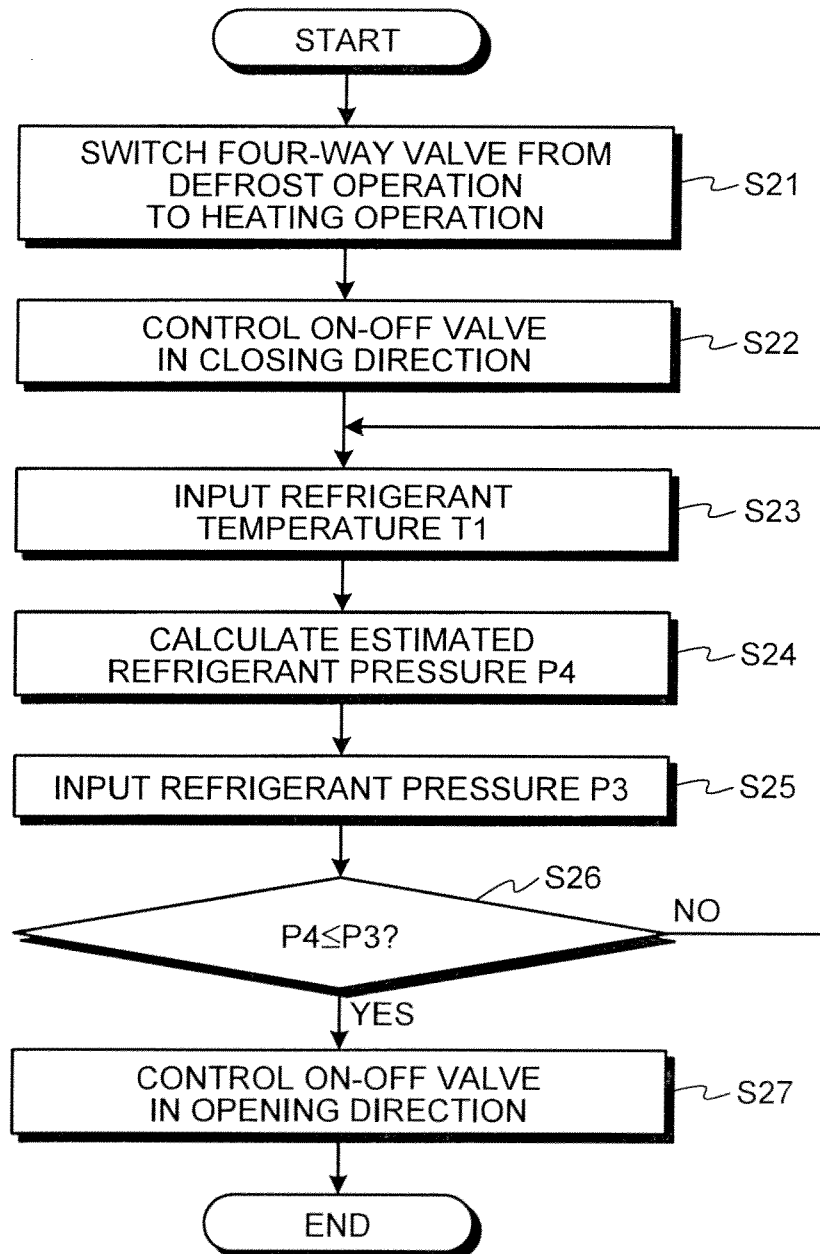


FIG.9

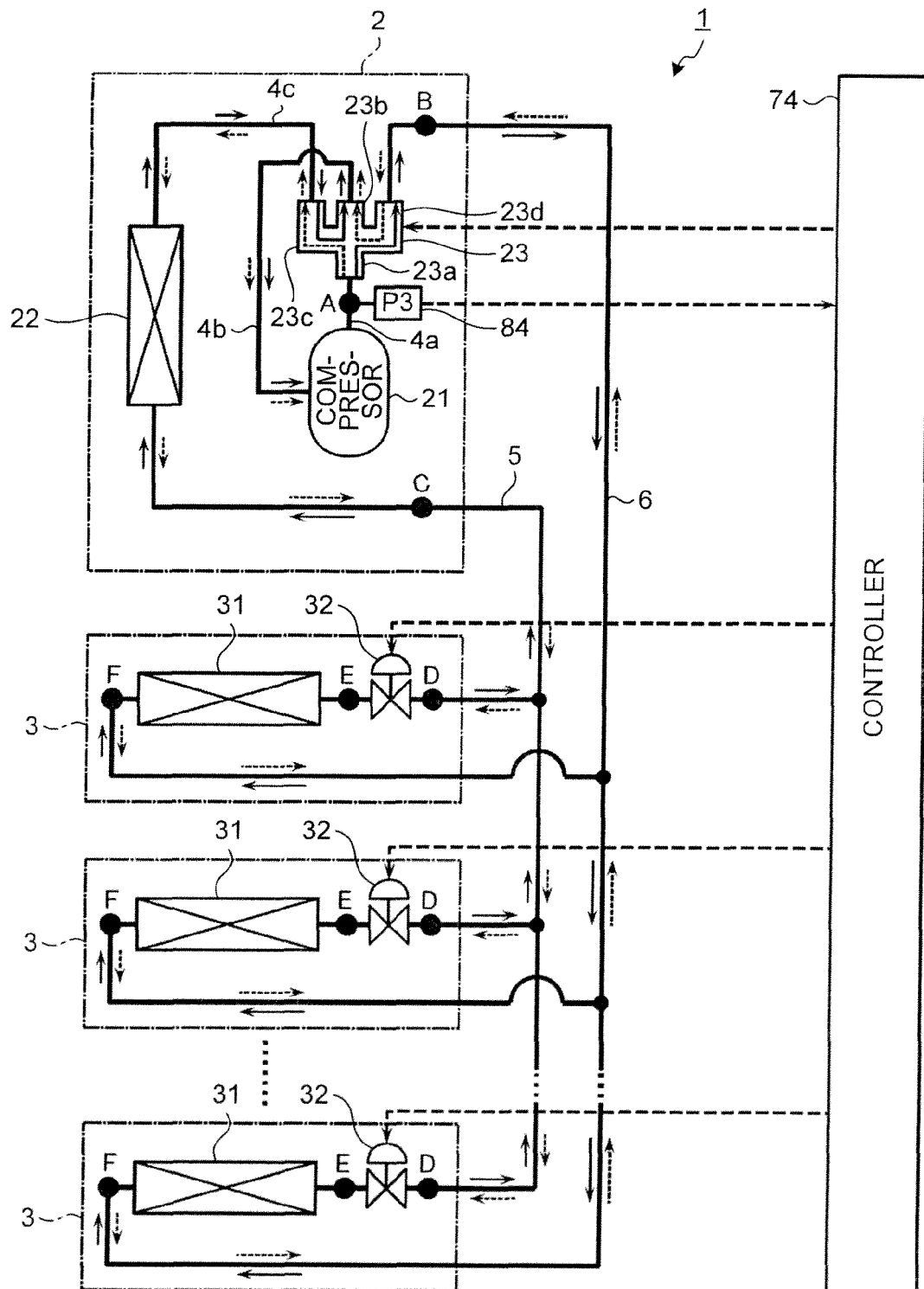


FIG.10

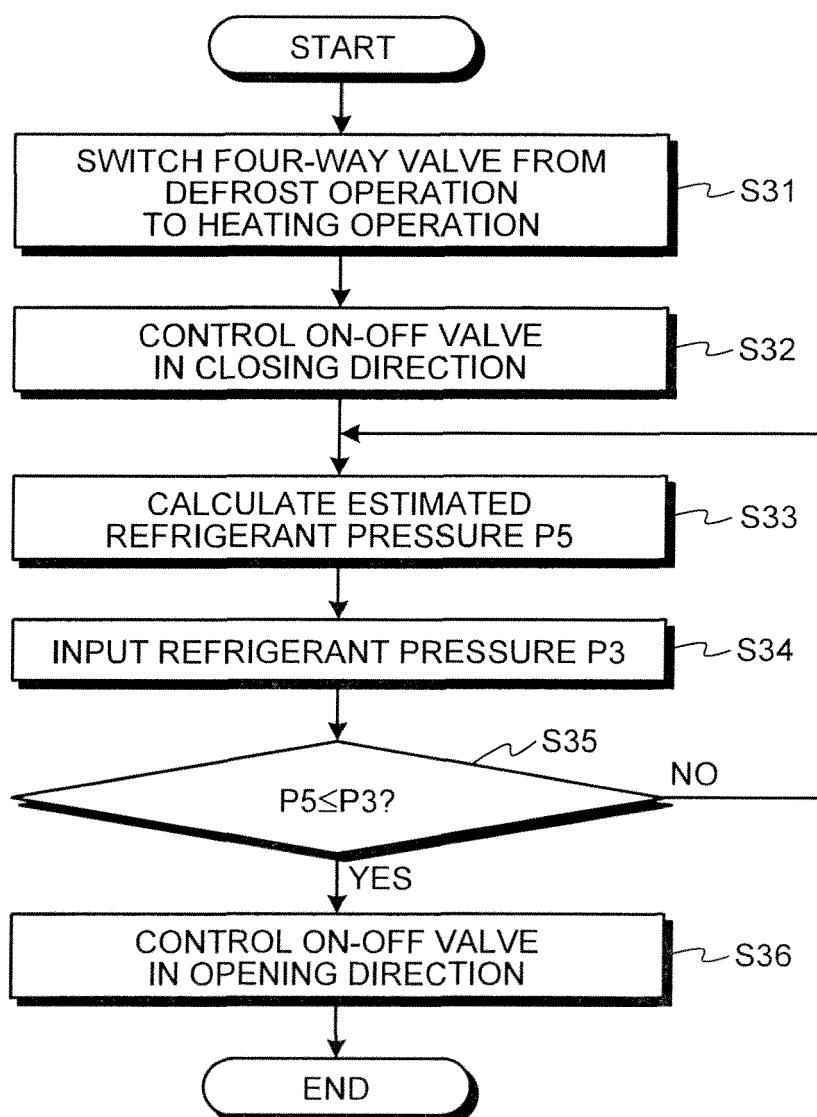


FIG.11

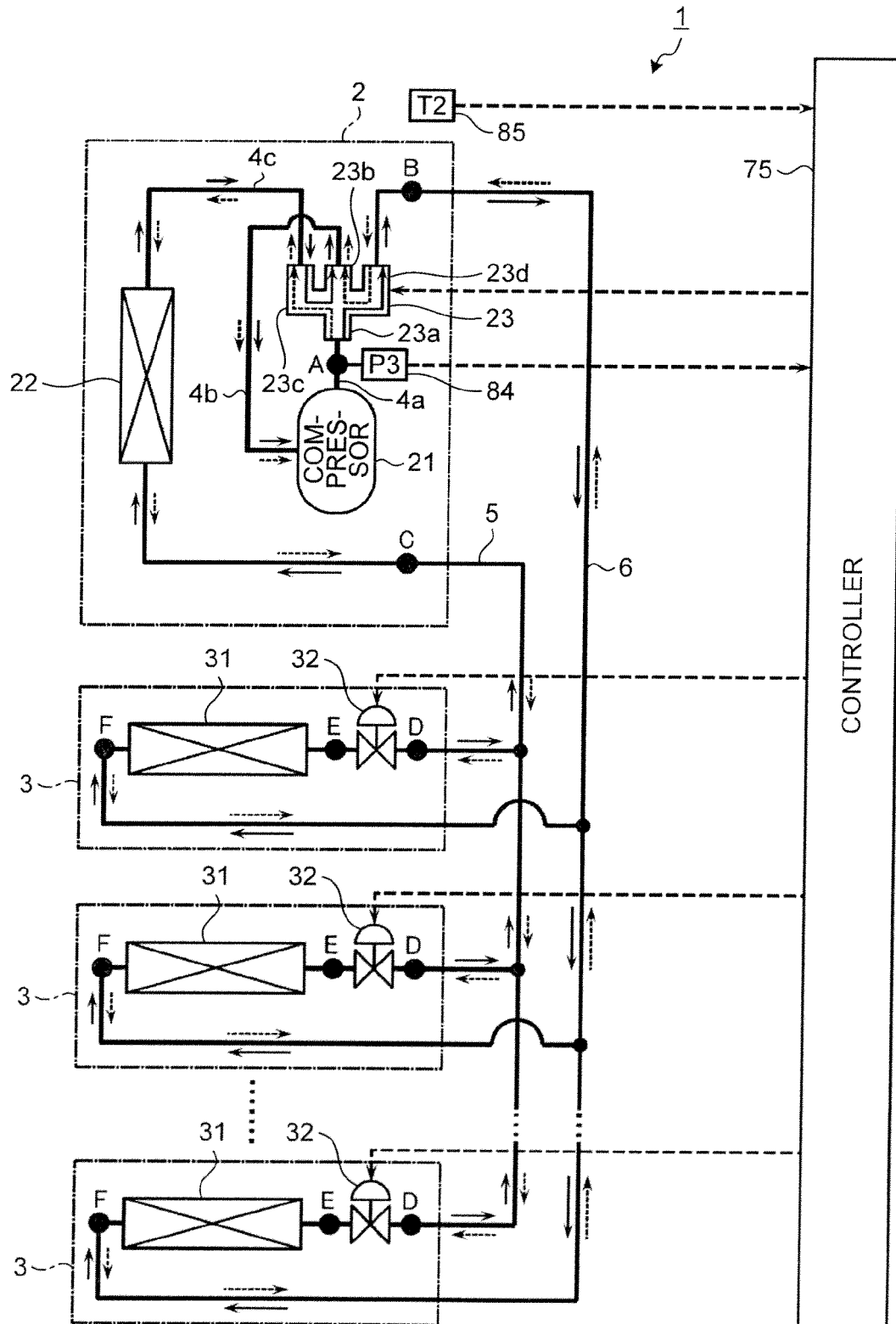
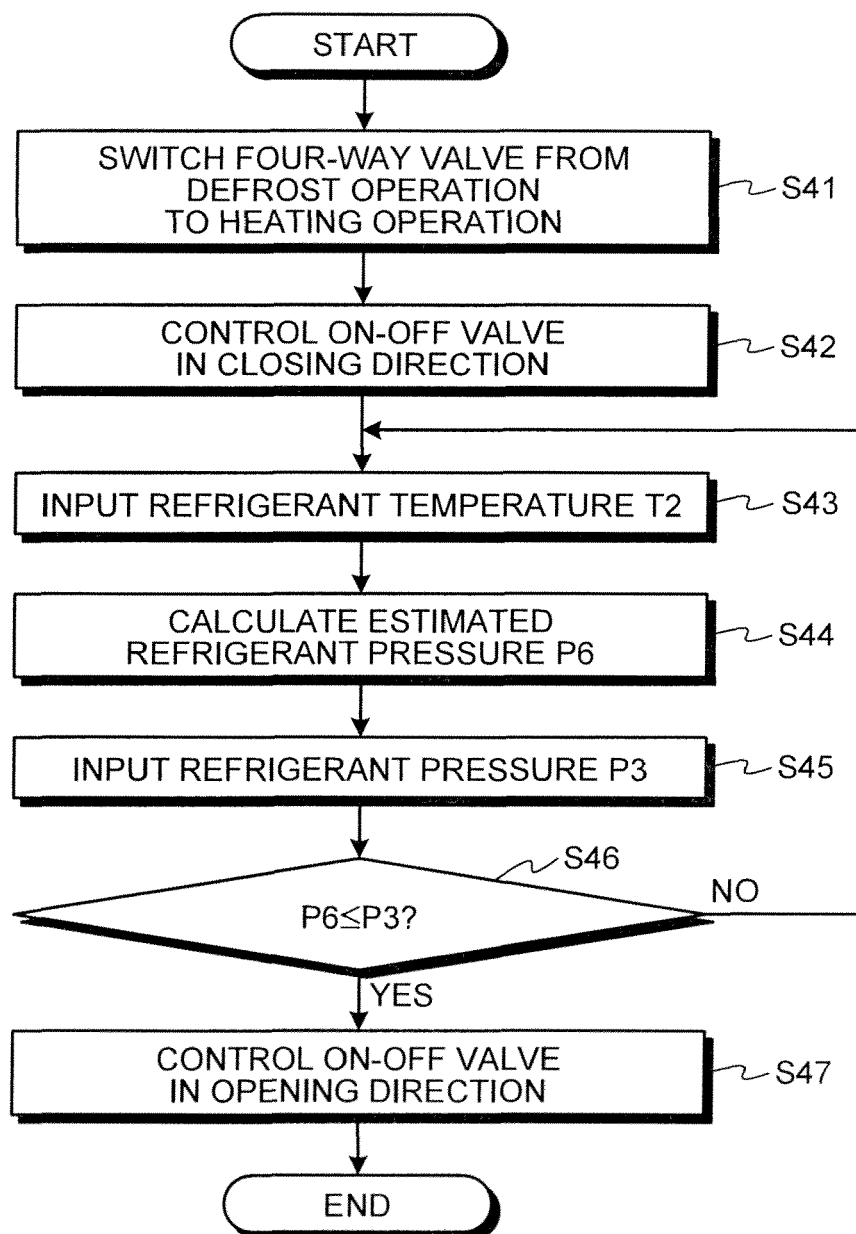


FIG.12



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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