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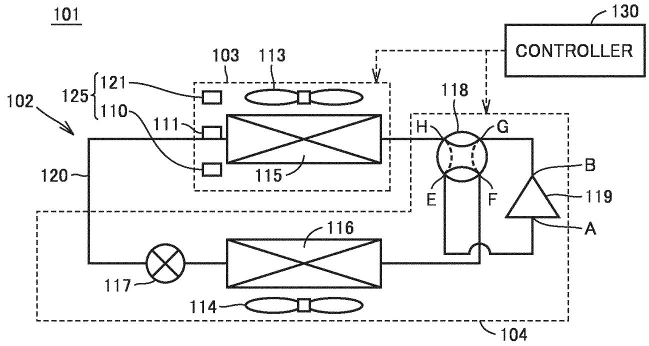
(54) AIR CONDITIONING DEVICE

(57) An air-conditioning apparatus (101) includes a refrigerant circuit (102), a pipe temperature sensor (111), an indoor air blower (113), an air-conditioning load sensor device (125), and a controller (130). The pipe temperature sensor (111) senses a condensing temperature (CT). The indoor air blower (113) regulates a volume of air sent to an indoor heat exchanger (115). The air-conditioning load sensor device (125) senses air-conditioning load. The controller (130) has a first mode and a second mode different from the first mode as operation modes, and controls a volume of air sent by the indoor air blower (113). In the second mode, the controller (130) has the indoor air blower (113) operate such that a volume of air is varied between a first volume of air and a second volume of air larger than the first volume of air with variation in condensing temperature. When air-conditioning load sensed by the air-conditioning load sensor device (125) becomes lower than a first threshold value in the first mode, the controller (130) changes the first mode to the second mode.

FIG.1



EP 3 508 795 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to an air-conditioning apparatus and particularly to control of blowing of air by an indoor unit.

BACKGROUND ART

[0002] In a heating operation by an air-conditioning apparatus, warm air moves upward because of its light specific gravity and a temperature at a floor surface tends to lower. Therefore, in conventional heating operations by the air-conditioning apparatus, comfort has been enhanced by carrying warm air toward feet with the use of a fan. In order to further enhance comfort during heating, an air-conditioner as described, for example, in Japanese Patent Laying-Open No. 2010-60250 (PTL 1) has been proposed.

[0003] The air-conditioner described in Japanese Patent Laying-Open No. 2010-60250 provides a more efficiently and comfortably air-conditioned space by controlling a direction and a volume of sent air in accordance with a position of a person in a room and an intention of a user.

CITATION LIST

PATENT LITERATURE

[0004] PTL 1: Japanese Patent Laying-Open No. 2010-60250

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005] With higher insulation and air-tightness of current houses, heating load tends to lower. Under such a condition as low heating load, heating capability of the air-conditioner is also set low. A problem as below arises in the air-conditioner described in Japanese Patent Laying-Open No. 2010-60250.

(1) In an attempt to ensure a volume of blown air while heating capability of an indoor heat exchanger is low, a temperature of blown air becomes low. Therefore, a temperature of air carried toward feet becomes low.
(2) When a volume of blown air is decreased, a temperature of blown air increases. The volume of air, however, is low, and therefore blown air light in specific gravity (warm air) soars due to cold air around feet heavier in specific gravity. Warm air thus cannot be carried toward feet.

[0006] The present invention was made to solve the problems as above. An object of the present invention is to provide an air-conditioning apparatus capable of supplying warm air toward feet by controlling a fan of an air-conditioner in order to make a temperature of indoor air uniform during a heating operation at a low load.

SOLUTION TO PROBLEM

[0007] An air-conditioning apparatus according to this invention includes a refrigerant circuit, a condensing temperature sensor, an air blower, an air-conditioning load sensor device, and a controller. Refrigerant circulates through the refrigerant circuit in an order of a compressor, a condenser, an expansion mechanism, and an evaporator. The condensing temperature sensor is configured to sense a condensing temperature which represents a refrigerant temperature in the condenser. The air blower is configured to regulate a volume of air sent to the condenser. The air-conditioning load sensor device is configured to sense air-conditioning load in an air-conditioned space. The controller has a first mode and a second mode different from the first mode as operation modes, and it is configured to control a volume of air sent by the air blower. In the second mode, the controller is configured to have the air blower operate to vary a volume of air between a first volume of air and a second volume of air larger than the first volume of air with variation in condensing temperature. In the first mode, the controller is configured to change the first mode to the second mode when the air-conditioning load sensed by the air-conditioning load sensor device becomes lower than a first threshold value.

ADVANTAGEOUS EFFECTS OF INVENTION

[0008] According to the present invention, by performing a fan intermittent operation (FIO) during a heating operation at a low load, a thermal boundary layer formed around a floor is destroyed and warm air can be supplied toward feet while soaring of warm air is prevented. Consequently, temperature oscillation around feet can be lessened and comfort in a room can be improved.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

Fig. 1 is a diagram showing one example of an air-conditioning apparatus 101 in a first embodiment.
Fig. 2 is a diagram showing one example of arrangement of components of an indoor unit 103.
Fig. 3 is a diagram showing one example of a flow of air in a room under FIO control in a heating operation.
Fig. 4 is a flowchart showing one example of a flow of control in the first embodiment.
Fig. 5 is a diagram for illustrating switching of an operation mode in step S2.

Fig. 6 is a diagram for illustrating variation in operation frequency of a compressor in step S3.

Fig. 7 is a diagram showing one example of a state of operation by an indoor air blower 113 in the first embodiment.

Fig. 8 is a diagram for illustrating variation in condensing temperature during a fan intermittent operation (FIO).

Fig. 9 is a diagram showing a part of Fig. 8 as being enlarged.

Fig. 10 is a diagram showing one example of an operation of each component before and after entry into a second mode (FIO) in the first embodiment.

Fig. 11 is a diagram showing one example of a control system in a second embodiment.

Fig. 12 is a diagram showing one example of an operation of each component before and after entry into the second mode (FIO) in the second embodiment.

Fig. 13 is a diagram showing a difference in timing of entry into the second mode (FIO).

DESCRIPTION OF EMBODIMENTS

[0010] An embodiment of the present invention will be described below in detail with reference to the drawings. Though a plurality of embodiments will be described below, combination as appropriate of features described in each embodiment is originally intended. The same or corresponding elements in the drawings have the same reference characters allotted and description thereof will not be repeated.

[First Embodiment]

(Construction of Air-Conditioning Apparatus 101)

[0011] Fig. 1 is a diagram showing one example of an air-conditioning apparatus 101 in a first embodiment of the present invention. As shown in Fig. 1, air-conditioning apparatus 101 includes an indoor unit 103, an outdoor unit 104, and a controller 130.

[0012] Indoor unit 103 includes an indoor air blower 113, an indoor heat exchanger 115, an infrared sensor 110, a pipe temperature sensor 111, and an indoor temperature sensor 121. Outdoor unit 104 includes an outdoor air blower 114, an outdoor heat exchanger 116, an expansion valve 117, a four-way valve 118, and a compressor 119. A refrigerant circuit 102 is implemented by ring-like connection of outdoor heat exchanger 116, expansion valve 117, four-way valve 118, compressor 119, and indoor heat exchanger 115 through a refrigerant pipe 120. A heat pump is formed by circulation of refrigerant through refrigerant circuit 102 with compression and expansion being repeated. Air-conditioning apparatus 101 air-conditions a room in an operation mode such as cooling/heating/air blow under the control by controller 130 of four-way valve 118, compressor 119, air blowers 113 and 114, and the like.

[0013] Fig. 1 shows a state that four-way valve 118 is set to heating. In this case, a port H and a port G communicate with each other and a port E and a port F communicate with each other in four-way valve 118. Refrigerant flows sequentially from a discharge port B of compressor 119 in the order of indoor heat exchanger 115, expansion valve 117, and outdoor heat exchanger 116 and reaches a suction port A of compressor 119.

[0014] Though not shown, during cooling, port H and port E communicate with each other and port G and port F communicate with each other in four-way valve 118. Refrigerant flows sequentially from discharge port B of compressor 119 in the order of outdoor heat exchanger 116, expansion valve 117, and indoor heat exchanger 115 and reaches suction port A of compressor 119.

(Construction of Indoor Unit 103)

[0015] Fig. 2 is a diagram showing one example of arrangement of components of indoor unit 103 in the first embodiment. In a main body of indoor unit 103, indoor heat exchanger 115, indoor air blower 113, pipe temperature sensor 111, infrared sensor 110, and a wind direction plate (louver) 112 are arranged. Indoor heat exchanger 115 is arranged on an upstream side of an air flow from indoor air blower 113.

[0016] An air outlet forms a passage for air on a downstream side of indoor air blower 113. A direction of air flow can be adjusted by changing an angle of wind direction plate (louver) 112 attached to the air outlet.

(Operation of Equipment in Heating Operation)

[0017] An indoor space is cooled and heated by cold air and warm air blown from indoor unit 103 of air-conditioning apparatus 101. Air-conditioning apparatus 101 incorporates a vapor compression refrigeration cycle, and indoor unit 103 and outdoor unit 104 are connected to each other through refrigerant pipe 120.

[0018] Compressor 119 compresses refrigerant at a low temperature and a low pressure and discharges refrigerant at a high temperature and a high pressure from discharge port B. Compressor 119 is driven by a not-shown inverter and an operation capacity thereof is controlled in accordance with a state of air-conditioning.

[0019] Outdoor heat exchanger 116 exchanges cold and warm heat supplied by refrigerant which flows through the refrigerant cycle with outdoor air. As described above, outdoor air is supplied to outdoor heat exchanger 116 by outdoor air blower 114. Expansion valve 117 is connected between indoor heat exchanger 115 and outdoor heat exchanger 116 and expands refrigerant by decompressing the same. Expansion valve 117 is implemented by a valve of which position is variably controlled, such as an electronic expansion valve. Four-way valve 118 is connected to discharge port B and suction port A of compressor 119 and switches a flow of refrigerant in accordance with an operation of air-conditioning apparatus 101 (a cooling operation and a heating operation).

(Indoor Air Blower 113 and Outdoor Air Blower 114)

[0020] Outdoor air blower 114 and indoor air blower 113 are implemented by fans which can vary flow rates of air supplied to outdoor heat exchanger 116 and indoor heat exchanger 115, respectively. A centrifugal fan or a multi-blade fan driven by a motor such as a DC fan motor can be employed as such a fan.

<Operation by Equipment>

[0021] In the present embodiment, in order to enhance comfort around feet while heating load is low, fan intermittent operation (FIO) control is carried out. FIO control refers to control for producing a flow of air for sending warm air toward feet by using a fan. In the description below, an operation mode in which a volume of air is determined based on setting made by a user through a remote controller is denoted as a normal operation mode (a first mode (fan common operation: FCO) below) and an operation mode in which a fan is intermittently turned on while air-conditioning load is low is denoted as an intermittent operation mode (a second mode (FIO) below).

[0022] Fig. 3 is a diagram showing one example of a flow of air in a room under FIO control in a heating operation in the first embodiment. Referring to Figs. 1 to 3, when heating load in an air-conditioned space R is low, controller 130 sets a downward direction of blow from indoor unit 103 by changing an angle of wind direction plate (louver) 112.

[0023] When a condensing temperature CT sensed by pipe temperature sensor 111 provided in indoor heat exchanger 115 is equal to or higher than a certain value (T1), controller 130 starts an operation of indoor air blower 113 at a fan rotation speed (N2). When condensing temperature CT sensed by pipe temperature sensor 111 becomes lower than a certain value (T2), controller 130 turns off indoor air blower 113 or has indoor air blower 113 operate at a low volume of air. Regardless of the operation by indoor air blower 113, controller 130 allows continued operations by compressor 119.

[0024] Therefore, when a surface temperature of indoor heat exchanger 115 increases and a condensing temperature sensed by pipe temperature sensor 111 is again equal to or higher than the certain value (T1) while indoor air blower 113 is turned off or operates at a low volume of air, indoor air blower 113 resumes its operation at the rotation speed (N2).

<Control Operation>

[0025] An operation by the air-conditioner constructed as above will be described with reference to a flowchart. Fig. 4 is a flowchart showing one example of a flow of control in the first embodiment of the present invention. Controller 130 which performs processing in the flowchart can be implemented by hardware such as a circuit device which performs these functions or by software read from a memory into a computing device such as a microcomputer or a CPU and executed by the computing device.

[0026] Referring to Fig. 4, when processing in the flowchart is started, initially in step S1, controller 130 senses air-conditioning load Q (kW). For example, in determining whether or not air-conditioning load Q is lower than a prescribed value Q2, a surface temperature of an object (a wall, a floor, or a human) present in an air-conditioned space can serve as a criterion.

[0027] Air-conditioning load sensor device 125 senses a surface temperature (a radiative temperature Tr) of an object present in the air-conditioned space with infrared sensor 110. When the surface temperature becomes lower than a first threshold value (YES in S2), controller 130 changes the first mode (FCO) to the second mode (FIO).

[0028] In another example, air-conditioning load Q is estimated based on radiative temperature Tr in a room detected by infrared sensor 110 shown in Fig. 2. Infrared sensor 110 may detect radiative temperatures Tr at a plurality of locations in a room. In such a case, a weighted average value can be adopted. For example, relation between radiative temperature Tr and air-conditioning load Q may be defined in a predetermined map, and air-conditioning load Q may be found based on radiative temperature Tr by referring to the map in step S1.

[0029] In estimating air-conditioning load Q, a difference between an outdoor air temperature and an indoor temperature, a difference between a temperature at a floor surface or an indoor temperature and a set temperature, an amount of solar radiation, and an indoor temperature may also be taken into consideration.

[0030] In succession, controller 130 determines in step S2 whether or not air-conditioning load Q is lower than prescribed value Q2 ($Q < Q2$). When a condition of $Q < Q2$ is satisfied in step S2 (YES in S2), the process proceeds to step S3. When the condition is not satisfied (NO in S2), the process proceeds to step S14.

[0031] Fig. 5 is a diagram for illustrating switching of an operation mode in step S2. Referring to Fig. 5, a condition that air-conditioning load Q estimated based on a radiative temperature with the use of infrared sensor 110 is lower than prescribed value Q2 ($Q < Q2$) is a condition for air-conditioning apparatus 101 to enter the second mode (FIO). A condition that air-conditioning load Q is lower than a prescribed value Q1 ($Q < Q2$) is a condition for turning off the compressor.

[0032] By thus comparing air-conditioning load Q and prescribed value Q2 defined as a criterion value with each other, controller 130 switches the operation mode between the second mode (FIO) and the first mode (FCO) as appropriate.

[0033] Though air-conditioning load sensor device 125 determines air-conditioning load based on a surface temperature in a room or a radiative temperature in the example in Fig. 1, it may determine air-conditioning load based on a rotation speed of compressor 119. In this case, air-conditioning load sensor device 125 senses a rotation speed of compressor 119 and controller 130 changes the first mode (FCO) to the second mode (FIO) when the rotation speed of compressor 119 becomes lower than a first threshold value (a set lower limit value F1 in a normal operation).

[0034] When the process proceeds from step S2 to step S3, controller 130 changes also an operation frequency of compressor 119. Fig. 6 is a diagram for illustrating variation in operation frequency of the compressor in step S3. Referring to Figs. 4 and 6, in step S3, controller 130 sets an operation frequency of the compressor to an operation frequency F2 approximately half of lower limit frequency F1 in the normal operation. When transition from the first mode (FCO) to the second mode (FIO) is made at time t1, the operation frequency of compressor 119 is changed from frequency F1 at the set lower limit value in the normal operation to frequency F2 approximately half of frequency F1. When air-conditioning load Q is equal to or higher than prescribed value Q2 in step S2, transition to the first mode (FCO) is made, and hence the operation frequency returns to frequency F1 at time t2.

[0035] In step S3, controller 130 changes a direction of air sent from indoor air blower 113 simultaneously with variation in operation frequency of compressor 119. In order to change the direction of air blow, air-conditioning apparatus 101 includes wind direction plate (louver) 112. Controller 130 then controls wind direction plate 112 to set the direction of air blow to a prescribed wind direction (corresponding to an angle θ2) in the second mode (FIO).

[0036] Though controller 130 sets an angle θ of wind direction plate (louver) 112 to an arbitrary angle θ1 set by a user in the first mode (FCO), it changes the angle to angle θ2 in the second mode (FIO). As shown in Fig. 2, angle θ2 indicating a prescribed wind direction is equal to or greater than 45° with angle θ of wind direction plate (louver) 112 in a direction vertical to the floor surface being defined as 90° and with an angle horizontal thereto being defined as 0°. Preferably, angle θ2 is within a range from 60 to 85°.

[0037] Thereafter, in succession to step S3, processing for intermittent operation of indoor air blower 113 is performed in steps S4 to S10.

[0038] Fig. 7 is a diagram showing one example of a state of operation by indoor air blower 113 in the first embodiment. During a heating operation at low capability by an air-conditioner, with downward angle θ of wind direction plate (louver) 112 being set, a volume of air is intermittently increased and decreased between a first volume of air and a second volume of air during a period from time t1 to t2 as shown. A rotation speed of the fan is set either to rotation speed N2 or 0 (rpm) and timing to switch the rotation speed from N2 to 0 and timing to switch the rotation speed from 0 to N2 are determined based on condensing temperature CT of indoor heat exchanger 115.

[0039] In the example shown in Fig. 7, a volume of air corresponding to rotation speed N2 is defined as the second volume of air and a volume of air (a volume of air = 0) corresponding to a state that indoor air blower 113 is turned off is defined as the first volume of air. The first volume of air should only be lower than the second volume of air and it does not necessarily have to be set to zero.

[0040] Fig. 8 is a diagram for illustrating variation in condensing temperature in the second mode (FIO). Two types of a temperature T1 and a temperature T2 are set as criteria for condensing temperature CT for turning on and off indoor air blower 113. In the second mode (FIO), condensing temperature CT is varied as increasing and decreasing between temperature T1 and temperature T2. Indoor air blower 113 is turned off during a period of increase tr and indoor air blower 113 is turned on during a period of decrease tf.

[0041] Fig. 9 is a diagram showing a part of Fig. 8 as being enlarged. While indoor air blower 113 is off, condensing temperature CT of indoor heat exchanger 115 increases from T2 to T1.

[0042] When condensing temperature CT reaches temperature T1 at time t3, indoor air blower 113 starts operating. During an operation of indoor air blower 113 from time t3 to t4, indoor heat exchanger 115 is cooled by sent air and therefore condensing temperature CT is lowered from T1 to T2. When condensing temperature CT is lowered to temperature T2 at time t4, indoor air blower 113 is turned off. Thereafter, turn-on and turn-off of operation of indoor air blower 113 is repeated also at times t5 and t6.

[0043] When condensing temperature CT becomes higher than first temperature T1 in the second mode (FIO) as shown in Fig. 9, controller 130 changes a volume of air sent from indoor air blower 113 from the first volume of air (a rotation speed of the fan = N2) to the second volume of air (a rotation speed of the fan = 0). When condensing temperature CT becomes lower than second temperature T2 (< T1), controller 130 changes a volume of air sent from indoor air blower 113 from the second volume of air (a rotation speed of the fan = 0) to the first volume of air (a rotation speed of the fan = N2).

[0044] Turn-on and turn-off of the fan is controlled based on a condensing temperature in steps SS4 to S10 in Fig. 4. Control will be described below again with reference to Fig. 4.

[0045] In succession to step S3, in step S4, controller 130 senses condensing temperature CT with pipe temperature sensor 111.

[0046] In succession, in step S5, controller 130 determines whether or not indoor air blower 113 is operating (= ON). When indoor air blower 113 is ON in step S5 (YES in S5), the process proceeds to step S6, and when indoor air blower 113 is OFF (NO in S5), the process proceeds to step S8.

[0047] In step S6, controller 130 determines whether or not condensing temperature CT measured with pipe temperature sensor 111 is lower than prescribed value T2. When a condition of CT < T2 is satisfied in step S6 (YES in S6), controller 130 turns off indoor air blower 113 in step S7 and the process proceeds to step S10. When the condition of CT < T2 is not satisfied in step S6 (NO in S6), controller 130 does not perform processing in step S7 but the process proceeds to step S10.

[0048] In step S8, controller 130 determines whether or not condensing temperature CT measured with pipe temperature sensor 111 is higher than prescribed value T1. When a condition of CT > T1 is satisfied in step S8 (YES in S8), controller 130 turns on indoor air blower 113 in step S9 and the process proceeds to step S10. When the condition of CT > T1 is not satisfied in step S8 (NO in S8), controller 130 does not perform processing in step S9 but the process proceeds to step S10.

[0049] In step S10, controller 130 senses a temperature in a room Ta with indoor temperature sensor 121. When temperature in a room Ta is higher than a prescribed value Ta_min (YES in S11), the process proceeds to step S12. When temperature in a room Ta is lower than prescribed value Ta_min (NO in S11), the process proceeds to step S14.

[0050] In step S12, controller 130 senses a sensory temperature Ta_t of a human body. A surface temperature in the room is measured with infrared sensor 110 as a guideline for the sensory temperature, and it can be defined as sensory temperature Ta_t.

[0051] When sensory temperature Ta_t is higher than a prescribed value Ta_set (YES in S13), the process returns to step S1 and controller 130 repeats the operations described above. When sensory temperature Ta_t is lower than prescribed value Ta_set (NO in S13), the process proceeds to step S14. In step S14, controller 130 sets the operation mode to the first mode (FCO) and has air-conditioning apparatus 101 normally operate.

[0052] The normal operation performed in the first mode should only be processing different from an intermittent operation of an indoor fan for repeating processing in steps S3 to S13, and various operations are assumed so long as processing is performed for controlling a volume of air or a temperature in a room in accordance with setting made by a user.

[0053] In steps S11 and S13, determination as to switching of the operation mode from the second mode to the first mode is made. Air-conditioning load sensor device 125 in Fig. 1 includes infrared sensor 110 which senses a surface temperature of an object present in an air-conditioned space and indoor temperature sensor 121 which senses an indoor temperature. When at least one of a first condition that indoor temperature Ta is lower than second threshold value Ta min and a second condition that a surface temperature (sensory temperature Ta t) is lower than a third threshold value Ta_set is satisfied during an operation in the second mode (FIO), controller 130 changes the operation mode from the second mode (FIO) to the first mode (FCO).

[0054] Fig. 10 is a diagram showing one example of an operation of each component before and after entry into the second mode (FIO) in the first embodiment. During a period from time t0 to t1, the normal operation (FCO) in heating is performed. A rotation speed of indoor air blower 113 is set to a rotation speed N1 determined by setting made by a user.

[0055] When transition from the normal operation (FCO) to an operation at low load (FIO) is made at time t1, rotation speed N of indoor air blower 113 is intermittently switched between 0 and N2, wind direction plate (louver) 112 is changed from arbitrary angle θ set during a normal operation to prescribed angle $\theta 2$ (= 60 to 85°), and an operation frequency of compressor 119 is changed from frequency F1 corresponding to the lower limit value in the normal operation to frequency F2 which is approximately half of the former.

[0056] Thus, under the control for an intermittent operation of indoor air blower 113 with an operation frequency of compressor 119 being fixed, a thermal boundary layer specific to air formed around a floor is destroyed, soaring of warm air is prevented, and oscillation of a temperature around feet is lessened.

[0057] Air-conditioning apparatus 101 according to the first embodiment will be summarized again with reference to Fig. 1 and the like. Air-conditioning apparatus 101 includes refrigerant circuit 102, pipe temperature sensor 111, indoor air blower 113, air-conditioning load sensor device 125, and controller 130. In refrigerant circuit 102, during heating, refrigerant circulates in the order of compressor 119, indoor heat exchanger 115 serving as a condenser, expansion valve 117, and outdoor heat exchanger 116 serving as an evaporator. Pipe temperature sensor 111 is configured to sense condensing temperature CT representing a refrigerant temperature in indoor heat exchanger 115. Indoor air blower 113 is configured to adjust an amount of heat radiation from indoor heat exchanger 115. Air-conditioning load sensor device 125 is configured to sense air-conditioning load in an air-conditioned space.

[0058] As represented by the flowchart in Fig. 4 and the waveform diagram in Fig. 10, controller 130 has the first mode (FCO) and the second mode (FIO) different from the first mode as the operation modes, and it is configured to control a volume of air sent from indoor air blower 113. In the second mode, controller 130 is configured to have indoor air blower 113 operate to change a volume of air between the first volume of air (zero) and the second volume of air (N2) higher than the first volume of air with variation in condensing temperature CT. As shown in Fig. 5, in the first mode, controller 130 is configured to change the first mode (FCO) to the second mode (FIO) when air-conditioning load Q sensed by air-conditioning load sensor device 125 becomes lower than first threshold value Q2.

[0059] Air-conditioning apparatus 101 according to the first embodiment achieves effects (1) to (3) below.

(1) By turning off the fan to increase a condensing temperature, a temperature of blown air can be increased even in an operation at a low frequency of the compressor. Warm air can be supplied toward feet when the fan is turned on again.
(2) By setting the wind direction plate to a downward direction, warm air can be directed toward feet. Warm air moves upward from below after it is sent toward feet owing to a temperature difference between blown warm air and air in a room. Therefore, an indoor temperature can be uniform even in an operation at a low frequency of the compressor.
(3) Even though the operation frequency of the compressor is low, a temperature in a room can uniformly be maintained. Therefore, such an operation that turn-on and turn-off of the compressor is repeated is suppressed and an energy saving effect can be expected.

[Second Embodiment]

[0060] A second embodiment of the present invention will be described below. An air-conditioning apparatus according to the second embodiment includes a controller which controls a plurality of indoor units 103 to set an indoor temperature in air-conditioned space R to a target temperature. Since the second embodiment is similar to the first embodiment in control of load sensing means, temperature sensing means, air blow control means, and wind direction control means of each indoor unit 103, illustration and description thereof will not be provided.
[0061] Fig. 11 is a diagram showing one example of a control system in the second embodiment. Indoor units 103A, 103B, and 103C are connected to a central controller 230 through communication devices 203, 204, and 205, respectively. Central controller 230 can control indoor units 103A, 103B, and 103C. Connection of indoor units 103A, 103B, and 103C to communication devices 203, 204, and 205 and connection of communication devices 203, 204, and 205 to central controller 230 may be wired or wireless, and a control command or equipment information should only be transmitted among them.
[0062] Fig. 12 is a diagram showing one example of an operation of each component before and after entry into the second mode (FIO) in the second embodiment. Control of load sensing means, temperature sensing means, air blow control means, and wind direction control means of indoor units 103A, 103B, and 103C is similar to control in the first embodiment as shown in Fig. 12. The second embodiment, however, is characterized by a slight difference in timing for indoor units 103A, 103B, and 103C to enter the second mode (FIO) among them.
[0063] Fig. 13 is a diagram showing a difference in timing of entry into the second mode (FIO). As shown in Fig. 13, timing for indoor unit 103B to enter the second mode (FIO) is delayed by a time lag FIOΔT as compared with the timing for indoor unit 103A to enter the second mode (FIO). By adjusting the time lag, a rotation speed of the fan, and setting of temperatures T1 and T2, while the fan of indoor unit 103A is turned off, warm air is blown from another indoor unit 103B or 103C.
[0064] In the second embodiment, as shown in Fig. 11 in a simplified manner, indoor heat exchanger 115 includes a first condenser 115A and a second condenser 115B connected in parallel to each other in the refrigerant circuit. Indoor air blower 113 includes a first air blower 113A and a second air blower 113A provided in correspondence with first condenser 115A and second condenser 115B, respectively. As shown in Fig. 13, central controller 230 controls first air blower 113A and second air blower 113B such that a period during which first air blower 113A sends air at the second volume of air (a fan rotation speed N2A) and a period during which second air blower 113B sends air at the second volume of air (a fan rotation speed N2B) do not overlap with each other in the second mode (FIO). Though not shown, a condenser and an air blower are provided also similarly in indoor unit 103C.
[0065] Under such control, air is sent alternately from the air blowers of the indoor units. Therefore, warm air is always supplied toward feet and oscillation of a temperature around the floor surface can be suppressed.
[0066] It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The scope of the present invention is defined by the terms of the claims rather than the description of the embodiments above and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0067] 101 air-conditioning apparatus; 103, 103A, 103B, 103C indoor unit; 104 outdoor unit; 110 infrared sensor; 111 pipe temperature sensor; 113 indoor air blower; 114 outdoor air blower; 115 indoor heat exchanger; 116 outdoor heat exchanger; 117 expansion valve; 118 four-way valve; 119 compressor; 120 refrigerant pipe; 121 indoor temperature sensor; 130 controller; 230 central controller; 203 communication device

Claims

1. An air-conditioning apparatus comprising:

a refrigerant circuit through which refrigerant circulates in an order of a compressor, a condenser, an expansion mechanism, and an evaporator;
a condensing temperature sensor configured to sense a condensing temperature which represents a refrigerant temperature in the condens-

er;
an air blower configured to regulate a volume of air sent to the condenser;
an air-conditioning load sensor device configured to sense air-conditioning load; and
a controller configured to control a volume of air sent by the air blower, the controller having a first mode and a second mode different from the first mode as operation modes,
in the second mode, the controller being configured to have the air blower operate to vary a volume of air between a first volume of air and a second volume of air larger than the first volume of air with variation in condensing temperature, and
in the first mode, the controller being configured to change the first mode to the second mode when the air-conditioning load sensed by the air-conditioning load sensor device becomes lower than a first threshold value.

2. The air-conditioning apparatus according to claim 1, wherein
the air-conditioning load sensor device senses a temperature of an air-conditioned space, and
the controller is configured to change the first mode to the second mode when the temperature becomes lower than a first threshold value.

3. The air-conditioning apparatus according to claim 1, wherein
the air-conditioning load sensor device comprises

a surface temperature sensor which senses a surface temperature of an object located in an air-conditioned space, and
an indoor temperature sensor which senses an indoor temperature, and

the controller is configured to change the operation mode from the second mode to the first mode when at least one of a first condition and a second condition is satisfied during operations in the second mode, the first condition being a condition that the indoor temperature is lower than a second threshold value, and the second condition being a condition that the surface temperature is lower than a third threshold value.

4. The air-conditioning apparatus according to claim 1, wherein
the air-conditioning load sensor device senses a rotation speed of the compressor, and
the controller is configured to change the first mode to the second mode when the rotation speed of the compressor becomes lower than a first threshold value.

5. The air-conditioning apparatus according to claim 1, the air-conditioning apparatus comprising a wind direction changing portion which changes a direction of air sent by the air blower, wherein
the controller is configured to control the wind direction changing portion to set the direction of air to a prescribed wind direction in the second mode.

6. The air-conditioning apparatus according to claim 5, wherein
an angle indicating the prescribed wind direction is equal to or greater than 45° with an angle indicating a direction vertical to a floor surface being defined as 90° and an angle indicating a direction horizontal to the floor surface being defined as 0°.

7. The air-conditioning apparatus according to claim 1, wherein
in the second mode, the controller is configured to change a volume of air sent by the air blower from the first volume of air to the second volume of air when the condensing temperature becomes higher than a first temperature,
and change a volume of air sent by the air blower from the second volume of air to the first volume of air when the condensing temperature becomes lower than a second temperature lower than the first temperature.

8. The air-conditioning apparatus according to claim 1, the air-conditioning apparatus further comprising:

an additional condenser connected in parallel to the condenser in the refrigerant circuit; and
an additional air blower provided in correspondence with the additional condenser, wherein
the controller is configured to control the air blower and the additional air blower to avoid overlapping of a period during which the air blower sends the second volume of air with a period during which the additional air blower sends the second volume of air in the second mode.

9. The air-conditioning apparatus according to any one of claims 1 to 8, wherein
the first volume of air refers to a volume of air corresponding to a state that the air blower is turned off.

FIG.1

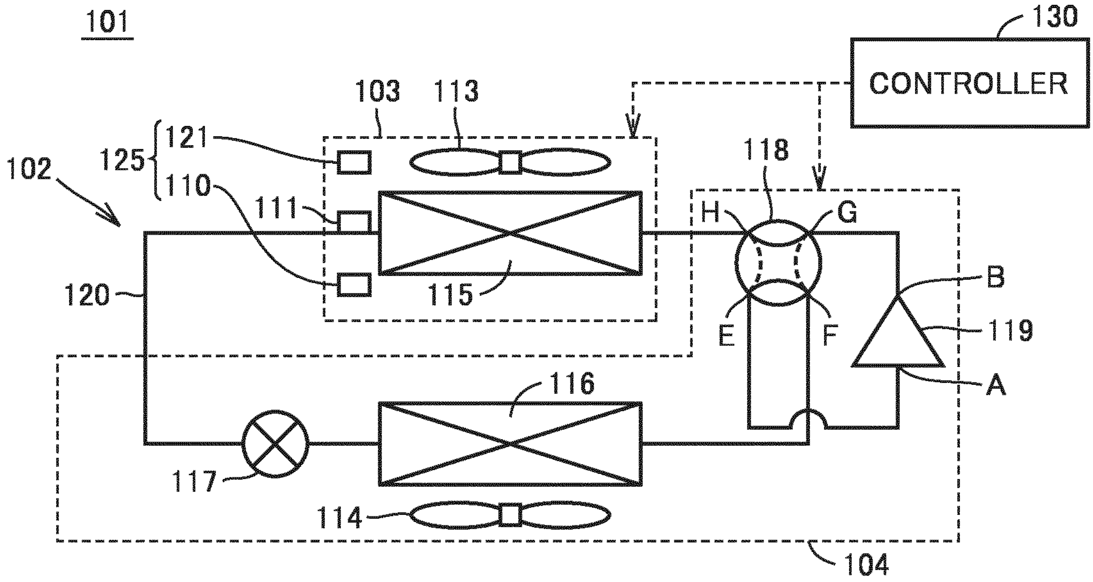

101
CONTROLLER
130
103
113
121
125
110
111
102
115
120
118
H
G
E
F
B
119
A
116
117
114
104

FIG.2

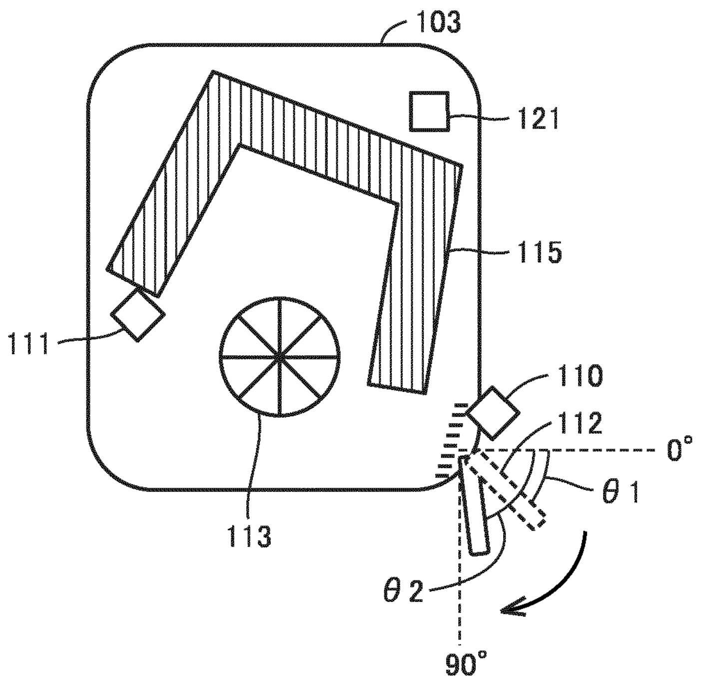

103
121
115
111
113
110
112
0°
θ 1
θ 2
90°

FIG.3

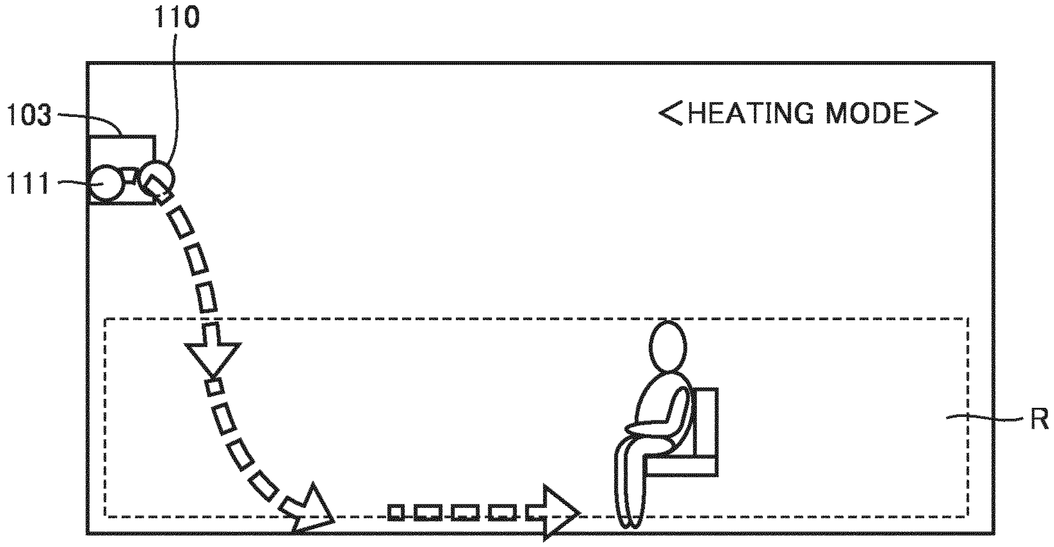


FIG.4

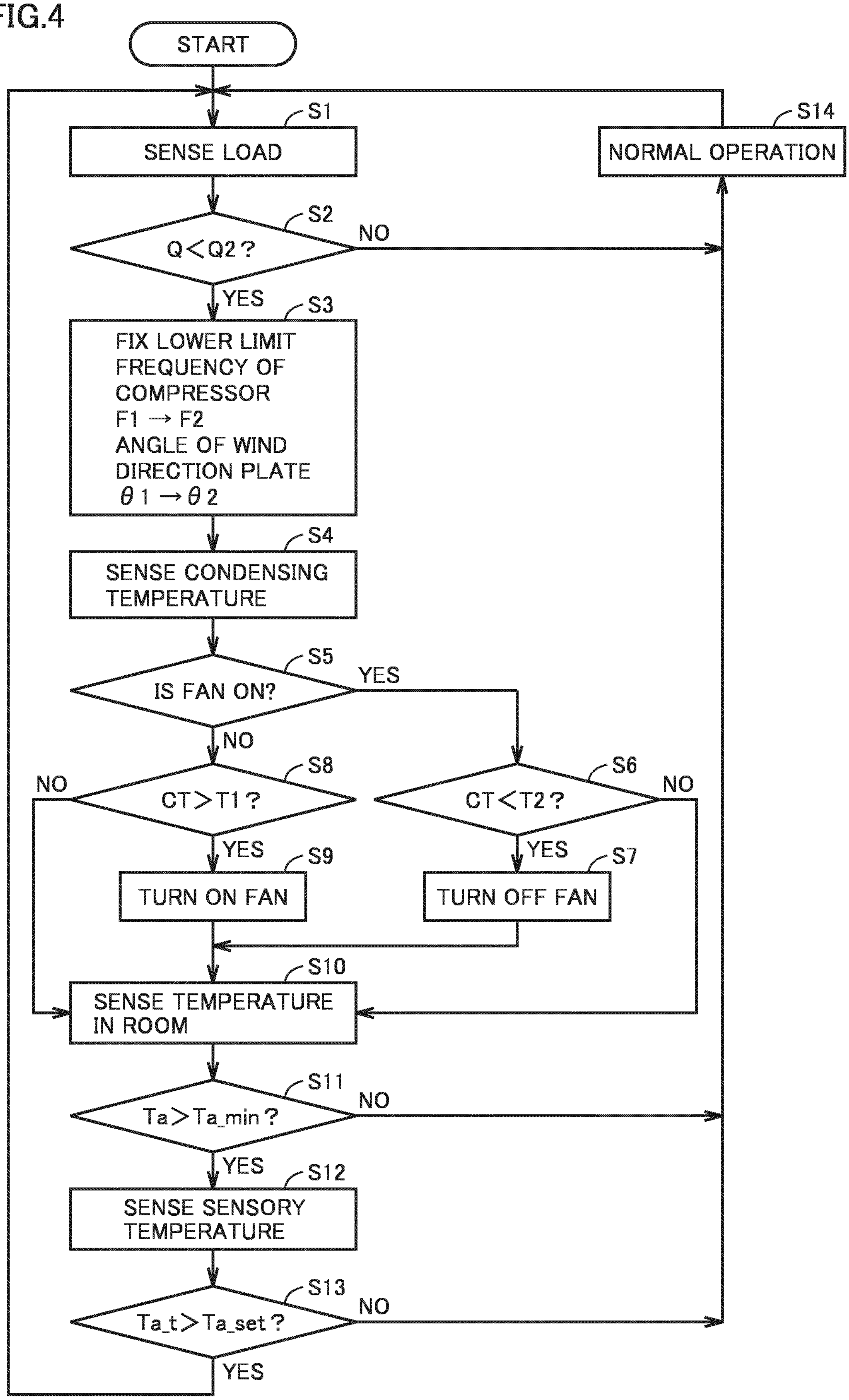

START
S1
SENSE LOAD
S2
Q<Q2?
NO
YES
S3
FIX LOWER LIMIT FREQUENCY OF COMPRESSOR F1 → F2 ANGLE OF WIND DIRECTION PLATE θ1 → θ2
S4
SENSE CONDENSING TEMPERATURE
S5
IS FAN ON?
YES
NO
S8
CT>T1?
NO
YES
S9
TURN ON FAN
S6
CT<T2?
NO
YES
S7
TURN OFF FAN
S10
SENSE TEMPERATURE IN ROOM
S11
Ta>Ta_min?
NO
YES
S12
SENSE SENSORY TEMPERATURE
S13
Ta_t>Ta_set?
NO
YES
S14
NORMAL OPERATION

FIG.5

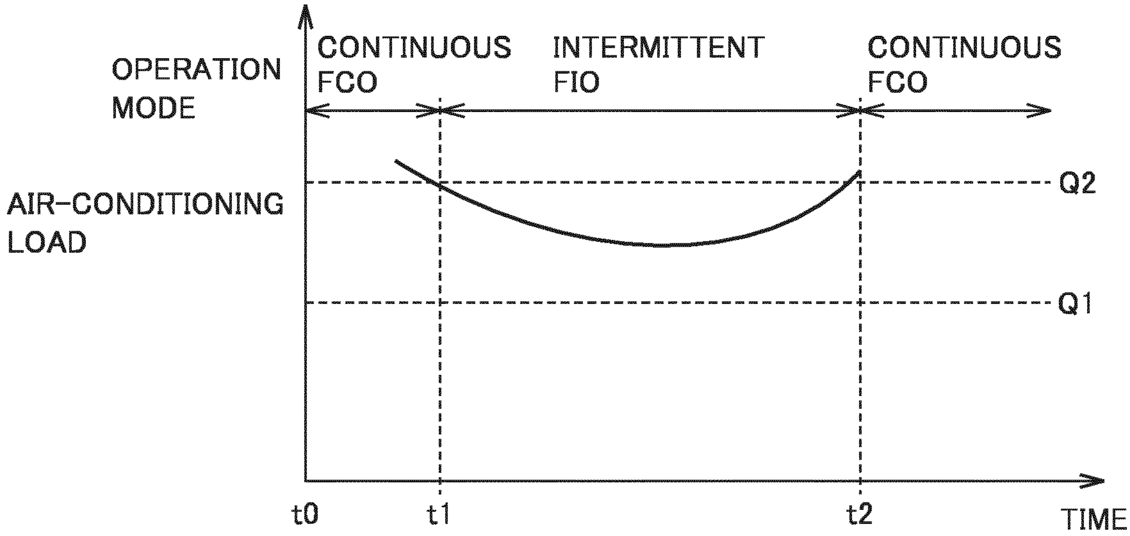

OPERATION
MODE
CONTINUOUS
FCO
INTERMITTENT
FIO
CONTINUOUS
FCO
AIR-CONDITIONING
LOAD
Q2
Q1
t0
t1
t2
TIME

FIG.6

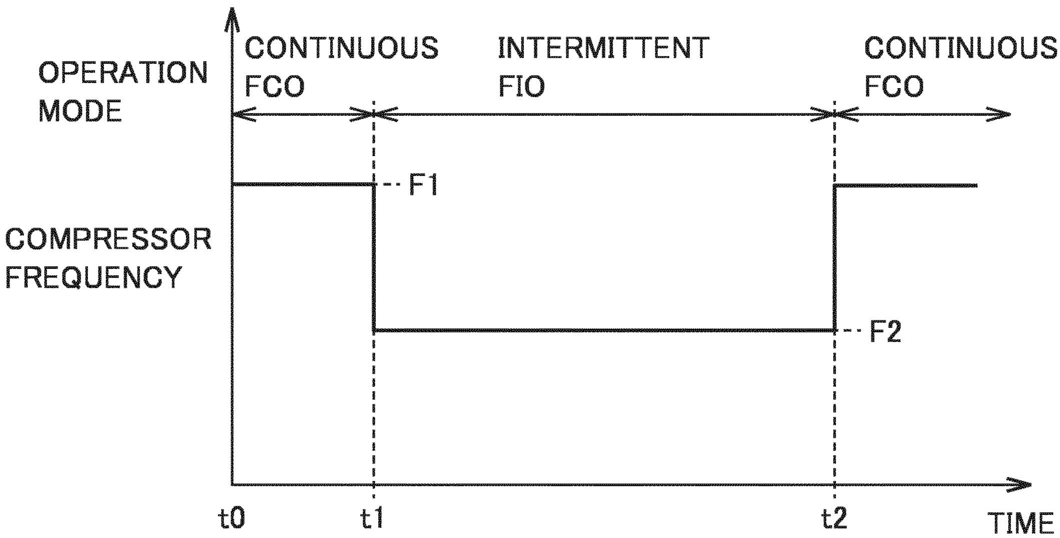

OPERATION
MODE
CONTINUOUS
FCO
INTERMITTENT
FIO
CONTINUOUS
FCO
F1
COMPRESSOR
FREQUENCY
F2
t0
t1
t2
TIME

FIG.7

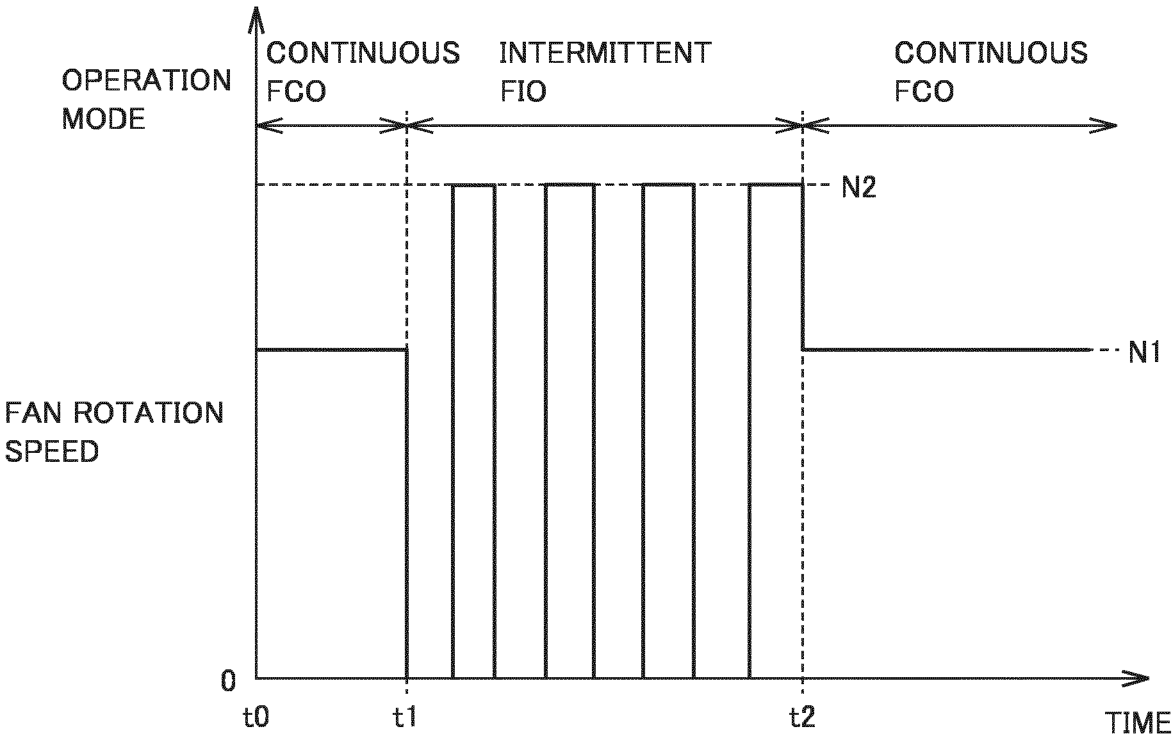

OPERATION
MODE
CONTINUOUS
FCO
INTERMITTENT
FIO
CONTINUOUS
FCO
N2
N1
FAN ROTATION
SPEED
0
t0
t1
t2
TIME

FIG.8

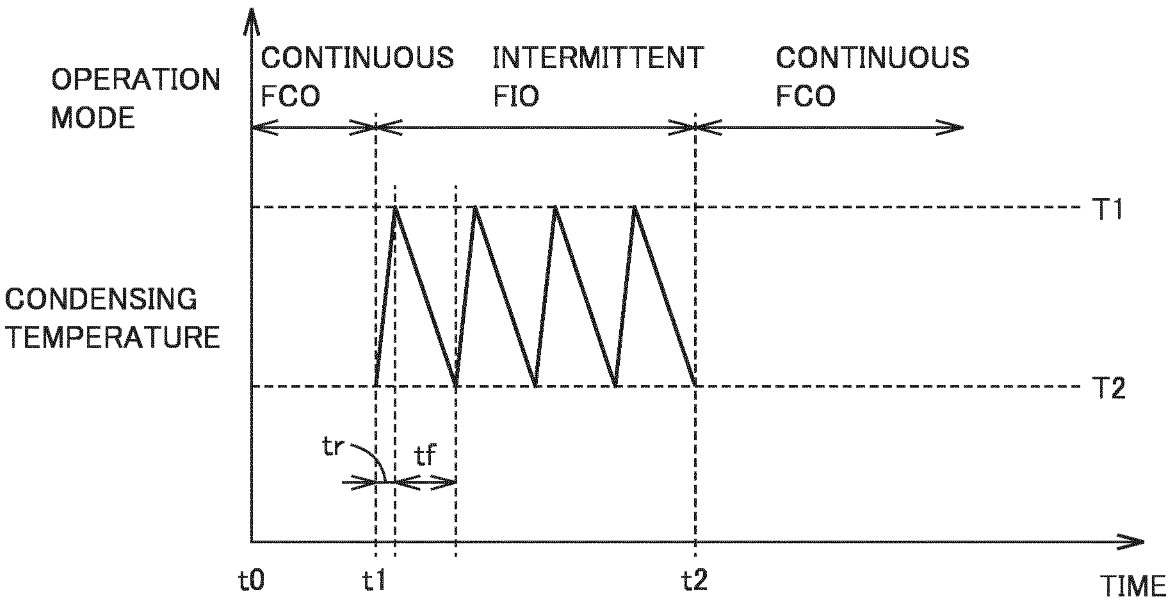

OPERATION
MODE
CONTINUOUS
FCO
INTERMITTENT
FIO
CONTINUOUS
FCO
T1
CONDENSING
TEMPERATURE
T2
tr
tf
t0
t1
t2
TIME

FIG.9

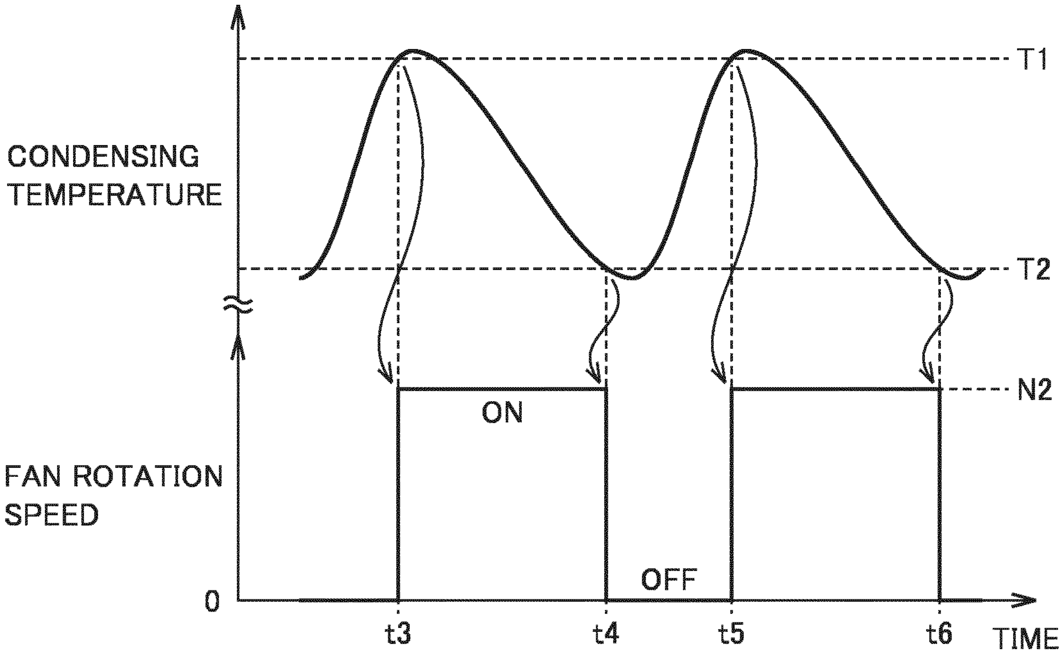

CONDENSING
TEMPERATURE
T1
T2
FAN ROTATION
SPEED
ON
OFF
N2
0
t3
t4
t5
t6
TIME

FIG.10

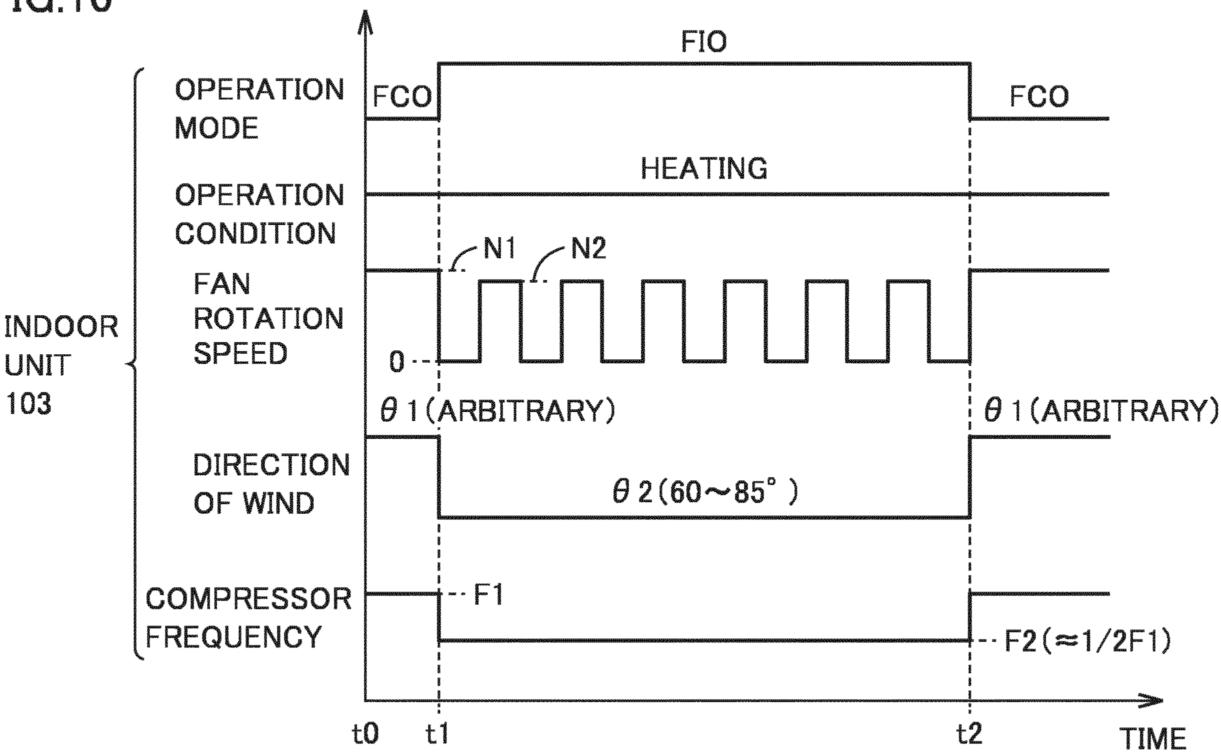

INDOOR
UNIT
103
OPERATION
MODE
FCO
FIO
FCO
OPERATION
CONDITION
HEATING
FAN
ROTATION
SPEED
N1
N2
0
θ 1 (ARBITRARY)
θ 1 (ARBITRARY)
DIRECTION
OF WIND
θ 2 (60～85°)
COMPRESSOR
FREQUENCY
F1
F2 (≈1/2F1)
t0
t1
t2
TIME

FIG.11

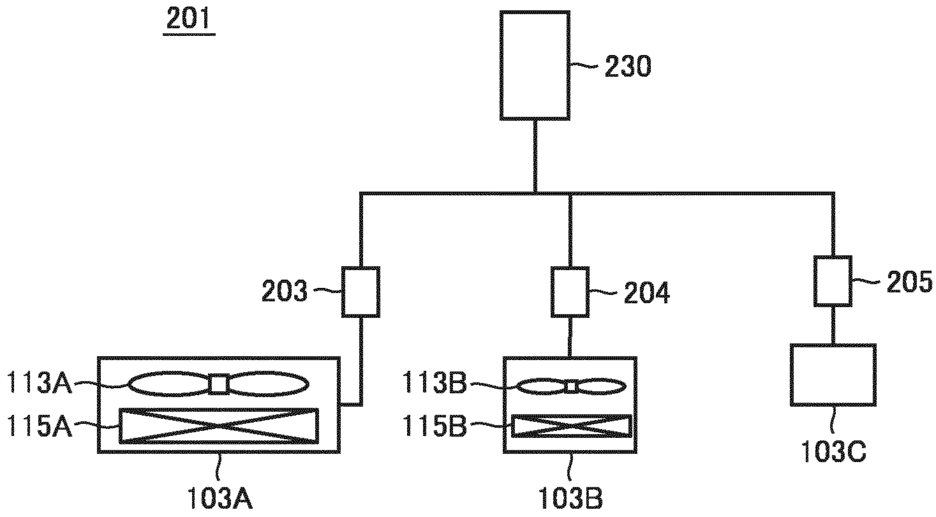

201
230
203
204
205
113A
115A
113B
115B
103A
103B
103C

FIG.12

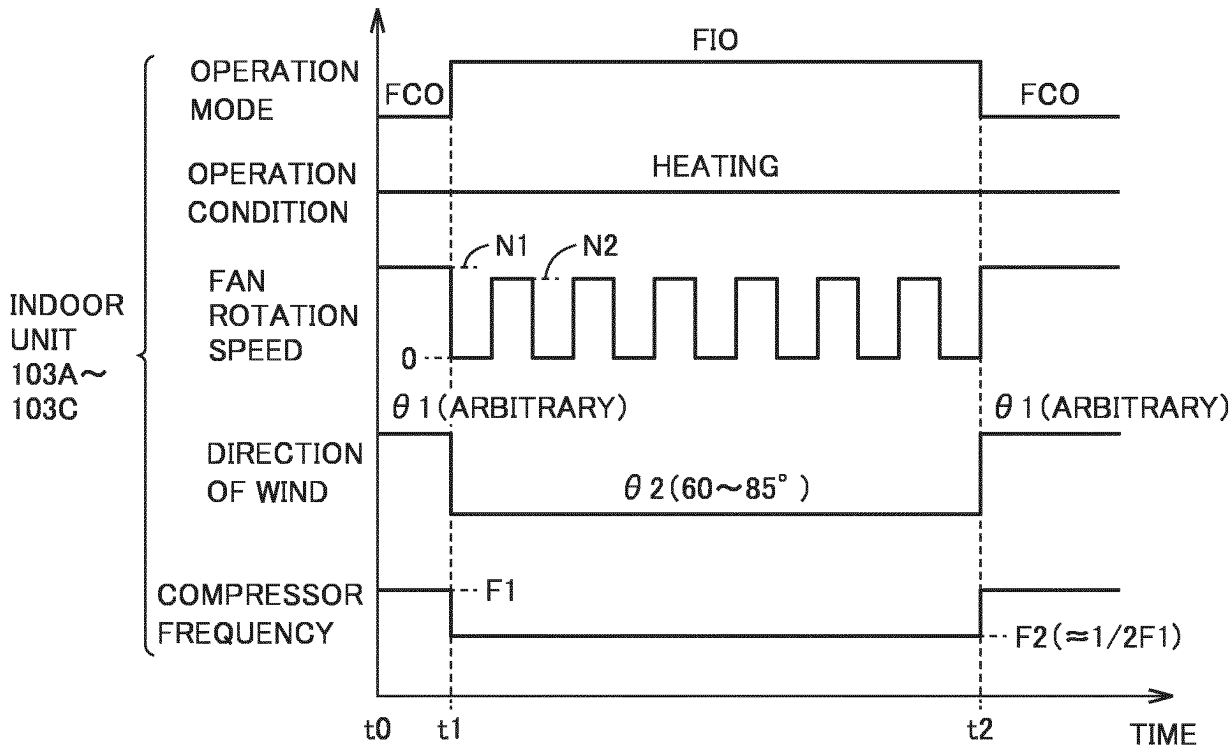
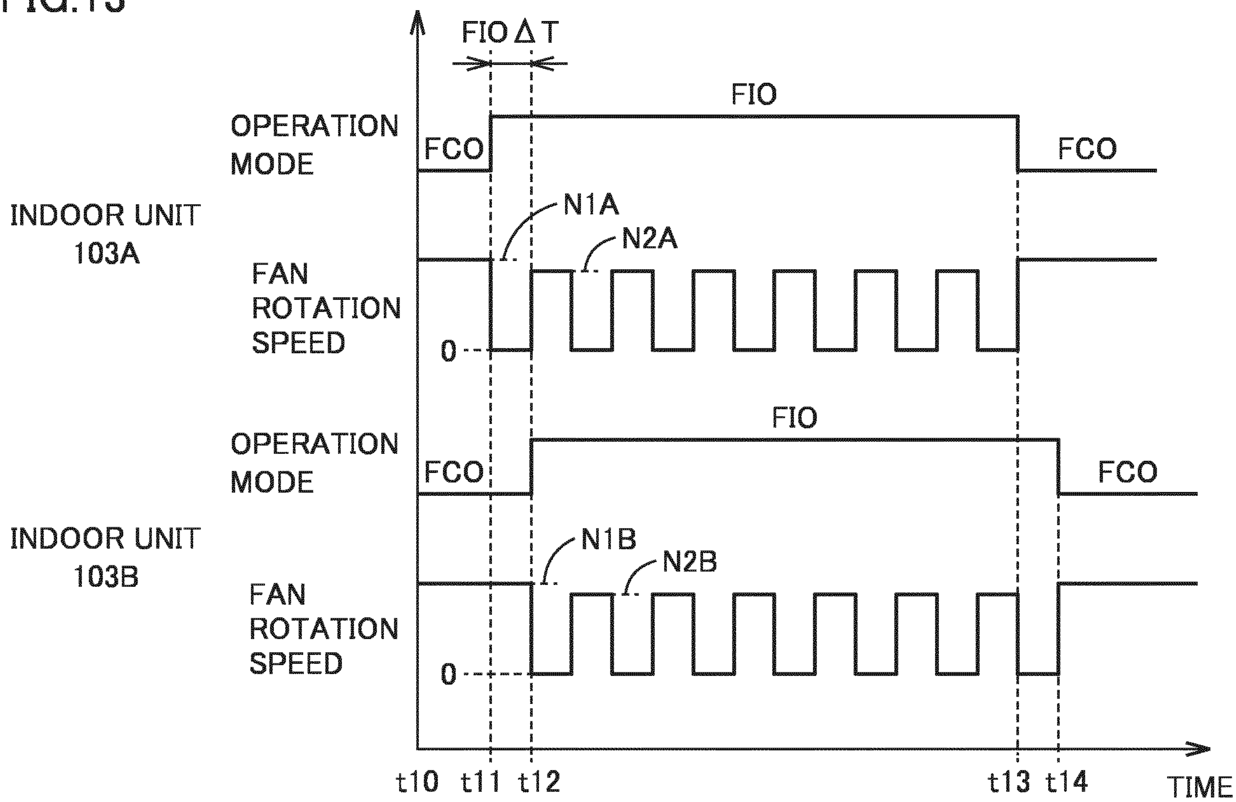

INDOOR UNIT 103A～103C
OPERATION MODE
FCO
FIO
FCO
OPERATION CONDITION
HEATING
FAN ROTATION SPEED
N1
N2
0
θ1(ARBITRARY)
θ1(ARBITRARY)
DIRECTION OF WIND
θ2(60～85°)
COMPRESSOR FREQUENCY
F1
F2(≈1/2F1)
t0
t1
t2
TIME

FIG.13


FIO ΔT
FIO
OPERATION MODE
FCO
FCO
INDOOR UNIT 103A
N1A
N2A
FAN ROTATION SPEED
0
FIO
OPERATION MODE
FCO
FCO
INDOOR UNIT 103B
N1B
N2B
FAN ROTATION SPEED
0
t10
t11
t12
t13
t14
TIME

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/075325

A. CLASSIFICATION OF SUBJECT MATTER
F24F11/02(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F24F11/02

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 2007-40554 A (Matsushita Electric Industrial Co., Ltd.), 15 February 2007 (15.02.2007), paragraphs [0016] to [0026]; fig. 1 to 3 (Family: none)	1,3,9 5,8-9 2,4,6-7
Y	JP 8-94158 A (Daikin Industries, Ltd.), 12 April 1996 (12.04.1996), paragraph [0005] (Family: none)	5,9

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
03 October 2016 (03.10.16)	11 October 2016 (11.10.16)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/075325

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2013-217550 A (Mitsubishi Heavy Industries, Ltd.), 24 October 2013 (24.10.2013), claims 1 to 3 & EP 2835595 A1 claims 1 to 3 & WO 2013/150885 A1 & CN 104081131 A	8-9

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2010060250 A **[0002] [0003] [0004] [0005]**