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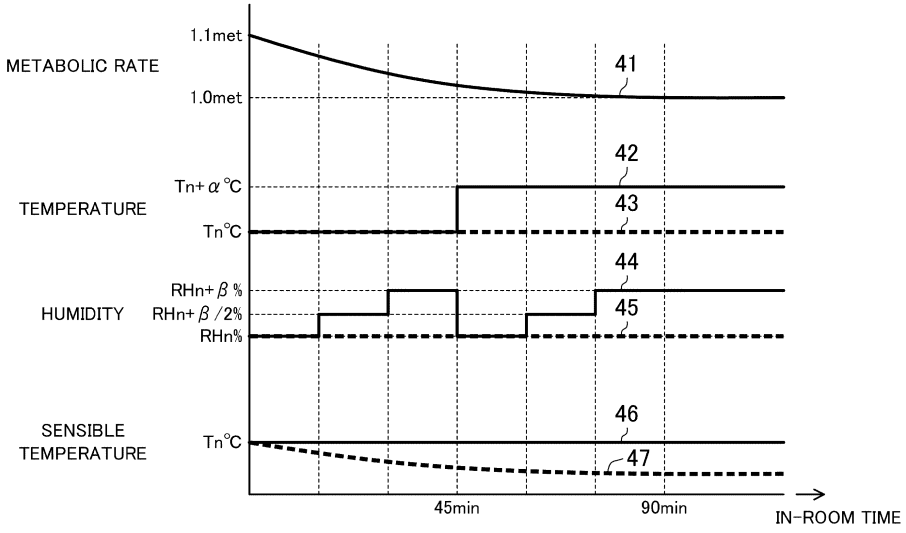
(54) **AIR CONDITIONING SYSTEM**

(57) An air-conditioning system includes a temperature control unit configured to control an indoor temperature; a humidity control unit (12) configured to control an indoor humidity; and a control unit (13) configured to control the temperature control unit (11) and the humidity control unit (12) so that the indoor temperature approaches a target temperature, and the indoor humidity approaches a target humidity. The control unit (13) is configured to perform an operation in a first mode where the target temperature and the target humidity are changed so as not to reduce a sensible temperature of a person (40) in a target room.

FIG.4



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to an air-conditioning system.

BACKGROUND ART

[0002] Separately controlling the temperature and the humidity of air by air conditioners to improve the comfort has been known. For example, the Patent Document 1 discloses an air-conditioning device including: a heat exchanger configured to exchange heat between heat-dissipating air and heat-absorbing air; a humidity medium for absorbing moisture from the heat-dissipating air and releases the moisture to the heat-absorbing air; a dehumidification means configured to regenerate the humidity medium; and a heat supply mean configured to supply heat to regenerate the humidity medium using the dehumidification means.

CITATION LIST

PATENT DOCUMENT

[0003] PATENT DOCUMENT 1: Japanese Unexamined Patent Publication No. 2000-320864

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0004] In the air conditioning using the conventional air-conditioning device, even if the indoor temperature and indoor humidity are kept constant, the user in a target room to be air-conditioned may feel deterioration in comfort.

[0005] An object of the present disclosure is to provide an air-conditioning system capable of further keeping comfort.

SOLUTION TO THE PROBLEM

[0006] A first aspect of the present disclosure is directed to an air-conditioning system including: a temperature control unit (11) configured to control an indoor temperature; a humidity control unit (12) configured to control an indoor humidity; and a control unit (13) configured to control the temperature control unit (11) and the humidity control unit (12) so that the indoor temperature approaches a target temperature and the indoor humidity approaches a target humidity. The control unit (13) is configured to perform an operation in a first mode where the target temperature and the target humidity are changed to substantially prevent a decline in a sensible temperature of a person (40) in a target room.

[0007] In the first aspect, the target temperature and the target humidity are controlled in consideration of the sensible temperature of the person (40) in the target room. This further keeps the comfort.

[0008] A second aspect of the present disclosure is an embodiment of the first aspect. In the second aspect, the control unit (13) performs, as the operation in the first mode, a first operation where the target humidity is stepwise increased once or multiple times while keeping the target temperature, and a second operation where the target temperature is increased and the target humidity is decreased, in this order at least once each.

[0009] In the second aspect, the target temperature and the target humidity are both changed. This enables the sensible temperature of the person (40) in the target room to be kept further accurately, as compared with the case of changing only the target temperature.

[0010] A third aspect of the present disclosure is an embodiment of the first or second aspect. In the third aspect, a target humidity at start of the operation in the first mode is set in a predetermined range determined so that a skin moisture content of the person (40) in the target room is in a suitable range.

[0011] The third aspect allows a person in the target room to be avoided from feeling itchy skin, sticky skin, and the like.

[0012] A fourth aspect of the present disclosure is an embodiment of any one of the first to third aspects. In the fourth aspect, a target humidity at start of the operation in the first mode is set to be equal to or lower than a predetermined upper limit at which growth of mold is avoided.

[0013] The fourth aspect allows avoidance of the growth of mold.

[0014] A fifth aspect of the present disclosure is an embodiment of any one of the first to fourth aspects. In the fifth aspect, the control unit (13) includes an estimator (31) configured to estimate a comfortable indoor temperature at which the person (40) in the target room feels comfortable, and the target temperature is the comfortable indoor temperature estimated by the estimator (31).

[0015] The fifth aspect enables control to estimate the comfortable indoor temperature for the person (40) in the target room.

[0016] A sixth aspect of the present disclosure is an embodiment of the fifth aspect. In the sixth aspect, the air-conditioning system further includes: an outdoor air temperature detector (26) configured to detect an outdoor air temperature; and a storage (32) storing relationship information (33) indicating a relationship between the comfortable temperature and the outdoor air temperature, and the control unit (13) estimates the comfortable temperature based on the outdoor air temperature detected using the outdoor air temperature detector (26), by using the relationship information (33) stored in the storage (32).

[0017] The sixth aspect enables setting a target temperature by using the outdoor air temperature and the relationship information (33).

[0018] A seventh aspect of the present disclosure is an embodiment of the fifth aspect. In the seventh aspect, the estimator (31) estimates the comfortable temperature from a learned model trained on a parameter for environment information including at least one of an indoor temperature, an indoor humidity, an indoor illuminance, an outdoor temperature, or an outdoor humidity, and a parameter for thermal sensation of the person (40) in the target room.

[0019] The seventh aspect enables setting the target temperature by using a learned model.

[0020] An eighth aspect of the present disclosure is an embodiment of any one of the first to seventh aspects. In the eighth aspect, the air-conditioning system further includes: a ventilation unit (14) configured to ventilate indoor air; and a carbon dioxide level detector (23) configured to detect a carbon dioxide level in the target room, and the control unit (13) operates the ventilation unit (14) when the carbon dioxide level detected using the carbon dioxide level detector (23) is equal to or higher than a predetermined level.

[0021] The eighth aspect enables control of the carbon dioxide level in the room.

[0022] A ninth aspect of the present disclosure is an embodiment of any one of the first to eighth aspects. In the ninth aspect, the air-conditioning system further includes: a controller (15) having a function to start the operation in the first mode.

[0023] The ninth aspect enables the use of the controller (15) to start an operation in the first mode.

[0024] A tenth aspect of the present disclosure is an embodiment of any one of the first to ninth aspects. In the tenth aspect, the air-conditioning system further includes: an activity detector (24) configured to detect an activity amount of the person (40) in the target room, and when the activity amount of the person (40) in the target room detected using the activity detector (24) is equal to or lower than a predetermined level, the control unit (13) starts the operation in the first mode.

[0025] The tenth aspect enables automatic start of the operation in the first mode in a situation where the operation in the first mode is desirably started.

[0026] An eleventh aspect of the present disclosure is an embodiment of any one of the first to ninth aspects. In the eleventh aspect, the air-conditioning system further includes: an activity detector (24) configured to detect an activity amount of the person (40) in the target room, and when the activity amount of the person (40) in the target room detected using the activity detector (24) is equal to or higher than a predetermined level during the operation in the first mode, the control unit (13) stops the operation in the first mode.

[0027] The eleventh aspect enables automatic stop of the operation in the first mode in a situation where the operation in the first mode is desirably stopped.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028]

FIG. 1 schematically illustrates a configuration of an air-conditioning system of the present disclosure.

FIG. 2 is a block diagram showing a control unit and components related to the control unit in the air-conditioning system of the present disclosure.

FIG. 3 is a flowchart illustrating an operation of the air-conditioning system of the present disclosure.

FIG. 4 illustrates an example control of an indoor temperature and indoor humidity performed by the air-conditioning system of the present disclosure.

FIG. 5 illustrates a method of determining a target humidity in the air-conditioning system of the present disclosure.

FIG. 6 illustrates an example method of determining a comfortable temperature set as a target temperature in the air-conditioning system of the present disclosure.

FIG. 7 illustrates an example method of determining a comfortable temperature set as a target temperature in the air-conditioning system of the present disclosure.

DESCRIPTION OF EMBODIMENTS

[0029] An embodiment of the present disclosure will be described with reference to the accompanying drawings. An exemplary air-conditioning system of the present embodiment has a configuration schematically illustrated in FIG. 1.

-Configuration of Air-Conditioning System-

[0030] As illustrated in FIG. 1, the air-conditioning system according to the present embodiment includes an air conditioner (10) including a temperature control unit (11) configured to adjust an indoor temperature, and a humidity control unit (12) configured to adjust an indoor humidity. The air conditioner (10) further includes a control unit (13) configured to control the temperature control unit (11) and the humidity control unit (12) so that the indoor temperature approaches a target temperature and the indoor humidity approaches a target humidity. The control unit (13) is configured to perform an operation in a first mode where the target temperature and the target humidity are changed so as not to reduce a sensible temperature of a person (40) in a target room.

[0031] The air conditioner (10) further includes a controller (15) for operating the air-conditioning system, and a ventilation unit (14) configured to ventilate the indoor air.

[0032] The air conditioner (10) further includes, as sensors (detectors) for detecting indoor environment information, an indoor temperature sensor (21) configured to detect a temperature, an indoor humidity sensor (22) con-

figured to detect a humidity, and a CO_2 level sensor (23) configured to detect a carbon dioxide level. The air conditioner (10) further includes an activity sensor (24) configured to detect an activity amount of a person (40) in a target room. The air conditioner (10) further includes, as sensors for detecting outdoor environment information, an outdoor temperature sensor (26) configured to detect a temperature sensor, and an outdoor humidity sensor (27) configured a humidity. Although not shown, the air conditioner (10) may further include a sensor for detecting other environment information, e.g., an illuminance.

[0033] Although not shown, the sensors (21, 22, 23, 24, 26, and 27) are wired or wirelessly connected to the air conditioner (10), and in turn, the control unit (13) of the air conditioner (10). Although the sensors are separately shown in FIG. 1, some of the sensors may be combined to be a single unit. Further, at least one of the sensors may be combined with the controller (15), or may be included in the air conditioner (10) or the ventilation unit (14).

[0034] The temperature control unit (11) may include, for example, a heat pump-type refrigeration apparatus configured to perform a vapor compression refrigeration cycle. Specifically, although not shown, the temperature control unit (11) may include a refrigerant circuit configured to circulate refrigerant to perform a refrigeration cycle. The humidity control unit (12) may be configured to control the indoor humidity using a solid moisture absorbent (not shown). The humidity control unit (12) may be configured to control the indoor humidity through absorbing moisture from air in either one of an indoor space or an outdoor space, and releasing the moisture to the other one. The humidity control unit (12) may also be configured to use separately a humidifier of, for example, ultrasonic-type or vaporizing type, and a dehumidifier using an adsorbent, for example, instead of being included in the air conditioner (10). The air conditioner (10) may only have one of an indoor humidification function or an indoor dehumidification function, and the other function may be provided as a separate device. If a humidifier/dehumidifier is used separate from the air conditioner (10), the humidifier/dehumidifier is also wired or connected wirelessly to the control unit (13).

[0035] The ventilation unit (14) may include a ventilation fan provided in an opening of a ceiling, a wall surface, or the like in the target room, and may further include, for example, an air passage or a damper (not shown), if necessary.

[0036] FIG. 2 is a block diagram showing a control unit (13) and components related to the control unit (13) in the air-conditioning system of the present embodiment. As shown in FIG. 2, the control unit (13) receives, for example, detection values from the indoor temperature sensor (21), the indoor humidity sensor (22), the CO_2 level sensor (23), the activity sensor (24), the outdoor temperature sensor (26), and the outdoor humidity sensor (27). The control unit (13) further receives, from the controller (15), a signal for operating the air-conditioning system.

[0037] As will be described in detail later, the control unit (13) includes an estimator (31) and a storage (32) storing model information (33). The control unit (13) controls the temperature control unit (11), the humidity control unit (12), and the ventilation unit (14) based on the detection values received from the sensors and the signal from the controller (15), and by using the model information (33) stored in the estimator (31) and the storage (32). As will be described later, the control unit (13) may be connected to an outside server and may transmit and receive information on control of the air-conditioning system.

-Operation of Air-conditioning System-

[0038] The operation of the air-conditioning system of the present embodiment will be described below. FIG. 3 is a flowchart illustrating an example of the operation. FIG. 4 illustrates example details of the control by the air-conditioning system.

[0039] First, an operation of the air-conditioning system in the first mode will be described with reference to the flowchart of FIG. 3. The first mode is an operation mode to prevent a reduction in the sensible temperature of the person (40) in the target room. The details of the first mode and operations performed in the steps will be described in detail below.

[0040] In Step S1, an operation in the first mode is started. The start of this operation may be achieved in response to an instruction of the start using the controller (15) by the person (40) in the target room. Alternatively, the activity status of the person (40) in the target room may be detected using the activity sensor (24), and if the detected activity amount of the person (40) is small, the operation in the first mode may be started. The start of this operation may be achieved when the user comes home and enters the target room, after the user takes a bath, or the like.

[0041] In Step S2, the sensors detect indoor environment conditions. Specifically, the indoor temperature sensor (21) and the indoor humidity sensor (22) detect an indoor temperature and an indoor humidity, respectively.

[0042] In Step S3, the target temperature for the indoor temperature is set. The target temperature is a temperature the control unit (13) controls the temperature control unit (11) to approach, and is determined in consideration of the comfort the person (40) in the target room feels.

[0043] In Step S4, whether the indoor humidity satisfies a predetermined condition is determined. The predetermined condition is determined also in consideration of the comfort the person (40) in the target room feels.

[0044] If it is determined that the indoor humidity does not satisfy the predetermined condition for the humidity in Step 4, the process proceeds to Step S5 to set a target humidity satisfying the condition.

[0045] If it is determined that the indoor humidity satisfies the predetermined condition for the humidity in Step 4, the process proceeds to Step S6 to set the indoor humidity as the target humidity.

[0046] After the target humidity is set in Step S5 or S6, the process proceeds to Step S7 to control environment conditions including the indoor temperature and the indoor humidity.

-Control of Temperature and Humidity in First Mode-

[0047] Environment control corresponding to Step S7 of FIG. 3 will be described below.

[0048] The air conditioner such as a room air conditioner controls a set temperature (air temperature) to be kept. This control is based on the assumption that once the temperature that a person in a target room feels comfort is set, keeping the temperature will keep the comfortable state where the person feels comfort will be kept. In FIG. 4, a target temperature (43) and a target humidity (45) in such a constant temperature control are both shown as constant values with no change.

[0049] However, according to the activity status of the person (40) in the target room, just simply keeping the same temperature may not keep the comfortable state. Particularly when the activity amount of the person (40) in the target room is small, e.g., when the person (40) is sitting still on a chair and relaxing, the person (40) may begin to feel cold if the same temperature is kept. This is due to the fact that when the humans are inactive (not moving their bodies), their metabolic rates gradually decrease, resulting in a low sensible temperature even at the same temperature.

[0050] In this regard, in FIG. 4, a metabolic rate (41) represents a metabolic rate of the person (40) in the target room relaxing (e.g., sitting still on a chair). The horizontal axis represents time, and even if the person (40) in the target room is relaxing in the same way, the initial metabolic rate (at 0 mins) is, for example, 1.1 met (metabolic equivalent). In contrast, the metabolic rate gradually decreases with continued relaxed state, and becomes 1.0 met after about 90 min. Such a decrease in metabolic rate results in a decrease in the sensible temperature. On average, the decrease in the metabolic rate described above occurs during the first 90 min after reaching the relaxed state, after which the metabolic rate is kept at the same.

[0051] FIG. 4 also shows the sensible temperature. The sensible temperature when the indoor temperature is kept at the initial value Tn°C of the set temperature is indicated by a broken line as the sensible temperature (47) under the constant temperature control. Even if the indoor temperature is kept at Tn°C, the sensible temperature (47) under the constant temperature control decreases with a decrease in the metabolic rate.

[0052] Such a decrease in the sensible temperature may deteriorate the comfort feeling of the person (40) in the target room, causing the person (40) to feel stressed and preventing the person (40) from relaxing. Further, the person (40) in the target room feels cold and thus takes an action to increase the set temperature of the air conditioning.

[0053] The air-conditioning system of the present embodiment enables performing an operation in the first mode (relaxing mode) to keep the sensible temperature of the person (40) in the target room from decreasing when the activity amount of the person (40) falls under the relaxed state.

[0054] The control unit (13) performs, in the first mode, a first operation where the target humidity is stepwise increased once or multiple times while keeping the target temperature, and a second operation where the target temperature is increased and the target humidity is decreased, in this order at least once each.

[0055] More specifically, the control unit (13) of the air-conditioning system in the first mode controls the temperature control unit (11) and the humidity control unit (12) to keep the sensible temperature of the person (40) in the target room at a constant value (initial value Tn). To achieve this, the indoor temperature is most basically required to be increased to match the decrease in the metabolic rate. However, the sensible temperature decreases gradually, and even if the set temperature is increased by the smallest adjustable unit (e.g., 0.5°C), the person in the target room may feel the temperature increase. This may cause the person (40) in the target room to feel stressed or change the temperature setting of the air-conditioning system.

[0056] To address this, the humidity is controlled in addition to the temperature to control the sensible temperature by a small unit, allowing the person (40) in the target room not to perceive the change. FIG. 4 shows an example of this.

[0057] In FIG. 4, suppose that the first mode is started at 0 mins on the horizontal axis. Suppose that in the target room at this time point, the temperature (an initial value of the temperature) is Tn°C, which is also the target temperature for control, the humidity (an initial value of the humidity) is RHn% (relative humidity), which is also a target humidity for control (i.e., an operation in the first mode is started in the state where the person (40) in the target room feels comfort).

[0058] When the person (40) in the target room is relaxed, the metabolic rate (41) begins to gradually decrease, and the sensible temperature also begins to decrease with the decrease in the metabolic rate (41) (this is the same as the sensible temperature (47) under the constant temperature control at this time) Therefore, after a certain time (15 minutes in the example of FIG. 4) has passed, the target humidity is increased to RHn + (β/2)%, as in a first mode target humidity (44). The sensible temperature increases with the increase in the humidity. This allows the sensible temperature of the person (40) in the target room to approach the target sensible temperature (46), which is kept to be constant. Strictly speaking, as with the sensible temperature (47) under the constant

temperature control, the sensible temperature decreases until the 15-min time point, and then increases to the target sensible temperature (46) with the increase in the first mode target humidity (44). However, a sufficiently small decrease in the sensible temperature at 15 minutes will not be perceived by the person (40) in the target room and is thus considered to be equivalent to achieving the target sensible temperature (46).

[0059] Note that the amount of increase in the first mode target humidity (44), i.e., $\beta/2$ is greater than or equal to the minimum unit that can be set as a target humidity. For example, if the air-conditioning system can control the relative humidity in 5% increments, $\beta/2$ may be 5% (β may be 10%).

[0060] If the person (40) in the target room remains in a relaxed state after 15 minutes has passed, the decrease in the metabolic rate (41) and the resulting decrease in the sensible temperature continue. Thus, at the time point after a certain time has passed further (at 30 minutes in FIG. 4), the first mode target humidity (44) is again increased to (RHn + β)%. This allows the sensible temperature of the person (40) in the target room to be kept around the target sensible temperature (46).

[0061] An operation where the target humidity in the first mode is stepwise increased once or multiple times while keeping a first mode target temperature (42), described above is referred to as a first operation.

[0062] When the relaxed state continues, the metabolic rate (41) continuously decreases until about 90 minutes have passed. Thus, the target temperature and the target humidity are continuously controlled to keep the sensible temperature of the person (40) in the target room. However, if the humidity is continuously increased, the high humidity can cause discomfort. Thus, at a certain time point (at 45 minutes in FIG. 4) the first mode target temperature (42) is increased (to (Tn + α)°C), while the first mode target humidity (44) is decreased (to RHn% in the example of FIG. 4). This allows the sensible temperature of the person (40) in the target room to be kept around the target sensible temperature (46) while keeping the humidity to be in the constant range. This operation is referred to as a second operation.

[0063] Note that the amount of increase in the target temperature, i.e., α, is greater than or equal to the minimum unit that can be set as a target temperature. For example, if the air-conditioning system can control the temperature in 0.5°C increments, α may be 0.5°C.

[0064] If the relaxed state further continues thereafter, the first mode target humidity (44) and the first mode target temperature (42) are controlled to keep the sensible temperature of the person (40) in the target room to be constant. After 90 minutes has passed, the decrease in the metabolic rate (41) ends, and the sensible temperature no longer decreases. Accordingly, ending the operation in the first mode at about 90 minutes and keeping the temperature and humidity at that time allows the sensible temperature of the person (40) in the target room to be kept without variations. At this time, in the example of FIG. 4, the temperature increases by α°C, and the humidity increases by β% from the time point when the operation in the first mode is started. If the values of α and β are as in the above example, the temperature increases by 0.5°C, and the humidity increases by 10%.

[0065] In the above example, the increase in the temperature is made only once. However, the increase may be made multiple times. In this case, the first operation where the target humidity is stepwise increased once or multiple times while keeping the target temperature, and the second operation where the target temperature is increased, and the target humidity is decreased are repeatedly performed in this order. The increase in the humidity is made in two steps by p/2°C increments, but can be made in one step to simplify the step, or in three or more steps.

[0066] The control is made with 15 minutes as a time unit, but this is a mere example, and other time unit can be used. The control is not necessarily made every time unit, and the intervals of the control can be gradually increased considering that the decrease in the metabolic rate (41) becomes gradually small.

[0067] As mentioned above, the duration of the operation in the first mode is desirably about 90 minutes. This is because an average duration until the reduction in the metabolic rate of the human in the relaxed state ends is about 90 minutes. However, in consideration of individual differences or the like, a slightly longer or shorter duration (e.g., about 75 minutes to about 115 minutes) may be set.

-Method of Determining Target Temperature and Target Humidity-

[0068] Next, the method of determining the target temperature and target humidity for control by the air-conditioning system will be described below.

[0069] The target temperature and target humidity can be the temperature and humidity set by the person (40) in the target room using the controller (15). However, the person (40) in the target room is not always able to make appropriate settings. Thus, automatically setting the target temperature and target humidity at which the person (40) feels comfort is desirable.

[0070] Hence, as illustrated in FIG. 2, the control unit (13) of the air-conditioning system includes: an estimator (31) configured to estimate an indoor temperature (comfortable temperature) at which the person (40) in the target room feels comfortable, and a storage (32) storing model information (33) using such an estimation. The control unit (13) receives environment information (particularly the temperature and humidity) on the indoor space and the outdoor space from the sensors. The estimator (31) estimates the comfortable temperature based on the information and the model information (33) stored in the storage (32). The comfortable temperature is a temperature at which the person (40) in the target room does not feel hot or cold, and is also referred to as a thermally neutral temperature.

[0071] The model information (33) can be, for example, Adaptive Comfort Model. This is a model specifying the thermally neutral temperature in the indoor space based on the historical data of the outdoor temperature experienced by the human. The estimator (31) may set the indoor target temperature based on such model information stored in the storage (32) and information on the outdoor temperature detected using the outdoor temperature sensor (26). As a matter of course, it is also possible to set the target temperature based on other information. As will be described later, the air-conditioning system may be connected to a server via the Internet or the like, and the target temperature estimated in the server may be used. Artificial intelligence may be used for this.

[0072] The target humidity is determined to satisfy conditions such as ensuring that the skin moisture content of the person (40) in the target room is in an appropriate range, and that the target humidity is below a predetermined upper limit at which the growth of mold in the target room can be avoided.

[0073] The low indoor humidity causes tendency to dry the skin of the person (40) in the target room, which causes discomfort such as itching or bulkiness. This tendency is highly correlated with an absolute humidity (the ratio of the mass of water vapor to the mass of dry air). Although it differs individually, the tendency is observed at the absolute humidity of, for example, 8 g/kg or less. Accordingly, as the target humidity, the absolute humidity is set to be preferably 8 g/kg or more, more preferably 9 g/kg or more.

[0074] In addition, the high indoor humidity causes discomfort such as feeling sticky on the skin of the person (40) in the target room. This is likely to occur, for example, when the absolute humidity is 21 g/kg or more. Accordingly, as the target humidity, the absolute humidity is set to be preferably 21 g/kg or less, more preferably 18 g/kg or less.

[0075] Further, at the too high humidity in the target room, mold is more likely to grow. This is highly correlated with a relative humidity, and mold noticeably grows at the relative humidity exceeding 60%. Accordingly, the target humidity is set to be preferably equal to or lower than the upper limit that can inhibit the growth of mold, for example, 60% or less.

[0076] Therefore, the target humidity preferably satisfies the following conditions (1) and (2):

(1) absolute humidity: 8 g/kg or more to 21 g/kg or less;
(2) relative humidity: 60% or less.

[0077] The predetermined conditions used to perform the determination in Step S4 of the flowchart of FIG. 3 can be the conditions (1) and (2).

[0078] The manner described above is shown in FIG. 5. FIG. 5 shows the correspondence of the absolute humidity (g/kg) to the relative humidity (the horizontal axis, %) and the temperature (the vertical axis, °C). For the cases satisfying the conditions (1) and (2), the range of cells in the table is enclosed in a bold line, and the numerical values are in bold. When the target temperature is set, the target humidity is set from this range.

[0079] For example, suppose that the indoor temperature detected using the indoor temperature sensor (21) is 22°C, and the indoor relative humidity detected using the indoor humidity sensor (22) is 35%. In this case, as shown in FIG. 5, the indoor absolute humidity is 6.8 g/kg, which fails to satisfy the condition (2).

[0080] Suppose that a comfortable temperature is 22°C, the humidity is selected to satisfy the condition (2) without changing the temperature. Further, in order to increase energy conservation and the like, the selection is made so that the amount of change is minimum. In FIG. 5, when the relative humidity is 45% while keeping the temperature at 22°C, the absolute humidity becomes 8.7 g/kg, which satisfies the condition (2). Accordingly, the environment control is performed at the initial target temperature of 22°C and the initial target humidity of 45%. Note that this is a mere example, and other method may be used to determine the target humidity.

[0081] When the indoor temperature detected using the indoor temperature sensor (21) is not a comfortable temperature, the target temperature is set using, for example, the model information (33) as described above. Then, a desirable target humidity relative to the target temperature is determined as shown in FIG. 5, for example. The operation in the first mode, which corresponds to the reduction in the metabolic rate (41) as shown in FIG. 4, may be performed after the indoor temperature reaches the target temperature using the temperature control unit (11).

(Variations)

-Control of Start and Stop of Operation in First Mode-

[0082] In the air-conditioning system of the present embodiment, the operation in the first mode may be started by the person (40) in the target room (using the controller (15)). Alternatively, the operation is preferably started automatically in response to detection of the relaxed state of the person (40) in the target room.

[0083] In order to achieve this, the activity amount of the person (40) in the target room is detected using the activity sensor (24). The activity sensor (24) is, for example, an infrared ray sensor, an imaging unit, or the like. When the activity sensor (24) detects that the activity amount of the person (40) in the target room is equal to or lower than a predetermined value, the control unit (13) starts the operation in the first mode. In this way, the control corresponding to the decrease in the sensible temperature can be performed without the operation by the person (40) in the target room. This is effective when the person (40) in the target room falls asleep, for example.

[0084] The activity amount of the person (40) in the

target room may increase during the operation in the first mode. In this case, the decrease in the metabolism of the person (40) in the target room is stopped, i.e., the decrease in the sensible temperature does not occur. If the operation in the first mode continues, the sensible temperature increases, which reduces the comfort the person (40) in the target room feels. Thus, when the activity amount of the person (40) in the target room reaches the predetermined value or more, the operation in the first mode is preferably stopped.

[0085] If the activity amount of the person (40) in the target room is large when the operation in the first mode is not performed, the operation in the first mode may be prohibited. This is the case where the activity amount of the person (40) in the target room becomes large although the operation in the first mode is scheduled to be performed by settings of a timer, learning by artificial intelligence, or the like.

-Use of External Server-

[0086] In the above description, the air-conditioning system of the present embodiment is controlled by a separate control unit (13). However, the air-conditioning system may be configured to be connected to an external server. In this case, the external server has functions corresponding to the estimator (31) and the storage (32) (the control unit (13) and the external server may both has the functions). This is illustrated in FIGS. 6 and 7. The external server may be a server for controlling a plurality of air-conditioning systems installed in the same building as the air-conditioning system, or may be a cloud server connected via the Internet.

[0087] FIG. 6 shows an air conditioner indoor unit (51) and a sensor unit (52) which constitute the air-conditioning system. The air conditioner indoor unit (51) corresponds to the air conditioner (10) of FIG. 1. The sensor unit (52) is a unit configured separately from the air conditioner indoor unit (51) including various sensors, and is positioned near the person (40) in the target room, for example. Specifically, the sensor unit (52) may have functions of the indoor temperature sensor (21), the indoor humidity sensor (22), and the CO_2 level sensor (23) of FIG. 1, and may further have functions of the activity sensor (24) and an illuminance sensor for detecting an indoor illuminance, and the like. The sensor unit (52) may further have a function of the controller (15) in a way that allows for a voice operation, for example.

[0088] The sensor unit (52) detects (measures) the indoor temperature, the indoor humidity, the indoor carbon dioxide level, the indoor illuminance, and the like, and transmit parameters including at least one of these pieces of environment information to a sensor connection server (53) connected via the Internet, or the like. The sensor unit (52) may transmit parameters on the thermal sensation of the person (40) in the target room to the sensor connection server (53) in the same manner. The parameters on the thermal sensation are gender, age, weight, and the like, which affect the feeling of hot and cold. The parameters may further include a parameter on the preferences for hot and cold (e.g., being sensitive to heat) of the person (40) in the target room.

[0089] The sensor connection server (53) has a function of an artificial intelligence (55). A learned model is generated in the sensor connection server (53) based on the information and the parameters transmitted from the sensor unit (52), and the comfortable temperature is determined. The information on the comfortable temperature determined is transmitted to another remote server (54). The remote server (54) transmits the comfortable temperature and the like received from the sensor connection server (53) to the air conditioner indoor unit (51) via the Internet or the like. The air conditioner indoor unit (51) controls the indoor temperature based on the comfortable temperature received.

[0090] FIG. 7 shows another example. FIG. 7 is the same as FIG. 6 in that the air-conditioning system includes an air conditioner indoor unit (51) and a sensor unit (52), and in configurations and functions thereof. However, in FIG. 7, the sensor connection server (53) is not used, and the sensor unit (52) transmits information on the indoor temperature detected and the like directly to the remote server (54). The remote server (54) has the function of the artificial intelligence (55), and in the remote server (54), the artificial intelligence (55) determines the comfortable temperature. The comfortable temperature determined is transmitted from the remote server (54) to the air conditioner indoor unit (51), and the indoor temperature is controlled based on the information.

[0091] The control unit (13) may use the artificial intelligence (55) without the external server.

-Control of Carbon Dioxide Level-

[0092] As shown in FIG. 1, the air-conditioning system of the present embodiment further includes a CO_2 level sensor (23) and a ventilation unit (14).

[0093] The carbon dioxide level is one of the indicators for evaluating the quality of indoor air, and is desirably kept to be less than a predetermined value. Therefore, when a carbon dioxide level in the target room detected using the CO_2 level sensor (23) becomes a predetermined value or more, the control unit (13) operates the ventilation unit (14) to ventilate its indoor space. As a specific example, the ventilation unit (14) may be operated when the carbon dioxide level becomes 1000 ppm or more, according to the guidelines established as environmental governing standards for buildings. If necessary, a sensor for detecting levels of gases different from carbon dioxide may be used to keep the carbon dioxide level to be equal to or lower than the predetermined level.

[0094] While the embodiment and variations thereof have been described above, it will be understood that various changes in form and details may be made without departing from the spirit and scope of the claims. The

foregoing embodiment and variations thereof may be combined and replaced with each other without deteriorating the intended functions of the present disclosure.

INDUSTRIAL APPLICABILITY

[0095] The present disclosure is useful as an air-conditioning system.

DESCRIPTION OF REFERENCE CHARACTERS

[0096]

11	Temperature Control Unit
12	Humidity Control Unit
13	Control Unit
14	Ventilation Unit
15	Controller
21	Indoor Temperature Sensor
22	Indoor Humidity Sensor
23	CO_2 Level Sensor (Carbon Dioxide Level Detector)
24	Activity Sensor (Activity Detector)
26	Outdoor Temperature Sensor (Outdoor Air Temperature Detector)
27	Outdoor Humidity Sensor
31	Estimator
32	Storage
33	Model Information (Relationship Information)
40	Person in Target Room
51	Air Conditioner Indoor Unit
52	Sensor Unit
53	Sensor Connection Server
54	Remote Server
55	Artificial Intelligence

Claims

1. An air-conditioning system comprising:

a temperature control unit (11) configured to control an indoor temperature;
a humidity control unit (12) configured to control an indoor humidity; and
a control unit (13) configured to control the temperature control unit and the humidity control unit so that the indoor temperature approaches a target temperature and the indoor humidity approaches a target humidity,
the control unit (13) being configured to perform an operation in a first mode where the target temperature and the target humidity are changed so as not to reduce a sensible temperature of a person (40) in a target room.

2. The air-conditioning system of claim 1, wherein
the control unit (13) performs, as the operation in the first mode, a first operation where the target humidity is stepwise increased once or multiple times while keeping the target temperature, and a second operation where the target temperature is increased, and the target humidity is decreased, in this order at least once each.

3. The air-conditioning system of claim 1 or 2, wherein
a target humidity at start of the operation in the first mode is set in a predetermined range determined so that a skin moisture content of the person (40) in the target room is in a suitable range.

4. The air-conditioning system of any one of claims 1 to 3, wherein
a target humidity at start of the operation in the first mode is set to be equal to or lower than a predetermined upper limit at which growth of mold is avoided.

5. The air-conditioning system of any one of claims 1 to 4, wherein

the control unit (13) includes an estimator (31) configured to estimate a comfortable indoor temperature at which the person (40) in the target room feels comfortable, and
the target temperature is the comfortable indoor temperature estimated by the estimator (31).

6. The air-conditioning system of claim 5, further comprising:

an outdoor air temperature detector (26) configured to detect an outdoor air temperature; and
a storage (32) storing relationship information (33) indicating a relationship between the comfortable temperature and the outdoor air temperature, wherein
the control unit (13) estimates the comfortable temperature based on the outdoor air temperature detected using the outdoor air temperature detector (26) by using the relationship information (33) stored in the storage (32).

7. The air-conditioning system of claim 5, wherein
the estimator (31) estimates the comfortable temperature from a learned model trained on a parameter for environment information including at least one of an indoor temperature, an indoor humidity, an indoor illuminance, an outdoor temperature, or an outdoor humidity, and a parameter for thermal sensation of the person in the target room.

8. The air-conditioning system of any one of claims 1 to 7, further comprising:

a ventilation unit (14) configured to ventilate indoor air; and

a carbon dioxide level detector (23) configured to detect a carbon dioxide level in the target room, wherein
the control unit (13) operates the ventilation unit (14) when the carbon dioxide level detected using the carbon dioxide level detector (23) is equal to or higher than a predetermined level.

9. The air-conditioning system of any one of claims 1 to 8, further comprising:
a controller (15) having a function to start the operation in the first mode.

10. The air-conditioning system of any one of claims 1 to 9, further comprising:

an activity detector (24) configured to detect an activity amount of the person (40) in the target room, wherein
when the activity amount of the person (40) in the target room detected using the activity detector (24) is equal to or lower than a predetermined level, the control unit (13) starts the operation in the first mode.

11. The air-conditioning system of any one of claims 1 to 9, further comprising:

an activity detector (24) configured to detect an activity amount of the person (40) in the target room, wherein
when the activity amount of the person (40) in the target room detected using the activity detector (24) is equal to or higher than a predetermined level during the operation in the first mode, the control unit (13) stops the operation in the first mode.

FIG.1

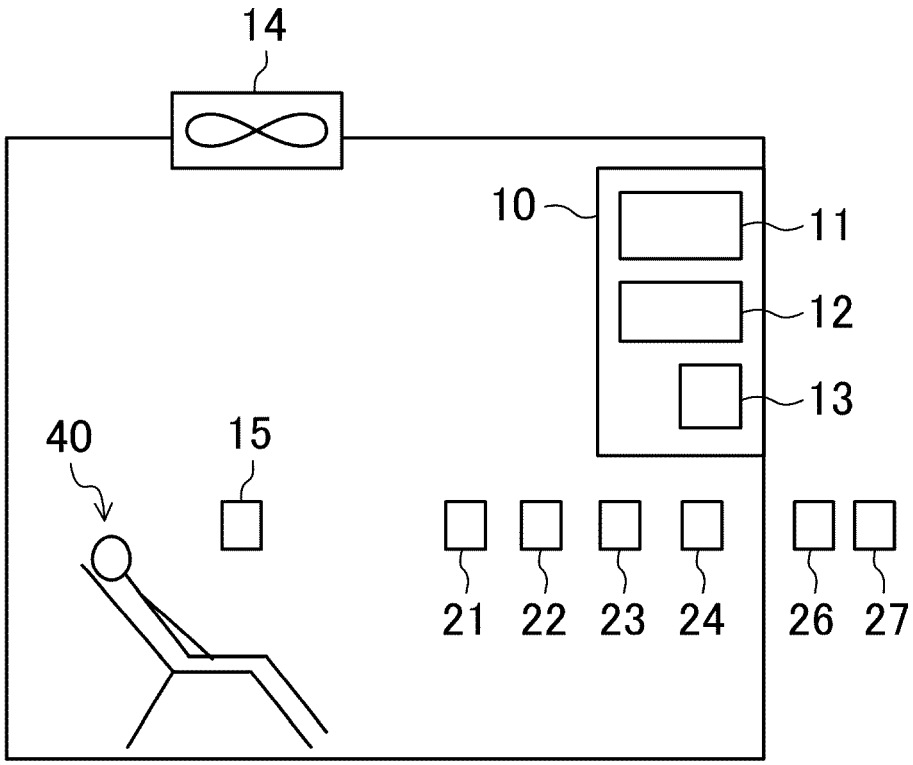


FIG.2

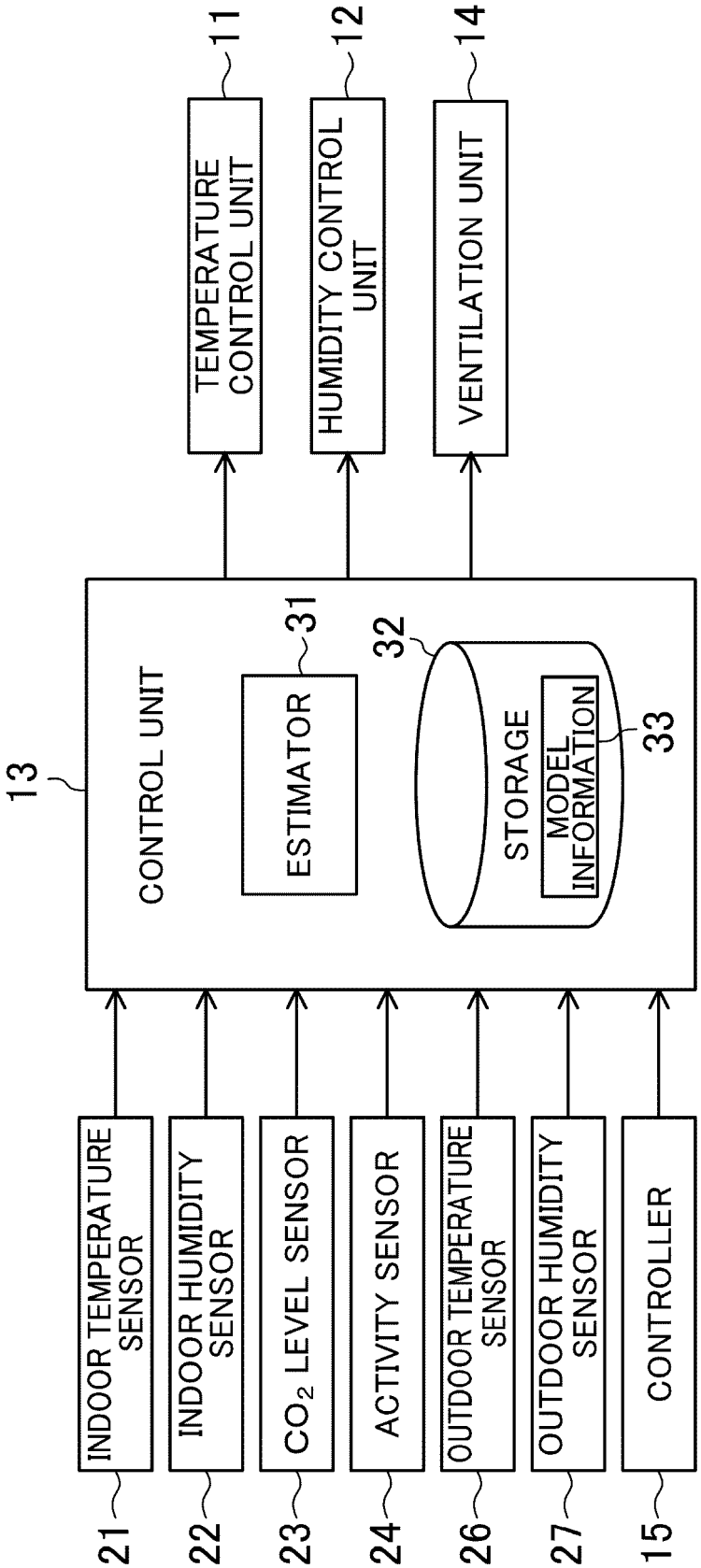

11
12
14
TEMPERATURE CONTROL UNIT
HUMIDITY CONTROL UNIT
VENTILATION UNIT
13
CONTROL UNIT
31
ESTIMATOR
32
STORAGE
MODEL INFORMATION
33
INDOOR TEMPERATURE SENSOR
INDOOR HUMIDITY SENSOR
CO_2 LEVEL SENSOR
ACTIVITY SENSOR
OUTDOOR TEMPERATURE SENSOR
OUTDOOR HUMIDITY SENSOR
CONTROLLER
21
22
23
24
26
27
15

FIG.3

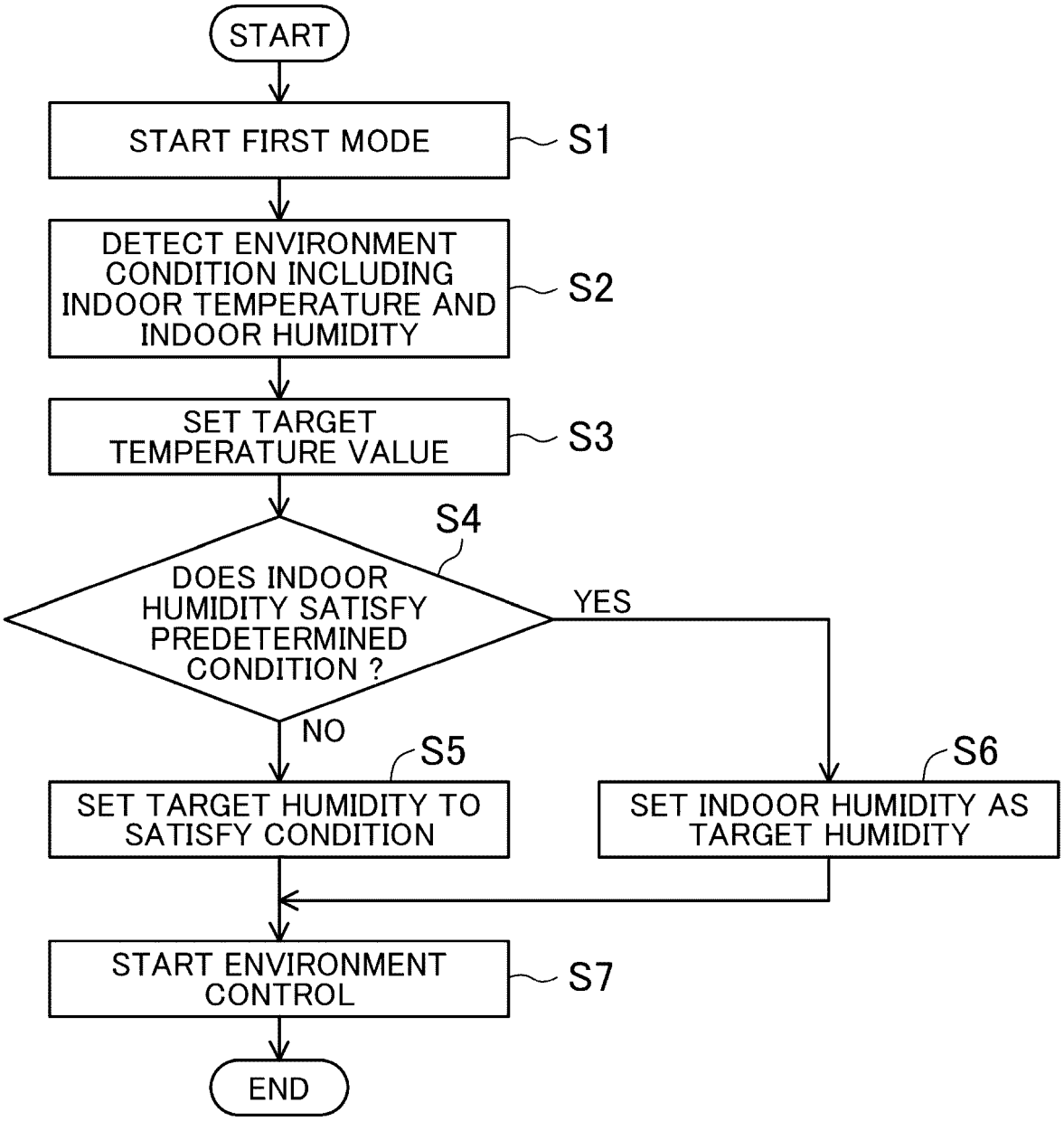

START
START FIRST MODE
S1
DETECT ENVIRONMENT CONDITION INCLUDING INDOOR TEMPERATURE AND INDOOR HUMIDITY
S2
SET TARGET TEMPERATURE VALUE
S3
S4
DOES INDOOR HUMIDITY SATISFY PREDETERMINED CONDITION ?
YES
NO
S5
SET TARGET HUMIDITY TO SATISFY CONDITION
S6
SET INDOOR HUMIDITY AS TARGET HUMIDITY
START ENVIRONMENT CONTROL
S7
END

FIG.4

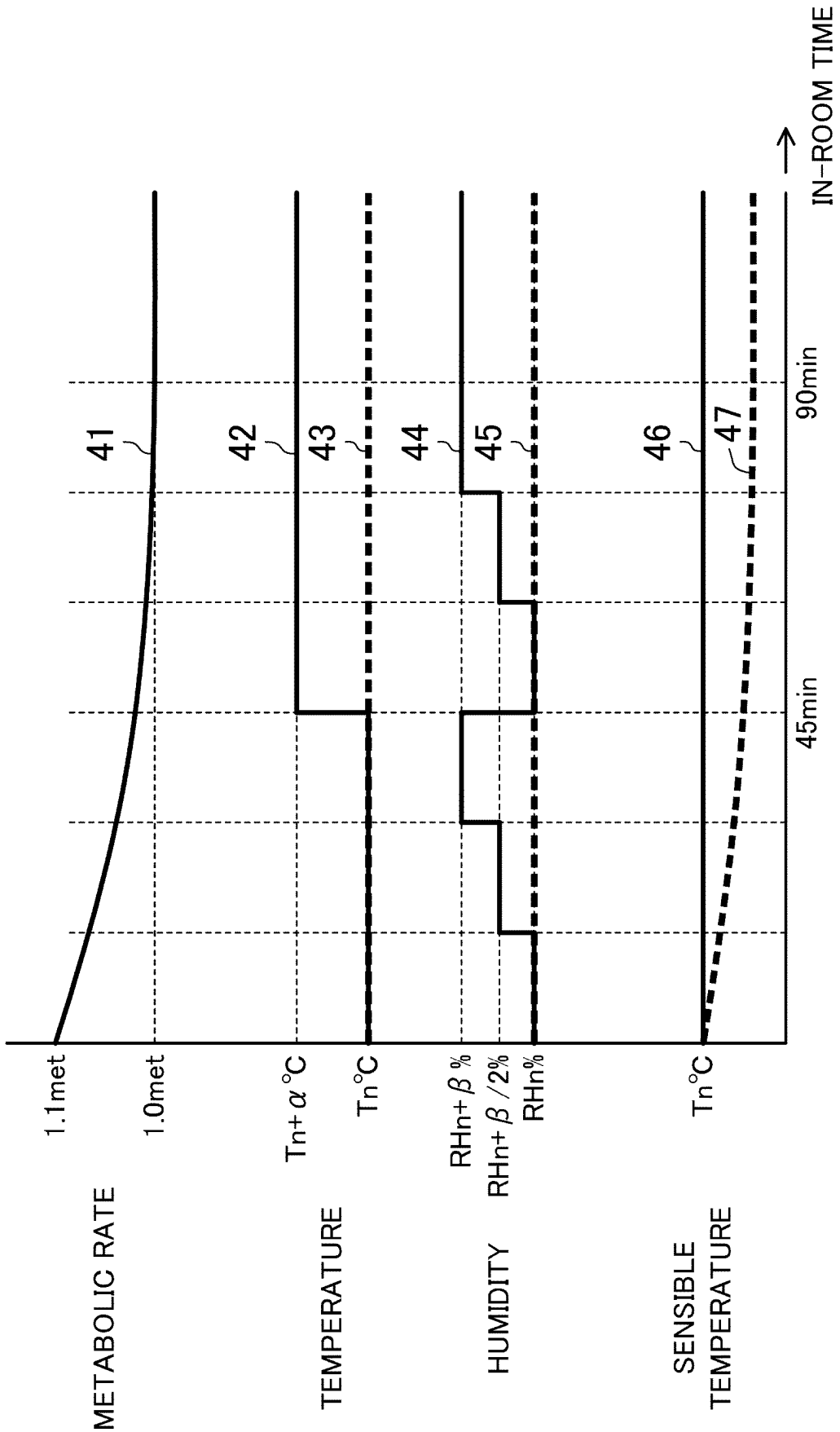

METABOLIC RATE
1.1met
1.0met
TEMPERATURE
Tn+α℃
Tn℃
HUMIDITY
RHn+β%
RHn+β/2%
RHn%
SENSIBLE TEMPERATURE
Tn℃
41
42
43
44
45
46
47
45min
90min
IN-ROOM TIME

FIG.5

HUMIDITY → TEMPERATURE ↓	35%	40%	45%	50%	55%	60%	65%	70%
14℃	4.2	4.8	5.4	6.1	6.7	7.3	7.9	8.5
16℃	4.8	5.4	6.1	6.8	7.5	8.2	8.8	9.5
18℃	5.4	6.2	6.9	7.7	8.5	9.2	10.0	10.8
20℃	6.0	6.9	7.7	8.6	9.5	10.3	11.2	12.0
22℃	6.8	7.8	8.7	9.7	10.7	11.6	12.6	13.6
24℃	7.6	8.7	9.8	10.9	12.0	13.1	14.2	15.3
26℃	8.5	9.8	11.0	12.2	13.4	14.6	15.9	17.1
28℃	9.5	10.9	12.2	13.6	15.0	16.3	17.7	19.0
30℃	10.6	12.1	13.6	15.2	16.7	18.2	19.7	21.2
32℃	11.8	13.5	15.2	16.9	18.5	20.2	21.9	23.6
34℃	13.2	15.0	16.9	18.8	20.7	22.6	24.4	26.3

FIG.6

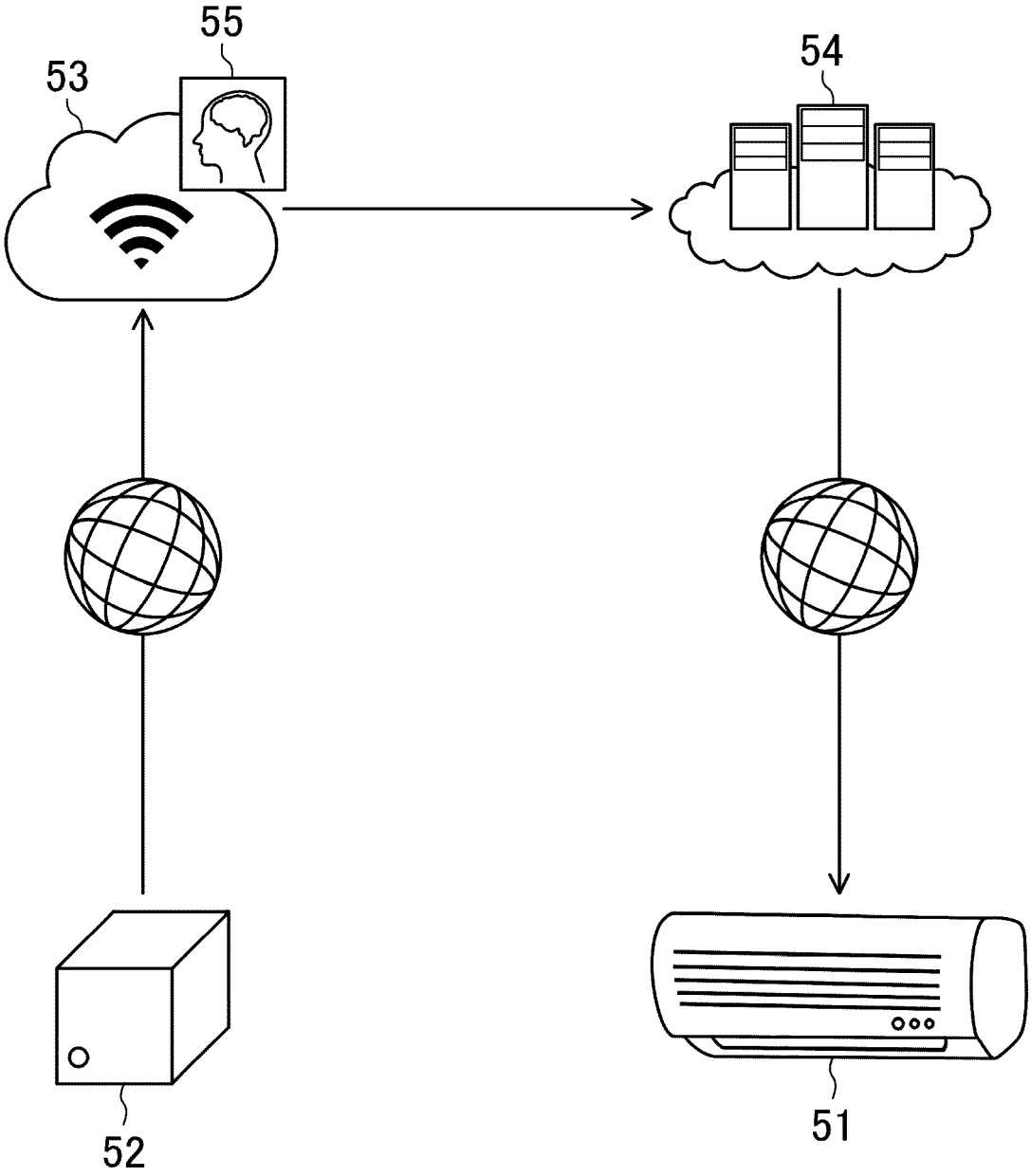
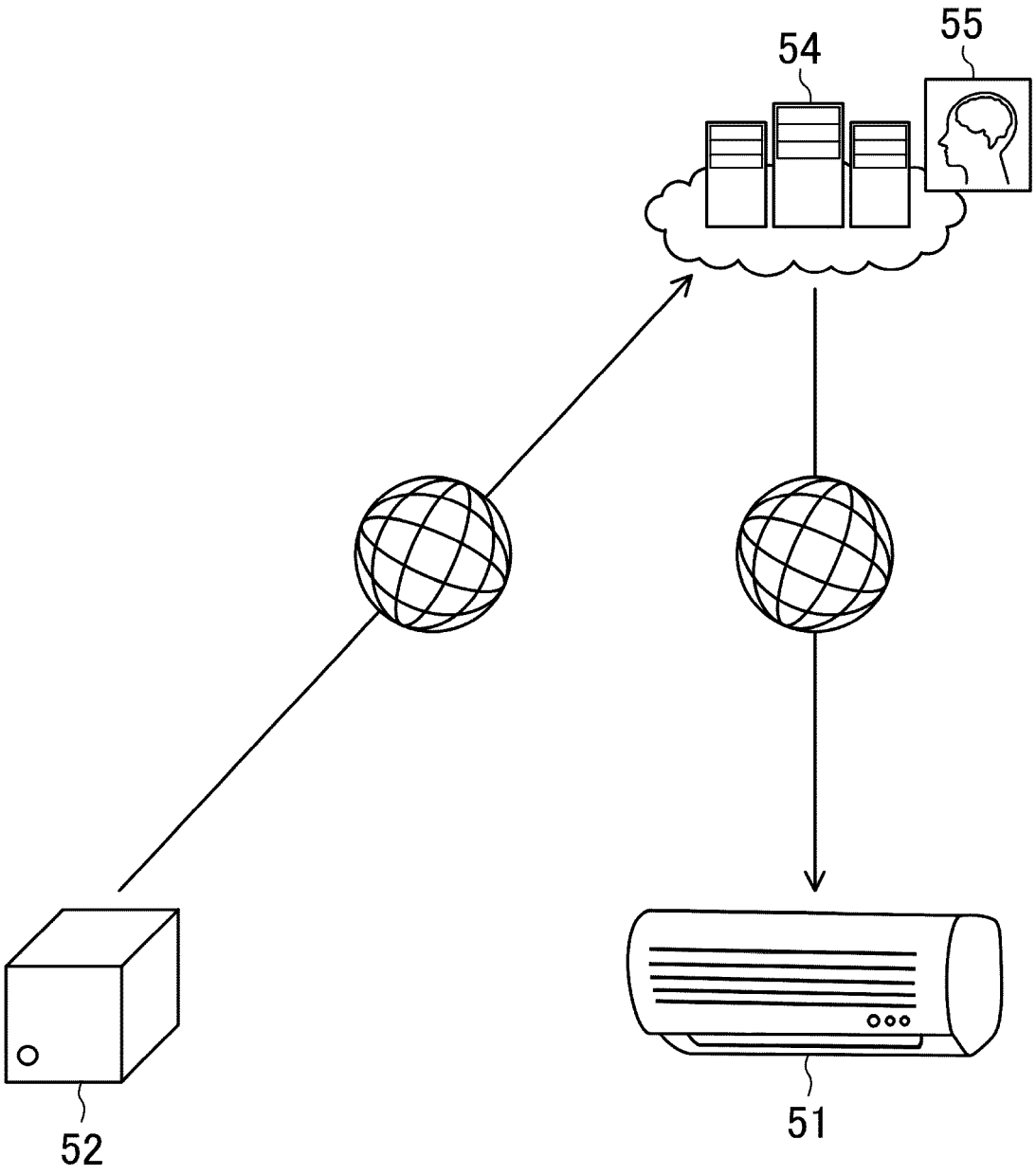


FIG.7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/015361

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F24F7/007(2006.01)i, F24F11/65(2018.01)i, F24F110/10(2018.01)n, F24F110/12(2018.01)n, F24F110/20(2018.01)n, F24F110/70(2018.01)n, F24F120/14(2018.01)n, F24F130/30(2018.01)n
FI: F24F11/65, F24F7/007 B, F24F110:10, F24F110:12, F24F110:20, F24F110:70, F24F120:14, F24F130:30

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl. F24F7/007, F24F11/65, F24F110/10, F24F110/12, F24F110/20, F24F110/70, F24F120/14, F24F130/30

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2020
Registered utility model specifications of Japan 1996-2020
Published registered utility model applications of Japan 1994-2020

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 7-004717 A (KUBOTA CORP.) 10 January 1995, paragraphs [0031]-[0075]	1, 5 3-6, 8-11 2, 7
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Y A	WO 2014/125805 A1 (PANASONIC CORP.) 21 August 2014, paragraphs [0023]-[0172]	6, 8-11 7
Y	WO 2009/096350 A1 (TOSHIBA CORP.) 06 August 2009, paragraphs [0013]-[0065]	8-11
A	JP 2003-185217 A (DAIKIN INDUSTRIES, LTD.) 03 July 2003, paragraphs [0034]-[0094]	1-11

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

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17.06.2020	30.06.2020
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/015361

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WO 2009/096350 A1	06.08.2009	US 2010/0307731 A1 paragraphs [0019]-[0077] US 2016/0195290 A1 DE 112009000227 T KR 10-2010-0106508 A CN 101925786 A TW 200949165 A CN 103292431 A TW 201337181 A	
JP 2003-185217 A	03.07.2003	(Family: none)	

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

REFERENCES CITED IN THE DESCRIPTION

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