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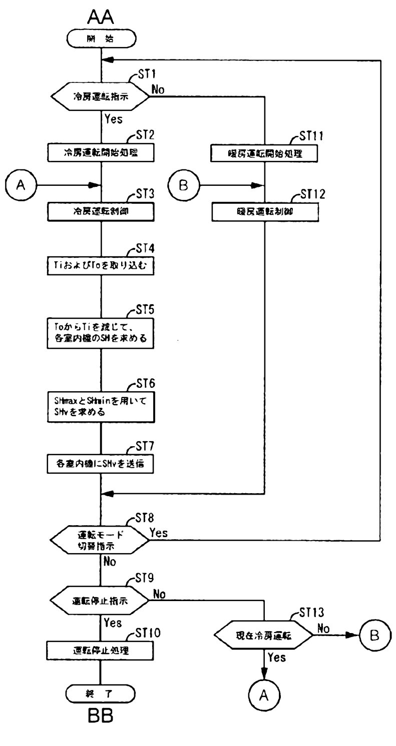
(54) Title: AIR CONDITIONING DEVICE

(54) 発明の名称： 空気調和装置



ST1...Cooling operation instruction
ST2...Cooling operation start process
ST3...Cooling operation control
ST4...Acquire Ti and To
ST5...Subtract Ti from To to find SH of each indoor unit
ST6...Use SHmax and SHmin to find SHv
ST7...Transmit SHv to each indoor unit
ST8...Operation mode switch instruction
ST9...Operation stop instruction
ST10...Operation stop process
ST11...Heating operation start process
ST12...Heating operation control
ST13...Current cooling operation
AA...Start
BB...End

(57) Abstract: Provided is an air conditioning device configured so that by causing a sufficient amount of refrigerant to flow into an indoor unit that is unable to provide cooling capacity, it is possible to provide sufficient cooling capacity in respective indoor units. When a refrigerant amount balancing control is executed, the degree of opening of indoor expansion valves 52a, 52b is choked in indoor units 5a, 5b that have a lower refrigerant superheat than a mean refrigerant superheat, therefore reducing the amount of refrigerant flowing into the indoor expansion valves 52a, 52b. In an indoor unit

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［続葉有］

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5c that has a greater refrigerant superheat than the mean refrigerant superheat, in turn, the choking of the degree of opening of the indoor expansion valves 52a, 52b causes the refrigerant pressure on the downstream side of an indoor expansion valve 52c to also decrease, therefore increasing the pressure difference between the upstream side and downstream side of the indoor expansion valve 52c and increasing the amount of refrigerant flowing into the indoor unit 5c. Due to this configuration, the cooling capacity of the indoor unit 5c is elevated.

(57) 要約：冷房能力が発揮できていない室内機に十分な量の冷媒を流入させることで、各室内機で十分な冷房能力を発揮できる空気調和装置を提供する。 冷媒量バランス制御を実行すると、平均冷媒過熱度より冷媒過熱度の小さい室内機５ａおよび５ｂでは室内膨張弁５２ａ、５２ｂの開度が絞られるので、室内膨張弁５２ａ、５２ｂに流入する冷媒量が減少する。一方、平均冷媒過熱度より冷媒過熱度の大きい室内機５ｃでは、室内膨張弁５２ａ、５２ｂの開度が絞られることに起因して室内膨張弁５２ｃの下流側の冷媒圧力も低下するので、室内膨張弁５２ｃの上流側と下流側の圧力差が大きくなって室内機５ｃに流入する冷媒量が増加する。これにより、室内機５ｃの冷房能力が上昇する。

DESCRIPTION

TITLE OF INVENTION : AIR CONDITIONER

TECHNICAL FIELD

[0001] The present invention relates to an air conditioner where a plurality of indoor units are connected to at least one outdoor unit by refrigerant pipes.

BACKGROUND ART

[0002] In the related art, when cooling operation is performed in an air conditioner where a plurality of indoor units are connected to at least one outdoor unit by a liquid pipe and a gas pipe, a degree of opening of an expansion valve corresponding to each indoor unit is adjusted such that a refrigerant superheating degree on a refrigerant exit side of the indoor heat exchanger of each indoor unit functioning as an evaporator becomes a predetermined reference value (for example, 2 deg.) (for example, see Patent Literature 1).

[0003] Specifically, for each indoor unit, a refrigerant temperature (hereinafter, described as a heat exchange entrance temperature) at a refrigerant entrance side of the indoor heat exchanger and a refrigerant temperature (hereinafter, described as a heat exchange exit temperature) at the refrigerant exit side of the indoor heat exchanger are detected, and the heat exchange entrance temperature is subtracted from the heat exchange exit temperature to determine refrigerant superheating degrees of the indoor units.

[0004] Then, the degrees of opening of the expansion valves corresponding to the indoor units are adjusted such that the obtained refrigerant superheating degrees of the indoor units become the above-described reference value. Specifically, when the refrigerant superheating degree obtained at a certain indoor unit is greater than the reference value, the degree of opening of the expansion valve corresponding to the indoor unit is increased. By increasing the degree of opening of the expansion valve, the amount of refrigerant flowing into the indoor heat exchanger of the indoor unit increases and the refrigerant superheating degree decreases. On the other hand, when the refrigerant superheating degree obtained at a certain indoor unit is smaller than the reference value, the degree of opening of the expansion valve corresponding to the indoor unit is decreased. By decreasing the degree of opening of the expansion valve, the amount of refrigerant flowing into the indoor heat exchanger of the indoor unit decreases and the refrigerant superheating degree increases.

CITATION LIST

PATENT LITERATURE

[0005] Patent Literature 1: JP-A-S63-29159

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0006] When cooling operation is performed by the above-mentioned air conditioner, the amount of refrigerant flowing into a specific indoor unit may be reduced depending on an installation state of the outdoor unit and each indoor unit. For example, if installation locations of the indoor units are higher than an installation location of the outdoor unit, and there is a height difference between the installation positions of the indoor units, since the refrigerant is less likely to flow into the indoor unit installed above, the amount of refrigerant flowing into the indoor unit is smaller than the amounts of refrigerant flowing into the other indoor units. At the time of cooling operation, the refrigerant flowing from the outdoor unit toward each indoor unit is condensed by the outdoor heat exchanger of the outdoor unit to become liquid refrigerant, and this is because the liquid refrigerant must flow to the indoor unit installed above the outdoor unit against gravity.

[0007] Further, even if the installation location of each indoor unit and the installation locations of the outdoor units are approximately the same height, if a distance between an indoor unit and the outdoor unit is different, the amount of refrigerant flowing into the indoor unit disposed at a location far from the outdoor unit is smaller than the amount of refrigerant flowing into the indoor unit disposed at a location near the outdoor unit. For the indoor unit installed at a location far from the outdoor unit, since the pressure loss due to the refrigerant pipe is greater than that of other indoor units, the length of the refrigerant pipe connecting the indoor unit to the outdoor unit is longer than that of each refrigerant pipe connecting the other indoor unit to the outdoor unit.

[0008] As described above, when the indoor units are installed in such a manner that the amount of refrigerant flowing into a specific indoor unit decreases, in a case where a distance between the indoor unit installed at the highest when the height difference between the indoor units is large (for example, 50 m or more) and the outdoor unit or between an indoor unit installed farthest from the outdoor unit and the outdoor unit is large (for example, 50 m or more), the amount of refrigerant flowing into the indoor unit is significantly decreased, resulting in a shortage of refrigerant, and there is a possibility that the cooling ability required by the user cannot be displayed.

[0009] On the other hand, at the time of cooling operation, even when the indoor units are not installed in such a manner that the amount of refrigerant flowing into a specific indoor unit decreases, in a case where the number of indoor units connected to the outdoor unit is large and the sum of rated capacities of the indoor units is greater than the a capacity of the outdoor units, the amount of refrigerant flowing into each indoor unit is small compared with when the total value of the rated capacities of the indoor units is equal to or smaller than the rated capacity of the outdoor unit.

[0010] As described above, when the number of indoor units connected to the outdoor unit is large and the total value of the capacities of the indoor units is greater than the capacity of the outdoor unit, in the indoor unit with a large air conditioning load (for example, the room temperature of the room where the indoor unit is installed is a high temperature close to 40 °C), the amount of refrigerant currently flowing in may be insufficient for the amount of refrigerant required to display the cooling capacity required by the user.

[0011] When there is an indoor unit where the amount of refrigerant flowing in is insufficient due to the above-described reason at the time of cooling operation and the cooling ability cannot be displayed, the refrigerant superheating degree in the indoor unit is a high value (for example, 8 deg.). At this time, as described in Patent Literature 1, even if the degree of opening of the corresponding expansion valve is increased in order to set the refrigerant superheating degree to the reference value in the indoor unit, because the amount of refrigerant flowing into the indoor unit is insufficient in the first place, the refrigerant superheating degree does not decrease. That is, even if the degree of opening of the expansion valve is increased to set the refrigerant superheating degree to the reference value in the indoor unit, the state in which the cooling ability cannot be displayed cannot be eliminated.

[0012] The present invention solves the above-mentioned problem, and an object thereof is to provide an air conditioner capable of displaying sufficient cooling ability at each indoor unit by allowing a sufficient amount of refrigerant to flow into indoor units where cooling ability cannot be displayed.

SOLUTION TO PROBLEM

[0013] To solve the above-mentioned problem, an air conditioner of the present invention is provided with: an outdoor device; a plurality of indoor units each of which includes an indoor heat exchanger and an indoor expansion valve; an superheating degree detector which detects a refrigerant superheating degree which is a superheating degree of a refrigerant flowing out from each indoor heat exchanger when each indoor heat exchanger is functioning as an evaporator; and a controller which adjusts degrees of opening of the plurality of indoor expansion valves. The controller executes a refrigerant amount balance control to adjust the degree of opening of each indoor expansion valve such that an average refrigerant superheating degree is obtained by averaging a maximum value and a minimum value of the refrigerant superheating degrees detected by the superheating degree detector, and the refrigerant superheating degree of each indoor unit becomes the average refrigerant superheating degree.

ADVANTAGEOUS EFFECTS OF INVENTION

[0014] According to the air conditioner of the present invention configured as described above, by executing the refrigerant amount balance control at the time of cooling operation, since refrigerant is distributed from the indoor units having the sufficient amount of refrigerant to the indoor units having the insufficient amount of refrigerant, it is possible to display sufficient cooling ability in each indoor unit during the cooling operation.

BRIEF DESCRIPTION OF DRAWINGS

[0015] FIGS. 1A and 1B are explanatory diagrams of an air conditioner in an embodiment of the present invention; FIG. 1A is a refrigerant circuit diagram; and FIG. 1B is a block diagram of an outdoor unit controller and an indoor unit controller.

FIG. 2 is an installation diagram of indoor units and an outdoor unit in the embodiment of the present invention.

FIG. 3 is a flowchart explaining processing at the outdoor controller in the embodiment of the present invention.

FIG. 4 is a flowchart explaining processing at the outdoor unit controller in another embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0016] Hereinafter, embodiments of the present invention will be described in detail based on the attached drawings. The embodiments will be described by using as an example an air conditioner where to one outdoor unit installed on the ground, three indoor units installed on the floors of the building, respectively, are connected in parallel and cooling operation or heating operation can be simultaneously performed by all the indoor units in an installation state where the amount of refrigerant flowing into a specific indoor unit during the cooling operation is insufficient. The present invention is not limited to the following embodiments and may be variously modified without departing from the gist of the present invention.

[First Embodiment]

[0017] As shown in FIG. 1A and FIG. 2, an air conditioner 1 of the present embodiment includes one outdoor unit 2 installed on the ground and three indoor units 5a to 5c installed on the floors of a building 600, respectively, and connected in parallel to the outdoor unit 2 by a liquid pipe 8 and a gas pipe 9. Specifically, the liquid pipe 8 has its one end connected to a closing valve 25 of the outdoor unit 2 and has its other end branched to be connected to liquid pipe connection portions 53a to 53c of the indoor units 5a to 5c. The gas pipe 9 has its one end connected to a closing valve 26 of the outdoor unit 2 and has its other end branched to be connected to gas pipe connection portions 54a to 54c of the indoor units 5a to 5c. This constitutes a refrigerant circuit 100 of the air conditioner 1.

[0018] First, the outdoor unit 2 will be described. The outdoor unit 2 includes a compressor 21, a four-way valve 22, an outdoor heat exchanger 23, an outdoor expansion valve 24, the closing valve 25 to which one end of the liquid pipe 8 is connected, the closing valve 26 to which one end of the gas pipe 9 is connected, an accumulator 28 and an outdoor fan 27. These devices except the outdoor fan 27 are interconnected by refrigerant pipes described below in detail, thereby constituting an outdoor unit refrigerant circuit 20 forming part of the refrigerant circuit 100.

[0019] The compressor 21 is a variable ability compressor the operation capacity of which is variable by being driven by a non-illustrated motor the rpm of which is controlled by an inverter. A refrigerant discharge side of the compressor 21 is connected to a port a of the four-way valve 22 described later by a discharge pipe 41, and a refrigerant suction side of the compressor 21 is connected to a refrigerant outflow side of the accumulator 28 by a suction pipe 42.

[0020] The four-way valve 22 is a valve for switching the direction in which the refrigerant flows, and is provided with four ports a, b, c and d. The port a is connected to the refrigerant discharge side of the compressor 21 by the discharge pipe 41 as mentioned above. The port b is connected to one refrigerant entrance and exit of the outdoor heat exchanger 23 by a refrigerant pipe 43. The port c is connected to a refrigerant inflow side of the accumulator 28 by a refrigerant pipe 46. The port d is connected to the closing valve 26 by an outdoor unit gas pipe 45.

[0021] The outdoor heat exchanger 23 performs heat exchange between the refrigerant and the outside air taken into the outdoor unit 2 by the rotation of the outdoor fan 27 described later. One refrigerant entrance and exit of the outdoor heat exchanger 23 is connected to the port b of the four-way valve 22 by the refrigerant pipe 43 as mentioned above, and the other refrigerant entrance and exit thereof is connected to the closing valve 25 by an outdoor unit liquid pipe 44.

[0022] The outdoor expansion valve 24 is provided on the outdoor unit liquid pipe 44. The outdoor expansion valve 24 is an electronic expansion valve, and by the degree of opening thereof being adjusted, the amount of refrigerant flowing into the outdoor heat exchanger 23 or the amount of refrigerant flowing out from the outdoor heat exchanger 23 is adjusted. The degree of opening of the outdoor expansion valve 24 is made full opening when the air conditioner 1 is performing cooling operation. When the air conditioner 1 is performing heating operation, by controlling the degree of opening thereof according to the discharge temperature of the compressor 21 detected by a discharge temperature sensor 33 described later, the discharge temperature is prevented from exceeding a performance upper limit value.

[0023] The outdoor fan 27 is made of a resin material, and disposed in the neighborhood of the outdoor heat exchanger 23. The outdoor fan 27 is rotated by a non-illustrated fan motor to thereby take the outside air into the outdoor unit 2 from a non-illustrated inlet, and discharges the outside air heat-exchanged with the refrigerant at the outdoor heat exchanger 23 from a non-illustrated outlet to the outside of the outdoor unit 2.

[0024] The accumulator 28, as mentioned above, has its refrigerant inflow side connected to the port c of the four-way valve 22 by the refrigerant pipe 46 and has its refrigerant outflow side connected to the refrigerant suction side of the compressor 21 by the suction pipe 42. The accumulator 28 separates the refrigerant having flown from the refrigerant pipe 46 into the accumulator 28 into a gas refrigerant and a liquid refrigerant and causes only the gas refrigerant to be sucked into the compressor 21.

[0025] In addition to the above-described components, various sensors are provided in the outdoor unit 2. As shown in FIG. 1A, the discharge pipe 41 is provided with a discharge pressure sensor 31 that detects the discharge pressure which is the pressure of the refrigerant discharged from the compressor 21 and the discharge temperature sensor 33 that detects the temperature of the refrigerant discharged from the compressor 21. In the neighborhood of the refrigerant inflow port of the accumulator 28 on the refrigerant pipe 46, a suction pressure sensor 32 that detects the pressure of the refrigerant sucked into the compressor 21 and a suction temperature sensor 34 that detects the temperature of the refrigerant sucked into the compressor 21 are provided.

[0026] Between the outdoor heat exchanger 23 and the outdoor expansion valve 24 on the outdoor unit liquid pipe 44, a outdoor heat exchange temperature sensor 35 for detecting the temperature of the refrigerant flowing into the outdoor heat exchanger 23 or the temperature of the refrigerant flowing out from the outdoor heat exchanger 23 is provided. In the neighborhood of a non-illustrated inlet of the outdoor unit 2, an outside air temperature sensor 36 that detects the temperature of the outside air flowing into the outdoor unit 2, that is, the outside air temperature is provided.

[0027] The outdoor unit 2 is provided with an outdoor unit controller 200. The outdoor unit controller 200 is mounted on a control board housed in a non-illustrated electric component box of the outdoor unit 2. As shown in FIG. 1B, the outdoor unit controller 200 includes a CPU 210, a storage unit 220, a communication unit 230 and a sensor input unit 240.

[0028] The storage unit 220 is formed of a ROM and a RAM, and stores a control program of the outdoor unit 2, detection values corresponding to detection signals from various sensors, control states of the compressor 21 and the outdoor fan 27, and the like. The communication unit 230 is an interface that performs communication with the indoor units 5a to 5c. The sensor input unit 240 receives the results of the detections at the sensors of the outdoor unit 2 and outputs them to the CPU 210.

[0029] The CPU 210 receives the above-mentioned results of the detections at the sensors of the outdoor unit 2 through the sensor input unit 240. Moreover, the CPU 210 receives the control signals transmitted from the indoor units 5a to 5c through the communication unit 230. The CPU 210 controls driving of the compressor 21 and the outdoor fan 27 based on the received detection results and control signals. Moreover, the CPU 210 controls switching of the four-way valve 22 based on the received detection results and control signals. Further, the CPU 210 adjusts the degree of opening of the outdoor expansion valve 24 based on the received detection results and control signals.

[0030] Next, the three indoor units 5a to 5c will be described. The three indoor units 5a to 5c includes indoor heat exchangers 51a to 51c, indoor expansion valves 52a to 52c, the liquid pipe connection portions 53a to 53c to which the other ends of the branched liquid pipe 8 are connected, the gas pipe connection portions 54a to 54c to which the other ends of the branched gas pipe 9 are connected, and indoor fans 55a to 55c, respectively. These devices except the indoor fans 55a to 55c are interconnected by refrigerant pipes described below in detail, thereby constituting indoor unit refrigerant circuits 50a to 50c forming part of the refrigerant circuit 100. The three indoor units 5a to 5c all have the same ability, and if refrigerant superheating degree on a refrigerant exit side of the indoor heat exchangers 51a to 51c at the time of cooling operation can be made not more than a predetermined value (for example, 4 deg.), sufficient cooling ability can be displayed at each indoor unit.

[0031] Since the components of the indoor units 5a to 5c are the same, in the following description, only the components of the indoor unit 5a are described, and description of the other indoor units 5b, 5c is omitted. Moreover, in FIG. 1, the component devices of the indoor units 5b, 5c corresponding to the component devices of the indoor unit 5a are denoted by reference designations where the last letters of the numbers assigned to the component devices of the indoor unit 5a are changed from a to b or c, respectively.

[0032] The indoor heat exchanger 51a performs heat exchange between the refrigerant and the indoor air taken into the indoor unit 5a from a non-illustrated inlet by the rotation of the indoor fan 55a described later, one refrigerant entrance and exit thereof is connected to the liquid pipe connection portion 53a by an indoor unit liquid pipe 71a, and the other refrigerant entrance and exit thereof is connected to the gas pipe connection portion 54a by an indoor unit gas pipe 72a. The indoor heat exchanger 51a functions as an evaporator when the indoor unit 5a performs cooling operation, and functions as a condenser when the indoor unit 5a performs heating operation.

The refrigerant pipes are connected to the liquid pipe connection portion 53a and the gas pipe connection portion 54a by welding, flare nuts or the like.

[0033] The indoor expansion valve 52a is provided on the indoor unit liquid pipe 71a. The indoor expansion valve 52a is an electronic expansion valve, and when the indoor heat exchanger 51a functions as an evaporator, that is, that is, when the indoor unit 5a performs heating operation, the degree of opening thereof is adjusted such that the refrigerant supercooling degree at the refrigerant exit (the side of the liquid pipe connection portion 53a) of the indoor heat exchanger 51a is a target refrigerant supercooling degree. Here, the target refrigerant supercooling degree is a refrigerant supercooling degree for sufficient heating ability to be displayed at the indoor unit 5a. When the indoor heat exchanger 51a functions as a evaporator, that is, when the indoor unit 5a performs cooling operation, the degree of opening of the indoor expansion valve 52a is adjusted such that the refrigerant superheating degree at the refrigerant exit (the side of the gas pipe connection portion 54a) of the indoor heat exchanger 51a is an average refrigerant supercooling degree described later.

[0034] The indoor fan 55a is made of a resin material, and disposed in the neighborhood of the indoor heat exchanger 51a. The indoor fan 55a is rotated by a non-illustrated fan motor to thereby take the indoor air into the indoor unit 5a from a non-illustrated inlet, and supplies the indoor air heat-exchanged with the refrigerant at the indoor heat exchanger 51a from a non-illustrated outlet into the room.

[0035] In addition to the above-described components, various sensors are provided in the indoor unit 5a. Between the indoor heat exchanger 51a and the indoor expansion valve 52a on the indoor unit liquid pipe 71a, a liquid side temperature sensor 61a that detects the temperature of the refrigerant flowing into the indoor heat exchanger 51a or flowing out from the indoor heat exchanger 51a is provided. The indoor unit gas pipe 72a is provided with a gas side temperature sensor 62a that detects the temperature of the refrigerant flowing out from the indoor heat exchanger 51a or flowing into the indoor heat exchanger 51a. In the neighborhood of a non-illustrated inlet of the indoor unit 5a, an inflow temperature sensor 63a that detects the temperature of the indoor air flowing into the indoor unit 5a, that is, the inflow temperature is provided.

[0036] The indoor unit 5a is provided with an indoor unit controller 500a. The indoor unit controller 500a is mounted on a control board housed in a non-illustrated electric component box of the indoor unit 5a, and as shown in FIG. 1B, is provided with a CPU 510a, a storage unit 520a, a communication unit 530a and a sensor input unit 540a.

[0037] The storage portion 520a is formed of a ROM and a RAM, and stores a control program of the indoor unit 5a, detection values corresponding to detection signals from various sensors, setting information related to an air-conditioning operation by the user, and the like. The communication portion 530a is an interface that performs communication with the outdoor unit 2 and the other indoor units 5b, 5c. The sensor input portion 540a receives the results of the detections at the sensors of the indoor unit 5a and outputs them to the CPU 510a.

[0038] The CPU 510a receives the above-mentioned results of the detections at the sensors of the indoor unit 5a through the sensor input unit 540a. Moreover, the CPU 510a receives, through a non-illustrated remote control light receiving portion, a signal containing operation information, timer operation setting and the like set by the user operating a non-illustrated remote control unit. Moreover, the CPU 510a transmits an operation start/stop signal and a control signal containing operation information (the set temperature, the room temperature, etc.) to the outdoor unit 2 through the communication portion 530a, and receives a signal containing information such as a temperature of the outside air detected by the outdoor unit 2 from the outdoor unit 2 through the communication portion 530a. The CPU 510a adjusts the degree of opening of the indoor expansion valve 52a and controls driving of the indoor fan 55a based on the received detection results and the signals transmitted from the remote control unit and the outdoor unit 2.

The above-described outdoor unit controller 200 and the indoor unit controllers 500a to 500c constitute the controller of the present invention.

[0039] The above-described air conditioner 1 is installed in a building 600 shown in FIG. 2. Specifically, the outdoor unit 2 is disposed on the ground; the indoor unit 5a, on the first floor; the indoor unit 5b, on the second floor; and the indoor unit 5c, on the third floor. The outdoor unit 2 and the indoor units 5a to 5c are interconnected by the above-described liquid pipe 8 and gas pipe 9, and these liquid pipe 8 and gas pipe 9 are buried in a non-illustrated wall or ceiling of the building 600. In FIG. 2, the difference in height between the indoor unit 5c installed on the highest floor (the third floor) and the indoor unit 5a installed on the lowest floor (the first floor) is represented as H.

[0040] Next, the flow of the refrigerant at the refrigerant circuit 100 and the operations of components at the time of the air-conditioning operation of the air conditioner 1 of the present embodiment will be described by using FIG. 1A. In the following description, a case where the indoor units 5a to 5c perform cooling operation will be described, and detailed description of a case where they perform heating operation is omitted. The arrows in FIG. 1A indicate the flow of the refrigerant at the time of cooling operation.

[0041] As shown in FIG. 1A, when the indoor units 5a to 5c perform cooling operation, the CPU 210 of the outdoor unit controller 200 switches the four-way valve 22 to the state shown by solid lines, that is, such that the port a and the port b of the four-way valve 22 communicate with each other and the port c and the port d communicate with each other. This brings the refrigerant circuit 100 into a heating cycle where the outdoor heat exchanger 23 functions as an condenser and the indoor heat exchangers 51a to 51c function as evaporators.

[0042] The high-pressure refrigerant discharged from the compressor 21 flows through the discharge pipe 41 into the four-way valve 22, and flows from the four-way valve 22 through the refrigerant pipe 43 into the outdoor heat exchanger 23. The refrigerant having flown into the outdoor heat exchanger 23 exchanges heat with the outside air taken into the outdoor unit 2 by the rotation of the outdoor fan 27 and is condensed. The refrigerant having flown out from the outdoor heat exchanger 23 flows from the outdoor unit liquid pipe 44, the outdoor expansion valve 24 the degree of opening of which is fully opened, and the closing valve 25 into the liquid pipe 8.

[0043] The refrigerant flowing through the liquid pipe 8 flows into the indoor unit 5a to 5c through the liquid pipe connection portions 53a to 53c. The refrigerant having flown into the indoor units 5a to 5c flows through the indoor unit liquid pipes 71a to 71c, is decompressed by the indoor expansion valves 52a to 52c, and flows into the indoor heat exchangers 51a to 51c. The refrigerant having flown into the indoor heat exchangers 51a to 51c exchanges heat with the indoor air taken into the indoor units 5a to 5c by the rotation of the indoor fans 55a to 55c, and is evaporated. As described above, the indoor heat exchangers 51a to 51c function as evaporators and the cooled indoor air heat-exchanged with the refrigerant at the indoor heat exchangers 51a to 51c is flown out form a non-illustrated outlet into the rooms, thereby performing cooling in the rooms where the indoor units 5a to 5c are installed.

[0044] The refrigerant having flown out from the indoor heat exchangers 51a to 51c flows through the indoor unit gas pipes 72a to 72c, and flows into the gas pipe 9 through the gas pipe connection portions 54a to 54c. The refrigerant flowing through the gas pipe 9 flows into the outdoor unit 2 through the closing valve 26. The refrigerant having flown into the outdoor unit 2 flows through the outdoor unit gas pipe 45, the four-way valve 22, the refrigerant pipe 46, the accumulator 28 and the suction pipe 42 in this order, is sucked by the compressor 21 and compressed again.

[0045] When the indoor units 5a to 5c perform heating operation, the CPU 210 switches the four-way valve 22 to the state shown by the broken line, that is, such that the port a and the port b of the four-way valve 22 communicate with each other and the port b and the port c communicate with each other. This brings the refrigerant circuit 100 into a heating cycle where the outdoor heat exchanger 23 functions as a evaporator and the indoor heat exchangers 51a to 51c function as condensers.

[0046] Next, the operation, workings and effects of the refrigerant circuit related to the present invention in the air conditioner 1 of the present embodiment will be described by using FIGS. 1 to 3. When the indoor heat exchangers 51a to 51c function as evaporators, liquid side temperature sensors 61a to 61c that detect the heat exchange entrance temperature, which is the temperature of the refrigerant flowing into the indoor heat exchangers 51a to 51c, and gas side temperature sensors 62a to 62c that detect the heat exchange exit temperature, which is the temperature of the refrigerant flowing out from the indoor heat exchangers 51a to 51c, the outdoor unit controller 200, the indoor unit controllers 500a to 500c are superheating degree detectors.

[0047] As described above using FIG. 2, in the air conditioner 1 of the present embodiment, the outdoor unit 2 is installed on the ground of the building 600 and the indoor units 5a to 5c are installed on the floors, respectively. That is, the outdoor unit 2 is installed in a lower position than the indoor units 5a to 5c, and there is a height difference H between the installation locations of the indoor unit 5a and the indoor unit 5c. In this case, the following problem arises when cooling operation is performed by the air conditioner 1.

[0048] In cooling operation, the gas refrigerant discharged from the compressor 21 flows from the discharge pipe 41 into the outdoor heat exchanger 23 through the four-way valve 22 and the refrigerant pipe 43, exchanges heat with the outside air in the outdoor heat exchanger 23, is condensed, and becomes the liquid refrigerant. At this time, since the outdoor unit 2 is installed in the lower position than the indoor units 5a to 5c, the liquid refrigerant condensed at the outdoor heat exchanger 23 and having flown out into the liquid pipe 8 flows through the liquid pipe 8 against gravity toward the indoor units 5a to 5c.

[0049] Therefore, it becomes more difficult for the liquid refrigerant having flown out into the liquid pipe 8 to flow toward the indoor units 5a to 5c as the installation positions of the indoor units 5a to 5c become high compared with that of the outdoor unit 2. When there is a height difference H in the installation positions of indoor units 5a to 5c, the pressure of the refrigerant on the upstream side (the side of the outdoor unit 2) of the indoor expansion valve 52c of the indoor unit 5c installed on the third floor is lower than the pressure of the refrigerant on the upstream side of the indoor expansion valves 52a, 52b of the indoor units 5a, 5b installed on the other floors. For this reason, a difference between the refrigerant pressure on the upstream side of the indoor expansion valve 52c of the indoor unit 5c and the refrigerant pressure on the downstream side thereof (the side of the indoor heat exchanger 51c) is small compared with a difference between the refrigerant pressure on the upstream side of the indoor expansion valves 52a, 52b of the indoor units 5a, 5b and the refrigerant pressure on the downstream side thereof.

[0050] In the state of the refrigerant circuit 100 as described above, the smaller the difference between the refrigerant pressure on the upstream side of the indoor expansion valves 52a to 52c and the refrigerant pressure on the downstream side thereof, the smaller the amounts of refrigerant passing through the indoor expansion valves 52a to 52c. Therefore, the amount of refrigerant flowing through the indoor unit 5c installed on the third floor is small compared with the amounts of refrigerant flowing in the other indoor units 5a, 5b. This becomes more conspicuous as the height difference H between the indoor unit 5a installed on the first floor (the lowest position) and the indoor unit 5c installed on the third floor (the highest position) increases. That is, as the height difference becomes larger, the liquid refrigerant flowing out from the outdoor unit 2 into the liquid pipe 8 becomes harder to flow toward the indoor unit 5c, and the amount of refrigerant flowing into the indoor unit 5c is smaller compared with the amounts of refrigerant flowing into the indoor units 5a, 5b.

[0051] If the height difference between the indoor unit 5a and the indoor unit 5c is equal to or greater than a certain value (for example, 50 m), the amount of refrigerant flowing into the indoor unit 5c may be insufficient for the amount of refrigerant required to display the required cooling ability. At this time, even if the degree of opening of the indoor expansion valve 52c is increased in order to increase the amount of refrigerant flowing into the indoor unit 5c, since the amount of refrigerant flowing from the outdoor unit 2 toward the indoor unit 5c is insufficient in the first place, the amount of refrigerant flowing into the indoor unit 5c does not increase, and there is a problem that a state in which the cooling ability cannot be exhibited cannot be eliminated.

[0052] Accordingly, in the present invention, when the air conditioner 1 performs cooling operation, the refrigerant superheating degree on the refrigerant exit side of the indoor heat exchangers 51a to 51c of the indoor units 5a to 5c (the side of gas side closing valves 54a to 54c) is calculated periodically (for example, every thirty seconds), the maximum value and the minimum value of the calculated refrigerant superheating degrees are extracted, and an average refrigerant superheating degree which is the average value of these is obtained. Then, a refrigerant amount balance control is executed in which the degrees of opening of the indoor expansion valves 52a to 52c of the indoor units 5a to 5c are adjusted so that the refrigerant superheating degree on the refrigerant exit side of the indoor heat exchangers 51a to 51c becomes the obtained average refrigerant superheating degree.

[0053] As described above, even if the indoor expansion valve 5c is enlarged, when the refrigerant does not flow to the indoor unit 5c and the amount of refrigerant is insufficient and no cooling ability is not displayed at the indoor unit 5c, the refrigerant superheating degrees of the indoor units 5a to 5c increase as the installation positions thereof become higher from the outdoor unit 2 such as 1 deg. in the indoor unit 5a, 2 deg. in the indoor unit 5b and 11 deg., in the indoor unit 5c. While the refrigerant superheating degree has a large value due to the insufficient amount of refrigerant in the indoor unit 5c, in the indoor units 5a and 5b, the amounts of refrigerant are larger than that of the indoor unit 5c, which indicates that the refrigerant superheating degree is a small value. That is, it indicates that the refrigerant distribution in each of the indoor units 5a to 5c is biased in the refrigerant circuit 100 during cooling operation.

[0054] If the refrigerant amount balance control is executed when the refrigerant distribution in each of the indoor units 5a to 5c is biased during the cooling operation, in the indoor units 5a, 5b whose refrigerant superheating degrees are smaller than the average refrigerant superheating degree (in the case of the above example, 6 deg. which is an average value of the maximum value: 11 deg. and the minimum value: 1 deg.), the degrees of opening of the indoor expansion valves 52a, 52b are narrowed in order to raise the refrigerant superheating degree to the average refrigerant superheating degree. Accordingly, the amounts of refrigerant flowing into the indoor units 5a, 5b are reduced, and the refrigerant pressure on the downstream side (sides of indoor heat exchangers 51a, 51b) of the indoor expansion valves 52a, 52b is reduced.

[0055] On the other hand, in the indoor unit 5c where the refrigerant superheating degree is higher than the average refrigerant superheating degree, since the refrigerant pressure on the downstream side of the indoor expansion valves 52a, 52b decreases and this decreases the refrigerant pressure on the downstream side of the indoor expansion valve 52c, the difference in pressure between the upstream side and the downstream side of the indoor expansion valve 52c increases. Accordingly, in order to reduce the refrigerant superheating degree of the indoor unit 5c to the average refrigerant superheating degree in the refrigerant amount balance control, when the degree of opening of the indoor expansion valve 52c is increased, the amount of refrigerant passing through the indoor expansion valve 52 increases, that is, the amount of refrigerant flowing into the indoor unit 5c increases, so that the cooling ability of the indoor unit 5c increases.

[0056] Next, the control at the time of cooling operation in the air conditioner 1 of the present embodiment will be described by using FIG. 3. FIG. 3 shows the flow of the processing related to the control performed by the CPU 210 of the outdoor unit controller 200 when the air conditioner 1 performs cooling operation. In FIG. 3, ST represents a step, and the number following this represents a step number. In FIG. 3, the processing related to the present invention is mainly described, and description of processing other than this, for example, general processing related to the air conditioner 1 such as control of the refrigerant circuit 100 corresponding to the operation conditions such as the set temperature and air volume specified by the user is omitted. In the following description, a case where all the indoor units 5a to 5c are performing cooling operation will be described as an example.

[0057] In the following description, the heat exchange entrance temperatures, which are the refrigerant temperature at the refrigerant entrance side of the indoor heat exchangers 51a to 51c detected by the liquid side temperature sensors 61a to 61c of the indoor units 5a to 5c, are set as Ti (unit: °C. When referring to the indoor units 5a to 5c individually, Tia to Tic), the heat exchange exit temperatures, which are the refrigerant temperature at the refrigerant exit side of the indoor heat exchangers 51a to 51c detected by the gas side temperature sensors 62a to 62c of the indoor units 5a to 5c, are set as To (unit: °C. When referring to the indoor units 5a to 5c individually, Toa to Toc), the refrigerant superheating degrees in the indoor units 5a to 5c obtained by subtracting the heat exchange entrance temperatures Ti from the heat exchange exit temperatures To are set as SH (unit: deg. When referring to the indoor units 5a to 5c individually, SHa to SHc), a maximum refrigerant superheating degree which is the maximum value among the refrigerant superheating degrees SH of the indoor units 5a to 5c is set as SHmax, and a minimum refrigerant superheating degree which is the minimum value of the refrigerant superheating degrees SH of the indoor units 5a to 5c is set as SHmin, and an average refrigerant superheating degree obtained by averaging the maximum refrigerant superheating degree SHmax and the minimum refrigerant superheating degree SHmin is set as SHv.

[0058] First, the CPU 210 determines whether the user's operation instruction is a cooling operation instruction or not (ST1).

When it is not a cooling operation instruction (ST1-No), the CPU 210 executes heating operation start processing which is the processing to start heating operation (ST11). Here, the heating operation start processing is that the CPU 210 operates the four-way valve 22 to bring the refrigerant circuit 100 into the heating cycle, and is the processing performed when the heating operation is started from the state where the air conditioner 1 is stopped, or when the cooling operation is switched from the cooling operation to the heating operation.

[0059] Then, the CPU 210 starts the compressor 21 and the outdoor fan 27 at predetermined rpm, instructs the indoor units 5a to 5c, through the communication unit 230, to control driving of the indoor fans 55a to 55c and adjust the degrees of opening of the indoor expansion valves 52a to 52c to thereby start control of heating operation (ST12), and advances the process to ST8.

[0060] At ST1, when it is a cooling operation instruction (ST1-Yes), the CPU 210 executes cooling operation start processing (ST2). Here, the cooling operation start processing is that the CPU 210 operates the four-way valve 22 to bring the refrigerant circuit 100 into the state shown in FIG. 1A, that is, bring the refrigerant circuit 100 into the cooling cycle, and is the processing performed when the cooling operation is started from the state where the air conditioner 1 is stopped, or when the cooling operation is switched from the heating operation to the cooling operation.

[0061] Then, the CPU 210 performs control of the cooling operation (ST3). In the cooling operation start processing, the CPU 210 starts the compressor 21 and the outdoor fan 27 at rpm corresponding to the ability required from the indoor units 5a to 5c. The CPU 210 fully opens the opening of the outdoor expansion valve 24. Further, the CPU 210 transmits an operation start signal indicating the start of cooling operation to the indoor units 5a to 5c through the communication unit 230.

[0062] The CPUs 510a to 510c of the indoor unit controllers 500a to 500c of the indoor units 5a to 5c having received the operation start signal through the communication units 530a to 530c start the indoor fans 55a to 55c at rpm corresponding to the user's air volume instruction. Further, the CPUs 510a to 510c subtracts the heat exchange entrance temperatures Tia to Tic detected by the liquid side temperature sensors 61a to 61c from the heat exchange exit temperatures Toa to Toc detected by the gas side temperature sensors 62a to 62c to obtain the refrigerant superheating degrees SHa to SHc at the refrigerant exit side of the exchangers 51a to 51c (the side of the gas pipe connection portions 54a to 54c. The opening degrees of the indoor expansion valves 52a to 52c are adjusted such that the obtained refrigerant superheating degrees SHa to SHc become the target refrigerant superheating degree (for example, 4 deg.) at the start of operation.

[0063] Here, the target refrigerant superheating degree is a value previously obtained by performing a test or the like and stored in the storage units 520a to 520c, and is a value where it has been confirmed that cooling ability is sufficiently displayed at each indoor unit. During the time from the start of cooling operation to when the state of the refrigerant circuit 100 is stabilized (for example, three minutes from the start of operation), the CPUs 510a to 510c adjust the degrees of opening of the indoor expansion valves 52a to 52c such that the refrigerant supercooling degrees become the above-mentioned target refrigerant superheating degree at the time of start of operation.

[0064] Then, the CPU 210 receives the heat exchange entrance temperatures Ti (Tia to Tic) and the heat exchange exit temperatures To (Toa to Toc) from the indoor units 5a to 5c through the communication unit 230 (ST4). The heat exchange entrance temperatures Ti and the heat exchange exit temperatures To are the detection values at the liquid side temperature sensors 61a to 61c and the gas side temperature sensors 62a to 6sc that the CPUs 510a to 510c receive at the indoor units 5a to 5c and transmit to the outdoor unit 2 through the communication units 530a to 530c. The above-mentioned detection values are received by the CPU 210 and the

CPUs 510a to 510c every predetermined time (for example, every 30 seconds) and stored in the storage unit 210 and the storage units 520a to 520c.

[0065] Next, the CPU 210 subtracts the heat exchange entrance temperature Ti from the heat exchange exit temperature To of each of the indoor units 5a to 5c received at ST4, and obtains the refrigerant superheating degrees SH of the indoor units 5a to 5c (ST5). Specifically, the CPU 210 subtracts the heat exchange entrance temperature Tia from the heat exchange exit temperature Toa of the indoor unit 5a to obtain the refrigerant superheating degree SHa, associates this with the indoor unit 5a, and stores it in the storage unit 220. Similarly, the CPU 210 obtains the refrigerant superheating degrees SHb, SHc for the indoor unit 5b and the indoor unit 5c, associates these with the indoor units 5b or 5c, and stores them in the storage unit 220.

[0066] Next, the CPU 210 sets the maximum value of the refrigerant superheat degrees SHa to SHc of the indoor units 5a to 5c obtained in ST5 as the maximum refrigerant superheating degree SHmax and the minimum value as the minimum refrigerant superheating degree SHmin, and the maximum refrigerant superheating degree SHmax and the minimum refrigerant superheating degree SHmin are averaged to obtain the average refrigerant superheating degree SHv (ST6). The average refrigerant superheating degree SHv is an arithmetic average value of the maximum refrigerant superheating degree SHmax and the minimum refrigerant superheating degree SHmin: [maximum refrigerant superheating degree SHmax + minimum refrigerant superheating degree SHmin] / 2.

[0067] Then, the CPU 210 transmits the average refrigerant superheating degree SHv obtained at ST6 to the indoor units 5a to 5c through the communication unit 230 (ST7). The CPUs 510a to 510c of the indoor units 5a to 5c having received the average refrigerant superheating degree SHv through the communication units 530a to 530c obtain the refrigerant superheating degrees SHa to SHc by subtracting the heat exchange entrance temperatures Tia to Tic detected by the liquid side temperature sensors 61a to 61c from the heat exchange exit temperature Toa to Toc detected by the gas side temperature sensors 62a to 62c, and adjust the degrees of opening of the indoor expansion valves 52a to 52c such that the obtained refrigerant superheating degrees SHa to SHc become the average refrigerant superheating degree SHv received from the outdoor unit 2.

The above-described processing from ST4 to ST7 is the processing related to the refrigerant amount balance control of the present invention.

[0068] The CPU 210 having finished the processing of ST7 determines whether there is an operation mode switching instruction by the user or not (ST8). Here, the operation mode instruction is an instruction to switch from the current operation (in this description, cooling operation) to another operation (heating operation). When there is an operation mode switching instruction (ST8-Yes), the CPU 210 returns the process to ST1. When there is no operation mode switching instruction (ST8-No), the CPU 210 determines whether there is an operation stop instruction by the user or not (ST9). The operation stop instruction is an instruction to stop the operation of all the indoor units 5a to 5c.

[0069] When there is an operation stop instruction (ST9-Yes), the CPU 210 executes operation stop processing (ST10), and ends the process. In the operation stop processing, the CPU 210 stops the compressor 21 and the outdoor fan 27 and fully closes the outdoor expansion valve 24. Moreover, the CPU 210 transmits an operation stop signal indicative of the stop of operation to the indoor units 5a to 5c through the communication unit 230. The CPUs 510a to 510c of the indoor units 5a to 5c having received the operation stop signal through the communication units 530a to 530c stop the indoor fans 55a to 55c and fully close the indoor expansion valves 52a to 52c.

[0070] When there is no operation stop instruction at ST9 (ST9-No), the CPU 210 determines whether the current operation is cooling operation or not (ST13). When the current operation is heating operation (ST13-Yes), the CPU 210 returns the process to ST3. When the current operation is not heating operation (ST13-No), that is, when the current operation is heating operation, the CPU 210 returns the process to ST12.

[Second Embodiment]

[0071] Next, a second embodiment of the present invention will be described by using mainly FIG. 4. What is different from the first embodiment is that in the second embodiment, the refrigerant amount balance control is started from the point of time when it is determined that there is an indoor unit where cooling ability required by the user cannot displayed, whereas in the first embodiment, the refrigerant amount balance control is executed from the time of start of cooling operation (precisely, from when the refrigerant circuit 100 is stabilized). Detailed description of points other than this, that is, the components of the air conditioner 1 and the state of the refrigerant circuit 100 at the time of cooling operation is omitted since it is the same as that of the first embodiment.

[0072] As described in the first embodiment, if the refrigerant amount balance control is executed, in the indoor unit where the refrigerant superheating degree is higher than the average refrigerant superheating degree of the indoor units 5a to 5c (in the first embodiment, the indoor unit 5c), the amount of refrigerant flowing into the indoor unit increases and cooling ability increases. On the other hand, in the indoor unit where the refrigerant superheating degree is lower than the average refrigerant superheating degree (in the first embodiment, the indoor units 5a, 5b), the amount of the refrigerant flowing into the indoor unit decreases compared with when the refrigerant amount balance control is not performed, and cooling ability decreases. That is, in order that cooling ability is displayed in the indoor unit 5c installed above where the required cooling ability cannot be displayed, cooling ability is decreased in the indoor units 5a, 5b installed below the indoor unit 5c.

[0073] In the first embodiment, the refrigerant amount balance control is executed from the time of start of cooling operation. Consequently, the refrigerant amount balance control is executed irrespective of whether there is an indoor unit where the required cooling ability cannot be displayed or not. If the refrigerant amount balance control is executed when there is no indoor unit where the required cooling ability cannot be displayed, cooling ability is unnecessarily decreased in the indoor unit where cooling ability is displayed.

[0074] On the contrary, in the second embodiment, whether there is an indoor unit where the required cooling ability cannot be displayed or not is determined by a method described below, and the refrigerant amount balance control is executed only when there is an indoor unit. Accordingly, while the cooling ability of the indoor unit where the required cooling ability cannot be displayed is prevented from being decreased unnecessarily at the time of cooling operation, when there is an indoor unit where the required heating ability cannot be displayed, the cooling ability of the indoor unit can be increased.

[0075] The determination as to the presence or absence of an indoor unit where the required cooling ability cannot be displayed is performed as follows. First, the CPU 210 of the outdoor unit 2 obtains the maximum refrigerant superheating degree SHmax and the minimum refrigerant superheating degree SHmin in the same manner as the method described in the first embodiment. If a refrigerant superheating degree difference (hereinafter, described as refrigerant superheating degree difference SHd (unit: deg.)) which is the difference between the maximum refrigerant superheating degree SHmax and the minimum refrigerant superheating degree SHmin is equal to or greater than a predetermined threshold superheating degree difference (for example, 8 deg., hereafter, described as threshold superheating degree difference SHTs (unit: deg.)), it is determined that the cooling ability required by the indoor unit having the maximum refrigerant superheating degree SHmax cannot be displayed.

[0076] Here, the threshold superheating degree difference SHTs is previously tested or the like and stored in the storage unit 220 of the outdoor unit controller 200, and if the refrigerant superheating degree difference SHd is equal to or greater than the threshold superheating degree difference SHTs, it is a value which determines that the cooling capacity required by the indoor unit having the maximum refrigerant superheating degree SHmax cannot be exhibited, and the amount of refrigerant flowing into the indoor unit is insufficient.

[0077] Next, the control at the time of cooling operation in the air conditioner 1 of the present embodiment will be described by using FIG. 4. FIG. 4 shows the flow of the processing related to the control performed by the CPU 210 of the outdoor unit controller 200 when the air conditioner 1 performs cooling operation. In FIG. 4, ST represents a step, and the number following this represents the step number. In FIG. 4, the processing related to the present invention is mainly described, and description of processing other than this, for example, general processing related to the air conditioner 1 such as control of the refrigerant circuit 100 corresponding to the operation conditions such as the set temperature and air volume specified by the user is omitted. In the following description, a case where all the indoor units 5a to 5c are performing cooling operation will be described as an example as in the first embodiment.

[0078] Since the flowchart shown in FIG. 4 is the same processing as the flowchart shown in FIG. 3 described in the first embodiment except the processing of ST36, detailed description thereof is omitted, and only the processing of ST36 will be described here.

[0079] The CPU 210 that has finished the processing of ST34 (corresponding to ST4 in the first embodiment) and ST35 (corresponding to ST5 in the first embodiment) sets the maximum value as the maximum refrigerant superheating degree SHmax and the minimum value as the minimum refrigerant superheating degree SHmin among the refrigerant superheating degrees SHa to SHc of the indoor units 5a to 5c obtained in ST35, and determines whether the refrigerant superheating degree difference SHd obtained by subtracting the minimum refrigerant superheating degree SHmin from the maximum refrigerant superheating degree SHmax is equal to or greater than the threshold superheating degree difference SHTs (ST36).

[0080] If the refrigerant superheating degree difference SHd is not equal to or greater than the threshold superheating degree difference SHTs (ST36-No), the CPU 210 determines that it is not necessary to execute the refrigerant amount balance control, and advances the process to ST39. On the other hand, if the refrigerant superheating degree difference SHd is equal to or greater than the threshold superheating degree difference SHTs (ST36-Yes), the CPU 210 determines that it is necessary to execute the refrigerant amount balance control, executes the processing of ST37 (corresponding to ST6 in the first embodiment) and ST38 (corresponding to ST7 in the first embodiment), and advances the process to ST39.

[0081] The above-described processing from ST34 to ST38 is the processing related to the refrigerant amount balance control in the second embodiment of the present invention.

[0082] As described above, the air conditioner 1 of the present invention executes the refrigerant amount balance control to adjust the degrees of opening of the indoor expansion valves 52a to 52c such that the refrigerant superheating degrees SHa to SHc in the indoor units 5a to 5c at the time of cooling operation become an average refrigerant superheating degree SHv obtained by averaging the maximum refrigerant superheating degree SHmax and the minimum refrigerant superheating degree SHmin among them. Accordingly, since the amount of refrigerant flowing into the indoor unit where the cooling ability cannot be displayed due to the shortage of the amount of refrigerant flowing thereinto, the cooling ability of the indoor unit is increased.

[0083] Although the invention has been described in detail with reference to specific embodiments, it will be apparent to those skilled in the art that various changes and modifications can be made without departing from the spirit and scope of the invention. The present application is based on a Japanese Patent Application (JP-A-2017-024454) filed on February 13, 2017, contents of which are incorporated herein by reference.

REFERENCE SIGNS LIST

[0084]

1 air conditioner

2 outdoor unit

5a~5c indoor unit

51a~51c indoor heat exchanger

52a~52c indoor expansion valve

61a~61c liquid side temperature sensor

62a~62c gas side temperature sensor

100 refrigerant circuit

200 outdoor unit controller

210 CPU

500a~500c indoor unit controller

510a~510c CPU

SH refrigerant superheating degree

SHv average refrigerant superheating degree

SHmax maximum refrigerant superheating degree

SHmin minimum refrigerant superheating degree

SHd refrigerant superheating degree difference

SHTs threshold superheating degree difference

Ti heat exchange entrance temperature

To heat exchange exit temperature

CLAIMS

1. An air conditioner comprising:

an outdoor device;

a plurality of indoor units each of which includes an indoor heat exchanger and an indoor expansion valve;

an superheating degree detector which detects a refrigerant superheating degree which is a superheating degree of a refrigerant flowing out from each indoor heat exchanger when each indoor heat exchanger is functioning as an evaporator; and

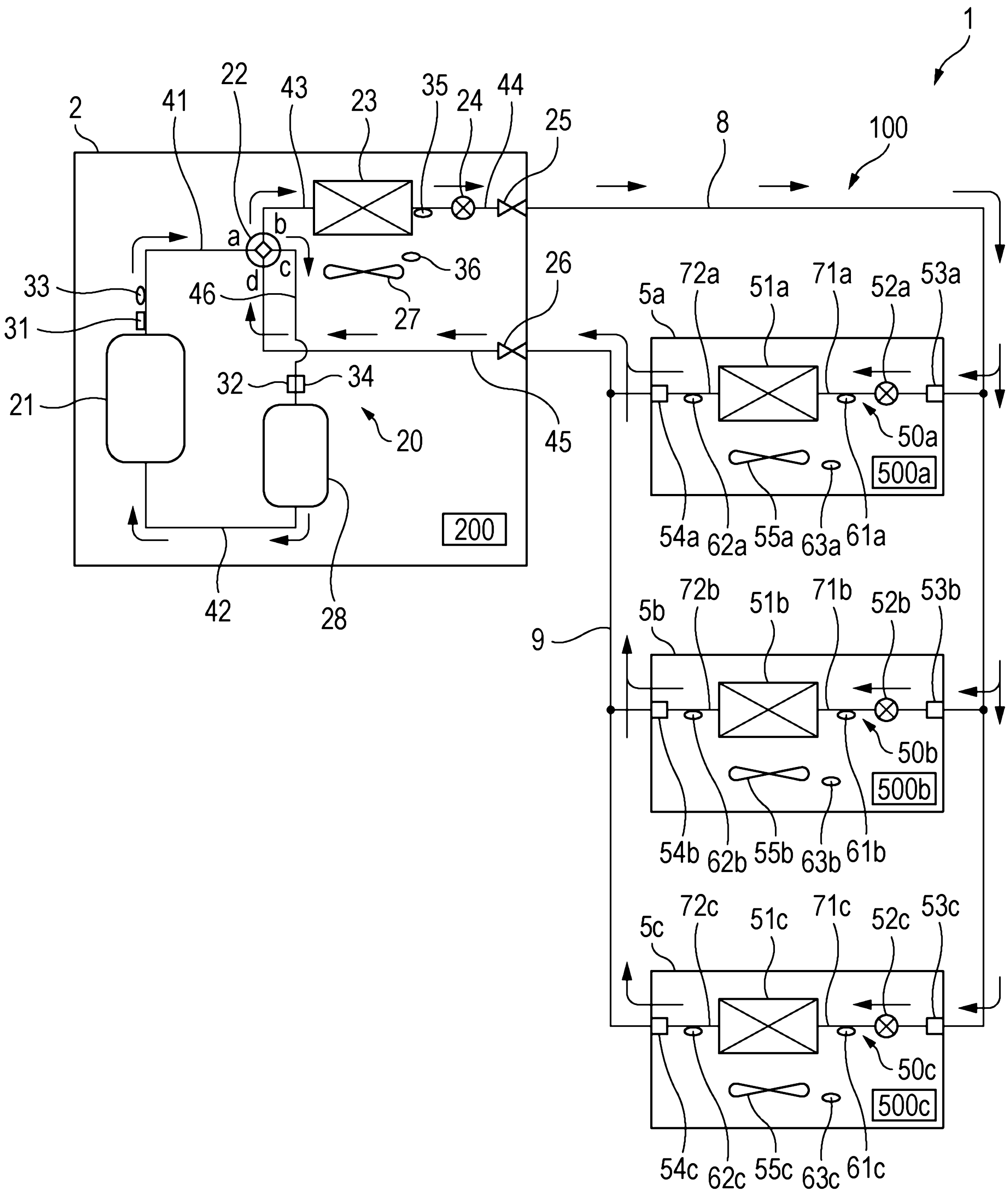
a controller which adjusts degrees of opening of the plurality of indoor expansion valves,

wherein the controller executes a refrigerant amount balance control to adjust the degree of opening of each indoor expansion valve such that an average refrigerant superheating degree is obtained by averaging a maximum value and a minimum value of the refrigerant superheating degrees detected by the superheating degree detector, and the refrigerant superheating degree of each indoor unit becomes the average refrigerant superheating degree.

2. The air conditioner according to claim 1,

wherein the controller obtains a refrigerant superheating degree difference which is a difference between the maximum value and the minimum value of the refrigerant superheating degrees of the indoor units, if the obtained refrigerant superheating degree difference is greater than a predetermined threshold superheating degree difference, it is determined whether there is an indoor unit where cooling ability required by the plurality of indoor units is not displayed or not, and when there is an indoor unit where the required heating ability cannot be displayed, the controller executes the refrigerant amount balance control.

FIG. 1A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26
32
34
20
45
28
42
200
9
5a
72a
51a
71a
52a
53a
50a
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54a
62a
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500b
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62b
55b
63b
61b
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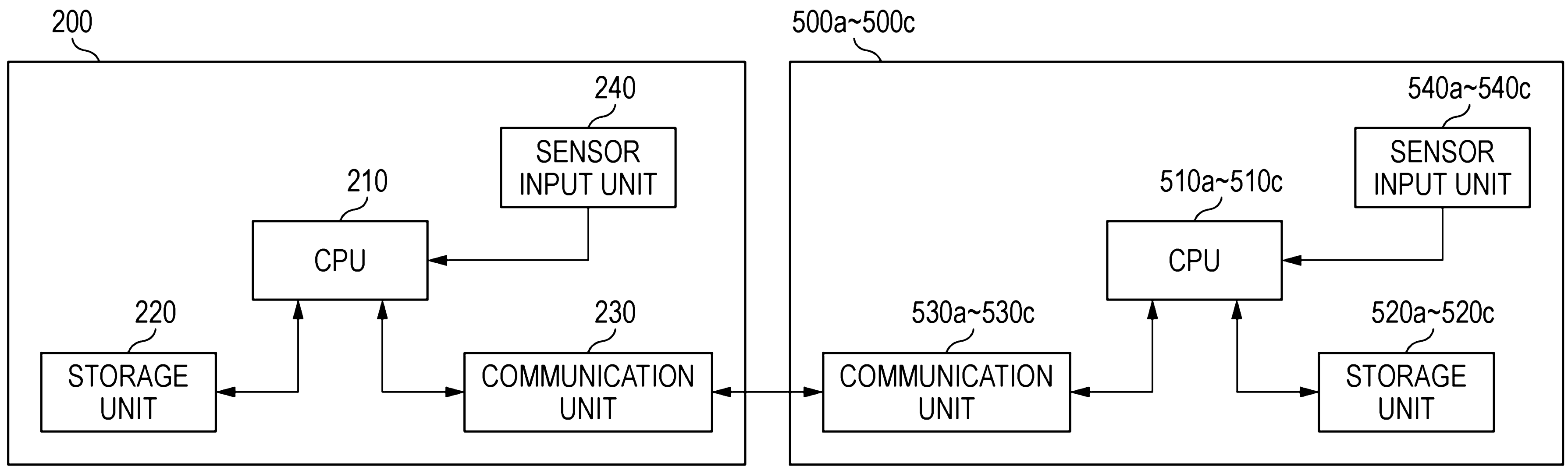
62c
55c
63c
61c

FIG. 1B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INPUT UNIT
210
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STORAGE
UNIT

FIG. 2

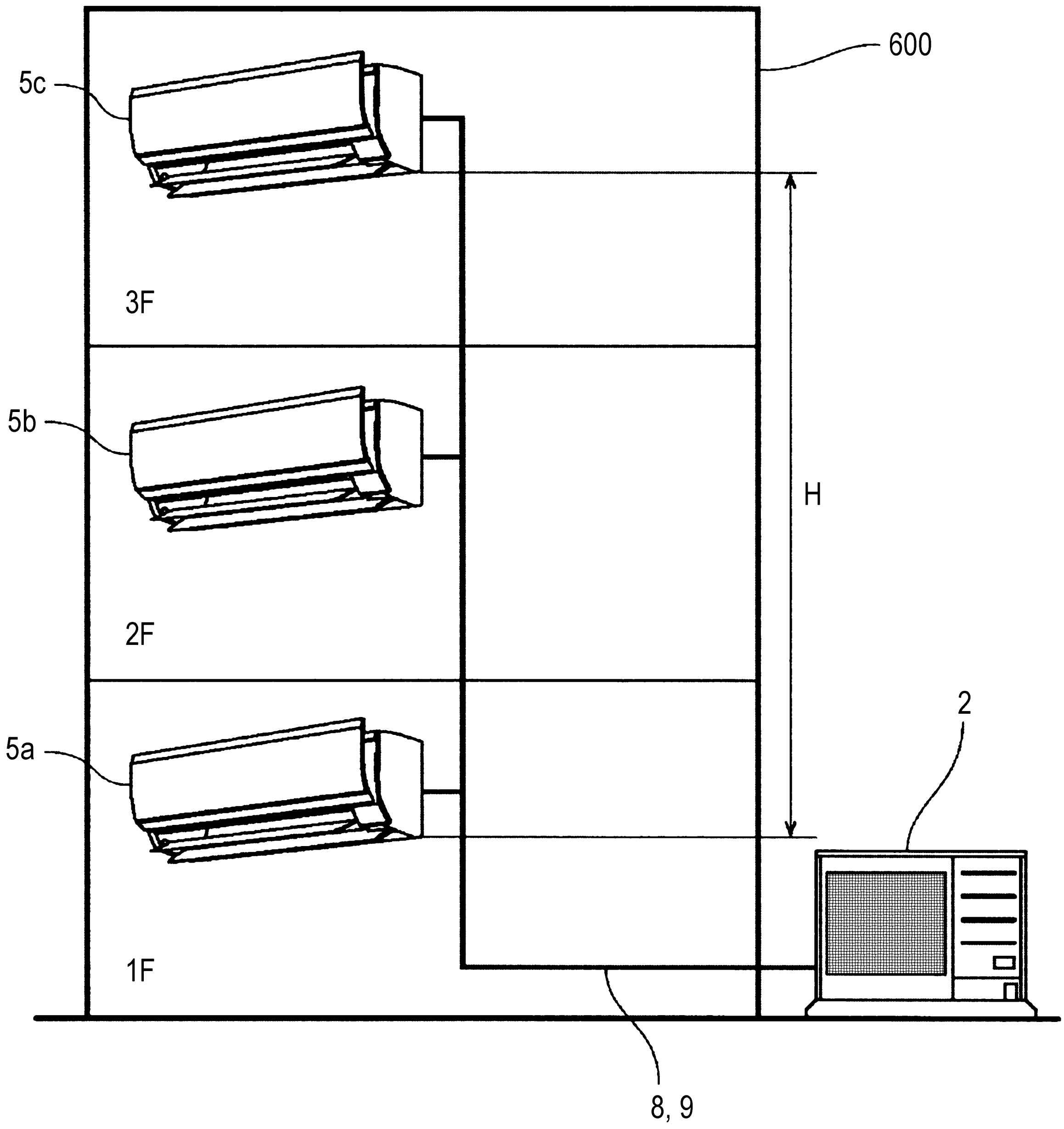
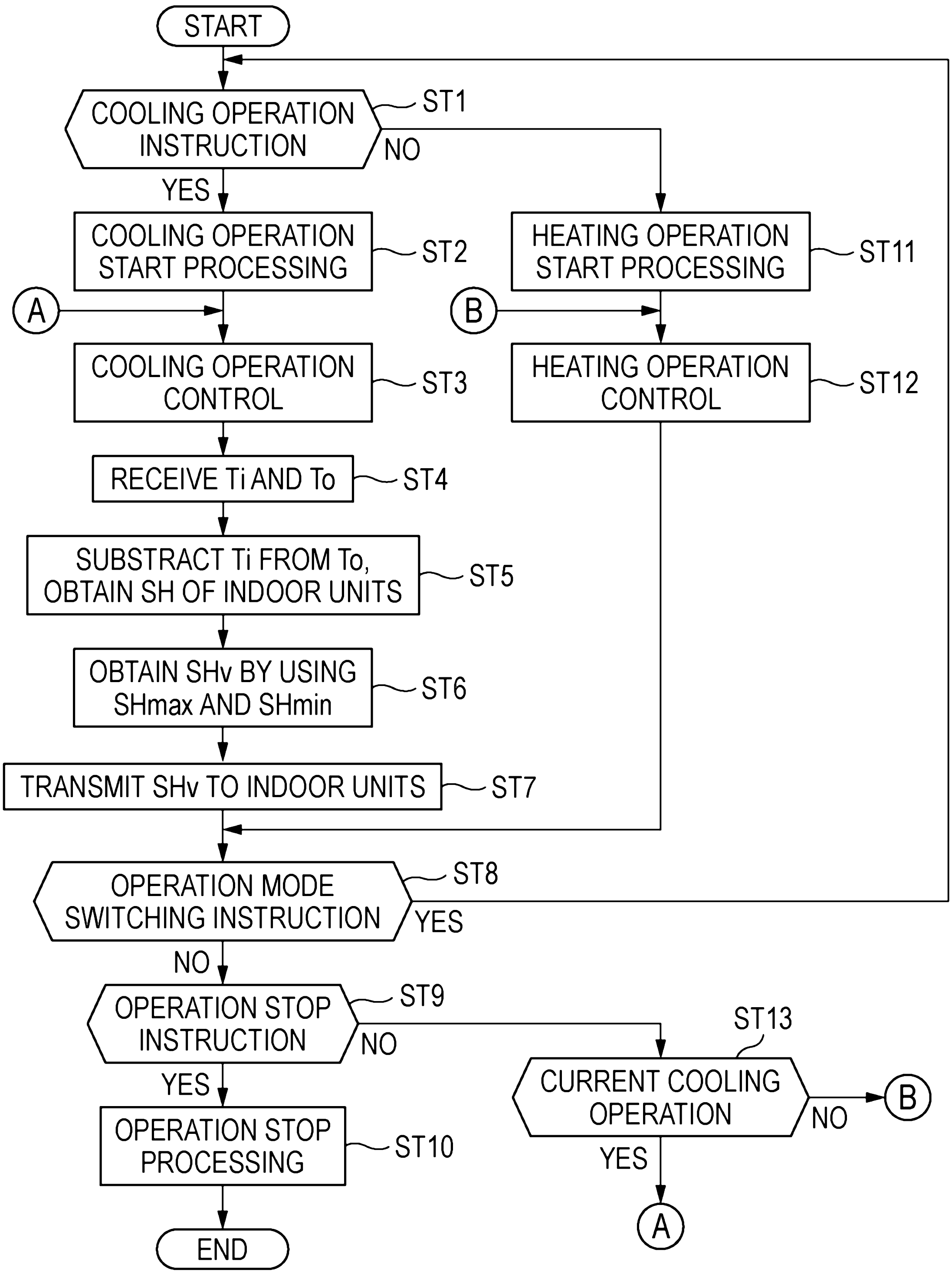


FIG. 3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COOLING OPERATION INSTRUCTION
ST1
NO
YES
COOLING OPERATION START PROCESSING
ST2
HEATING OPERATION START PROCESSING
ST11
A
B
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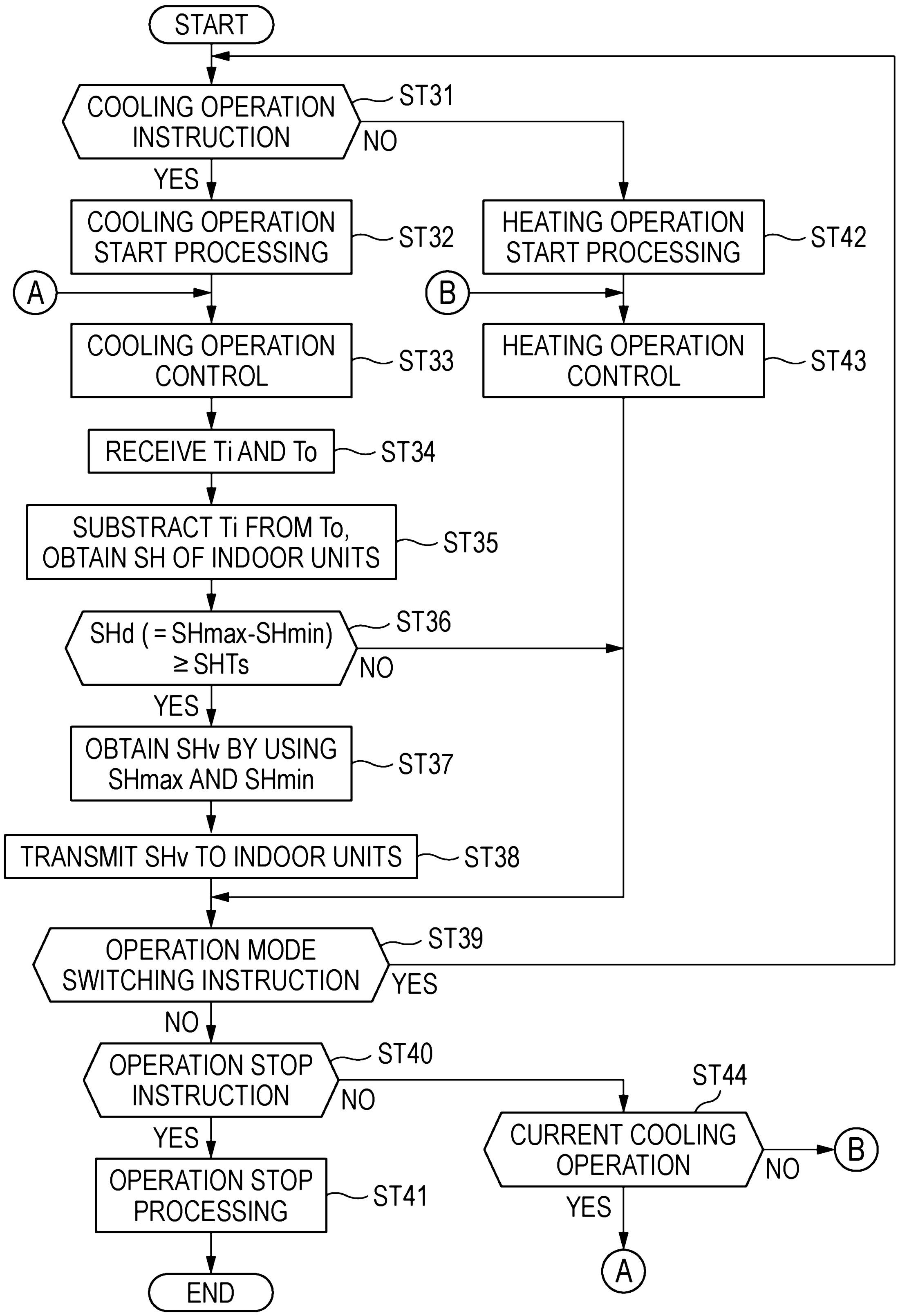
ST3
HEATING OPERATION CONTROL
ST12
RECEIVE Ti AND To
ST4
SUBSTRACT Ti FROM To, OBTAIN SH OF INDOOR UNITS
ST5
OBTAIN SHv BY USING SHmax AND SHmin
ST6
TRANSMIT SHv TO INDOOR UNITS
ST7
OPERATION MODE SWITCHING INSTRUCTION
ST8
YES
NO
OPERATION STOP INSTRUCTION
ST9
NO
ST13
CURRENT COOLING OPERATION
NO
B
YES
OPERATION STOP PROCESSING
ST10
YES
A
END

FIG. 4


START
COOLING OPERATION INSTRUCTION
ST31
NO
YES
COOLING OPERATION START PROCESSING
ST32
HEATING OPERATION START PROCESSING
ST42
A
B
COOLING OPERATION CONTROL
ST33
HEATING OPERATION CONTROL
ST43
RECEIVE Ti AND To
ST34
SUBSTRACT Ti FROM To, OBTAIN SH OF INDOOR UNITS
ST35
SHd (= SHmax-SHmin) ≥ SHTs
ST36
NO
YES
OBTAIN SHv BY USING SHmax AND SHmin
ST37
TRANSMIT SHv TO INDOOR UNITS
ST38
OPERATION MODE SWITCHING INSTRUCTION
ST39
YES
NO
OPERATION STOP INSTRUCTION
ST40
NO
YES
OPERATION STOP PROCESSING
ST41
END
ST44
CURRENT COOLING OPERATION
NO
B
YES
A