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(54) AIR CONDITIONING SYSTEM, CONTROLLER, CONTROL METHOD, AND PROGRAM

(57) An air conditioning system of an embodiment includes a first indoor unit, a second indoor unit, and a control unit. The first indoor unit blows temperature-controlled air from a ceiling part of a space to an inside of the space. The second indoor unit blows temperature-controlled air from a floor part of the space to the inside of the space. The control unit controls an operation of the second indoor unit based on a lower part temperature and a target lower part temperature. The lower part temperature is a temperature in a lower part of the space. The target lower part temperature is a target of the lower part temperature. The control unit controls the operation of the second indoor unit based on time information associated with a temperature of the space.

FIG. 1

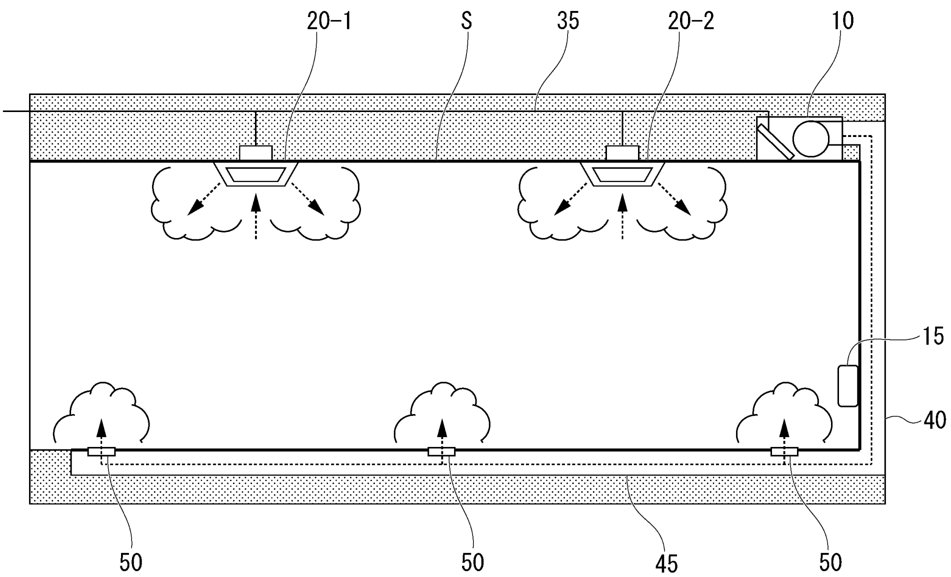

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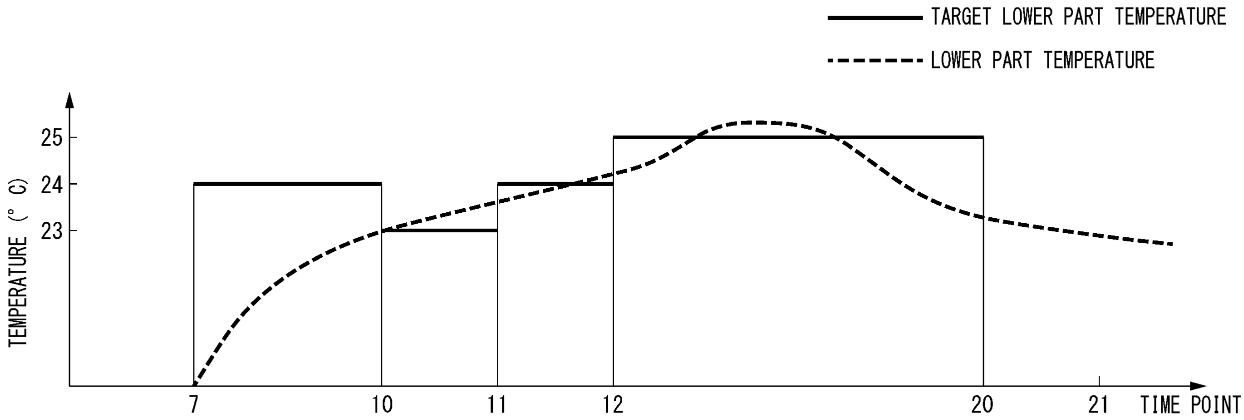
FIG. 7


TARGET LOWER PART TEMPERATURE
LOWER PART TEMPERATURE
TEMPERATURE (° C)
25
24
23
7
10
11
12
20
21
TIME POINT

Description

[TECHNICAL FIELD]

[0001] An embodiment of the present invention relates to an air conditioning system, a controller, a control method, and a program.

[BACKGROUND ART]

[0002] Air conditioning system including a first indoor unit and a second indoor unit has been proposed. The first indoor unit blows temperature-controlled air from an upper part of a space to an inside of the space. The second indoor unit blows temperature-controlled air from under a floor of the space to the inside of the space. For the air conditioning system, reduction of energy consumption is necessary.

[CITATION LIST]

[PATENT LITERATURE]

[0003] [Patent Literature 1] Japanese Patent No. 3263324

[SUMMARY OF THE INVENTION]

[PROBLEMS TO BE SOLVED BY THE INVENTION]

[0004] A problem to be solved by the present invention is to provide an air conditioning system, a controller, a control method, and a program capable of reducing energy consumption.

[MEANS FOR SOLVING THE PROBLEMS]

[0005] An air conditioning system of an embodiment includes a first indoor unit, a second indoor unit, and a control unit. The first indoor unit blows temperature-controlled air from a ceiling part of a space to an inside of the space. The second indoor unit blows temperature-controlled air from a floor part of the space to the inside of the space. The control unit controls an operation of the second indoor unit based on a lower part temperature and a target lower part temperature. The lower part temperature is the temperature in the lower part of the space. The target lower part temperature is the target of the lower part temperature. The control unit controls the operation of the second indoor unit based on time information associated with the temperature of the space.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[0006]

FIG. 1 is a schematic view for explaining an overview of air conditioning control by an air conditioning system according to an embodiment.

FIG. 2 is a block diagram showing an overall configuration of the air conditioning system according to the embodiment.

FIG. 3 is a diagram showing an example of an upper limit temperature of a blowing temperature in a high-load mode.

FIG. 4 is a diagram showing an example of an upper limit temperature of a blowing temperature in a low-load mode.

FIG. 5 is a flowchart showing an operation of a floor blowing indoor unit.

FIG. 6 is a flowchart showing an operation of a ceiling blowing indoor unit.

FIG. 7 is a diagram showing an example of setting a target lower part temperature with respect to a point in time.

FIG. 8 is a diagram showing an example of a temperature distribution of the space due to sunlight incident.

[EMBODIMENTS FOR CARRYING OUT THE INVENTION]

[0007] Hereinafter, an air conditioning system, a controller, a control method, and a program according to the embodiment will be described with reference to the drawings.

[0008] FIG. 1 is a schematic view for explaining an overview of air conditioning control by the air conditioning system 1 according to the embodiment.

[0009] FIG. 1 shows a vertical cross-sectional view of a portion of a building having a space S. The building is, for example, an office building, and the space S is a space in which people are active such as an office space. However, the building may also be, for example, a house, and the space S may be a space in which people reside, such as a dwelling space. The air conditioning system 1 according to the embodiment is a system for conditioning air inside the space S. The air conditioning system 1 is a system having a floor blowing air conditioner and a ceiling blowing air conditioner combined thereto.

[0010] An indoor unit (hereinafter referred to as a "floor blowing indoor unit 10") of the floor blowing air conditioner is installed above the ceiling of the space S. A remote thermo-sensor 15 is installed on a side wall inside the space S. Two indoor units (hereinafter referred to as a "ceiling blowing indoor unit 20-1" and a "ceiling blowing indoor unit 20-2") of the ceiling blowing air conditioner are installed on the ceiling of the space S. Hereinafter, the ceiling blowing indoor unit 20-1 and the ceiling blowing indoor unit 20-2 will be simply referred to as a "ceiling blowing indoor unit 20" when they do not need to be distinguished from each other.

[0011] A vertical duct 40 is installed outside the space S along the side wall. The floor of the space S is a double floor and functions as an underfloor air supply chamber 45. Furthermore, a horizontal duct may be used instead of the underfloor air supply chamber 45. Three blowing outlets 50 are provided on a floor of the space S. Air in the underfloor air supply chamber 45 can move into the space S by way of the blowing outlets 50.

[0012] Note that, the number of blowing outlets 50 is not limited to three, and may be any number equal to or greater than one. Furthermore, it is desirable that the blowing outlets 50 be provided in appropriate number, with positions and intervals such that a temperature particularly at a position on the lower part of the space S is made uniform. Furthermore, an outdoor unit 30 shown in FIG. 2 to be described later is installed outside the space S.

[0013] The air conditioning system 1 according to the embodiment is a multi-type air conditioning system in which one floor blowing indoor unit 10, two ceiling blowing indoor units 20, and one outdoor unit 30 are connected via a refrigerant pipe 35 (connecting pipe). Furthermore, the number of the floor blowing indoor units 10 and the number of the ceiling blowing indoor units 20 are not limited to the above-described numbers, and may each be any number equal to or greater than one. It is desirable that the ceiling blowing indoor units 20 be provided in appropriate number, with positions and intervals such that a temperature particularly at a position on the upper part of the space S is made uniform.

[0014] The refrigerant pipe 35 is a pipe for allowing a refrigerant to flow back and forth between the floor blowing indoor unit 10 and the ceiling blowing indoor units 20, and the outdoor unit 30. The refrigerant pipe 35 connects the floor blowing indoor unit 10, the ceiling blowing indoor unit 20-1, and the ceiling blowing indoor unit 20-2 in parallel. The floor blowing indoor unit 10 and the ceiling blowing indoor units 20, and the outdoor unit 30 are connected by the refrigerant pipe 35 to form a refrigeration cycle in which the refrigerant is circulated.

[0015] As described above, the air conditioning system 1 has a configuration in which both the floor blowing indoor unit 10 and the ceiling blowing indoor units 20 are used. Also, as it is obvious that the floor blowing indoor unit 10 and the ceiling blowing indoor units 20 are connected to the same outdoor unit 30, the floor blowing indoor unit 10 and the ceiling blowing indoor units 20 are indoor units of the air conditioner of the same air conditioning system. However, the floor blowing indoor unit 10 and the ceiling blowing indoor units 20 are not limited to being connected to the same outdoor unit 30. A configuration in which, for example, the outdoor unit 30 connected to the floor blowing indoor unit 10 and the outdoor unit 30 connected to the ceiling blowing indoor units 20 are installed separately may be used.

[0016] Generally, when heating is performed only by the ceiling blowing indoor units 20, the temperature in the lower part of the space S is relatively lower than the temperature in the upper part. Therefore, a person in the room may feel uncomfortable with the cold due to the relatively low temperature around his or her feet, and may change a set temperature of the air conditioner to a higher temperature. A change to a higher set temperature in such an environment causes a state of an excessive heating operation and causes a waste of energy.

[0017] The air conditioning system 1 according to the embodiment can further reduce an upper and lower temperature difference inside the space S by using the floor blowing air conditioner in addition to the ceiling blowing air conditioner in combination. Therefore, since the temperature around the feet of the person in the room becomes relatively higher, the person in the room may feel comfortable even if the temperature in the upper part inside the space S is a lower temperature. As described above, according to the air conditioning system 1, the set temperature of the air conditioning system 1 can be lowered without impairing comfort, and thereby energy consumption is reduced.

[0018] As shown in FIG. 1, air discharged from the floor blowing indoor unit 10 is first discharged to the vertical duct 40. The air discharged to the vertical duct 40 is further discharged to the underfloor air supply chamber 45 which is a double-floor space to which the vertical duct 40 is connected. The air discharged to the underfloor air supply chamber 45 is further blown into the space S from the three blowing outlets 50 provided on the floor of the space S. The floor blowing indoor unit 10 controls a blowing temperature of the air blown out from the blowing outlets 50 based on a temperature measured by the remote thermo-sensor 15.

[0019] The remote thermo-sensor 15 is a sensor that measures the temperature at a position in the lower part of the space S (hereinafter referred to as a "lower part temperature"). The remote thermo-sensor 15 is installed at a position in a lower part of the side wall in the space S. In the embodiment, the remote thermo-sensor 15 is installed at a position at a height of 30 cm above the floor. The remote thermo-sensor 15 is configured to be able to transmit a signal to the floor blowing indoor unit 10. The remote thermo-sensor 15 transmits a signal indicating a measured lower part temperature to the floor blowing indoor unit 10. Therefore, the floor blowing indoor unit 10 can recognize the lower part temperature of the space S, and control a blowing temperature of the air to be blown into the space S from the blowing outlets 50 based on the lower part temperature.

[0020] Also, a plurality of remote thermo-sensors 15 may be installed in the space S. In this case, the floor blowing indoor unit 10 may control a blowing temperature of the air blown out from the blowing outlet 50 based on, for example, an average value of the temperatures measured by the plurality of remote thermo-sensors 15.

[0021] The plurality of ceiling blowing indoor units 20 each include a suction temperature sensor 21 to be described later. The suction temperature sensor 21 is a sensor that measures a temperature of the air suctioned into each of the ceiling blowing indoor units 20 from the inside of the space S (hereinafter referred to as a "suction temperature"). The ceiling blowing indoor unit 20 estimates a temperature at a position in the upper part of the space S (hereinafter referred to as an "upper part temperature") based on the temperature measured by the suction temperature sensor 21. In the embodiment, the upper part temperature is a temperature at a position at a height of substantially 120 cm above the floor in the space S. The ceiling blowing indoor unit 20 controls the upper part temperature of the space S based on a set temperature set by a user.

[0022] Note that, the ceiling blowing indoor unit 20 previously recognizes that, for example, the upper part temperature will become lower than the suction temperature by a predetermined amount (for example, 2°C). The ceiling blowing indoor unit 20 estimates the upper part temperature by subtracting the predetermined temperature described above from the suction temperature measured by the suction temperature sensor 21.

[0023] Note that, the ceiling blowing indoor unit 20 may include a sensor capable of directly measuring the upper part temperature of the space S instead of the suction temperature sensor 21. In such case, the sensor measuring the upper part temperature may be installed, for example, at a position in an upper part of the side wall (for example, at a position at a height of about 120 cm above the floor). That is, the temperature sensor provided in the ceiling blowing indoor unit 20 may be any sensor as long as it is a sensor capable of measuring or estimating the upper part temperature of the space S.

[0024] FIG. 2 is a block diagram showing an overall configuration of the air conditioning system 1 according to the embodiment. As shown in FIG. 2, the air conditioning system 1 includes the floor blowing indoor unit 10, the remote thermo-sensor 15, the ceiling blowing indoor unit 20-1, the ceiling blowing indoor unit 20-2, a remote controller 25, the outdoor unit 30, and the refrigerant pipe 35.

[0025] The floor blowing indoor unit 10 and the ceiling blowing indoor units 20 each include, for example, an indoor heat exchanger, an indoor expansion valve, and an indoor blower, which are not shown in the drawings.

[0026] The indoor blower is a blower having a centrifugal fan. However, the fan included in the indoor blower may be a fan of another structure such as an axial flow fan. The fan included in the indoor blower is disposed to face the indoor heat exchanger. Due to an operation of the fan of the indoor blower, the air above the ceiling of the space S is suctioned into the floor blowing indoor unit 10, and the air inside the space S is suctioned into each of the ceiling blowing indoor units 20. The air suctioned into each of the floor blowing indoor unit 10 and the ceiling blowing indoor units 20 is heat-exchanged with the refrigerant by the indoor heat exchanger and is discharged into the space S again by the operation of the fan.

[0027] As shown in FIG. 2, the floor blowing indoor unit 10 is configured to include a blowing temperature controller 11. The blowing temperature controller 11 sequentially acquires information indicating the lower part temperature of the space S that is periodically (for example, every 5 seconds) transmitted from the remote thermo-sensor 15. The blowing temperature controller 11 controls the blowing temperature of the air to be blown into the space S from the blowing outlet 50 according to the lower part temperature based on the acquired information. Furthermore, the blowing temperature controller 11 is configured in advance such that the blowing temperature of the air blown into the space S from the blowing outlet 50 can be controlled to a desired temperature.

[0028] For example, the blowing temperature controller 11 stores in advance the temperature of the air that is lowered while the air discharged from the floor blowing indoor unit 10 is blown into the space S from the blowing outlet 50. The blowing temperature controller 11 controls the indoor heat exchanger so that the air from the floor blowing indoor unit 10 is discharged to the vertical duct 40 at a temperature higher by an amount corresponding to the lowered temperature.

[0029] Note that, in the embodiment, the blowing temperature controller 11 has been configured to be provided in the floor blowing indoor unit 10, but is not limited thereto. For example, the blowing temperature controller 11 may be provided in the outdoor unit 30 or may be provided in a control device (external device) which is not shown in the drawings.

[0030] The blowing temperature controller 11 includes, for example, a processor such as a central processing unit (CPU) connected via a bus, a memory, an auxiliary storage device, and the like. The blowing temperature controller 11 reads and executes a program from, for example, the auxiliary storage device. The auxiliary storage device is configured using a storage medium such as, for example, a magnetic hard disk device or a semiconductor storage device. For example, the auxiliary storage device is configured using a non-volatile memory such as an electrically erasable programmable read-only memory (EEPROM).

[0031] The program may be stored in a storage (for example, a storage device including a non-transitory storage medium) in advance or may be stored in a removable storage medium (the non-transitory storage medium) such as a digital versatile disc (DVD) or a compact disc (CD)-read-only memory (ROM) and installed when the storage medium is mounted in a drive device.

[0032] Note that, all or part of the blowing temperature controller 11 may be realized by using hardware such as an application specific integrated circuit (ASIC), a programmable logic device (PLD), or a field programmable gate array (FPGA). The program may be recorded on a computer-readable recording medium. The above-described storage medium may be referred to as the recording medium. The computer-readable recording medium refers to a portable medium such as a flexible disk, a magneto-optical disk, a ROM, or a CD-ROM, and a storage device such as a hard disk incorporated in a computer system. The program may be transmitted via a telecommunication line.

[0033] The floor blowing indoor unit 10 includes, for example, a signal input unit which is not shown in the drawings. The signal input unit receives an input of a signal output from the remote thermo-sensor 15 and outputs the signal to the blowing temperature controller 11. For example, the signal input unit is connected to be able to communicate with the remote thermo-sensor 15 via a communication interface such as RS-232C (Recommended Standard-232C), RS-422A (Recommended Standard-422A), RS-485 (Recommended Standard-485), or USB (Universal Serial Bus). The signal input unit receives a signal input via the communication interface. The signal input unit is connected to an internal bus, which is not shown in the drawings, and outputs the signal to the blowing temperature controller 11 via the internal bus.

[0034] Note that, the signal input unit may receive an input of a signal output from the remote thermo-sensor 15 and store data of the lower part temperature of the space S based on the signal in a storage medium such as an auxiliary storage device as sensor data. In this case, the blowing temperature controller 11 controls the blowing temperature of the air blown into the space S based on the sensor data stored in the storage medium.

[0035] The remote controller 25 is an input interface that receives user's operation input regarding a setting of the air conditioning system 1. For example, the remote controller 25 receives an operation input instructing switching between ON and OFF of a power supply state of the air conditioning system 1. Alternatively, for example, the remote controller 25 receives an operation input that instructs a set temperature. In order to bring the inside of the space S into a desired temperature, the user operates the remote controller 25 and performs an operation input to instruct a temperature setting.

[0036] The remote controller 25 outputs the input instruction information to the ceiling blowing indoor unit 20-1. Furthermore, the remote controller 25 and the ceiling blowing indoor unit 20-1 may be connected by wire or wirelessly. The instruction information input to the ceiling blowing indoor unit 20-1 is further transmitted to the ceiling blowing indoor unit 20-2, the outdoor unit 30, and the floor blowing indoor unit 10 as well. Therefore, the air conditioning system 1 can control a temperature inside the space S, control switching between ON and OFF of the power supply state of the air conditioning system 1, and the like based on the instruction information input from the remote controller 25.

[0037] Note that, a transmission means of the instruction information input from the remote controller 25 in the air conditioning system 1 is not limited to the above-described configuration. For example, it may be configured such that the instruction information input from the remote controller 25 is first transmitted to a control device (external device) which is not shown in the drawings, and further transmitted from the control device to the floor blowing indoor unit 10, each of the ceiling blowing indoor units 20, and the outdoor unit 30.

[0038] The blowing temperature controller 11 of the floor blowing indoor unit 10 controls the blowing temperature of the air to be blown into the space S from the blowing outlet 50 in different operation modes from each other depending on, for example, whether the air conditioning system 1 has a low load or a high load. Furthermore, details of the operation mode will be described in detail later.

[0039] In the embodiment, in order to simplify the explanation, when the air conditioning system 1 is at high load means when the air conditioning system 1 is started. This is because, generally, when the system is started, it is assumed that there is often a state in which a difference between a set temperature set by the user and an actual temperature inside the space S is large, and a load on the air conditioning system 1 is in a state of relatively high.

[0040] Also, in order to simplify the explanation in the embodiment, when the air conditioning system 1 has a low load refers to a time other than when the air conditioning system 1 is started. This is because, generally, at a time other than when the system is started, it is assumed that there is often a state in which the difference between a set temperature and an actual temperature inside the space S is small, a load on the air conditioning system 1 is relatively small, and operation is stable.

[0041] However, the air conditioning system 1 being at high load and at low load are not limited to the above-described cases, and, for example, the term "at high load" may refer to a general state in which there is a large difference between the set temperature and the actual temperature inside the space S, and the term "at low load" may refer to a general state in which there is a small difference between the set temperature and the actual temperature inside the space S.

[0042] The blowing temperature controller 11 of the floor blowing indoor unit 10 performs a heating operation in a high-load mode, which will be described later, until the lower part temperature measured by the remote thermo-sensor 15 reaches the set temperature based on the information input from remote controller 25. A target lower part temperature serving as a target of a lower part temperature is the set temperature input from the remote controller 25. The blowing temperature controller 11 controls an operation of the floor blowing indoor unit 10 based on the lower part temperature and the target lower part temperature. The blowing temperature controller 11 stops the heating operation when the measured lower part temperature has reached the set temperature.

[0043] Also, after the heating operation has been stopped, the blowing temperature controller 11 resumes the heating operation in a low-load mode, which will be described later, when the measured lower part temperature has dropped by a predetermined temperature. In the embodiment, the blowing temperature controller 11 resumes the heating operation when the measured lower part temperature has dropped from the set temperature by 0.5°C.

[0044] As shown in FIG. 2, the ceiling blowing indoor unit 20 is configured to include the suction temperature sensor 21. As described above, the suction temperature sensor 21 measures the suction temperature of the air suctioned into the ceiling blowing indoor unit 20 from the inside of the space S. The ceiling blowing indoor unit 20 estimates the upper part temperature of the space S based on the suction temperature measured by the suction temperature sensor 21.

[0045] The ceiling blowing indoor unit 20 performs the heating operation until an estimated upper part temperature reaches the temperature (target upper part temperature) that is lower than the set temperature by a predetermined temperature and that is based on information input from the remote controller 25. The ceiling blowing indoor unit 20 stops the heating operation when the estimated upper part temperature has reached a temperature lower than the set temperature by a predetermined temperature. Also, after the heating operation has been stopped, the ceiling blowing indoor unit 20 resumes the heating operation when the estimated upper part temperature has dropped by a predetermined temperature.

[0046] In the embodiment, the ceiling blowing indoor unit 20 stops the heating operation when the estimated upper part temperature has reached a temperature lower than the set temperature by 2°C. Thereafter, the ceiling blowing indoor unit 20 resumes the heating operation when the estimated upper part temperature has dropped by 0.5°C from the temperature lower than the set temperature by 2°C (that is, the upper part temperature has reached the temperature lower than the set temperature by 2.5°C).

[0047] The outdoor unit 30 includes, for example, an outdoor heat exchanger, a four-way valve, a compressor, an outdoor expansion valve, an outdoor blower, and an accumulator, which are not shown in the drawings. The refrigerant pipe 35 connects the outdoor expansion valve, the outdoor heat exchanger, the four-way valve, the compressor, and the accumulator.

[0048] The outdoor heat exchanger is, for example, a finned tube type heat exchanger. The four-way valve is a valve for switching a direction in which the refrigerant flows in the refrigerant pipe 35. The four-way valve switches a direction in which the refrigerant flows between a direction during a heating operation and a direction during a cooling operation (or during a defrosting operation) that is a direction opposite to the direction during the heating operation. However, the air conditioning system 1 in the embodiment may be a dedicated air conditioning system for heating.

[0049] The compressor can change an operating frequency by a known inverter control. The compressor suctions the refrigerant through a suction port and compresses the refrigerant inside. The compressor discharges the compressed refrigerant to the outside through a discharge port. The accumulator is attached to the suction port of the compressor. The accumulator separates the refrigerant into a liquid refrigerant and a gas refrigerant, and stores the liquid refrigerant.

[0050] Hereinafter, control of the blowing temperature by the blowing temperature controller 11 of the floor blowing indoor unit 10 in each operation mode will be described.

[0051] The blowing temperature controller 11 controls the blowing temperature based on a preset upper limit temperature that is different according to the operation mode. The blowing temperature controller 11 sequentially controls the blowing temperature so that the blowing temperature does not exceed the upper limit temperature and reaches a temperature closer to the upper limit temperature. Hereinafter, an operation mode at high load (when the system is started) is referred to as a "high-load mode," and an operation mode at low load (at the time other than when the system is started) is referred to as a "low-load mode".

[0052] FIG. 3 is a diagram showing an example of the upper limit temperature of the blowing temperature in the high-load mode. In the graph shown in FIG. 3, the horizontal axis represents a lower part temperature of the space S measured by the remote thermo-sensor 15, and the vertical axis represents a blowing temperature of the air blown out from the blowing outlet 50 controlled by the blowing temperature controller 11. Note that, both the units of the lower part temperature and the blowing temperature shown in FIG. 3 are in Celsius (°C).

[0053] As shown in FIG. 3, in the high-load mode, when the lower part temperature of the space S is lower than or equal to 20°C, the upper limit temperature of the blowing temperature is the temperature obtained by adding 10°C to the lower part temperature. Furthermore, as shown in FIG. 3, in the high-load mode, when the lower part temperature of the space S is higher than or equal to 20°C, the upper limit temperature of the blowing temperature is a constant temperature, and is 30°C.

[0054] Generally, a buoyancy effect occurs based on a relationship between the lower part temperature and the blowing temperature, and warm air in the lower part of the space S may rise to the upper part of the space S. Therefore, reducing the upper and lower temperature difference inside the space S by raising the lower part temperature is hindered. The line of the upper limit temperature of the blowing temperature shown in FIG. 3 is an example of a line appropriately set to suppress rise of the warm air due to such a buoyancy effect.

[0055] That is, the line of the upper limit temperature of the blowing temperature shown in FIG. 3 is determined in advance based on general research findings, in which it was found that the buoyancy effect becomes significant when the blowing temperature is higher than the lower part temperature by 10°C or more in the case in which the lower part temperature is lower than or equal to 20°C. Moreover, the line of the upper limit temperature is determined in advance based on general research findings, in which it was found that the buoyancy effect becomes significant when the blowing temperature exceeds 30°C in the case in which the lower part temperature is higher than or equal to 20°C.

[0056] During an operation in the high-load mode, the blowing temperature controller 11 acquires information indicating the lower part temperature of the space S that is output periodically (for example, every 5 seconds) from the remote thermo-sensor 15. The blowing temperature controller 11 determines the upper limit temperature of the blowing temperature corresponding to the measured lower part temperature based on the line of the upper limit temperature of the blowing temperature shown in FIG. 3.

[0057] Note that, information indicating the line of the upper limit temperature of the blowing temperature shown in FIG. 3 is stored in advance in, for example, the auxiliary storage device described above. The blowing temperature controller 11 sequentially controls the blowing temperature so that the blowing temperature does not exceed the determined upper limit temperature and reaches a temperature closer to the determined upper limit temperature.

[0058] The blowing temperature controller 11 stops the heating operation when the measured lower part temperature has reached the set temperature. Thereafter, when the measured lower part temperature drops by a predetermined temperature (0.5°C in the embodiment) from the set temperature, the blowing temperature controller 11 resumes the heating operation in the low-load mode.

[0059] FIG. 4 is a diagram showing an example of the upper limit temperature of the blowing temperature in the low-load mode. Similarly to FIG. 3, in the graph shown in FIG. 4, the horizontal axis represents a lower part temperature of the space S measured by the remote thermo-sensor 15, and the vertical axis represents a blowing temperature of the air blown out from the blowing outlet 50 controlled by the blowing temperature controller 11. Note that, both the units of the lower part temperature and the blowing temperature shown in FIG. 4 are in Celsius (°C).

[0060] As shown in FIG. 4, in the low-load mode, when the lower part temperature of the space S is lower than or equal to 19°C, similarly to the aforementioned high-load mode, the upper limit temperature of the blowing temperature is the temperature obtained by adding 10°C to the lower part temperature. In contrast, in the low-load mode, when the lower part temperature of the space S is higher than or equal to 19°C, control is carried out by the upper limit temperature different from the aforementioned high-load mode.

[0061] As shown in FIG. 4, when the lower part temperature of the space S is higher than or equal to 19°C, the upper limit temperature of the blowing temperature in the low-load mode is a temperature lower than the upper limit temperature of the blowing temperature of the aforementioned high-load mode shown in FIG. 3. As shown in FIG. 4, the line of the upper limit temperature of the blowing temperature is the curve line including the intersection point of the lower part temperature of 19°C and the blowing temperature of 29°C and the intersection point of the lower part temperature of 26°C and the blowing temperature of 26°C. This curved line is a line that draws a gentle curve so that the blowing temperatures are slightly lower than those on a straight line directly connecting the two intersections described above.

[0062] Note that, the curved line of the upper limit temperature of the blowing temperature is a line derived based on field investigation. The curved line is an example of a line that is appropriately set so that the warm air blown up from the blowing outlet 50 does not make the person in the room feel that his or her face is hot.

[0063] Note that, the intersection point of the lower part temperature of 19°C and the blowing temperature of 29°C is determined based on the intersection point of: the line of the temperature on which the upper limit temperature of the blowing temperature is obtained by adding 10°C to the lower part temperature; and the line of the lower part temperature of 19°C. Note that, the lower part temperature of 19°C is obtained by field research and is the temperature serving as an indication for the lower limit that does not cause a person in the room to feel cold.

[0064] Note that, the intersection point of the lower part temperature of 26°C and the blowing temperature of 26°C is determined based on the intersection point of: the line at which the lower part temperature and the blowing temperature are equal to each other shown by a dashed-dotted line in FIG. 4; and the line of the lower part temperature of 26°C. Note that, the lower part temperature of 26°C is obtained by field research and is the temperature serving as an indication for the upper limit that does not cause a person in the room to feel hot.

[0065] The blowing temperature controller 11 acquires information indicating the lower part temperature of the space S that is output periodically (for example, every 5 seconds) from the remote thermo-sensor 15 during an operation in the low-load mode. The blowing temperature controller 11 determines the upper limit temperature of the blowing temperature corresponding to the measured lower part temperature based on the line of the upper limit temperature of the blowing temperature shown in FIG. 4.

[0066] Furthermore, information indicating the line of the upper limit temperature of the blowing temperature shown in FIG. 4 is stored in advance in, for example, the auxiliary storage device described above. The blowing temperature controller 11 sequentially controls the blowing temperature so that the blowing temperature does not exceed the determined upper limit temperature and reaches a temperature closer to the determined upper limit temperature.

[0067] The blowing temperature controller 11 stops the heating operation when the measured lower part temperature has reached the set temperature. Thereafter, when the measured lower part temperature drops by a predetermined temperature (0.5°C in the embodiment) from the set temperature, the blowing temperature controller 11 resumes the heating operation in the low-load mode.

[0068] An example of an operation of the floor blowing indoor unit 10 will be described below. FIG. 5 is a flowchart showing an operation of the floor blowing indoor unit 10 according to the embodiment. The operation of the floor blowing indoor unit 10 shown in the flowchart of FIG. 5 is started when, for example, power of the air conditioning system 1 is turned on.

[0069] The blowing temperature controller 11 of the floor blowing indoor unit 10 waits for an input of information indicating a set temperature instruction (step S101). The set temperature instruction refers to an instruction received by an operation input of the user to the remote controller 25 for controlling the temperature inside the space S to a desired set temperature. The information indicating the set temperature instruction is, for example, output from the remote controller 25 and input to the floor blowing indoor unit 10 via the ceiling blowing indoor unit 20-1.

[0070] When the blowing temperature controller 11 receives an input of the information indicating the set temperature instruction (step S101, YES), the blowing temperature controller 11 starts floor blowing control in which the blowing temperature is sequentially controlled based on, for example, the upper limit temperature of the blowing temperature corresponding to the lower part temperature of the space S during the heating operation in the high-load mode shown in FIG. 3 and the information indicating the lower part temperature of the space S periodically (for example, every 5 seconds) input from the remote thermo-sensor 15 (step S102).

[0071] Next, the blowing temperature controller 11 continues the floor blowing control in the high-load mode until the lower part temperature of the space S that is periodically (for example, every 5 seconds) input from the remote thermo-sensor 15 reaches the set temperature (target lower part temperature) based on the information indicating the set temperature instruction (step S104).

[0072] In the meantime, if the blowing temperature controller 11 receives an input of information indicating an operation end instruction (step S103, YES), the blowing temperature controller 11 ends the floor blowing control (step S111). As described above, the operation of the floor blowing indoor unit 10 shown in the flowchart of FIG. 5 ends. The operation end instruction refers to, for example, an instruction received by an operation input of the user to the remote controller 25 for turning off the power of the air conditioning system 1.

[0073] When the lower part temperature of the space S that is periodically (for example, every 5 seconds) input from the remote thermo sensor 15 has reached the set temperature (the target lower part temperature) (step S104, YES), the blowing temperature controller 11 temporarily stops the floor blowing control (step S105).

[0074] Next, the blowing temperature controller 11 maintains a state of temporarily stopping the floor blowing control until the lower part temperature of the space S that is periodically (for example, every 5 seconds) input from the remote thermo sensor 15 becomes lower than the set temperature by 0.5°C (step S107).

[0075] In the meantime, if the blowing temperature controller 11 receives an input of the information indicating the operation end instruction (step S106, YES), the blowing temperature controller 11 ends the floor blowing control (step S111). As described above, the operation of the floor blowing indoor unit 10 shown in the flowchart of FIG. 5 ends.

[0076] When the lower part temperature of the space S that is periodically (for example, every 5 seconds) input from the remote thermo sensor 15 becomes lower than the set temperature by 0.5°C (step S107, YES), the blowing temperature controller 11 starts floor blowing control in which the blowing temperature is sequentially controlled based on, for example, the upper limit temperature of the blowing temperature corresponding to the lower part temperature of the space S during the heating operation in the low-load mode shown in FIG. 4 and the information indicating the lower part temperature of the space S periodically (for example, every 5 seconds) input from the remote thermo-sensor 15 (step S108).

[0077] Next, the blowing temperature controller 11 continues the floor blowing control in the low-load mode until the lower part temperature of the space S that is periodically (for example, every 5 seconds) input from the remote thermo-sensor 15 reaches the set temperature (target lower part temperature) based on the information indicating the set temperature instruction (step S110).

[0078] In the meantime, if the blowing temperature controller 11 receives an input of the information indicating the operation end instruction (step S109, YES), the blowing temperature controller 11 ends the floor blowing control (step S111). As described above, the operation of the floor blowing indoor unit 10 shown in the flowchart of FIG. 5 ends.

[0079] When the lower part temperature of the space S that is periodically (for example, every 5 seconds) input from the remote thermo sensor 15 has reached the set temperature (the target lower part temperature) (step S110, YES), the blowing temperature controller 11 temporarily stops the floor blowing control (step S105). The blowing temperature controller 11 repeats the operations after step S106 described above.

[0080] Next, an example of an operation of the ceiling blowing indoor unit 20-1 will be described below. FIG. 6 is a flowchart showing an operation of the ceiling blowing indoor unit 20-1 according to the embodiment. The operation of the ceiling blowing indoor unit 20-1 shown in the flowchart of FIG. 6 is started when, for example, power of the air conditioning system 1 is turned on. Furthermore, since an operation of the ceiling blowing indoor unit 20-2 is basically the same as the operation of the ceiling blowing indoor unit 20-1 to be described below, description thereof will be omitted.

[0081] The ceiling blowing indoor unit 20-1 waits for an input of information indicating a set temperature instruction (step S201). As described above, the set temperature instruction refers to an instruction received by an operation input of the user to the remote controller 25 for controlling the temperature inside the space S to a desired set temperature. The information indicating the set temperature instruction is input from, for example, the remote controller 25.

[0082] When the ceiling blowing indoor unit 20-1 receives an input of the information indicating the set temperature instruction (step S201, YES), the ceiling blowing indoor unit 20-1 notifies the floor blowing indoor unit 10, the ceiling blowing indoor unit 20-2, and the outdoor unit 30 of the information indicating the set temperature instruction (step S202).

[0083] Next, the ceiling blowing indoor unit 20-1 starts ceiling blowing control for controlling the upper part temperature of the space S based on the upper part temperature of the space S estimated based on a temperature measured by the suction temperature sensor 21 and the set temperature set by the user (step S203).

[0084] Next, the ceiling blowing indoor unit 20-1 continues the ceiling blowing control until the upper part temperature of the space S estimated based on the temperature measured by the suction temperature sensor 21 reaches a temperature (target upper part temperature) lower than the set temperature based on the information indicating the set temperature instruction by 2°C (step S205).

[0085] In the meantime, if the ceiling blowing indoor unit 20-1 receives an input of information indicating an operation end instruction (step S204, YES), the ceiling blowing indoor unit 20-1 ends the ceiling blowing control (step S209). As described above, the operation of the ceiling blowing indoor unit 20-1 shown in the flowchart of FIG. 6 ends. As described above, the operation end instruction refers to, for example, an instruction received by an operation input of the user to the remote controller 25 for turning off power of the air conditioning system 1.

[0086] When the upper part temperature of the space S estimated based on the temperature measured by the suction temperature sensor 21 has reached the temperature (target upper part temperature) lower than the set temperature by 2°C (step S205, YES), the ceiling blowing indoor unit 20-1 temporarily stops the ceiling blowing control (step S206).

[0087] Next, the ceiling blowing indoor unit 20-1 maintains a state in which the ceiling blowing control is temporarily stopped until the upper part temperature of the space S estimated based on the temperature measured by the suction temperature sensor 21 reaches a temperature that is even lower by 0.5°C from the temperature lower than the set temperature by 2°C (that is, the upper part temperature reaches a temperature lower than the set temperature by 2.5°C) (step S208).

[0088] In the meantime, if the ceiling blowing indoor unit 20-1 receives an input of the information indicating the operation end instruction (step S207, YES), the ceiling blowing indoor unit 20-1 ends the ceiling blowing control (step S209). As described above, the operation of the ceiling blowing indoor unit 20-1 shown in the flowchart of FIG. 6 ends.

[0089] When the upper part temperature of the space S estimated based on the temperature measured by the suction temperature sensor 21 has reached a temperature that is even lower by 0.5°C from the temperature lower than the set temperature by 2°C (step S208, YES), the ceiling blowing indoor unit 20-1 resumes the ceiling blowing control that controls the upper part temperature of the space S based on the upper part temperature of the space S estimated based on the temperature measured by the suction temperature sensor 21 and the set temperature set by the user (step S203). The ceiling blowing indoor unit 20-1 repeats the operations after step S204 described above.

[0090] As described above, when the system is started, the air conditioning system 1 according to the embodiment performs the heating operation with all units using the floor blowing indoor unit 10 and the ceiling blowing indoor unit 20. Therefore, the temperature inside the space S is quickly raised to a temperature close to the set temperature. Then, the air conditioning system 1 stops the ceiling blowing indoor unit 20 at the point in time when the upper part temperature has risen to a temperature lower than the set temperature by 2°C and switches to a heating operation using only the floor blowing indoor unit 10. Thereafter, the temperature inside the space S is controlled only by the heating operation of the floor blowing indoor unit 10 if it is within a controllable range by the floor blowing indoor unit 10.

[0091] Also, the air conditioning system 1 according to the embodiment finely controls the blowing temperature at low load (for example, at a time other than when the system is started) compared to a case at high load, and thereby comfort can be further improved.

[0092] The blowing temperature controller 11 of the floor blowing indoor unit 10 controls the operation of the floor blowing indoor unit 10 based on time information.

[0093] Even when the air conditioning system 1 is stopped, the temperature of the space S varies due to various reasons depending on time passage. For example, the temperature of the space S rises due to the effect of solar insolation during daylight. The blowing temperature controller 11 controls the operation of the floor blowing indoor unit 10 based on time information associated with the temperature of the space S. In the following explanation, specific examples such as time, temperature, or the like may be noted in brackets.

[0094] FIG. 7 is a diagram showing an example of setting a target lower part temperature with respect to a point in time. For example, an operation of the floor blowing indoor unit 10 of the air conditioning system 1 begins at 7:00 a.m. The operation of the air conditioning system 1 begins according to instruction information of power ON input from the remote controller 25. When the operation of the air conditioning system 1 begins, instruction information of the set temperature is input from the remote controller 25. For example, the set temperature is 24°C.

The blowing temperature controller 11 sets a first temperature as a target lower part temperature. The first temperature is calculated based on the set temperature input from the external remote controller 25. The target lower part temperature is the target of the lower part temperature of the space S. For example, the first temperature is the same as the set temperature and is 24°C. The blowing temperature controller 11 sets, as the first temperature (24°C), the target lower part temperature when the operation of the air conditioning system 1 begins.

[0095] The blowing temperature controller 11 begins the operation of the floor blowing indoor unit 10 in the high-load mode. The lower part temperature rises by the operation of the floor blowing indoor unit 10.

[0096] The blowing temperature controller 11 controls the operation of the floor blowing indoor unit 10 based on information according to the first time.

[0097] The first time is the time at which the temperature of the space S rises during daylight. Generally, the temperature inside the space S rises due to the effect of the solar insolation at times of daytime, after 12:00 (until about 15:00 p.m.). For example, the first time is 12:00.

[0098] The time earlier than the first time (12:00) by a first predetermined amount of time is the second time. For example, the first predetermined amount of time is two hours, and the second time is 10:00 a.m. In the example shown in FIG. 7, the operation of the floor blowing indoor unit 10 begins at 7:00 a.m. earlier than the second time (10:00 a.m.). As shown in FIG. 1, warm air sent from the floor blowing indoor unit 10 blown into the space S from the blowing outlets 50 of the floor surface through the underfloor air supply chamber 45. Heat accumulates under the floor with an increase in the temperature of the space S.

[0099] The blowing temperature controller 11 acquires information indicating the lower part temperature of the space S from the remote thermo sensor 15. The blowing temperature controller 11 determines whether or not the lower part temperature of the space S has reached the second temperature at the second time (10:00 a.m.) shown in FIG. 7. The second temperature is the temperature lower than the first temperature (24°C) by an amount of the first predetermined temperature. For example, the first predetermined temperature is 1°C, and the second temperature is 23°C. If a time sufficiently has elapsed from the beginning of the operation of the floor blowing indoor unit 10 (7:00 a.m.) to the second time (10:00 a.m.), the lower part temperature has reached the second temperature (23°C) at the second time (10:00 a.m.).

[0100] When the lower part temperature has reached the second temperature (23°C) at the second time (10:00 a.m.), the blowing temperature controller 11 sets the second temperature (23°C) as the target lower part temperature. Since the lower part temperature has reached the second temperature (23°C), the lower part temperature has reached the target lower part temperature. The blowing temperature controller 11 temporarily stops the operation of the floor blowing indoor unit 10.

[0101] If a time sufficiently has elapsed from the beginning of the operation of the floor blowing indoor unit 10 (7:00 a.m.) to the second time (10:00 a.m.), a sufficient amount of heat has accumulated under the floor. Even when the operation of the floor blowing indoor unit 10 was temporarily stopped, the lower part temperature of the indoor S rises little by little due to an effect of heat accumulation under the floor. The first predetermined amount of time (two hours), that is, the interval between the second time (10:00 a.m.) and the first time (12:00), is a time period in which the lower part temperature continuously rises due to the effect of heat accumulation under the floor. If the first time (12:00) has elapsed, the lower part temperature rises due to solar insolation. After the second time (10:00 a.m.), the lower part temperature the first temperature (24°C) that is the same as the set temperature input from the remote controller 25 has reached. Even when the operation of the floor blowing indoor unit 10 was temporarily stopped at the second time (10:00 a.m.), the lower part temperature reaches the first temperature (24°C). As the operation of the floor blowing indoor unit 10 was temporarily stopped, energy consumption of the floor blowing indoor unit 10 is reduced.

[0102] The blowing temperature controller 11 sets the first temperature (24°C) as the target lower part temperature at the third time.

[0103] The third time is later than the second time (10:00 a.m.) by a second predetermined amount of time. For example, the second predetermined amount of time is one hour, and the third time is 11:00 a.m. The third time (11:00 a.m.) is the time earlier than the first time (12:00).

[0104] When the lower part temperature of the space S is higher than the temperature obtained by subtracting 0.5°C from the target lower part temperature at the third time (11:00 a.m.), the blowing temperature controller 11 continues the non-operation of the floor blowing indoor unit 10. When the lower part temperature is lower than the temperature obtained by subtracting 0.5°C from the target lower part temperature, the blowing temperature controller 11 resumes the operation of the floor blowing indoor unit 10. The blowing temperature controller 11 resumes the operation of the floor blowing indoor unit 10 by the low-load mode.

[0105] In a case in which solar insolation is not sufficient due to rain or the like, there is a possibility that the lower part temperature does not smoothly rise after the second time (10:00 a.m.). In this case, there is a possibility that the lower part temperature does not reach the first temperature (24°C). As the first temperature (24°C) is set as the target lower part temperature, the lower part temperature reaches the first temperature (24°C) by the operation of the floor blowing indoor unit 10.

[0106] In a case in which solar insolation is sufficient and the lower part temperature smoothly rises after the second time (10:00 a.m.), even in the case in which the first temperature (24°C) is set as the target lower part temperature at the third time (11:00 a.m.), the non-operation of the floor blowing indoor unit 10 continues. The second predetermined amount of time (one hour), that is, the interval between the second time (10:00 a.m.) and the third time (11:00 a.m.) is a time period in which the lower part temperature smoothly rises from the second temperature (23°C) to near the first temperature (24°C). Since the non-operation of the floor blowing indoor unit 10 continues, energy consumption of the floor blowing indoor unit 10 is reduced.

[0107] FIG. 8 is a diagram showing an example of a temperature distribution of the space due to incidence of sunlight R. The blowing temperature controller 11 carries out an operation suppression process of the floor blowing indoor unit 10 based on information according to a first time range. The first time range is a time range in which the sunlight R enters the space S, for example, 10:00 a.m. to 15:00 p.m.

[0108] As described above, the floor blowing indoor unit 10 is installed above the ceiling of the space S. The floor blowing indoor unit 10 suctions air in the ceiling part of the space S from a suction hole 12 provided at the ceiling of the space S. The floor blowing indoor unit 10 includes a suction temperature sensor 13. The suction temperature sensor 13 outputs information representing the suction temperature that is the temperature of the air suctioned by the floor blowing indoor unit 10. The suction temperature corresponds to the ceiling part temperature that is the temperature of the ceiling part of the space S.

[0109] When the ceiling part temperature exceeds a threshold value in the first time range (10:00 a.m. to 15:00 p.m.), the blowing temperature controller 11 carries out the operation suppression process of the floor blowing indoor unit 10. For example, the threshold value is 26°C. The operation suppression process is a process of temporarily stopping the operation of the floor blowing indoor unit 10. The operation suppression process may be a process of lowering the target lower part temperature. As the target lower part temperature is lowered, the lower part temperature of the space S exceeds the target lower part temperature, and the operation of the floor blowing indoor unit 10 is temporarily stopped.

[0110] When the sunlight R enters the space S, the temperature of the ceiling part of the space S firstly rises, thereafter, the upper part temperature (a temperature at near 120 cm above the floor) and the lower part temperature (a temperature at near the remote thermo sensor 15, 30 cm above the floor) rise. There is a possibility that the lower part temperature does not reach the first temperature (24°C) at the point in time when the ceiling part temperature exceeds the threshold value (26°C). Even when the operation of the floor blowing indoor unit 10 was temporarily stopped, as the sunlight R continuously enters the space S, the temperature of each of parts of the space S rises, the lower part temperature reaches the first temperature (24°C). As the operation of the floor blowing indoor unit 10 was temporarily stopped, energy consumption of the floor blowing indoor unit 10 is reduced.

[0111] The blowing temperature controller 11 carries out a temperature correction process from the fourth time.

[0112] As shown in FIG. 7, the fourth time is the time later than the second time (10:00 a.m.) by a third predetermined amount of time. For example, the third predetermined amount of time is two hours, and the fourth time is 12:00.

[0113] The temperature correction process is a process of setting the third temperature as the target lower part temperature. The third temperature is the temperature higher than the first temperature (24°C) by an amount of the second predetermined temperature. For example, the second predetermined temperature is 1°C, and the third temperature is 25°C. The temperature correction process may be a process of using the lower part temperature as a temperature being lower by an amount of the second predetermined temperature (1°C).

[0114] As described above, if a time sufficiently has elapsed from the beginning of the operation of the floor blowing indoor unit 10 (7:00 a.m.) to the second time (10:00 a.m.), a sufficient amount of heat has accumulated under the floor. As the third predetermined amount of time (two hours) has elapsed from the second time (10:00 a.m.), an amount of heat also accumulates in the remote thermo sensor 15. The remote thermo sensor 15 outputs information representing the temperature higher than an actual lower part temperature by an amount of the second predetermined temperature (1°C) due to an effect of heat accumulation. The effect of heat accumulation of the remote thermo sensor 15 continuously occurs until the operation of the air conditioning system 1 is stopped.

[0115] From the fourth time (12:00), the blowing temperature controller 11 sets the third temperature (25°C) as the target lower part temperature in the temperature correction process. Even in a case in which the remote thermo sensor 15 outputs information representing the temperature higher than an actual lower part temperature by an amount of the second predetermined temperature (1°C), the third temperature (25°C) that is the temperature higher than the first temperature (24°C) by an amount of the second predetermined temperature (1°C) is set as the target lower part temperature, the actual lower part temperature is adjusted to be the first temperature (24°C).

[0116] From the fourth time (12:00), the blowing temperature controller 11 uses the lower part temperature output from the remote thermo sensor 15 as a temperature being lower by an amount of the second predetermined temperature (1°C) in the temperature correction process. Even in a case in which the remote thermo sensor 15 outputs a temperature higher than the actual lower part temperature by an amount of the second predetermined temperature (1°C), the blowing temperature controller 11 can use the actual lower part temperature as a control temperature.

[0117] From the fourth time (12:00), the blowing temperature controller 11 causes the output of the floor blowing indoor unit 10 to be lowered, and the blowing temperature controller 11 operates the floor blowing indoor unit 10.

[0118] As described above, the blowing temperature controller 11 causes the blowing temperature from the blowing outlets 50 (refer to FIG. 8) to be close to the upper limit temperature shown in FIG. 4 during the operation of the floor blowing indoor unit 10 in the low-load mode. As described above, the suction temperature sensor 13 (refer to FIG. 8) outputs information representing the suction temperature that is the temperature of the air suctioned by the floor blowing indoor unit 10. The blowing temperature controller 11 calculates the output of the floor blowing indoor unit 10 based on the difference between the blowing temperature and the suction temperature.

[0119] The blowing temperature controller 11 similarly calculates the output of the floor blowing indoor unit 10 before or after the fourth time (12:00). The blowing temperature controller 11 multiplies the calculated output of the floor blowing indoor unit 10 by a predetermined proportion and determines the output of the floor blowing indoor unit 10 after the fourth time (12:00). For example, the predetermined proportion is 0.6. Accordingly, the blowing temperature is suppressed to be within a temperature obtained by adding approximately +2°C to the suction temperature.

[0120] A large amount of heat is accumulated in each of parts of the space S from under floor to the remote thermo sensor 15 at the fourth time (12:00). Even in a case of suppressing the blowing temperature, the lower part temperature of the space S rises due to the effect of heat accumulation. As the output of the floor blowing indoor unit 10 is suppressed, energy consumption of the floor blowing indoor unit 10 is reduced.

[0121] The blowing temperature controller 11 controls the operation of the floor blowing indoor unit 10 based on information according to the fifth time.

[0122] The fifth time is the time at which an operation of the air conditioning system 1 (the ceiling blowing indoor unit 20 and the floor blowing indoor unit 10) are stopped during night. The fifth time is the time set by a timer of the remote controller 25, for example, 21:00 p.m. The time earlier than the fifth time (21:00 p.m.) by an amount of a fourth predetermined amount of time is the sixth time. For example, the fourth predetermined amount of time is one hour, and the sixth time is 20:00 p.m.

[0123] When the lower part temperature of the space S has reached the target lower part temperature before the sixth time (20:00 p.m.), the blowing temperature controller 11 carries out the operation suppression process of the floor blowing indoor unit 10 at the sixth time (20:00 p.m.). When the lower part temperature has reached the target lower part temperature before the sixth time (20:00 p.m.), at the sixth time (20:00 p.m.), the operation of the floor blowing indoor unit 10 is temporarily stopped or the floor blowing indoor unit 10 is operated by the low-load mode.

[0124] When the lower part temperature has reached the target lower part temperature before the sixth time (20:00 p.m.), the lower part temperature of the sixth time (20:00 p.m.) is close to the target lower part temperature. A sufficient amount of heat has accumulated under the floor at the sixth time (20:00 p.m.). Even when the operation of the floor blowing indoor unit 10 was stopped at the sixth time (20:00 p.m.), the lower part temperature is maintained to be near the target lower part temperature due to the effect of heat accumulation under the floor until the fifth time (21:00 p.m.). The fourth predetermined amount of time (one hour), that is, the interval between the sixth time (20:00 p.m.) and the fifth time (21:00 p.m.) is a time period in which the lower part temperature is maintained due to the effect of heat accumulation under the floor. As the operation of the floor blowing indoor unit 10 is stopped at the sixth time (20:00 p.m.) earlier than the fifth time (21:00 p.m.), energy consumption of the floor blowing indoor unit 10 is reduced.

[0125] As described above in detail, the air conditioning system 1 according to the embodiment includes the ceiling blowing indoor unit 20, the floor blowing indoor unit 10, and the blowing temperature controller 11. The ceiling blowing indoor unit 20 blows temperature-controlled air from the ceiling part of the space S to the inside of the space S. The floor blowing indoor unit 10 blows temperature-controlled air from the floor part of the space S to the inside of the space S. The blowing temperature controller 11 controls the operation of the floor blowing indoor unit 10 based on the lower part temperature and the target lower part temperature. The lower part temperature is the temperature in the lower part of the space S. The target lower part temperature is the target of the lower part temperature. The blowing temperature controller 11 controls the operation of the floor blowing indoor unit 10 based on time information associated with the temperature of the space S.

[0126] As the operation of the floor blowing indoor unit 10 is controlled based on time information associated with the temperature of the space S, even in a case of suppressing the operation of the floor blowing indoor unit 10, the lower part temperature comes close to the target lower part temperature. Consequently, energy consumption of the air conditioning system 1 is reduced.

[0127] The time information is the information of the first time (12:00) at which the temperature of the space S rises during daylight. Before the second time (10:00 a.m.) that is the time earlier than the first time (12:00) by an amount of the first predetermined amount of time (two hours), there is a case in which, the first temperature (24°C) calculated based on the input from the remote controller 25 is set as the target lower part temperature, and an operation of the floor blowing indoor unit 10 begins. There is a case in which the lower part temperature has reached the second temperature (23°C) that is the temperature lower than the first temperature (24°C) by an amount of the first predetermined temperature (1°C) at the second time (10:00 a.m.). In such cases, the blowing temperature controller 11 sets the second temperature (23°C) as the target lower part temperature from the second time (10:00 a.m.) and controls the operation of the floor blowing indoor unit 10.

[0128] In such cases, a sufficient amount of heat has accumulated under the floor at the second time (10:00 a.m.). As the second temperature (23°C) is set as the target lower part temperature at the second time (10:00 a.m.), the operation of the floor blowing indoor unit 10 is temporarily stopped. Even when the operation of the floor blowing indoor unit 10 was temporarily stopped at the second time (10:00 a.m.), the lower part temperature reaches the first temperature (24°C). As the operation of the floor blowing indoor unit 10 was temporarily stopped, energy consumption of the air conditioning system 1 is reduced.

[0129] The time earlier than the first time (12:00) and later than the second time (10:00 a.m.) by an amount of the second predetermined amount of time (one hour) is the third time (11:00 a.m.). From the third time (11:00 a.m.), the blowing temperature controller 11 sets the first temperature (24°C) as the target lower part temperature controls the operation of the floor blowing indoor unit 10.

[0130] There is a case in which the lower part temperature does not smoothly rise after the second time (10:00 a.m.). As the first temperature (24°C) is set as the target lower part temperature from the third time (11:00 a.m.), the lower part temperature reaches the first temperature (24°C) by the operation of the floor blowing indoor unit 10.

[0131] In a case in which the lower part temperature smoothly rises after the second time (10:00 a.m.), even in a case of setting the first temperature (24°C) as the target lower part temperature from the third time (11:00 a.m.), the temporal non-operation of the floor blowing indoor unit 10 continues. Energy consumption of the air conditioning system 1 is reduced.

[0132] The time information is the information of the first time range (10:00 a.m. to 15:00 p.m.) in which the sunlight R enters the space S. The temperature of the ceiling part of the space S is the ceiling part temperature. In a case in which the ceiling part temperature exceeds the threshold value (26°C) in the first time range (10:00 a.m. to 15:00 p.m.), the blowing temperature controller 11 carries out the operation suppression process of the floor blowing indoor unit 10. The operation suppression process is a process of temporarily stopping the operation of the floor blowing indoor unit 10 or a process of lowering the target lower part temperature.

[0133] When the sunlight R enters the space S, the temperature of the ceiling part of the space S firstly rises, thereafter, the lower part temperature rises. Even when the operation of the floor blowing indoor unit 10 was temporarily stopped, the temperature of each of parts of the space S rises, the lower part temperature reaches the first temperature (24°C). As the operation of the floor blowing indoor unit 10 was temporarily stopped, energy consumption of the air conditioning system 1 is reduced.

[0134] The time later than the second time (10:00 a.m.) by an amount of the third predetermined amount of time (two hours) is the fourth time (12:00). The blowing temperature controller 11 carries out the temperature correction process from the fourth time (12:00) and controls an operation of the floor blowing indoor unit 10. The temperature correction process is a process of setting the third temperature (25°C) higher than the first temperature (24°C) by an amount of the second predetermined temperature (1°C) as the target lower part temperature or a process of using the lower part temperature as a temperature being lower by an amount of the second predetermined temperature (1°C).

[0135] As the third predetermined amount of time (two hours) has elapsed from the second time (10:00 a.m.), heat accumulates in the remote thermo sensor 15, and the remote thermo sensor 15 outputs information representing the temperature higher than an actual lower part temperature by an amount of the second predetermined temperature (1°C). The actual lower part temperature is adjusted to be the first temperature (24°C) by the temperature correction process.

[0136] From the fourth time (12:00), the blowing temperature controller 11 causes the output of the floor blowing indoor unit 10 to be lowered and controls the operation of the floor blowing indoor unit 10.

[0137] A large amount of heat is accumulated in each of parts of the space S from under floor to the remote thermo sensor 15 at the fourth time (12:00). Even in the case of lowering the output of the floor blowing indoor unit 10, the lower part temperature rises due to the effect of heat accumulation. Energy consumption of the air conditioning system 1 is reduced by lowering the output of the floor blowing indoor unit 10.

[0138] The time information is the information of the fifth time (21:00 p.m.) at which the operations of the ceiling blowing indoor unit 20 and the floor blowing indoor unit 10 are stopped during night. The time earlier than the fifth time (21:00 p.m.) by an amount of the fourth predetermined amount of time (one hour) is the sixth time (20:00 p.m.). When the lower part temperature reaches the target lower part temperature before the sixth time (20:00 p.m.), the blowing temperature controller 11 stops the operation of the floor blowing indoor unit 10 at the sixth time (20:00 p.m.).

[0139] If the lower part temperature has reached the target lower part temperature before the sixth time (20:00 p.m.), a sufficient amount of heat has accumulated under the floor at the sixth time (20:00 p.m.). Even when the operation of the floor blowing indoor unit 10 was stopped at the sixth time (20:00 p.m.), the lower part temperature is maintained to be near the target lower part temperature due to the effect of heat accumulation under the floor until the fifth time (21:00 p.m.). Energy consumption of the air conditioning system 1 is reduced by stopping the operation of the floor blowing indoor unit 10 at the sixth time (20:00 p.m.) earlier than the fifth time (21:00 p.m.).

[0140] Part of the air conditioning system 1 of the above-described embodiment may be realized by a computer. In that case, a program for realizing these functions may be recorded on a computer-readable recording medium and realized by causing a computer system to read and execute the program recorded on the recording medium. Furthermore, the "computer system" described herein includes an operating system (OS) and a hardware such as peripherals. Also, the "computer-readable recording medium" refers to a portable medium such as a flexible disk, a magneto-optical disk, a read-only memory (ROM), or a compact disc read-only memory (CD-ROM), and a storage device such as a hard disk built in the computer system. Furthermore, the "computer-readable recording medium" may include one that holds a program dynamically for a short period of time such as a communication line in a case in which programs are transmitted via a network such as the Internet or a communication line such as a telephone line, and one that holds a program for a certain period of time such as volatile memories inside a computer system serving as a server or client in the above-described case. Furthermore, the above-described program may be a program for realizing some of the above-described functions, further may be a program for realizing the above-described functions in combination with programs already recorded on the computer system, and may be realized by using hardware such as a programmable logic device (PLD), a field programmable gate array (FPGA), or the like.

[0141] According to at least one embodiment described above, the blowing temperature controller 11 is provided which controls an operation of the floor blowing indoor unit 10 based on time information associated with the temperature of the space S. Accordingly, it is possible to reduce energy consumption of the air conditioning system 1.

[0142] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

[DESCRIPTION OF REFERENCE NUMERALS]

[0143] R...sunlight, S...space, 1...air conditioning system, 10...floor blowing indoor unit (second indoor unit), 11...blowing temperature controller (control unit), 20...ceiling blowing indoor unit (first indoor unit), 25...remote controller (external).

Claims

1. An air conditioning system comprising:

a first indoor unit that blows temperature-controlled air from a ceiling part of a space to an inside of the space;
a second indoor unit that blows temperature-controlled air from a floor part of the space to the inside of the space; and
a control unit that controls an operation of the second indoor unit based on a lower part temperature and a target lower part temperature, the lower part temperature being a temperature in a lower part of the space, the target lower part temperature being a target of the lower part temperature, wherein
the control unit controls the operation of the second indoor unit based on time information associated with a temperature of the space.

2. The air conditioning system according to claim 1, wherein

the time information is information according to a first time when the temperature of the space rises during daylight, wherein
before a second time earlier than the first time by a first predetermined amount of time, in a case in which a first temperature calculated based on an input from an outside is set as the target lower part temperature, and the operation of the second indoor unit began, and in a case in which the lower part temperature reaches a second temperature that is a temperature lower than the first temperature by an amount of a first predetermined temperature at the second time, from the second time, the control unit sets the second temperature as the target lower part temperature and controls the operation of the second indoor unit.

3. The air conditioning system according to claim 2, wherein

in a case in which a time earlier than the first time and later than the second time by a second predetermined amount of time is a third time,
from the third time, the control unit sets the first temperature as the target lower part temperature and controls the operation of the second indoor unit.

4. The air conditioning system according to any one of claims 1 to 3, wherein

the time information is information according to a first time range in which sunlight enters the space,

in a case in which a temperature of the ceiling part of the space is referred to as a ceiling part temperature,

the control unit carries out an operation suppression process of the second indoor unit in a case in which the ceiling part temperature exceeds a threshold value in the first time range, and

the operation suppression process is a process of stopping the operation of the second indoor unit or a process of lowering the target lower part temperature.

5. The air conditioning system according to claim 2, wherein

in a case in which a time later than the second time by a third predetermined amount of time is a fourth time,

from the fourth time, the control unit carries out a temperature correction process and controls the operation of the second indoor unit, and

the temperature correction process is a process of setting a third temperature that is a temperature higher than the first temperature by an amount of a second predetermined temperature as the target lower part temperature or a process of using the lower part temperature as a temperature being lower by an amount of the second predetermined temperature.

6. The air conditioning system according to claim 5, wherein
from the fourth time, the control unit lowers an output of the second indoor unit and controls the operation of the second indoor unit.

7. The air conditioning system according to any one of claims 1 to 3, wherein

the time information is information according to a fifth time when the operations of the first indoor unit and the second indoor unit are stopped during night,

in a case in which a time earlier than the fifth time by a fourth predetermined amount of time is a sixth time,

the control unit stops the operation of the second indoor unit at the sixth time in a case in which the lower part temperature reached the target lower part temperature before the sixth time.

8. A controller of an air conditioning system,

the air conditioning system comprising:

a first indoor unit that blows temperature-controlled air from a ceiling part of a space to an inside of the space; and

a second indoor unit that blows temperature-controlled air from a floor part of the space to the inside of the space, wherein

the controller controls an operation of the second indoor unit based on time information associated with a lower part temperature, a target lower part temperature, and a temperature of the space,

the lower part temperature is a temperature in a lower part of the space, and

the target lower part temperature is a target of the lower part temperature.

9. A control method of an air conditioning system,

the air conditioning system comprising:

a first indoor unit that blows temperature-controlled air from a ceiling part of a space to an inside of the space; and

a second indoor unit that blows temperature-controlled air from a floor part of the space to the inside of the space, wherein

the control method comprises a step of controlling an operation of the second indoor unit based on time information associated with a lower part temperature, a target lower part temperature, and a temperature of the space,

the lower part temperature is a temperature in a lower part of the space, and

the target lower part temperature is a target of the lower part temperature.

10. A program used in a computer of an air conditioning system,

the air conditioning system comprising:

a first indoor unit that blows temperature-controlled air from a ceiling part of a space to an inside of the space; and

a second indoor unit that blows temperature-controlled air from a floor part of the space to the inside of the space, wherein

the program causes the computer of the air conditioning system to execute a step of controlling an operation of the second indoor unit based on time information associated with a lower part temperature, a target lower part temperature, and a temperature of the space,

the lower part temperature is a temperature in a lower part of the space, and

the target lower part temperature is a target of the lower part temperature.

FIG. 1

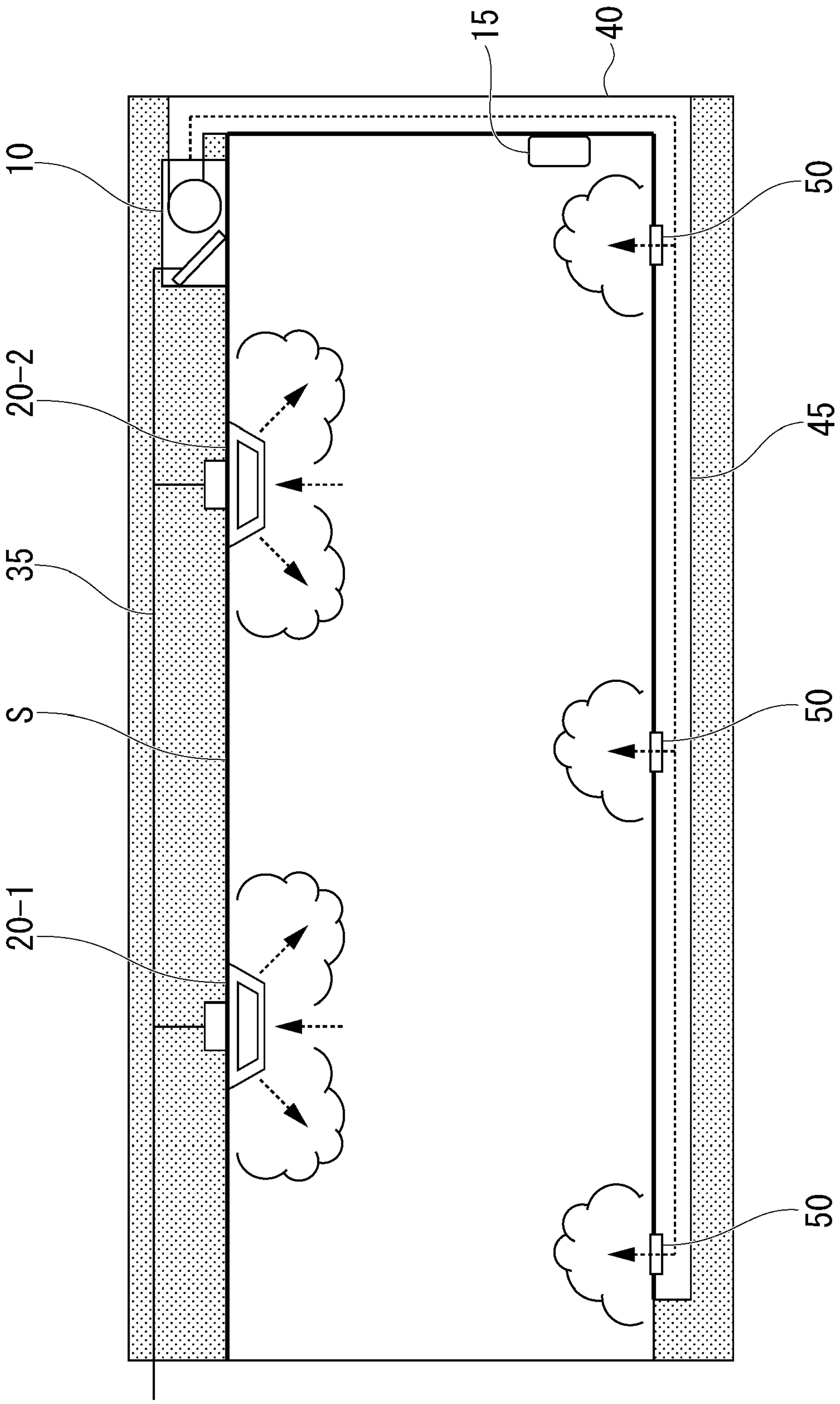


FIG. 2

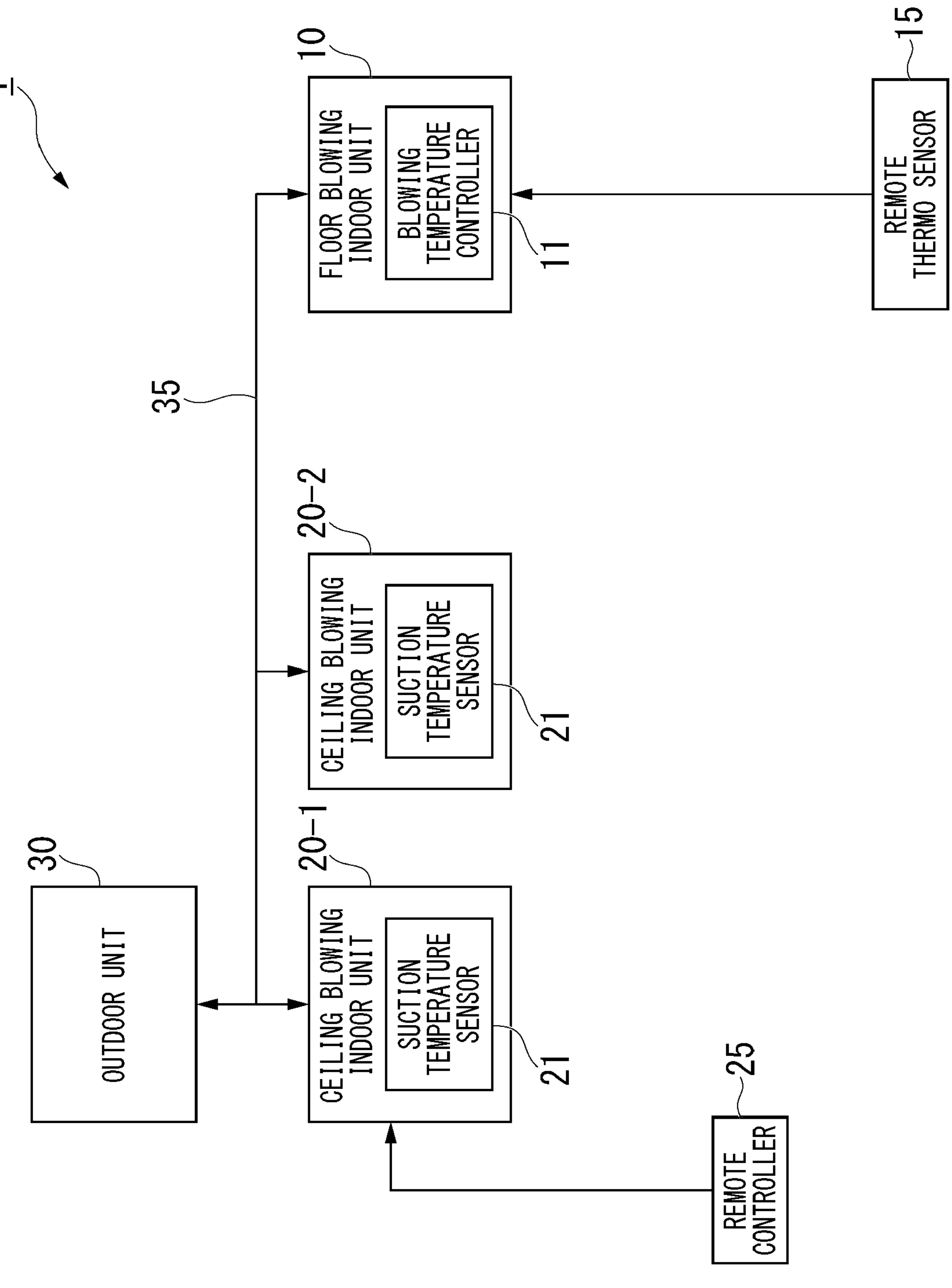

1
30
OUTDOOR UNIT
35
20-1
CEILING BLOWING INDOOR UNIT
SUCTION TEMPERATURE SENSOR
21
20-2
CEILING BLOWING INDOOR UNIT
SUCTION TEMPERATURE SENSOR
21
10
FLOOR BLOWING INDOOR UNIT
BLOWING TEMPERATURE CONTROLLER
11
25
REMOTE CONTROLLER
15
REMOTE THERMO SENSOR

FIG. 3

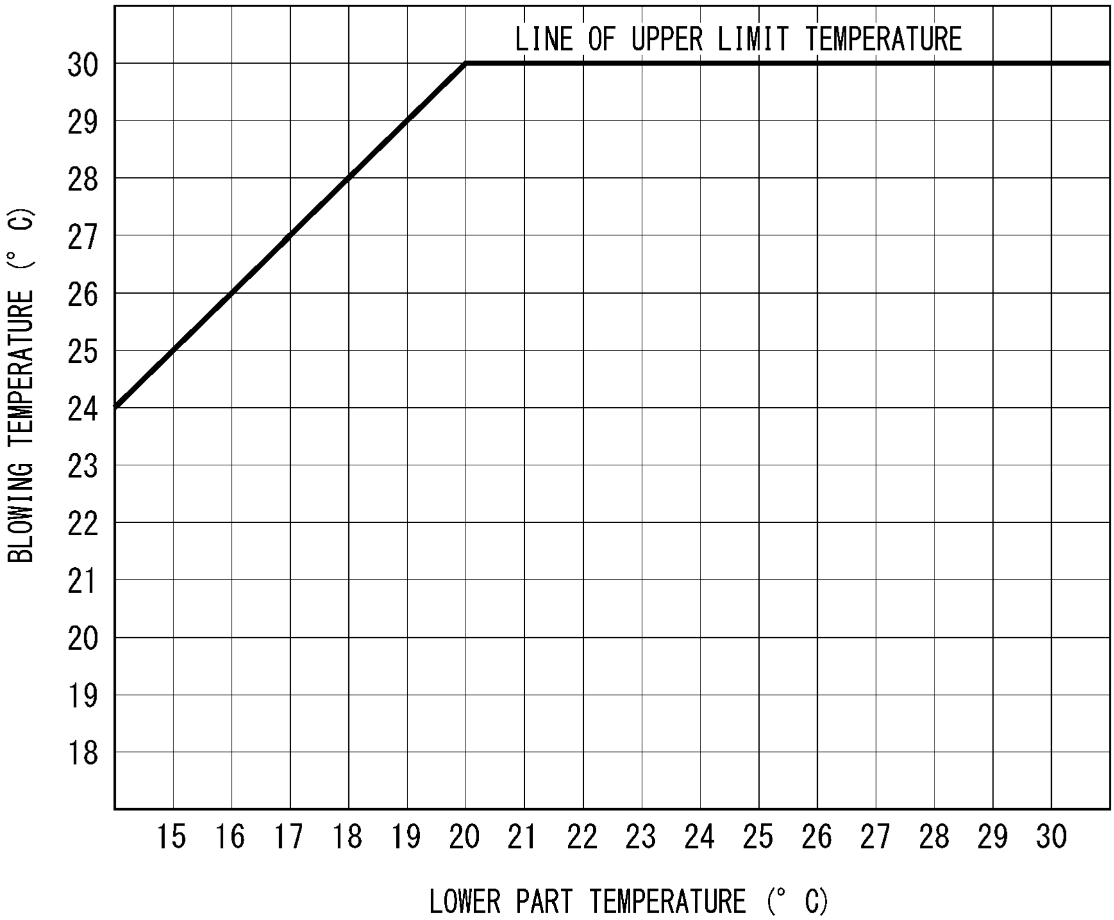
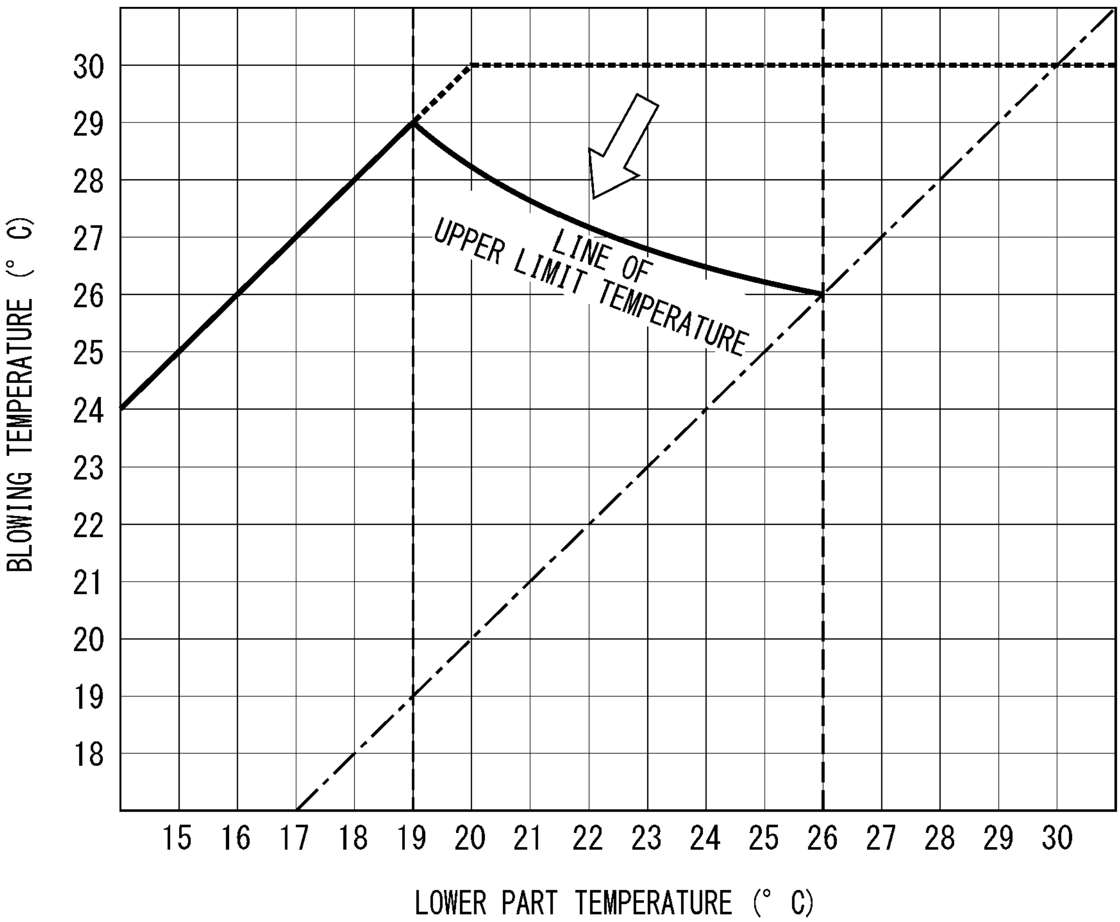

LINE OF UPPER LIMIT TEMPERATURE
BLOWING TEMPERATURE (° C)
30
29
28
27
26
25
24
23
22
21
20
19
18
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
LOWER PART TEMPERATURE (° C)

FIG. 4



BLOWING TEMPERATURE (° C)
30
29
28
27
26
25
24
23
22
21
20
19
18
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
LOWER PART TEMPERATURE (° C)
LINE OF
UPPER LIMIT TEMPERATURE

FIG. 5

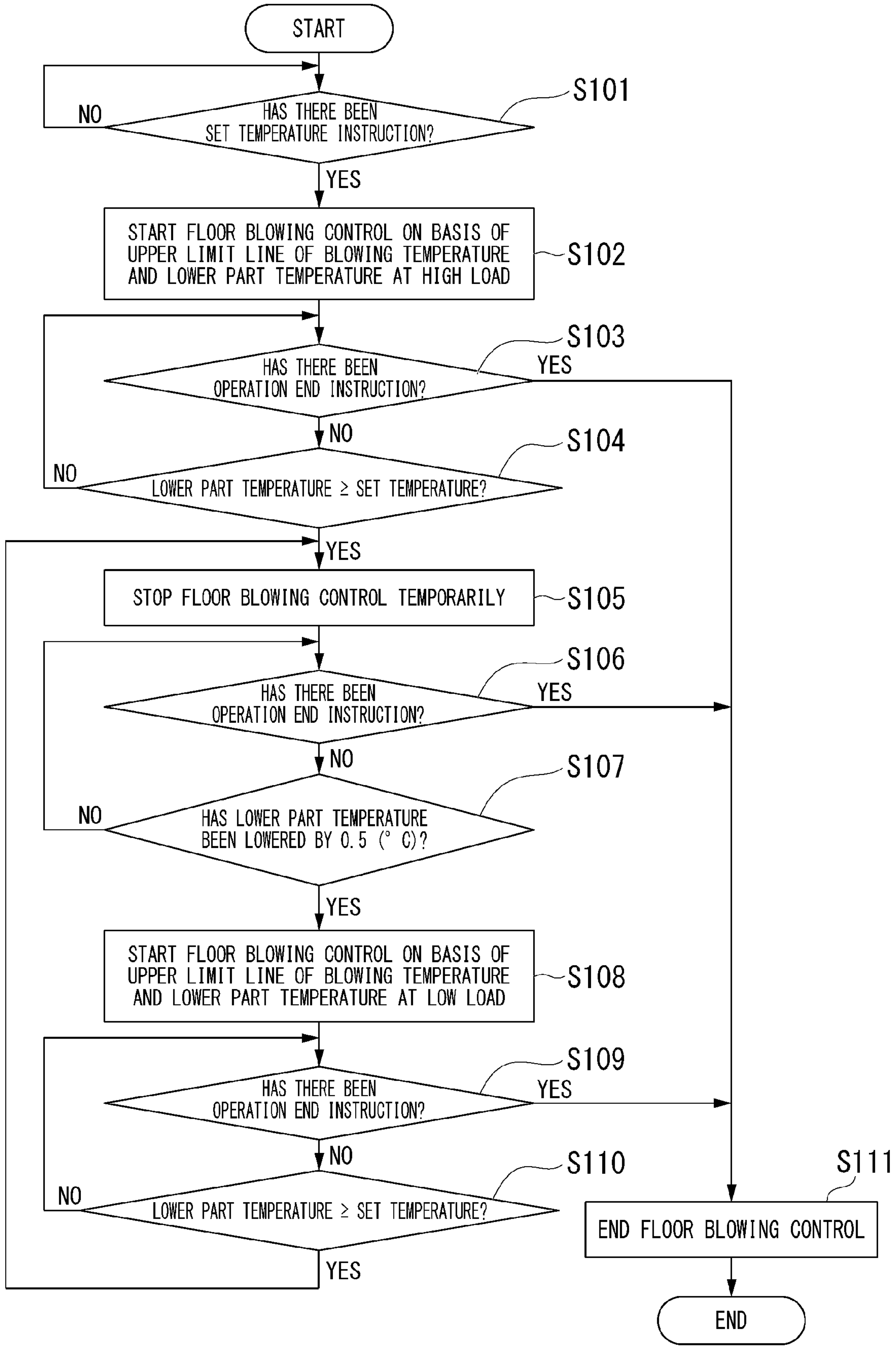

START
HAS THERE BEEN SET TEMPERATURE INSTRUCTION?
S101
NO
YES
START FLOOR BLOWING CONTROL ON BASIS OF UPPER LIMIT LINE OF BLOWING TEMPERATURE AND LOWER PART TEMPERATURE AT HIGH LOAD
S102
HAS THERE BEEN OPERATION END INSTRUCTION?
S103
YES
NO
LOWER PART TEMPERATURE ≥ SET TEMPERATURE?
S104
NO
YES
STOP FLOOR BLOWING CONTROL TEMPORARILY
S105
HAS THERE BEEN OPERATION END INSTRUCTION?
S106
YES
NO
HAS LOWER PART TEMPERATURE BEEN LOWERED BY 0.5 (° C)?
S107
NO
YES
START FLOOR BLOWING CONTROL ON BASIS OF UPPER LIMIT LINE OF BLOWING TEMPERATURE AND LOWER PART TEMPERATURE AT LOW LOAD
S108
HAS THERE BEEN OPERATION END INSTRUCTION?
S109
YES
NO
LOWER PART TEMPERATURE ≥ SET TEMPERATURE?
S110
NO
YES
END FLOOR BLOWING CONTROL
S111
END

FIG. 6

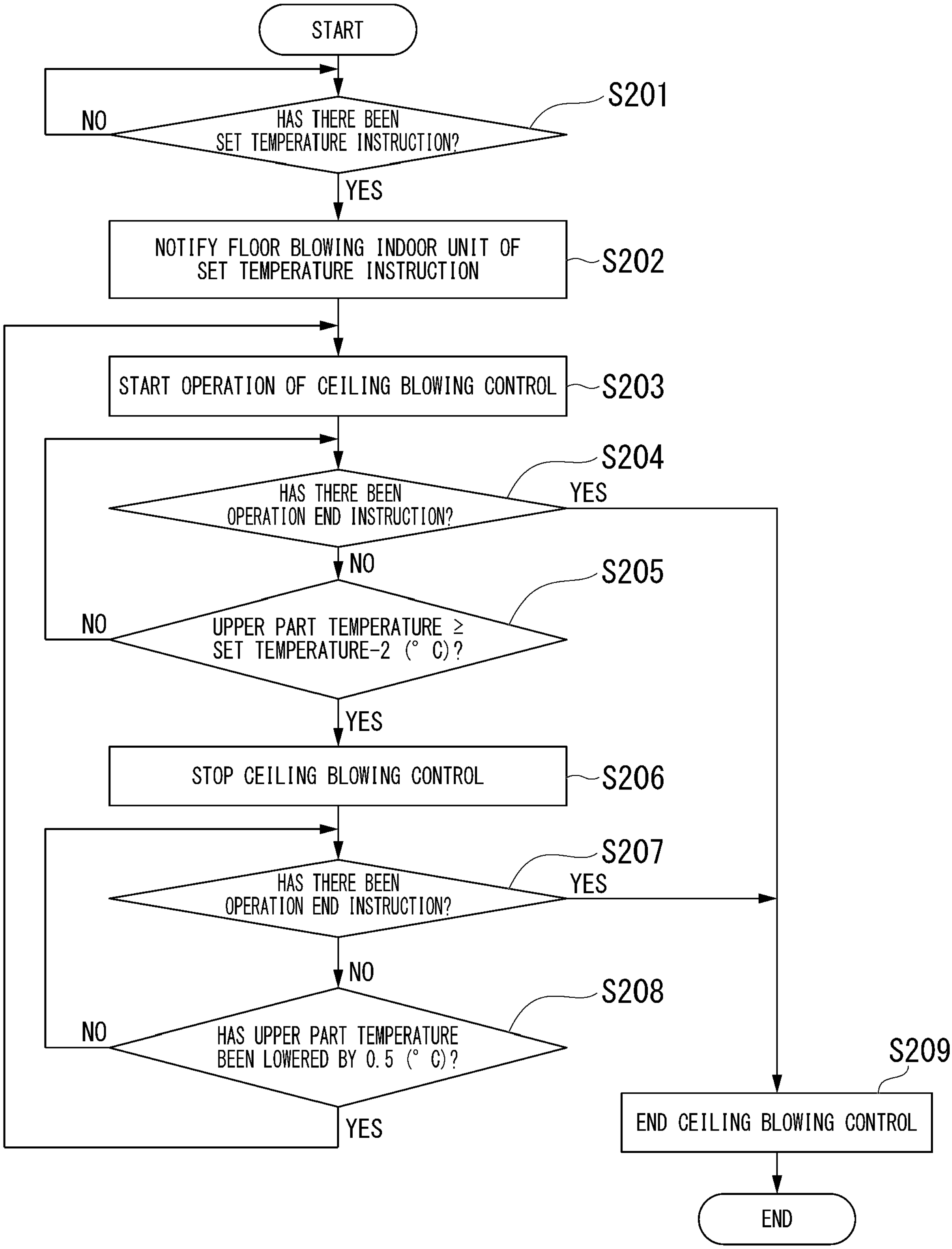

START
HAS THERE BEEN SET TEMPERATURE INSTRUCTION?
S201
NO
YES
NOTIFY FLOOR BLOWING INDOOR UNIT OF SET TEMPERATURE INSTRUCTION
S202
START OPERATION OF CEILING BLOWING CONTROL
S203
HAS THERE BEEN OPERATION END INSTRUCTION?
S204
YES
NO
UPPER PART TEMPERATURE ≥ SET TEMPERATURE-2 (° C)?
S205
NO
YES
STOP CEILING BLOWING CONTROL
S206
HAS THERE BEEN OPERATION END INSTRUCTION?
S207
YES
NO
HAS UPPER PART TEMPERATURE BEEN LOWERED BY 0.5 (° C)?
S208
NO
YES
END CEILING BLOWING CONTROL
S209
END

FIG. 7

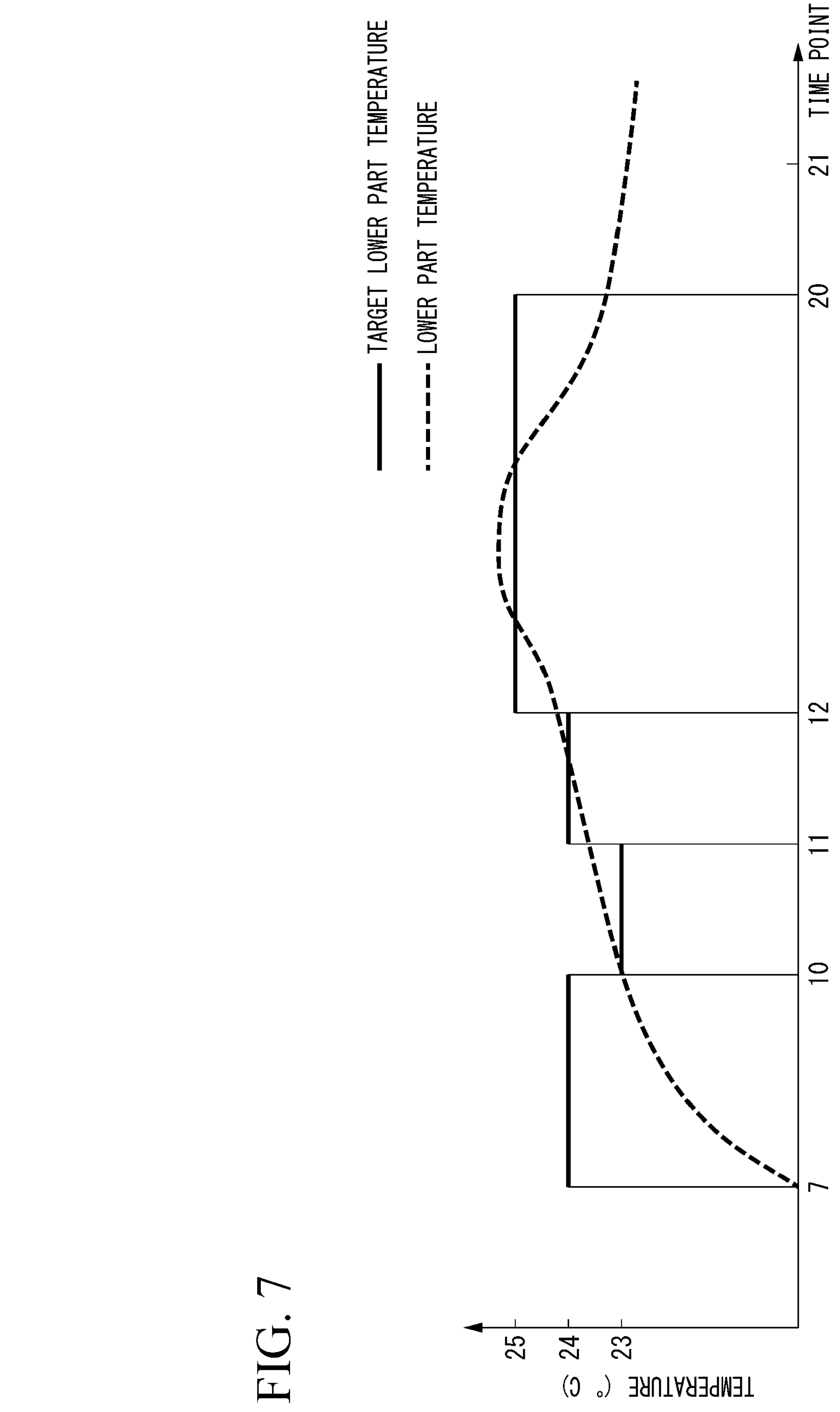
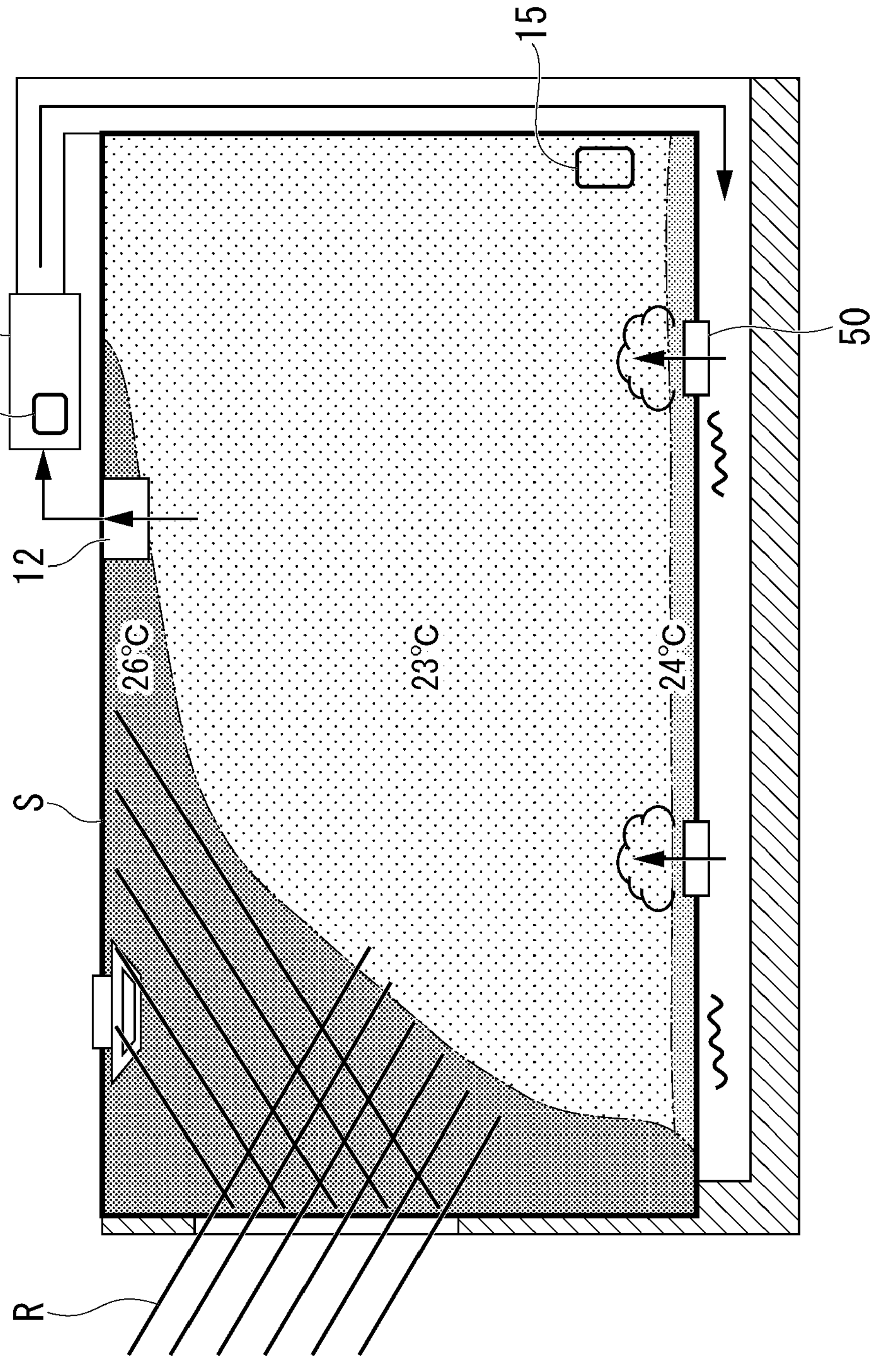

TARGET LOWER PART TEMPERATURE
LOWER PART TEMPERATURE
TEMPERATURE (° C)
25
24
23
TIME POINT
7
10
11
12
20
21

FIG. 8



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EUROPEAN SEARCH REPORT

Application Number
EP 24 16 2757

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2022/215252 A1 (TOSHIBA CARRIER CORP [JP]) 13 October 2022 (2022-10-13) * paragraphs [0001] - [0121]; figures 1-6 *	1-10	INV. F24D5/02 F24D5/12 F24D19/10 F24H15/254
X	JP 2022 161664 A (NARA NATIONAL INSTITUTE OF HIGHER EDUCATION AND RES ET AL.) 21 October 2022 (2022-10-21) * paragraphs [0009] - [0136]; figures 1-9 *	1-10	
A	WO 2016/016659 A1 (OVE ARUP & PARTNERS INTERNAT LTD [GB]) 4 February 2016 (2016-02-04) * page 11, line 4 - page 15, line 12; figures 1-2 *	1-10	
			TECHNICAL FIELDS SEARCHED (IPC)
			F24D F24F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	10 July 2024	Hoffmann, Stéphanie

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

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10-07-2024

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		WO 2022215252 A1	13-10-2022
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		JP 2022123026 A	23-08-2022
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		WO 2016016659 A1	04-02-2016

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- JP 3263324 B **[0003]**