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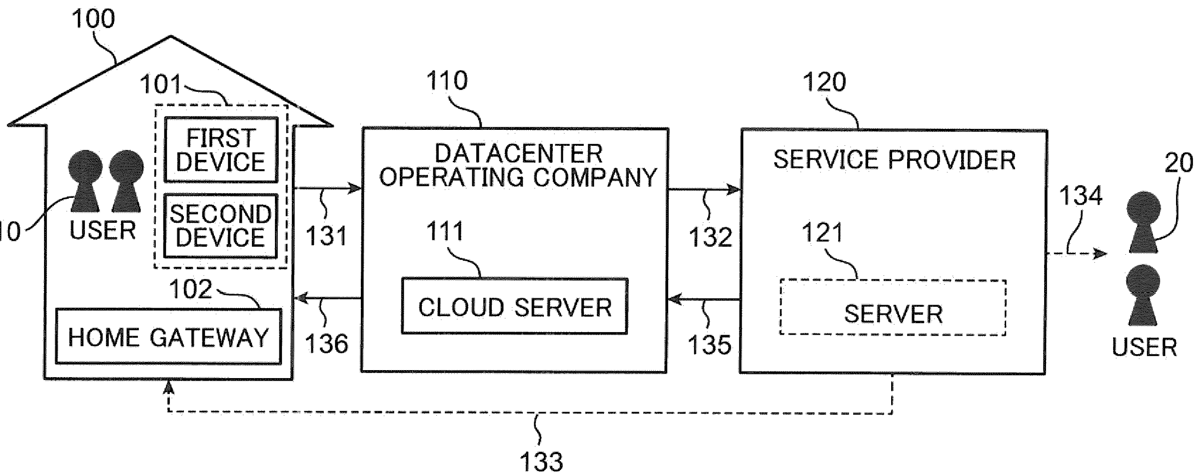
(54) METHOD AND APPARATUS FOR PROCESSING INFORMATION

(57) A method for processing information includes: acquiring at least a temperature and a humidity measured by a sensor disposed in a space where a sleeping person exists and an air conditioner is provided; acquiring falling-asleep decision information for deciding whether the person falls asleep; determining air blow control information concerning an air blow to bring an indicative value indicating a thermal condition to a target value by using at least the acquired temperature and humidity after deciding based on the acquired falling-asleep decision information that the person falls asleep; and controlling the air blow of the air conditioner by using the determined air blow control information.

FIG.1



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Description

Technical Field

[0001] The present disclosure relates to a method and an apparatus for processing information to control an air conditioner provided in a space where a sleeping person exists.

Background Art

[0002] Conventional methods for each controlling air condition in a space where a sleeping person exists include, for example, a technology described in Japanese Patent No. 4538941 (hereinafter, referred to as "Patent Literature 1").

[0003] Patent Literature 1 proposes an air conditioner which calculates a heat balance quantity Q of a human body based on an indoor temperature, a relative indoor humidity, an airflow speed, an average radiation temperature, a metabolic rate of the human body, and a heat resistance of a garment, and executes air conditioning in such a way that the heat balance quantity Q reaches a predetermined value.

[0004] Besides, for example, Yoh KAWASHIMA and Naoshi KAKITSUBA, "Optimal Thermal Conditions during Night Sleep in Summer", Human and Living Environment, Japanese Society of Human-Environment System, 2004, Vol. 11, No. 1, pp. 17-23 (hereinafter, referred to as "Non-Patent Literature 1") discloses results of tests concerning an optimal cooling condition for sleep in summer. Non-Patent Literature 1 discloses that an optimal control method for sleep in summer is includes controlling the air temperature constantly at 28°C to 29°C, setting the humidity at around 40% when a person falls asleep, and increasing the humidity up to around 60% after a lapse of approximately three hours when a body temperature starts stabilizing.

Summary of Invention

[0005] The air conditioner described in Patent Literature 1 controls a temperature and a humidity in such a way that a heat balance quantity Q during sleep reaches a predetermined value. However, a comfortable thermal condition environment is not constant entirely during the sleep. Therefore, the air conditioner described in Patent Literature 1 may fail to keep a comfortability for a sleeping person.

[0006] The present disclosure has been achieved to solve the problems, and has an object to provide a method and an apparatus for processing information which enables to establish a comfortable sleeping environment for a person.

[0007] A method for processing information according to one aspect of the present disclosure includes, by a computer: acquiring at least a temperature and a humidity measured by a sensor disposed in a space where a sleeping person exists and an air conditioner is provided; acquiring falling-asleep decision information for deciding whether the person falls asleep; determining air blow control information concerning an air blow to bring an indicative value indicating a thermal condition to a target value by using at least the acquired temperature and humidity after deciding based on the acquired falling-asleep decision information that the person falls asleep; and controlling the air blow of the air conditioner by using the determined air blow control information.

[0008] This disclosure makes it possible to achieve a comfortable sleeping environment for a person.

Brief Description of Drawings

[0009]

FIG. 1 is a diagram showing a conceptional view of a service provided by an air condition controlling system according to an embodiment of the present disclosure.

FIG. 2 is a diagram showing an example in which a device manufacturer is a datacenter operating company.

FIG. 3 is a diagram showing an example in which both or one of a device manufacturer and a managing company are/is a datacenter operating company.

FIG. 4 is a block diagram showing a configuration of the air condition controlling system according to the embodiment of the present disclosure.

FIG. 5 is a diagram illustrating a sleep state of a person.

FIG. 6 is a table showing a structure of a history database (DB) which stores sensor information acquired by a sensor information acquiring part and air conditioning control information acquired by a control information acquiring part.

FIG. 7 is a table showing a structure of the history DB which stores sleep state information and biological information acquired by a sleep state information acquiring part.

FIG. 8 is a diagram showing a display screen displayed on a terminal unit when receiving, before the person gets to sleep, setting of an estimated sleep starting time and an estimated awaking time.

FIG. 9 is a diagram showing display screens displayed on the terminal unit before and after receiving an input by a user who makes a subjective evaluation about a thermal condition environment during sleep when awaking.

FIG. 10 is a table showing a structure of the history DB which stores a thermal condition environment subjective evaluation acquired by an interface.

FIG. 11 is a table showing a structure of a setting database (DB) in the embodiment of the present disclosure.

FIG. 12 is a graph chronologically showing a control flow of the air conditioner in the embodiment of the present disclosure.

FIG. 13 is a flowchart showing a data accumulating process executed by the air conditioner and a cloud server in the embodiment of the present disclosure.

FIG. 14 is a flowchart showing a data accumulating process executed by a sleep state detector and the cloud server in the embodiment of the present disclosure.

FIG. 15 is a flowchart showing an air condition setting process executed by the cloud server in the embodiment of the present disclosure.

FIG. 16 is a flowchart showing a thermal condition indication raising process executed by the cloud server in the embodiment of the present disclosure.

FIG. 17 is a diagram illustrating a way of determining, in accordance with a sleep cycle, a time when to start raising the thermal condition indication in the embodiment of the present disclosure.

FIG. 18 is a diagram illustrating a timing to change a control parameter for the air conditioner in the embodiment of the present disclosure.

FIG. 19 is a diagram illustrating an example in which the thermal condition indication rises to reach an awaking time thermal condition indication by a thermal condition indication raising process finished time prior to the estimated awaking time.

FIG. 20 is a flowchart showing another thermal condition indication raising process executed by the cloud server when using a PMV as the thermal condition indication in the embodiment of the present disclosure.

FIG. 21 is a diagram showing a conceptional view of a service provided by an air condition controlling system of service type 1 (proprietary datacenter type cloud service).

FIG. 22 is a diagram showing a conceptional view of a service provided by an air condition controlling system of service type 2 (cloud service using IaaS).

FIG. 23 is a diagram showing a conceptional view of a service provided by an air condition controlling system of service type 3 (cloud service using PaaS).

FIG. 24 is a diagram showing a conceptional view of a service provided by an air condition controlling system of service type 4 (cloud service using SaaS).

Description of Embodiments

Underlying Knowledge Forming Basis of Present Disclosure

[0010] The air conditioner described in Patent Literature 1 controls a temperature and a humidity in such a way that a thermal balance quantity Q during sleep reaches a predetermined value. However, a comfortable thermal condition environment is not constant entirely during the sleep. For example, a person has a biorhythm that a temperature of a body core part lowers during night and rises at the break of dawn. It is therefore preferable to gradually make a warm indoor thermal condition environment in accordance with the biorhythm.

[0011] Moreover, an increase in an amount of the air blowing from an air conditioner may lead to occurrence of a noise, and a direct contact of the blown air with a skin of the person. Consequently, a comfortability for the person during the sleep may be decreased.

[0012] To solve the above-described problems, a method for processing information according to an aspect of the present disclosure includes, by a computer: acquiring at least a temperature and a humidity measured by a sensor disposed in a space where a sleeping person exists and an air conditioner is provided; acquiring falling-asleep decision information for deciding whether the person falls asleep; determining air blow control information concerning an air blow to bring an indicative value indicating a thermal condition to a target value by using at least the acquired temperature and humidity after deciding based on the acquired falling-asleep decision information that the person falls asleep; and controlling the air blow of the air conditioner by using the determined air blow control information.

[0013] In this configuration, the air blow control information concerning the air blow to bring the indicative value indicating the thermal condition to the target value is determined by using at least the temperature and the humidity measured by the sensor disposed in the space where the sleeping person exists and the air conditioner is provided, after deciding that the person falls asleep. Besides, the air blow of the air conditioner is controlled by using the determined air blow control information. This configuration therefore makes it possible to reduce a noise occurring from the air conditioner and prevent the person from coming into direct contact with the air blow on the skin by decreasing the amount of the air blow coming from the air conditioner, and thus can achieve a comfortable sleeping environment for the person.

[0014] The method for processing information may further include: determining temperature control information concerning a temperature to bring the indicative value to the target value after starting the controlling of the air blow using the air blow control information; and controlling a set temperature for the air conditioner by using the determined temperature control information.

[0015] In this configuration, the temperature to bring the indicative value to the target value is determined after the controlling of the air blow using the air blow control information is started, and a set temperature for the air conditioner is controlled so that the temperature in the space reaches the determined temperature. This configuration therefore makes it possible to bring the indicative value to the target value by controlling the set temperature for the air conditioner, and thus can achieve a comfortable sleeping environment for the person. Such achievement of the comfortable sleeping environment can be said to prevent a person from sleeping insufficiently or awaking during the sleep.

[0016] The method for processing information may further include: controlling a dehumidifying operation of the air conditioner after staring the controlling of the air blow using the air blow control information.

[0017] In this configuration, the dehumidifying operation of the air conditioner is controlled after the controlling of the air blow using the air blow control information is started. This configuration therefore makes it possible to bring the indicative value to the target value by controlling the dehumidifying operation of the conditioner, and thus can achieve a comfortable sleeping environment for the person.

[0018] The method for processing information may further include: controlling the dehumidifying operation after starting the controlling of the set temperature using the temperature control information.

[0019] In this configuration, the humidity in the space is decreased by the dehumidifying operation in a case that the humidity in the space reaches a predetermined value or higher after the controlling of the set temperature is started to keep the humidity in the space comfortable for the person. The configuration thus can achieve a comfortable sleeping environment for the person.

[0020] The method for processing information may further include: acquiring reactive information concerning a reaction of the person in the space to at least one of the air blow, the temperature, and the humidity; and determining based on the acquired reactive information whether to execute the controlling of the air blow, the controlling of the set temperature, and the controlling of the dehumidifying operation, and determining a content or an execution order of the controlling of the air blow, the controlling of the set temperature, and the controlling of the dehumidifying operation.

[0021] In this configuration, it is determined based on the reactive information concerning the reaction of the person in the space to at least one of the air blow, the temperature, and the humidity whether to execute the controlling of the air blow, the controlling of the set temperature, and the controlling of the dehumidifying operation, and further determined is a content or an execution order of the controlling of the air blow, the controlling of the set temperature, and the controlling of the dehumidifying operation. Accordingly, it is possible to provide a more comfortable sleeping environment corresponding to an individual difference in the reaction of the person to the air blow, the temperature, and the humidity.

[0022] The method for processing information may further include: raising the target value as time elapses after deciding based on the acquired falling-asleep decision information that the person falls asleep.

[0023] In this configuration, the indicative value rises as time elapses in accordance with a rise of the target value to reach an optimal value at the time when the person finally awakes. The configuration therefore can achieve a comfortable sleeping environment for the person.

[0024] The method for processing information may further include: acquiring biological information of the person in the space; and determining a time when to increase the target value based on the acquired biological information.

[0025] This configuration makes it possible to prevent the sleeping person from awaking in the mid of the sleep by, for example, raising the target value not at a time when the person is in light sleeping, but at a time when the person is in deep sleeping. The configuration thus can achieve a comfortable sleeping environment for the person.

[0026] The method for processing information may further include: acquiring evaluation information concerning an evaluation by the person in the space about a result of a past controlling of the air blow using at least the air blow control information; and determining the target value based on the acquired evaluation information.

[0027] In this configuration, the evaluation about the result of the controlling of the air blow using at least the past air blow control information is reflected in the target value at the time when the person awakes. Accordingly, it is possible to provide a more comfortable environment reflecting the evaluation by the person in the space about the result of the control during the sleep.

[0028] The method for processing information may further includes: acquiring biological information of the person in the space by performing measurement during the controlling of the air blow using at least the air blow control information; and determining the target value based on the acquired biological information.

[0029] In this configuration, the biological information of the person in the space as obtained by performing the measurement during the controlling of the air blow using at least the air blow control information is reflected in the target value at the time when the person awakes. Accordingly, it is possible to provide a more comfortable sleeping environment in response to the biological information of the person with respect to the controlling of the set temperature during the sleep.

[0030] An apparatus for processing information according to another aspect of the present disclosure includes: a sensor information acquiring part which acquires at least a temperature and a humidity measured by a sensor disposed in a space where a sleeping person exists and an air conditioner is provided; a falling-asleep decision information acquiring part which acquires falling-asleep decision information for deciding whether the person falls asleep; a determining part which determines air blow control information concerning an air blow to bring an indicative value indicating a thermal condition to a target value by using at least the acquired temperature and humidity after deciding based on the acquired falling-asleep decision information that the person falls asleep; and a controller which controls the air blow of the air conditioner by using the determined air blow control information.

[0031] In this configuration, the air blow control information concerning the air blow to bring the indicative value indicating the thermal condition to the target value is determined by using at least the temperature and the humidity measured by the sensor disposed in the space where the sleeping person exists and the air conditioner is provided, after deciding that the person falls asleep. Besides, the air blow of the air conditioner is controlled by using the determined air blow control information. This configuration therefore makes it possible to reduce a noise occurring from the air conditioner and prevent the person from coming into direct contact with the air blow on the skin by decreasing the amount of the air blow coming from the air conditioner, and thus can achieve a comfortable sleeping environment for the person.

[0032] Hereinafter, an embodiment of the present invention will be described with reference to the accompanying drawings. It should be noted that the following embodiment illustrates one example of the invention, and not delimit the protection scope of the present invention.

Embodiment

[0033] First, a conceptional view of a service provided by an air condition controlling system in this embodiment will be described.

[0034] FIG. 1 is a diagram showing a conceptional view of a service provided by the air condition controlling system according to an embodiment of the present disclosure. FIG. 2 is a diagram showing an example in which a device manufacturer is a datacenter operating company. FIG. 3 is a diagram showing an example in which both or one of a device manufacturer and a managing company are/is a datacenter operating company.

[0035] The air condition controlling system includes a group 100, a datacenter operating company 110, and a service provider 120.

[0036] A group 100 is, for example, a company, a party, or a home, and the scale thereof does not matter. The group 100 contains a plurality of devices 101 including a first device and a second device, and a home gateway 102. The plurality of devices 101 include a device (e.g. a smartphone, a personal computer (PC), or a television) connectable to the Internet, and a device (e.g. a lighting fixture, a washing machine, or a refrigerator) unconnectable to the Internet by itself. The plurality of devices 101 may include a device which is unconnectable to the Internet by itself, but is connectable to the Internet via the home gateway 102. User 10 uses the plurality of the devices 101 in the group 100.

[0037] A datacenter operating company 110 includes a cloud server 111. The cloud server 111 is a virtual server associated with a variety of devices via the Internet. The cloud server 111 mainly manages huge data (big data) which have difficulty in management by widely used database managing tools or the like. The datacenter operating company 110 manages data, manages the cloud server 111, and operates a datacenter which performs these operations. The details of the services performed by the datacenter operating company 110 will be described later.

[0038] The datacenter operating company 110 is not limited to a company which merely manages data or operates the cloud server 111. For example, as illustrated in FIG. 2, in the case of a device manufacturer which develops and manufactures one of the plurality of devices 101 manages data or manages the cloud server 111, the device manufacturer is the datacenter operating company 110. Furthermore, the number of datacenter operating companies 110 is not limited to one. For example, as illustrated in FIG. 3, in the case of the device manufacturer and another managing company jointly or sharingly manage data or operates the cloud server 111, both or one of the device manufacturer and the managing company are/is the datacenter operating company 111.

[0039] A service provider 120 has a server 121. The scale of the server 121 does not matter. Thus, the server 121 includes, for example, a memory in a PC for personal use. Also, the service provider 120 may not have the server 121 in another case.

[0040] In the aforementioned services, the home gateway 102 is not a necessary element. For example, in the case that the cloud server 111 manages all the data, the home gateway 102 is unnecessary. Furthermore, in the case that all the devices in a house are connected to the Internet, a device unconnectable to the Internet by itself may not exist.

[0041] Next, a flow of log information (operation history information and working history information) in the aforementioned services will be described.

[0042] The first device or the second device in the group 100 transmits corresponding log information to the cloud server 111 of the datacenter operating company 110. The cloud server 111 collects the log information of the first device or the second device (see the arrow 131 in FIG. 1). The log information here is information indicating, for example, operation conditions or operation dates and times of the plurality of devices 101. For example, the log information includes a viewing history of a television, information of recording reservation of a recorder, an operation date and time of a washing machine, a quantity of laundry, dates and times at which a refrigerator is opened and closed, the number of times of the opening and closing of the refrigerator, but is not limited to these pieces of information, and may include a variety of pieces of information acquirable from a variety of devices. The log information may be directly provided from the plurality of devices 101 themselves to the cloud server 111 via the Internet. Also, the log information may be temporarily collected from the plurality of devices 101 to the home gateway 102, and provided from the home gateway 102 to the cloud server 111.

[0043] Subsequently, the cloud server 111 of the datacenter operating company 110 provides the collected log information to the service provider 120 at a discrete extent. The discrete extent may be an extent to which the datacenter operating company 110 can organize and provide the collected information to the service provider 120, or an extent to which the service provider 120 requests. The information is defined to be provided at the discrete extent, but may not be provided at the discrete extent. Alternatively, the amount of information to be provided may vary depending on a condition. The log information is stored in the server 121 provided in the service provider 120, if necessary (see the arrow 132 in FIG. 1).

[0044] Then, the service provider 120 organizes the log information into information suitable for a service provided to a user, and provides the organized information to the user. The user provided with the information may be the user 10 who uses the plurality of devices 101, or may be an external user 20. A method for providing information to the users 10, 20 may include, for example, directly providing the information to the users 10, 20, from the service provider 120 (the arrows 133 and 134 in FIG. 1). A method for providing the information to the user 10 may include, for example, providing the information to the user 10 via the cloud server 111 of the datacenter operating company 110 again (the arrows 135 and 136 in FIG. 1). Moreover, the cloud server 111 of the datacenter operating company 110 may organize the log information into information suitable for the service provided to the user, and provide the organized information to the service provider 120.

[0045] It should be noted that the user 10 may be the same as or different from the user 20.

[0046] FIG. 4 is a block diagram showing a configuration of the air condition controlling system according to the embodiment of the present disclosure.

[0047] The air condition controlling system includes, an air conditioner 310, a cloud server 320, a sleep state detector 330, and a terminal unit 340. The configuration of the cloud server 320 partly or entirely belongs to either a cloud server of the datacenter operating company or a server of the service provider.

[0048] The air conditioner 310 is communicatively connected to the cloud server 320 via a network. Furthermore, the sleep state detector 330 is communicatively connected to the cloud server 320 via the network. The terminal unit 340 is communicatively connected to the cloud server 320 via the network. The network is, for example, the Internet.

[0049] The air conditioner 310 is a device, e.g., a room air conditioner, which adjusts an air quality environment in a room. The air conditioner 310 includes sensors 311, a sensor information acquiring part 312, an air condition controlling part 313, a control information acquiring part 314, and a communication part 315

[0050] The air condition controlling part 313 has a control function of adjusting an air temperature or a humidity in the room, specifically, has an air conditioning function, such as a cooling function of cooling the room, a warming function of warming the room, and a dehumidifying function of decreasing the humidity in the room It is sufficient that the air condition controlling part 313 has a control function of controlling a temperature or a humidity in the room, and thus the function should not be limited to the air conditioning function. The air condition controlling part 313 performs the controlling by using a control parameter designated by an air condition setting part 355 of the cloud server 320. The control parameter includes, for example, an operational status, an operational mode, a set temperature, an airflow amount, and an airflow direction. The operational status is a parameter indicating whether to turn on or off a power supply of the air conditioner 310. The operational mode is a parameter indicating any one of a cooling mode, a warming mode, a dehumidifying mode, and an automatic mode to operate the air conditioner 310. The set temperature is a parameter indicating a target temperature designated by the air conditioner 310. The airflow amount is a parameter indicating an amount of the air blowing out of the air conditioner 310. The airflow direction is a parameter indicating a direction in which the air blowing out of the air conditioner 310 flows.

[0051] The sensors 311 include various sensors mounted in the air conditioner 310. For example, the sensors 311 include: a temperature sensor which measures an indoor temperature; a humidity sensor which measures an indoor humidity; another temperature sensor which measures an outdoor temperature; another humidity sensor which measures an outdoor humidity; a human sensor which detects whether a person exists in a room; and a power sensor which measures an amount of power consumed by the air conditioner 310. The human sensor detects a person by using infrared rays, for example. The power sensor calculates a power amount from an electric current flowing when the air conditioner 310 works. The sensors 311 may include a sensor which measures a temperature of the air blow at an air blow outlet, and a sensor which measures a rotational speed (cooling and warming intensity) of a compressor. Moreover, the sensors 311 may measure at least a temperature and a humidity in a space where the air conditioner 310 is provided.

[0052] The sensor information acquiring part 312 acquires various sensor information by using the sensors 311 mounted in the air conditioner 310. The sensor information acquired from the sensors 311 by the sensor information acquiring part 312 includes, for example, an indoor temperature, an indoor humidity, an outdoor temperature, an outdoor humidity, existence/absence information indicating whether a person exists, and an amount of power consumed by the air conditioner 310. The sensor information acquiring part 312 may acquire a temperature of the air blow at the air blow outlet, and the rotational speed of the compressor.

[0053] The control information acquiring part 314 acquires the air conditioning control information from the air condition controlling part 313. The air conditioning control information indicates a control content of the air condition controlling part 313, specifically, includes parameter information such as an operational status, an operational mode, a set temperature, an airflow direction, and an airflow amount.

[0054] The communication part 315 transmits various information to the cloud server 320, and receives various information from the cloud server 320. The communication part 315 transmits the sensor information acquired by the sensor information acquiring part 312 to the cloud server 320. The communication part 315 further transmits the air conditioning control information acquired by the control information acquiring part 314 to the cloud server 320. The communication part 315 receives a control parameter sent by the cloud server 320, and outputs the received control parameter to the air condition controlling part 313.

[0055] The sleep state detector 330 includes an electric wave sensor 331, a sleep state information acquiring part 332, and a communication part 333. The sleep state detector 330 is arranged, for example, above or below a bed on which the person sleeps.

[0056] The electric wave sensor 331 is mounted to the sleep state detector 330, and measures the biological information of the person without any contact therewith. The electric wave sensor 331 measures the biological information of the person by irradiating the person with a microwave, and measuring from the Doppler shift of a reflective wave a very small change in a distance between the electric wave sensor 331 and the person. The biological information includes, for example, an amount of body motion (hereinafter, referred to as "body motion amount"), a breathing rate, and a heart rate.

[0057] The sleep state information acquiring part 332 acquires the biological information from the electric wave sensor 331, and estimates a sleep state of the person based on the acquired biological information. The sleep state information acquiring part 332 outputs the acquired biological information and the estimated sleep state information to the communication part 333.

[0058] FIG. 5 is a diagram illustrating a sleep state of a person. In FIG. 5, a vertical axis indicates the sleep state, and a horizontal axis indicates an elapsed sleep time.

[0059] As shown in FIG. 5, the sleep of a person can be classified into a plurality of sleep states changing as time elapses in accordance with a sleep depth and a sleep characteristic. As shown in FIG. 5, the sleep is classified into a REM sleep state and a NON-REM sleep sate. The REM sleep state represents one sleep state along with a rapid eye movement. In the REM sleep state, the brain is active whereas the body is in rest. It is said that a person is highly likely to dream during the REM sleep state. The NON-REM sleep state represents another sleep state without the rapid eye movement. The NON-REM sleep state is further subdivided into four stages, i.e., stages 1 to 4, in accordance with the sleep depth. The stage 4 has the deepest sleep level. In the NON-REM sleep state, a brain wave having a low frequency and a high amplitude is frequently measured, the brain wave being called as a delta wave having a frequency of 1Hz to 4Hz. A person normally reaches the stage 3 or 4 of the NON-REM sleep state within 45 to 60 minutes after falling asleep, and then gradually sleeps lighter and enters the REM sleep state within the subsequent one to two hours. Thereafter, the NON-REM state and the REM state alternately repeat with a sleep cycle of 90 to 110 minutes.

[0060] The biological information including the body motion amount, the breathing rate, and the heart rate has an interrelationship with the sleep states shown in FIG. 5. For example, a deep sleep stage represented by the stage 3 or 4 of the NON-REM sleep state is known to exhibit a less body motion amount and a lower heart rate variability (RRI). The sleep state information acquiring part 332 estimates the sleep state of the person based on the biological information in a real time by using the aforementioned interrelationship. The sleep state is sent, as sleep state information, to the cloud server 320. The sleep state information acquiring part 332 estimates based on the biological information the sleep state of the person among from the awaking state, the REM-sleep state, the stage 1 of the NON-REM sleep state, the stage 2 of the NON-REM sleep state, the stage 3 of the NON-REM sleep state, and the stage 4 of the NON-REM sleep state.

[0061] The communication part 333 transmits the biological information acquired by the sleep state information acquiring part 332 and the sleep state information estimated by the sleep state information acquiring part 332 to the cloud server 320.

[0062] Although the sleep state information acquiring part 332 estimates the sleep state in the embodiment, the present disclosure should not be particularly limited thereto. Not the sleep state detector 330 but the cloud server 320 may estimate the sleep state. In this case, the cloud server 320 may include a sleep state estimating part. The sleep state estimating part may estimate the sleep state by using the biological information including the body motion amount, the breathing rate, and the heart rate sent from the sleep state detector 330, or past data stored in a history database (DB) 361.

[0063] Moreover, although the sleep state detector 330 includes a non-contact type of electric wave sensor in the embodiment, any sensor adapted to acquire the biological information which is available to estimate the sleep state can be used without limitation to the electric wave sensor. For example, the sleep state detector 330 may include a contact type of sensor. The sleep state detector 330 may be, for instance, a wearable terminal to be attached onto an arm. The wearable terminal may include a non-contact type of sensor which measures the biological information including the body motion amount and the heart rate. Moreover, a pressure sensitive type of sensor disposed below a mat on which the person lies to sleep may measure the biological information.

[0064] In the embodiment, the air conditioner 310 may include the electric wave sensor 331 and the sleep state information acquiring part 332.

[0065] The cloud server 320 includes a communication part 321, a processor 322, and a memory 323. The processor 322 includes a sensor information storing part 351, a control information storing part 352, a sleep state information storing part 353, a control parameter determining part 354, the air condition setting part 355, and an interface 356. The memory 323 includes the history DB 361 and a setting database (DB) 362.

[0066] The communication part 321 receives the sensor information and the air conditioning control information sent by the air conditioner 310, the sleep state information and the biological information sent by the sleep state detector 330, and the setting information sent by the terminal unit 340.

[0067] The communication part 321 acquires at least the temperature and the humidity measured by the sensor 311 disposed in the space where the sleeping person exists and the air conditioner 310 is provided.

[0068] The sensor information storing part 351 stores in the history DB 361 the sensor information including the indoor temperature, the indoor humidity, the existence/absence information, and the power amount acquired by the sensor information acquiring part 312 of the air conditioner 310. The sensor information includes at least the indoor temperature and the indoor humidity. The communication part 321 makes a request for the sensor information to the air conditioner 310 periodically (e.g., per minute) via a network such as the Internet. The communication part 321 receives the sensor information sent by the air conditioner 310 in response to the request from the cloud server 320. The sensor information storing part 351 stores in the history DB 361 the sensor information received by the communication part 321. The communication part 315 of the air conditioner 310 may periodically (i.e., per minute) upload the sensor information acquired by the sensor information acquiring part 312 to the cloud server 320.

[0069] The control information storing part 352 stores in the history DB 361 the air conditioning control information acquired by the control information acquiring part 314 of the air conditioner 310. The communication part 321 makes a request for the air conditioning control information to the air conditioner 310 periodically (e.g., per minute) via a network such as the Internet. The communication part 321 receives the air conditioning control information sent by the air conditioner 310 in response to the request from the cloud server 320. The control information storing part 352 stores in the history DB 361 the air conditioning control information received by the communication part 321. The communication part 315 of the air conditioner 310 may periodically (e.g., per minute) upload the air conditioning control information acquired by the control information acquiring part 314 to the cloud server 320. The communication part 315 of the air conditioner 310 may upload the air conditioning control information to the cloud server 320 when triggered by an incident that a control content is changed.

[0070] The communication part 321 acquires the sleep state information used to decide whether the person falls asleep. The sleep state information is exemplary falling-asleep decision information.

[0071] The sleep state information storing part 353 stores in the history DB 361 the sleep state information acquired by the sleep state information acquiring part 332 of the sleep state detector 330. The communication part 321 makes a request for the sleep state information to the air conditioner 310 periodically (e.g., every 5 minutes) via a network such as the internet. The sleep state information storing part 353 stores in the history DB 361 the sleep state information received by the communication part 321. The communication part 333 of the sleep state detector 330 may periodically (e.g., every 5 minutes) upload the sleep state information acquired by the sleep state information acquiring part 332 to the cloud server 320.

[0072] The communication part 333 of the sleep state detector 330 may transmit to the cloud server 320 the biological information in addition to the sleep state information. In this case, the communication part 321 of the cloud server 320 receives the sleep state information and the biological information sent by the air conditioner 310. The sleep state information storing part 353 stores in the history DB 361 the biological information as well as the sleep state information.

[0073] The history DB 361 is a database which stores the sensor information received from the sensor information storing part 351, the air conditioning control information received from the control information storing part 352, and the sleep state information received from the sleep state information storing part 353. The database typically has a format of a relational database, e.g., SQL, but may be a NoSQL based database, e.g., a Key-Value type database, structuring data having a simple relationship.

[0074] FIG. 6 is a table showing a structure of the history DB which stores the sensor information acquired by the sensor information acquiring part and the air conditioning control information acquired by the control information acquiring part. FIG. 7 is a table showing a structure of the history DB which stores the sleep state information and the biological information acquired by the sleep state information acquiring part.

[0075] In the table of FIG. 6, the column "ID" represents identification information unique to identify each record, and the column "TIME" represents a time at which each piece of the information is acquired. The columns "INDOOR TEMPERATURE", "INDOOR HUMIDITY", "OUTDOOR TEMPERATURE", "TEMPERATURE OF AIR BLOW", "EXISTENCE/ABSENCE INFORMATION", and "POWER AMOUNT" represent the sensor information acquired by the sensor information acquiring part 312. The columns "OPERATIONAL STATUS", "OPERATIONAL MODE", "SET TEMPERATURE", "AIRFLOW AMOUNT", and "AIRFLOW DIRECTION" represent the air conditioning control information acquired by the control information acquiring part 314. The sensor information and the air conditioning control information is managed together in the one table for easier explanation, but may be managed individually by different tables. Moreover, the column "POWER AMOUNT" in FIG. 6 represents an integrated amount of power (wh) from a past record to a current record.

[0076] In the table of FIG. 7, the column "ID" represents identification information unique to identify each record, and the column "TIME" represents a time at which each piece of the information is acquired. The columns "SLEEP STATE", "HEART RATE", "BREATHING RATE", and "BODY MOTION AMOUNT" represent the information acquired by the sleep state information acquiring part 332. The column "SLEEP STATE" represents each sleep state of the person illustrated in FIG. 5 at each time. The word "WAKE" represents an awaking state, the word "REM" represents the REM sleep state, the word "STAGE 1" represents the stage 1 of the NON-REM sleep state, the word "STAGE 2" represents the stage 2 of the NON-REM sleep state, the word "STAGE 3" represents the stage 3 of the NON-REM sleep state, and the word "STAGE 4" represents the stage 4 of the NON-REM sleep state.

[0077] The column "HEART RATE" represents a heart rate at each time, particularly, a heart rate per minute in the example shown in FIG. 7. The column "BREATHING RATE" represents a breathing rate at each time, particularly, a breathing rate per minute in the example shown in FIG. 7. The column "BODY MOTION AMOUNT" represents an amount of body motion at each time, for example, a maximal body motion amount per minute, or a value obtained by normalizing the number of times exceeding a threshold to decide the body motion per minute to the value of 0 to 100.

[0078] The terminal unit 340 is, for example, a smartphone, a tablet-type computer, or a personal computer. The terminal unit 340 includes an input part and a display part which are unillustrated. The terminal unit 340 receives an input by a user concerning an estimated sleep starting time and an estimated awaking time before the user gets to sleep, and further receives another input by the user who makes a subjective evaluation about a thermal condition environment during sleep when awaking. Moreover, the terminal unit 340 sends to the cloud server 320 the estimated sleep starting time, the estimated awaking time, and a result of the thermal condition environment subjective evaluation (i.e., "evaluation information") respectively input by the user.

[0079] The interface 356 is an external interface which receives an input by the user, and is, for instance, in the form of a WebAIP (Application Programming Interface) for communication at a protocol "http/https". The interface 356 stores in the setting DB 362 or the history DB 361 the setting information received from the terminal unit 340. The setting information includes, for example, the estimated sleep starting time and the estimated awaking time. The interface 356 may send the sleep state information, the air conditioning control information, or the sensor information stored in the history DB 361 to the terminal unit 340 via the communication part 321.

[0080] FIG. 8 is a diagram showing a display screen displayed on the terminal unit when receiving, before the person gets to sleep, setting of an estimated sleep starting time and an estimated awaking time. As shown in FIG. 8, the terminal unit 340 displays a setting screen 341 to receive an input of an estimated sleep starting time and an estimated awaking time for each day of a week. The setting screen 341 includes items 1801 and 1802 to each receive the input of the estimated sleep starting time and the estimated awaking time. The item 1801 of the example in FIG. 8 shows the estimated sleep starting time set at 23:00, and the estimated awaking time set at 7:00 for Monday, Tuesday, Wednesday, Thursday, and Friday. The item 1802 shows the estimated sleep starting time set at 23:30, and the estimated awaking time set at 8:00 for Saturday and Sunday. When each of the items 1801 and 1802 displayed on the terminal unit 340 is tapped, the display screen is changed to a detail screen for setting the estimated sleep starting time and the estimated awaking time. Consequently, the setting information is sent to the cloud server 320 upon completion of the setting.

[0081] FIG. 9 is a diagram showing display screens displayed on the terminal unit before and after receiving an input by a user who makes a subjective evaluation about a thermal condition environment during sleep when awaking. As shown in FIG. 9, when a current time indicates the estimated awaking time, the terminal unit 340 displays an awaking screen 342 to urge the user to input a subjective evaluation about the thermal condition environment during the sleep. The awaking screen 342 shown in FIG. 9 displays thereon a character image saying "HOW ABOUT AIR CONDITIONING TODAY? PUSH ONE OF ICONS!", and five icons representing five evaluation levels of "cold", "a little cold", "comfortable", "a little hot", and "hot". The user inputs on the awaking screen 342 the subjective evaluation about the thermal condition environment during the sleep.

[0082] The terminal unit 340 displays an evaluation result screen 343 in response to the tapping of any one of the five icons by the user. Subsequently, one of the evaluation levels of "cold", "a little cold", "comfortable", "a little hot", and "hot" as selected by the user is sent, as an evaluation result, to the cloud server 320. In the embodiment, the subjective evaluation by the user about the thermal condition environment is defined as "thermal condition environment subjective evaluation". The thermal condition environment subjective evaluation may be further classified into a temperature perception, a humidity perception, and a comfortability, rather than only the temperature perception including the five levels of "cold", "a little cold", "comfortable", "a little hot", and "hot". Moreover, the thermal condition environment subjective evaluation may be dividedly made in an early stage, a mid-stage, and a late stage of the sleep. The communication part 321 of the cloud server 320 receives the result of the thermal condition environment subjective evaluation, and the interface 356 stores in the history DB 361 the received result of the thermal condition environment subjective evaluation.

[0083] FIG. 10 is a table showing a structure of the history DB which stores the thermal condition environment subjective evaluation acquired by the interface. Specifically, the history DB 361 manages the thermal condition environment subjective evaluation in the table shown in FIG. 10. The history DB 361 stores the thermal condition environment subjective evaluation together with an actual sleep starting time and an actual awaking time.

[0084] In the table in FIG. 10, the column "ID" represents identification information unique to identify each record, and the column "ACTUAL SLEEP STARTING TIME" represents a time when the user actually gets to sleep. A time when the sleep sate acquired by the sleep state detector 330 transits from the awaking state to the NON-REM sleep state is stored as the actual sleep starting time. The column "ACTUAL AWAKING TIME" represents a time when the user actually awakes. A time when the sleep state acquired by the sleep state detector 330 transits from the NON-REM sleep state to the awaking state is stored as the actual awaking time. The column "THERMAL CONDITION ENVIRONMENT SUBJECTIVE EVALUATION" represents an evaluation result by the user about the thermal condition environment during the sleep, and shows any one of the five evaluation levels of "1: COLD", "2: A LITTLE COLD", "3: COMFORTABLE", "4: A LITTLE HOT", and "5: HOT".

[0085] In each of the examples in FIGS. 8 and 9, an image displayed by an application of the terminal unit 340 is illustrated, but any form of application is adoptable. The terminal unit 340 may receive an input of the setting information and the thermal condition environment subjective evaluation by using an interactive application such as a Virtual Personal Assistant (VPA).

[0086] The setting DB 362 is a database which stores the setting information acquired by the interface 356. The database typically has a format of a relational database, e.g., SQL, but may be a NoSQL based database, e.g., a Key-Value type database, structuring data having a simple relationship.

[0087] FIG. 11 is a table showing a structure of the setting DB in the embodiment of the present disclosure. The table of the setting DB 362 includes the columns "ID", "ESTIMATED SLEEP STARTING TIME", "ESTIMATED AWAKING TIME", "DAY OF WEEK", and "AWAKING TIME THERMAL CONDITION INDICATION". The column "ID" represents identification information unique to identify each record. The column "ESTIMATED SLEEP STARTING TIME" represents an estimated sleep starting time input by the user. The column "ESTIMATED AWAKING TIME" represents an estimated awaking time input by the user. The column "DAY OF WEEK" represents a target day for the estimated sleep time and the estimated awaking time of each record. An application executed by the terminal unit 340 shown in FIG. 8 is used to set these values. The column "AWAKING TIME THERMAL CONDITION INDICATION" represents a target indication at the awaking time, particularly, indicates a value of a discomfort index in the example of FIG. 11. The awaking time thermal condition indication is used in a process of the control parameter determining part 354. Details of the process executed by the control parameter determining part 354 will be described later.

[0088] The control parameter determining part 354 calculates a control parameter for controlling the air conditioner 310 by using the history DB 361 and the setting DB 362. The control parameter determining part 354 determines air blow control information concerning an air blow to bring an indicative value indicating a thermal condition to a target value by using at least the acquired temperature and humidity after deciding based on the acquired sleep state information (falling-asleep decision information) that the person falls asleep. For example, the control parameter determining part 354 reduces an amount of the air to blow out of the air conditioner 310 after a lapse of a predetermined time (e.g., one hour) from the decision that the person falls asleep.

[0089] The control parameter determining part 354 determines temperature control information concerning a temperature to bring the indicative value to the target value after starting the controlling of the air blow using the air blow control information. The control parameter determining part 354 determines the temperature control information concerning the temperature to bring the indicative value to the target value by using an ultimate target value (awaking time thermal condition indication) at the time when a person awakes. Specifically, the control parameter determining part 354 determines an amount of change in a target value at each time or in a chronological target value by using the ultimate target value. Further, the control parameter determining part 354 determines the air blow control information based on the amount of change in the target value at each time or in the chronological target value. For example, to change the target value in proportion to a time, the control parameter determining part 354 raises the target value as time elapses by determining a current target value based on the ultimate target value after deciding based on the acquired sleep state information (falling-asleep decision information) that the person falls asleep. However, the change in the target value is not necessarily proportional to the time, but may be made in another manner. For example, the target value may be changed in accordance with a characteristic or a favor of the user.

[0090] The air condition setting part 355 notifies the control parameter determined by the control parameter determining part 354 to the air conditioner 310 via the communication part 321. The communication part 321 transmits the control parameter output from the air condition setting part 355 to the air conditioner 310. The air condition setting part 355 controls the air blow of the air conditioner 310 by using the air blow control information determined by the control parameter determining part 354.

[0091] The air condition setting part 355 controls a set temperature of the air conditioner 310 by using the temperature control information determined by the control parameter determining part 354 The air condition setting part 355 controls a dehumidifying operation of the air conditioner 310 after starting the controlling of the air blow using the air blow control information. The air condition setting part 355 controls the dehumidifying operation after starting the controlling of the set temperature using the temperature control information.

[0092] FIG. 12 is a graph chronologically showing a control flow of the air conditioner in the embodiment of the present disclosure.

[0093] In FIG. 12, a horizontal axis indicates an elapsed sleep time, and a vertical axis indicates a temperature, a discomfort index, a humidity, and an airflow amount. A dashed line 1102 indicates a chronological transition of the discomfort index. A solid line 1103 indicates a chronological transition of the humidity. A solid line 1104 indicates a chronological transition of the set temperature for the air conditioner 310 determined by the control parameter determining part 354. A solid line 1105 indicates a chronological transition of an amount of the air actually blowing out of an internally equipped unit of the air conditioner 310. An operational mode 1107 indicates a chronological change of the operational mode of the air conditioner 310. Further, in FIG. 12, the cooling operation is executed in an earlier stage during the sleep, and the operation is switched to the dehumidifying operation later. Hereinafter, the control of the air conditioner 310 will be described with reference to the graph shown in FIG. 12.

[0094] In FIG. 12, the air condition from a room entering time to a sleep starting time of a user is set in accordance with a favor of the user. Specifically, the user sets any operational mode, airflow amount, airflow direction, and set temperature by using a remote controller to remotely operate the air conditioner 310. The control parameter determining part 354 decides that the user starts to sleep and calculates the control parameter when the current time exceeds the estimated sleep starting time stored in the setting DB 362. The control parameter determining part 354 maintains the control parameter at the sleep starting time without changing the control parameter for the air conditioner 310 until a lapse of one hour from a falling-asleep detection time when it is detected that the user falls asleep. The detection that the user falls asleep is made based on the sleep state information sent from the sleep state detector 330.

[0095] The control parameter determining part 354 decides that the person falls asleep upon detection of the sleep state representing the deep sleep stage (i.e., the stage 3 or 4 of the NON-REM sleep state) on or after the sleep starting time (estimated sleep starting time). The time period of one hour after the user falls asleep is defined as an initial sleep cycle. The initial sleep cycle is the most important for good sleep. Hence, a sleeping environment at the sleep starting time is kept without being changed during the time period of the one hour from the falling-asleep detection time.

[0096] In the embodiment, although the control parameter at the sleep starting time is maintained until the lapse of one hour from the falling-asleep detection time, the present disclosure should not be particularly limited thereto. It is sufficient that the control parameter determining part 354 maintains the control parameter at the sleep starting time until a lapse of a predetermined time from the falling-asleep detection time. Such a predetermined time may be adjusted, for example, based on a sleep history of the user.

[0097] After the lapse of the one hour from the falling-asleep detection time, the controller parameter determining part 354 changes the control parameter for the air conditioner 310 in such a way as to gradually warm the room by using the thermal condition indication. In the example shown in FIG. 12, a discomfort index is used as the thermal condition indication. The discomfort index represents the thermal condition indication calculated from a temperature and a humidity by using the following Formula (1):

$$\text{Discomfort index (DI)} = 0.81 \times T + 0.01 \times H \times (0.99 \times T - 14.3) + 46.3 \cdots (1).$$

[0098] In the Formula (1), "T" represents a dry-bulb temperature (°C), and "H" represents a humidity (%). The control parameter determining part 354 determines the control parameter for the air condition controlling to achieve the awaking time discomfort index (awaking time thermal condition indication) set in the setting DB 362.

[0099] The interface 356 of the cloud server 320 acquires evaluation information indicating an evaluation (thermal condition environment subjective evaluation) by the user existing in the space about the result of the controlling of the air blow using at least the past air blow control information. The interface 356 determines based on the acquired evaluation information a target value (awaking time thermal condition indication). The interface 356 updates an ultimate target value (awaking time thermal condition indication) stored in the setting DB 362 to the determined ultimate target value (awaking time thermal condition indication).

[0100] The awaking time thermal condition indication is set at a value to achieve comfort based on a past thermal condition environment subjective evaluation in the history. For example, the awaking time discomfort index is set at 77.5, and the air conditioner 310 is controlled in such a way that the discomfort index reaches the set awaking time discomfort index. Thereafter, if the user evaluates that it is hot when awaking, the awaking time discomfort index is lowered down to 77.0 for the next control. Conversely, if the user evaluates that it is cold when awaking, the awaking time discomfort index is raised up to 78.0. As shown in FIG. 12, after the lapse of one hour from the falling-asleep detection time, the control parameter determining part 354 changes the set temperature for the air conditioner 310 in such a way that the discomfort index transits along a line segment 1101 which connects the awaking time discomfort index at the estimated awaking time and the discomfort index at the time after the lapse of one hour from the falling-asleep detection time with each other.

[0101] When a user sleeps for the first time, the control parameter determining part 354 may set, as an initial value of the awaking time thermal condition indication, a value obtained by adding a predetermined value to a value of a thermal condition indication from a sleep starting time to a time after a lapse of one hour from a falling-asleep detection time. For instance, if the discomfort index at the sleep starting time indicates 75, the control parameter determining part 354 sets 77 by adding the predetermined value "2" to the discomfort index at the sleep starting time as an initial value of the awaking time thermal condition indication. Here, the predetermined value to be added is set at "2", for example, but may be calculated from a past awaking time thermal condition indication indicative of comfort for another user. This configuration makes it possible to determine a preferable awaking time thermal condition indication even in use of the system for the first time.

[0102] Moreover, when a user sleeps for the first time, an initial value of the awaking time thermal condition indication may be determined based on a subjective evaluation by the user about an air condition, such as "sensitive to heat", "sensitive to cold", or "normal". For example, the terminal unit 340 may receive an input of the subjective evaluation by the user before the user gets to sleep. The interface 356 may determine the awaking time discomfort index at 76 if the subject evaluation by the user indicates "sensitive to heat", determine the awaking time discomfort index at 77 if the subjective evaluation by the user indicates "normal", and determine the awaking time discomfort index at 78 if the subjective evaluation by the user indicates "sensitive to cold". This configuration makes it possible to determine a favorable awaking time thermal condition indication even in use of the system for the first time. The interface 356 preliminarily sets, in the setting DB 362, the subjective evaluation by the user about the air condition.

[0103] In the embodiment, the interface 356 may acquire the biological information of a person in a space by performing measurement during the controlling of the air blow using at least the air blow control information for the air conditioner 310, and determine the target value (awaking time thermal condition indication) based on the acquired biological information. The biological information includes, for example, a body motion amount of a sleeping person. The interface 356 acquires a body motion amount of a sleeping user from the history DB 361 when the user awakes. The interface 356 determines whether the body motion amount of the sleeping user indicates not lower than a predetermined value indicating awaking in the mid of the sleep. When determining that the body motion amount of the sleeping user reaches the predetermined value or higher, the interface 356 decreases a current value of the awaking time thermal condition indication stored in the setting DB 362. Conversely, when determining that the body motion amount of the sleeping user is lower than the predetermined value, the interface 356 maintains the current value of the awaking time thermal condition indication stored in the setting DB 362.

[0104] Meanwhile, operational modes of the air conditioner 310 for household include a "cooling" mode and a "dehumidifying" mode for summer. An amount of water (steam) containable in the air varies depending on a temperature. As the air has a higher temperature, the air contains a more amount of water. As the air has a lower temperature, the air contains a less amount of water. The air conditioner 310 utilizes the characteristics of the air. That is, the air conditioner 310 lowers the indoor temperature by cooling and discharges water condensed due to the lowered temperature to the outside, thereby decreasing the humidity in the room and thus accomplishing dehumidification. If the air blow is sent in a state that the water condensed by the cooling remains in the internally equipped unit, an incident called as "humidity return" that the air containing water is returned to the room will occur. It is typical to hold the air blowing for a predetermined period along with a stop of an operation of a compressor during the dehumidifying operation of the air conditioner 310 with the aim of avoiding the humidity return. In other words, the air blow is continuously sent in a constant amount during the cooling operation of the air conditioner 310, and is intermittently sent during the dehumidifying operation of the air conditioner 310. The air blow may be intermittently sent even during the cooling operation depending on a control of the air conditioner 310. However, the air blow is sent in a constant amount during the cooling operation in the present embodiment.

[0105] Since the air blow affects the senses of touch and hearing of a person, the intermittent sending of the air blow during the sleep is unfavorable. Therefore, it is preferable to send the air blow in a constant amount by executing the cooling operation as much as possible. However, the user may feel uncomfortable when the humidity is too high even with the current thermal condition indication falling within a predetermined range. In this case, it is preferable to change the operational mode to the dehumidifying operation. The control parameter determining part 354 switches the operational mode from the cooling operation to the dehumidifying operation when a current humidity exceeds an acceptable range of a humidity set in advance, e.g., a humidity limit exceeding point shown in FIG. 12.

[0106] It should be noted that the discomfort index is merely used as an exemplary thermal condition indication, and thus another thermal condition indication may be apparently adoptable. The thermal condition indication may be, for example, a heat balance quantity, a Predicted Mean Vote (PMV), or a Standard New Effective Temperature (SET) each calculated from a temperature, a humidity, an airflow speed, a radiation temperature, a metabolic rate, and an amount of a garment. If parameters include such an airflow speed, it is preferable to preferentially decrease the airflow speed to gradually raise the thermal condition indication. Specifically, the control parameter determining part 354 minimizes the airflow amount and changes the airflow direction to a direction away from the person, and thereafter, raise the set temperature. Accordingly, it is possible to prevent the person from awaking during the sleep due to the air flow affecting the senses of touch or hearing of the person by minimizing the influence of the airflow speed in the aforementioned manner.

[0107] Details of the process executed by the control parameter determining part 354 will be described with reference to flowcharts shown in FIGS. 15 and 16.

[0108] Heretofore, the configuration of the air condition controlling system according to the embodiment is described.

[0109] Next, processing performed by the air condition controlling system according to the embodiment will be described. The processing performed by the air condition controlling system according to the embodiment includes three processes, i.e., a data accumulating process executed by the air conditioner 310 and the cloud server 320, a data accumulating process executed by the sleep state detector 330 and the cloud server 320, and an air condition setting process executed by the cloud server 320.

[0110] FIG. 13 is a flowchart showing the data accumulating process executed by the air conditioner and the cloud server in the embodiment of the present disclosure.

[0111] First, in step S1, the sensor information acquiring part 312 of the air conditioner 310 acquires from the sensors 311 sensor information including: an indoor temperature; an indoor humidity; existence/absence information indicating whether a person exists in a room; and an amount of power consumed by the air conditioner 310.

[0112] Next, in step S2, the control information acquiring part 314 of the air conditioner 310 acquires from the air condition controlling part 313 air conditioning control information including an operational status, an operational mode, a set temperature, an airflow direction, and an airflow amount.

[0113] Subsequently, in step S3, the communication part 315 of the air conditioner 310 transmits to the cloud server 320 the sensor information acquired in the step S1 and the air conditioning control information acquired in the step S2.

[0114] In step S4, the communication part 321 of the cloud server 320 receives the sensor information and the air conditioning control information sent by the air conditioner 310,

[0115] In subsequent step S5, the sensor information storing part 351 stores the sensor information in the history DB 361.

[0116] In further subsequent step S6, the control information storing part 352 stores the air conditioning control information in the history DB 361.

[0117] In step S7, the communication part 315 of the air conditioner 310 executes a standby for a predetermined time period (e.g., one minute). After a lapse of the predetermined time period, the flow returns to the step S1.

[0118] The data accumulating process is executed whenever a communication route between the air conditioner 310 and the cloud server 320 is established, and the power supply is on. In this way, all the indoor environment information and the air conditioning control information is stored in the history DB 361. In FIG. 13, the acquisition of the sensor information and the acquisition of the air conditioning control information are sequentially executed, but may be parallelly executed. The control information acquiring part 314 may acquire the air conditioning control information at a time when a control content is changed, rather than periodically acquiring the air conditioning control information, and upload the acquired information to the cloud server 320.

[0119] Heretofore, the data accumulating process executed by the air conditioner 310 is described.

[0120] FIG. 14 is a flowchart showing the data accumulating process executed by the sleep state detector and the cloud server in the embodiment of the present disclosure.

[0121] First, in step S11, the sleep state information acquiring part 332 of the sleep state detector 330 acquires biological information including a heart rate, a breathing rate, and a body motion amount of a person.

[0122] Next, in step S12, the sleep state information acquiring part 332 estimates a sleep state of the person based on the acquired biological information. The sleep state indicates any one of an awaking state, a REM sleep state, and stages 1 to 4 of a NON-REM sleep state.

[0123] Subsequently, in step S13, the communication part 333 of the sleep state detector 330 transmits the biological information acquired in the step S11 and the sleep state information estimated in the step S12 to the cloud server 320.

[0124] In step S14, the communication part 321 of the cloud server 320 receives the biological information and the sleep state information sent by the sleep state detector 330.

[0125] In subsequent step S15, the sleep state information storing part 353 stores in the history DB 361 the biological information and the sleep state information.

[0126] In step S16, the communication part 333 of the sleep state detector 330 executes a standby for a predetermined time period (e.g., one minute). After a lapse of the predetermined time period, the flow returns to the step S11.

[0127] The data accumulating process is executed whenever a communication route between the sleep state detector 330 and the cloud server 320 is established, and the biological information of the person is acquired. In this way, all the biological information and the sleep state information is stored in the history DB 361.

[0128] The sleep state detector 330 may send only the sleep state information to the cloud server 320, and the sleep state information storing part 353 may store only the sleep state information in the history DB 361.

[0129] Heretofore, the data accumulating process executed by the sleep state detector 330 is described.

[0130] FIG. 15 is a flowchart showing the air condition setting process executed by the cloud server in the embodiment of the present disclosure.

[0131] First, in step S21, the control parameter determining part 354 compares a current time with an estimated awaking time stored in the setting DB 362, and determines whether or not the current time exceeds the estimated awaking time. When the current time is determined to exceed the estimated awaking time (YES in the step S21), the flow proceeds to step S27.

[0132] Conversely, when the current time is determined not to exceed the estimated awaking time (NO in the step S21), in step S22, the control parameter determining part 354 compares the current time with a time obtained by adding a predetermined time to a falling-asleep detection time, and determines whether or not the current time exceeds the time obtained by adding the predetermined time to the falling-asleep detection time. The predetermined time in the embodiment is, for example, one hour, but the present disclosure should not be limited thereto. The control parameter determining part 354 detects that the person falls asleep based on the sleep state information sent by the sleep state detector 330. Upon detection of a record of a sleep state representing a deep sleep stage (i.e., the stage 3 or 4 of the NON-REM sleep state) on or after an estimated sleep starting time stored in the setting DB 362, the control parameter determining part 354 determines the time of the detected record as the falling-asleep detection time.

[0133] When the current time is determined to exceed the time obtained by adding the predetermined time to the falling-asleep detection time (YES in the step S22), the control parameter determining part 354 performs, in step S23, a thermal condition indication raising process to determine a control parameter. The thermal condition indication raising process will be described with reference to FIG. 16.

[0134] Subsequently, in step S24, the air condition setting part 355 sends the control parameter determined by the control parameter determining part 354 to the air conditioner 310 via the communication part 321.

[0135] Conversely, when the current time is determined not to exceed the time obtained by adding the predetermined time to the falling-asleep detection time (NO in the step S22), the control parameter determining part 354 maintains, in step S25, setting of a current control parameter for the air conditioner 310. In this case, the control parameter determining part 354 may avoid setting another control parameter for the air conditioner 310. Alternatively, the control parameter determining part 354 may acquire the current control parameter for the air conditioner 310 with reference to the history DB 361. The air condition setting part 355 may send to the air conditioner 310 the current control parameter acquired by the control parameter determining part 354.

[0136] In step S26, the control parameter determining part 354 executes a standby for a predetermined time period (e.g., one minute). After a lapse of the predetermined time period, the flow returns to the step S21.

[0137] Besides, when the current time is determined to exceed the estimated awaking time in the step S21 (YES in the step S21), the communication part 321 receives, in step S27, a result of a thermal condition environment subjective evaluation sent by the terminal unit 340.

[0138] In subsequent step S28, the interface 356 updates an awaking time thermal condition indication stored in the setting DB 362 in response to the result of the thermal condition environment subjective evaluation received by the communication part 321. For example, if the result of the thermal condition environment subjective evaluation indicates "cold" or "a little cold", the interface 356 updates the awaking time thermal condition indication to be higher than a current value. If the result of the thermal condition environment subjective evaluation indicates "comfortable", the interface 356 maintains the awaking time thermal condition indication at the current value. Furthermore, if the result of the thermal condition environment subjective evaluation indicates "hot" or "a little hot", the interface 356 updates the awaking time thermal condition indication to be lower than the current value.

[0139] Heretofore, the air condition setting process executed by the cloud server 320 is described.

[0140] FIG. 16 is a flowchart showing the thermal condition indication raising process executed by the cloud server in the embodiment of the present disclosure.

[0141] First, in step S41, the control parameter determining part 354 determines whether a current airflow amount of the air conditioner 310 matches an airflow amount at a sleep starting time.

[0142] When the current airflow amount of the air conditioner 310 is determined to match the airflow amount at the sleep starting time (YES in the step S41), the control parameter determining part 354 determines, in step S42, the airflow amount of the air conditioner 310 at a minimal value. In this case, the control parameter determining part 354 may change the airflow direction to a direction away from a sleeping person so as not to disturb the sleeping person, thereby preventing the person from coming into contact with the flow of the air blow.

[0143] Next, in step S43, the control parameter determining part 354 determines an airflow amount change lapse time. The airflow amount change lapse time represents a time determined based on a time period from a change in the airflow amount to a change in the temperature. The change in the airflow amount influences a thermal condition indication. Therefore, the airflow amount change lapse time is determined based on a history showing an amount of conversion from the change in the airflow amount to a temperature and a humidity in view of a time period when the change in the airflow amount is stabilized. For instance, when changing the airflow amount from level 5 to level 1, the control parameter determining part 354 determines a time after a lapse of 30 minutes from the time of the change in the airflow amount as the airflow amount change lapse time. When changing the airflow amount from level 3 to level 1, the control parameter determining part 354 determines a time after a lapse of 15 minutes from the time of the change in the airflow amount as the airflow amount change lapse time. When changing the airflow amount from level 1 to level 1, the control parameter determining part 354 determines a time after a lapse of 0 minute from the time of the change in the airflow amount as the airflow amount change lapse time. It is seen from these perspectives that the time period from the time of the change in the airflow amount to the airflow amount change lapse time is shorter, as the amount of change in the air blow is smaller.

[0144] Subsequently, in step S44, the control parameter determining part 354 compares a current time with the airflow amount change lapse time, and determines whether or not the current time exceeds the airflow amount change lapse time. When the current time is determined not to exceed the airflow amount change lapse time (NO in the step S44), the thermal condition indication raising process is finished.

[0145] Conversely, when the current time is determined to exceed the airflow amount change lapse time (YES in the step S44), the control parameter determining part 354 acquires from the setting DB 362 an awaking time discomfort index "DI_Last" represents the awaking time thermal condition indication, and fruther calculates, in step S45, a current target discomfort index "DI_Target" to reach the awaking time discomfort index "DI_Last". As shown in FIG. 12, the control parameter determining part 354 calculates the current target discomfort index "DI_Targdet" along the line segment 1101 which connects the awaking time discomfort index and a discomfort index at a time after a lapse of one hour from a falling-asleep detection time with each other.

[0146] The control parameter determining part 354 calculates the current target discomfort index "DI_Target" at a current time "t_Now" by using the following Formula (2):

$$DI\_Target = DI\_Start + (DI\_Last - DI\_Start) \times \{(t\_Now - t\_Start) / (t\_Last - t\_Start)\} \cdots (2).$$

[0147] In the Formula (2), "DI_Start" represents a discomfort index at a time after a lapse of one hour from a falling-asleep detection time, "t_Start" represents a time after the lapse of the one hour from the falling-asleep detection time, and "t_Last" represents an estimated awaking time. The control parameter determining part 354 acquires from the history DB 361 a temperature and a humidity at the time "t_Start" after the lapse of the one hour from the falling-asleep detection time, and calculates the discomfort index "DI_Start" at the time after the lapse of the one hour from the falling-asleep detection time.

[0148] Moreover, in step S46, the control parameter determining part 354 calculates a current target temperature "T_Target" to achieve the current target discomfort index "DI_Target".

[0149] The current target discomfort index "DI_Target" is expressed by the following Formula (3) using the current target temperature "T_Target" and a current humidity "H_Now":

$$DI\_Target = 0.81 \times T\_Target + 0.01 \times H\_Now \times (0.99 \times T\_Target - 14.3) + 46.3 \cdots (3).$$

[0150] The current target temperature T_Target is expressed by the following Formula (4) based on modification of the Formula (3):

$$T\_Target = \{(DI\_Target + 14.3 \times 0.01 \times H\_Now - 46.3) / (0.81 + 0.99 \times 0.01 \times H\_Now)\} \cdots (4).$$

[0151] The control parameter determining part 354 calculates the current target temperature "T_Target" by using the Formula (4).

[0152] In subsequent step S47, the control parameter determining part 354 determines the current target temperature "T_Target" as a set temperature for the air conditioner 310. In this case, if the set temperature is defined by every 0.5 degree, the control parameter determining part 354 may round the target temperature "T_Target" up to every 0.5 degree. For example, if the current target temperature "T_Target" is 25.3 °C, the set temperature is rounded up to 25.5 °C.

[0153] In further subsequent step S48, the control parameter determining part 354 determines whether the current humidity "H_Now" is a threshold or higher. The threshold in the embodiment is, for example, 80%.

[0154] When the current humidity "H_Now" is determined to be lower than the threshold (NO in the step S48), the control parameter determining part 354 determines, in step S49, a cooling operation as an operational mode for the air conditioner 310.

[0155] Conversely, when the current humidity "H_Now" is determined to be the threshold or higher (YES in the step S48), the control parameter determining part 354 determines, in step S50, a dehumidifying operation as the operational mode for the air conditioner 310.

[0156] Regarding the step S48 in the flow, once the operational mode has been changed to the dehumidifying operation, the operational mode may be maintained without being rechanged to the cooling operation until the current humidity "H_Now" reaches a value obtained by subtracting a predetermined value from the threshold. The predetermined value is, for example, 5%. This makes it possible to avoid frequent changes of the operational mode for the air conditioner 310.

[0157] Heretofore, the thermal condition indication raising process executed by the cloud server 320 is described.

[0158] The air condition controlling system according to the present embodiment having this configuration can control a thermal condition environment to be kept comfortable for a user until the user awakes after getting to sleep.

[0159] In the embodiment, although the operational mode is changed to the dehumidifying operation when a current humidity exceeds a preliminarily set threshold like the humidity limit exceeding point shown in FIG. 12, the threshold may be set based on a comfortability for a sleeping user. For example, mid-sleep awakening occurrence rates in a past sleep of a user respectively at the humidity of 60%, 70%, 80%, and 90% are compared with one another. If the mid-sleep awakening occurrence rate increases as the humidity increases, the user is highly sensitive to the humidity. In this case, the threshold may be set at a lower value. Conversely, if no change is seen in the mid-sleep awakening occurrence rates, the threshold may be set at a higher value. This configuration makes it possible to provide a more comfortable sleeping environment for a person by reflecting an individual difference in a reaction to the humidity by the user.

[0160] Although the thermal condition indication is raised toward the awaking by changing the set temperature for the air conditioner 310 in the embodiment, a parameter other than the set temperature may be changed depending on the performance or the form of the air conditioner 310. For example, the air conditioner 310 having a function of controlling a humidity can raise the thermal condition indication by increasing a set humidity in place of the set temperature. In this case, the control parameter determining part 354 may calculate, in the step S46, the current target humidity "H_Target" in place of the current target temperature "T_Target", and determine the current target humidity "H_Target" as the set humidity to achieve the current target discomfort index "DI_Target". This configuration can accomplish the controlling suitable for the performance of the air conditioner 310.

[0161] As described above, if it is achievable to raise the thermal condition indication by changing both the settings of the temperature and the humidity, thresholds respectively for the temperature and the humidity may be defined in such a way that the temperature and the humidity reach the thresholds or lower. For example, if the threshold of the temperature is defined as 28°C, the control parameter determining part 354 raises the set temperature, and increases the set humidity after the current temperature reaches 28°C. This configuration can accomplish the controlling in view of any value of a component unseen in the thermal condition indication.

[0162] Moreover, if it is achievable to raise the thermal condition indication by changing both the settings of the temperature and the humidity, the setting of the temperature or the setting of the humidity may be preferentially changed depending on a history of a user in past. For example, either a temperature change or a humidity change during the sleep may be determined as affecting the sleep more seriously. When the temperature change is determined to affect the sleep less seriously than the humidity change, the set temperature may be preferentially changed. Conversely, when the temperature change is determined to affect the sleep more seriously than the humidity change, the set humidity may be preferentially changed. This configuration makes it possible to provide a more comfortable sleeping environment for a person by reflecting an individual difference in a reaction to the temperature and the humidity by the user.

[0163] The control parameter determining part 354 may acquire reactive information concerning a reaction of a person existing in a space to at least one of an air blow, a temperature, and a humidity. The control parameter determining part 354 may determine based on the acquired reactive information whether to execute controlling of the air blow, controlling of the set temperature, and controlling of the dehumidifying operation, and determine a content or an execution order of the controlling of the air blow, the controlling of the set temperature, and the controlling of the dehumidifying operation. The reactive information includes, for example, evaluation information indicating an evaluation about a past result of the controlling, or a body motion amount contained in the biological information. The control parameter determining part 354 may determine the dehumidifying operation as the next operational mode when the evaluation indicates a discomfort about a result of the controlling of the set temperature, or the body motion amount indicates a predetermined value or higher about the result of the controlling of the set temperature.

[0164] Although a time when to start raising the thermal condition indication is defined as a time after a lapse of one hour from the falling-asleep detection time in the embodiment, the present disclosure should not be limited thereto. The time when to start raising the thermal condition indication may be determined in accordance with a sleep cycle.

[0165] FIG. 17 is a diagram illustrating a way of determining, in accordance with a sleep cycle, a time when to start raising the thermal condition indication in the embodiment of the present disclosure.

[0166] As shown in FIG. 17, the control parameter determining part 354 may start raising the thermal condition indication at time t1 after a transition to a second-time deep sleep stage (the stage 3 or 4 of the NON-REM sleep state) or at time t2 after a transition to a third-time deep sleep stage in a sleep cycle. Normally, the mid-sleep awakening occurrence rate relative to the thermal condition environment is low in such a deep sleep stage. Hence, a time after a transition to the deep sleep stage is preferable as a time to start changing the thermal condition. In this case, the control parameter determining part 354 determines, in the step S22 in FIG. 15, whether the sleep state of the user transits from the REM sleep state to the stage 3 or 4 of the NON-REM sleep state by using the sleep state information sent by the sleep state detector 330. This configuration makes it possible to raise the thermal condition indication at an optimal time for the user.

[0167] Although a time when to start raising the thermal condition indication is defined as a time after a lapse of one hour from the falling-asleep detection time in the embodiment, the control parameter determining part 354 may start raising the thermal condition indication at a time when a sweat rate of a user lowers once it has risen in a case that the sleep state detector 330 can measure the sweat rate. Generally, a temperature of a body core part of a person lowers at a time when the person falls asleep, and the heat is discharged to the outside. Thus, the sweat rate increases. Moreover, it is known that the sleep depth and the sweat rate have an interrelationship with each other. The sweat rate increases in the stage 3 or 4 of the NON-REM sleep state. It is desired to maintain a comfortable setting at a sleep starting time while the sweat rate is increasing. Under the circumstances, the control parameter determining part 354 detects a time when the sweat rate stabilizes and decreases, and further starts raising the thermal condition indication at a time of the detection.

[0168] The sleep state detector 330 detects the sweat rate of the sleeping user and sends information concerning the detected sweat rate to the cloud server 320. The communication part 321 of the cloud server 320 receives the information concerning the swear rate sent by the sleep state detector 330. The control parameter determining part 354 determines, in the step S22 in FIG. 15, whether or not the sweat rate decreases. When the sweat rate is determined to decrease, the flow proceeds to the step S23. Conversely, when the sweat rate is determined not to decrease, the flow proceeds to the step S25. This configuration makes it possible to provide a comfortable sleeping environment for a person owing to the achievement in maintaining a transition of the comfortable temperature at the sleep starting time.

[0169] Although a time when to start raising the thermal condition indication is defined as a time after a lapse of one hour from the falling-asleep detection time in the embodiment, the control parameter determining part 354 may start raising the thermal condition indication at a time when a skin temperature of the user lowers once it has risen in a case that the sleep state detector 330 can measure the skin temperature. Generally, a temperature of a body core part of a person lowers at a time when the person falls asleep, and the heat is discharged to the outside. Thus, the skin temperature rises. It is desired to maintain a comfortable setting at a sleep starting time while the skin temperature is rising. Under the circumstances, the control parameter determining part 354 detects a time when the skin temperature stabilizes and lowers, and further starts raising the thermal condition indication at a time of the detection.

[0170] The sleep state detector 330 detects the skin temperature of the sleeping user, and sends information concerning the detected skin temperature to the cloud server 320. The communication part 321 of the cloud server 320 receives the information concerning the skin temperature sent by the sleep state detector 330. The control parameter determining part 354 determines, in the step S22 in FIG. 15, whether or not the skin temperature lowers. When the skin temperature is determined to lower, the flow proceeds to the step S23. Conversely, when the skin temperature is determined not to lower, the flow proceeds to the step S25. This configuration makes it possible to provide a comfortable sleeping environment for a person owing to the achievement in maintaining a transition of the comfortable temperature at the sleep starting time while the skin temperature is high or the temperature of the core body part is lowering. Note that if the temperature of the core body part is able to be estimated with use of the skin temperature, the time when to start raising the thermal condition may be determined by using the estimated value of the core body part.

[0171] As described above, the control determining part 354 acquires the biological information of the person in the space. The biological information includes, for example, the sweat rate or the skin temperature. The control parameter determining part 354 determines a time when to start raising a target value based on the acquired biological information.

[0172] Although the time when to start raising the thermal condition indication is defined as a time after a lapse of one hour from the falling-asleep detection time in the embodiment, the control parameter determining part 354 may start raising the thermal condition indication during a time period of 4 a.m. to 5 a.m. in which the temperature of the body core part starts rising. Generally, a temperature of a body core part of a person lowers at a time when the person falls asleep, and rises during the time period of 4 a.m. to 5 a.m.

[0173] The control parameter determining part 354 starts raising the thermal condition indication at the time when the temperature of the body core part rises. The control parameter determining part 354 determines, in the step S22 in FIG. 15, whether or not a current time falls within the time period of 4 a.m. to 5 a.m. When the current time is determined to fall within the time period of 4 a.m. to 5 a.m., the flow proceeds to the step S23. Conversely, when the current time is determined not to fall within the time period of 4 a.m. to 5 a.m., the flow proceeds to the step S25. This configuration makes it possible to provide a comfortable sleeping environment for a person owing to the achievement in raising the thermal condition indication in accordance with the time period in which the temperature of the body core part rises.

[0174] Although a time when to start raising the thermal condition indication is defined as a time after a lapse of one hour from the falling-asleep detection time in the embodiment, the control parameter determining part 354 may determine an optimal time to start raising the thermal condition indication based on a result of learning of a body motion amount, the number of mid-sleep awakening times, and a thermal condition environment subjective evaluation in a past sleep.

[0175] For example, if the body motion amount and the number of mid-sleep awakening times increase, and the thermal condition environment subjective evaluation indicates "a little hot" or "hot" at the time to start raising the thermal condition indication, the time to start raising the thermal condition indication is considered too early. Therefore, the control parameter determining part 354 delays the time to start raising the thermal condition indication in a case that the body motion amount and the number of mid-sleep awakening times increase and further a frequency that the thermal condition environment subjective evaluation indicates hot feeling in awaking is a predetermined value or higher at the time to start raising the thermal condition indication. Conversely, if the body motion amount and the number of mid-sleep awakening times increase, and the thermal condition environment subjective evaluation indicates "a little cold" or "cold" at the time to start raising the thermal condition indication, the time to start raising the thermal condition indication is considered too late. Therefore, the control parameter determining part 354 expedites the time to start raising the thermal condition indication in a case that the body motion amount and the number of mid-sleep awakening times increase and further a frequency that the thermal condition environment subjective evaluation indicates cold feeling in awaking is a predetermined value or higher at the time to start raising the thermal condition indication. The control parameter determining part 354 executes the determination in the step S22 in FIG. 15 by using the adjusted time. This configuration makes it possible to provide a thermal condition environment suitable for a comfortability of a user individually.

[0176] Furthermore, in the embodiment, as shown in FIG. 12, the thermal condition indication rises along the line segment 1101 which connects the thermal condition indication (discomfort index) obtained by adding one hour to the falling-asleep detection time and the awaking time thermal condition indication (awaking time discomfort index) with each other. This aims at minimizing a change in the thermal condition environment so as to avoid awaking during the sleep. However, normally, in the conditioner 310, the set temperature is defined by every 1 degree or 0.5 degree. This means that the thermal condition environment may rapidly change depending on a change in the set temperature. Therefore, the control parameter for the air conditioner 310 may be preferably changed during a time period indicating a deep sleep stage, i.e., the stage 3 or 4 of the NON-REM sleep sate, to raise the thermal condition indication toward the estimated awaking time.

[0177] FIG. 18 is a diagram illustrating a timing to change a control parameter for the air conditioner in the embodiment of the present disclosure. A curve 1701 in FIG. 18 indicates a sleep depth (depth of the sleep) of the sleeping user, and shows a larger sleep depth at a lower position than an upper position in the curve. In other words, the sleep depth at the lower position indicates the stage 3 or 4 of the NON-REM sleep state. FIG. 18 further illustrates first to fifth deep sleep time periods indicating the stage 3 or 4 of the NON-REM sleep state. A solid line 1702 indicates a chronological transition of the set temperature determined by the parameter determining part 354. A dashed line 1703 indicates a chronological transition of the discomfort index.

[0178] Typically, the mid-awaking occurrence rate relative to the thermal condition environment is lower in a deep sleep stage of the sleep, and therefore a change in the thermal condition is considered less likely to influence the sleep. Accordingly, the time period indicating the deep sleep stage is preferable as a time to change the thermal condition environment. The control parameter determining part 354 determines whether a current sleep state of the user indicates the stage 3 or 4 of the NON-REM sleep state by using the sleep state information acquired from the sleep state detector 330. Only when the current sleep state of the user is determined as the stage 3 or 4 of the NON-REM sleep state, the control parameter determining part 354 determines a control parameter. This configuration makes it possible to appropriately raise the thermal condition indication at a time when the sleeping user feels no discomfort.

[0179] Moreover, the stage 3 or 4 NON-REM of the sleep state may not be seen due to a sleep state peculiar to an individual or a detection error. In such a case, the control parameter may be changed in a priority order of the stage 2 of the NON-REM sleep state, the REM sleep state, and the stage 1 of the NON-REM sleep state by providing a timeout period.

[0180] Although the control parameter determining part 354 raises the thermal condition indication to reach the awaking time thermal condition indication by the estimated awaking time in the embodiment, the present disclosure should not be limited thereto. The control parameter determining part 354 may raise the thermal condition indication to reach the awaking time thermal condition indication by a thermal condition indication raising process finished time prior to the estimated awaking time.

[0181] FIG. 19 is a diagram illustrating an example of the embodiment in which the thermal condition indication rises to reach the awaking time thermal condition indication by the thermal condition indication raising process finished time prior to the estimated awaking time. A dashed line 1102 in FIG. 19 indicates a chronological transition of the discomfort index.

[0182] After a lapse of one hour from the falling-asleep detection time, the control parameter determining part 354 changes the set temperature of the air conditioner 310 in such a way that a discomfort index transits along a line segment 1901 which connects an awaking time discomfort index at the thermal condition indication raising process finished time prior to the estimated awaking time and a discomfort index at a time after the lapse of one hour from the falling-asleep detection time with each other. A thermal condition indication raising process starting time in FIG. 19 indicates the time after the lapse of the one hour from the falling-asleep detection time. This configuration makes it possible to provide a thermal condition environment further reflecting the favor of the user by adjusting, based a thermal condition environment subjective evaluation, the thermal condition indication raising process finished time. For example, if the mid-sleep awakening is frequently seen at a later stage of the sleep, and the thermal condition environment subjective evaluation indicates "hot" or "a little hot", the control parameter determining part 354 can adjust, e.g., delay, the thermal condition indication raising process finished time.

[0183] Although the discomfort index is used as the thermal condition indication in the embodiment, another thermal condition indication may be used instead. The thermal condition indication may be, for example, another parameter such as a heat balance quantity of a human body or a PMV each calculated from a temperature, a humidity, an airflow speed, a radiation temperature, a metabolic rate, and an amount of a garment. The airflow speed, the radiation temperature, the metabolic rate, and the amount of the garment are required to be measured in adoption of the heat balance quantity or the PMV. In this case, the sensors 311 of the air conditioner 310 may measure them. Furthermore, in place of the measurement by the sensors 311, the airflow speed may be calculated from an airflow amount and an airflow direction of the air conditioner 310, the radiation temperature may be estimated from an air temperature and an outdoor temperature, the metabolic rate may be a representative value during the sleep, and the amount of the garment may be input by the user from the terminal unit 340.

[0184] FIG. 20 is a flowchart showing another thermal condition indication raising process executed by the cloud server when using the PMV as the thermal condition indication in the embodiment of the present disclosure.

[0185] First, in step S61, the control parameter determining part 354 acquires from the setting DB 362 an awaking time PMV value "PMV_Last" that represents an awaking time thermal condition indication, and calculates a current target PMV value "PMV Target" to reach the awaking time PMV value "PMV_Last". The control parameter determining part 354 calculates the current target PMV value "PMV_Target" in such a way that the current target PMV value "PMV_Target" is along a line segment which connects the awaking time PMV value, and a PMV value at a time after a lapse of one hour from the falling-asleep detection time.

[0186] The PMV is a thermal condition indication advocated by prof. Fanger in Technical University of Denmark in 1967. The PMV denotes a formula taking a human body heat load and a metabolic rate into consideration, and is calculated from a temperature, a humidity, an airflow speed, a radiation heat, the metabolic rate, and an amount of a garment. The radiation heat may be correctly measured with use of a sensor, or may be indicated by a value estimated from the temperature. The metabolic rate may be measured with use of the sensor, or set at a predetermined value based on a knowledge in a past sleep. The amount of the garment may be measured with use of a sensor, or set at a value obtained by receiving an input by the user concerning a garment which the user wears during the sleep, and corresponding to the input concerning the garment. The airflow speed may be measured with use of a sensor, or set at a value estimated from setting of the airflow amount of the air conditioner 310. The PMV is a thermal condition indication calculated from the aforementioned six requirements, and a detail of the formula will be omitted.

[0187] The control parameter determining part 354 calculates the current target PMV value "PMV_Target" at the current time "t_Now" by using the following Formula (5):

$$\text{PMV\_Target} = \text{PMV\_Start} + (\text{PMV\_Last} - \text{PMV\_Start}) \times \{(\text{t\_Now} - \text{t\_Start}) / (\text{t\_Last} - \text{t\_Start})\} \cdots (5).$$

[0188] In the Formula (5), "PMV_Start" represents a PMV value at a time after a lapse of one hour from the falling-asleep detection time, "t_Start" represents a time after the lapse of the one hour from the falling-asleep detection time, and "t_Last" represents an estimated awaking time. The control parameter determining part 354 acquires from the history DB 361 a temperature, a humidity, an airflow speed, a radiation heat, a metabolic rate, and an amount of a garment at the time "t_Start" after the lapse of the one hour from the falling-asleep detection time, and calculates the PMV value "PMV_Start" at the time after the lapse of the one hour from the falling asleep detection time.

[0189] Next, in step S62, the control parameter determining part 354 determines whether or not a current airflow amount of the air conditioner 310 indicates a minimal value. When the current airflow amount of the air conditioner 310 is determined as a minimal value (YES in the step S62), the flow proceeds to step S65.

[0190] Conversely, when the current airflow amount of the air conditioner 310 is not determined as the minimal value (NO in the step S62), the control parameter determining part 354 calculates, in step S63, a current target air flow peed "W_Target" to achieve the current target PMV value "PMV_Target". The parameters other than the airflow speed are used with their current values.

[0191] Subsequently, in step S64, the control parameter determining part 354 determines an airflow amount corresponding to the current target airflow speed "W_Target" as the set airflow amount of the air conditioner 310. The airflow amount corresponding to the current target airflow speed may be calculated with use of past history data. Moreover, the control parameter determining part 354 may calculate the airflow amount corresponding to the current target airflow speed by using data showing a relationship between a preliminarily measured airflow speed and an airflow amount of the air conditioner 310.

[0192] Further, in the step S65, the control parameter determining part 354 calculates a current target temperature "T_Target" to achieve the current target PMV value "PMV_Target". The parameters other than the temperature may be used with their current values.

[0193] In subsequent step S66, the control parameter determining part 354 determines the current target temperature "T_Target" as a set temperature for the air conditioner 310. When the set temperature is defined by every 0.5 degree, the control parameter determining part 354 rounds the current target temperature "T_Target" up to every 0.5 degree. For example, if the current target temperature "T_Target" is 25.3 °C, the set temperature is rounded up to 25.5°C.

[0194] In further subsequent step S67, the control parameter determining part 354 determines whether or not a current humidity "H_Now" is a threshold or higher. The threshold in the embodiment is, for example, 80%.

[0195] When the current humidity "H_Now" is determined to be lower than the threshold (NO in the step S67), the control parameter determining part 354 determines, in step S68, a cooling operation as an operational mode for the air conditioner 310.

[0196] Conversely, when the current humidity "H_Now" is determined to be the threshold or higher (YES in the step S67), the control parameter determining part 354 determines, in step S69, a dehumidifying operation as the operational mode for the air conditioner 310.

[0197] Regarding the step S67 in the flow, once the operational mode has been changed to the dehumidifying operation, the operational mode may be maintained without being rechanged to the cooling operation until the current humidity "H_Now" reaches a value obtained by subtracting a predetermined value from the threshold. The predetermined value may be, for example, 5%. This makes it possible to avoid frequent changes of the operational mode for the air conditioner 310.

[0198] Heretofore, the thermal condition indication raising process executed by the cloud server 320 and using the PMV as the thermal indication is described. This configuration makes it possible to set an airflow amount based on the thermal condition indication, and therefore, set the airflow amount in more detail.

[0199] In the embodiment, the air conditioner 310, in place of the cloud server 320, may include the sensor information storing part 351, the sensor information storing part 352, the sleep state information storing part 353, the control parameter determining part 354, the air condition setting part 355, the interface 356, the history database 361, and the setting database 362. In this configuration, the air condition controlling system may exclude the cloud server 320.

[0200] Although described is an example in which a target value of an indication is changed with use of an ultimate target value of the indication in the embodiment, the present disclosure should not be limited thereto. For example, the target value of the indication may be changed with use of a predetermined change pattern.

[0201] Additionally, described in the embodiment is another example in which the terminal unit 340, such as a smartphone, configured to receive a manual input receives an input by the user, thereby acquiring evaluation information. However, the evaluation information may be input via another input device. Specifically, the evaluation information may be acquired via a device which receives a voice input. In another way, a device including a micro phone, such as a smart speaker, and a speaker may receive an input by a user. Alternatively, the evaluation information may be acquired from the user by way of a voice-based communication type of interaction.

[0202] Heretofore, the air condition controlling system according to the embodiment is described.

[0203] The techniques described in the aforementioned aspects are realized by, for example, the following types of cloud services. However, the types of cloud services that realize the techniques described in the aspects are not limited to the following types.

(Service type 1: Proprietary data center type cloud service)

[0204] FIG. 21 is a diagram illustrating a conceptional of services provided by an air condition controlling system of service type 1 (proprietary data center type cloud service). In the present type, the service provider 120 acquires information from the group 100, and provides a service to a user. In the present type, the service provider 120 has functions of a data center operating company. In other words, the service provider 120 owns a cloud server 111 that manages big data. Therefore, a data center operating company does not exist.

[0205] In the present type, the service provider 120 operates and manages the data center (cloud server) 203. In addition, the service provider 120 manages an operating system (OS) 202 and an application 201. The service provider 120 provides a user with a service using the OS 202 and the application 201 managed by the service provider 120 (the arrow 204).

(Service type 2: Cloud service using IaaS)

[0206] FIG. 22 is a diagram illustrating a conceptional view of a service provided by an air condition controlling system of service type 2 (cloud service using IaaS). In this case, IaaS is an abbreviation of Infrastructure as a Service and refers to a cloud service provision model where an infrastructure for building and running a computer system itself is provided as an Internet-based service.

[0207] In the present type, the data center operating company 110 operates and manages the data center (cloud server) 203. In addition, the service provider 120 manages an OS 202 and an application 201. The service provider 120 provides a user with a service using the OS 202 and the application 201 managed by the service provider 120 (the arrow 204).

(Service type 3: Cloud service using PaaS)

[0208] FIG. 23 is a diagram illustrating a conceptional view of a service provided by an air condition controlling system of service type 3 (cloud service using PaaS). In this case, PaaS is an abbreviation of Platform as a Service and refers to a cloud service provision model where a platform that constitutes a foundation for building and running software is provided as an Internet-based service.

[0209] In the present type, the data center operating company 110 manages the OS 202 and operates and manages the data center (cloud server) 203. In addition, the service provider 120 manages the application 201. The service provider 120 provides a user with a service using the OS 202 managed by the data center operating company 110 and the application 201 managed by the service provider 120 (the arrow 204).

(Service type 4: Cloud service using SaaS)

[0210] FIG. 24 is a diagram illustrating a conceptional view of a service provided by an air condition controlling system of service type 4 (cloud service using SaaS). In this case, SaaS is an abbreviation of Software as a Service. The cloud service using SaaS is a cloud service provision model having, for example, a function that enables a user such as a company or an individual that does not own a data center (cloud server) to use an application provided by a platform provider that owns a data center (cloud server) via a network such as the Internet.

[0211] In the present type, the data center operating company 110 manages the application 201, manages the OS 202, and operates and manages the data center (cloud server) 203. In addition, the service provider 120 provides the user with a service using the OS 202 and the application 201 managed by the data center operating company 110 (the arrow 204).

[0212] As described above, the service provider 120 provides services in all types of cloud services. In addition, for example, an OS, an application, a database for big data, and the like may be developed in-house or may be outsourced by the service provider or the data center operating company.

[0213] In the embodiment described above, each component may be implemented with dedicated hardware or by executing a software program suitable for the component. Each component may be implemented by a program execution unit such as a CPU or a processor reading and executing a software program recorded on a recording medium, such as a hard disk or a semiconductor memory.

[0214] Part or all of functions of the device according to the embodiment of the present disclosure are typically implemented as a large scale integration (LSI), which is an integrated circuit. These functions may be formed as separate chips, or some or all of the functions may be included in one chip. The circuit integration is not limited to LSI, and may be implemented using a dedicated circuit or a general-purpose processor. A field programmable gate array (FPGA) that is programmable after manufacturing of an LSI or a reconfigurable processor in which connections and settings of circuit cells within the LSI are reconfigurable may be used.

[0215] Part or all of functions of the device according to the embodiment of the present disclosure may be implemented by a processor such as a CPU executing a program.

[0216] Numerical values used above are merely illustrative to be used to specifically describe the present disclosure, and thus the present disclosure is not limited to the illustrative numerical values.

[0217] Order in which steps shown in the flowcharts are executed is merely illustrative to be used to specifically describe the present disclosure, and thus steps may be executed in order other than the above order as long as similar effects are obtained. Some of the steps may be executed simultaneously (in parallel) with other steps.

[0218] The method and the apparatus for processing information according to the present disclosure can achieve a comfortable sleeping environment for a person, and therefore is beneficial as a method and an apparatus for processing information to control an air conditioner provided in a space where a sleeping person exists.

[0219] This application is based on Japanese Patent application No. 2018-237479 filed on December 19, 2018 and No. 2019-156296 filed on August 29, 2019 in Japan Patent Office, the contents of which are hereby incorporated by reference information concerning an air blow to bring an indicative value indicating a thermal condition to the target value by using at least the acquired temperature and humidity after deciding.

[0220] Although the present invention has been fully described by way of example with reference to the accompanying drawings, it is to be understood that various changes and modifications will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the present invention hereinafter defined, they should be construed as being included therein.

Claims

1. A method for processing information comprising, by a computer:

acquiring at least a temperature and a humidity measured by a sensor disposed in a space where a sleeping person exists and an air conditioner is provided;
acquiring falling-asleep decision information for deciding whether the person falls asleep;
determining air blow control information concerning an air blow to bring an indicative value indicating a thermal condition to a target value by using at least the acquired temperature and humidity after deciding based on the acquired falling-asleep decision information that the person falls asleep; and
controlling the air blow of the air conditioner by using the determined air blow control information.

2. The method according to claim 1, further comprising:

determining temperature control information concerning a temperature to bring the indicative value to the target value after starting the controlling of the air blow using the air blow control information; and
controlling a set temperature for the air conditioner by using the determined temperature control information.

3. The method according to claim 2, further comprising:
controlling a dehumidifying operation of the air conditioner after staring the controlling of the air blow using the air blow control information.

4. The method according to claim 3, further comprising:
controlling the dehumidifying operation after starting the controlling of the set temperature using the temperature control information.

5. The method according to claim 3, further comprising:

acquiring reactive information concerning a reaction of the person in the space to at least one of the air blow, the temperature, and the humidity; and
determining based on the acquired reactive information whether to execute the controlling of the air blow, the controlling of the set temperature, and the controlling of the dehumidifying operation, and determining a content or an execution order of the controlling of the air blow, the controlling of the set temperature, and the controlling of the dehumidifying operation.

6. The method according to any one of claims 1 to 5, further comprising:
raising the target value as time elapses after deciding based on the acquired falling-asleep decision information that the person falls asleep.

7. The method according to claim 6, further comprising:

acquiring biological information of the person in the space; and
determining a time when to increase the target value based on the acquired biological information.

8. The method according to any one of claims 1 to 7, further comprising:

acquiring evaluation information concerning an evaluation by the person in the space about a result of a past controlling of the air blow using at least the air blow control information; and
determining the target value based on the acquired evaluation information.

9. The method according to any one of claims 1 to 8, further comprising:

acquiring biological information of the person in the space by performing measurement during the controlling of the air blow using at least the air blow control information; and
determining the target value based on the acquired biological information.

10. An apparatus for processing information, comprising:

a sensor information acquiring part which acquires at least a temperature and a humidity measured by a sensor disposed in a space where a sleeping person exists and an air conditioner is provided;
a falling-asleep decision information acquiring part which acquires falling-asleep decision information for deciding whether the person falls asleep;
a determining part which determines air blow control information concerning an air blow to bring an indicative value indicating a thermal condition to a target value by using at least the acquired temperature and humidity after deciding based on the acquired falling-asleep decision information that the person falls asleep; and
a controller which controls the air blow of the air conditioner by using the determined air blow control information.

FIG.1

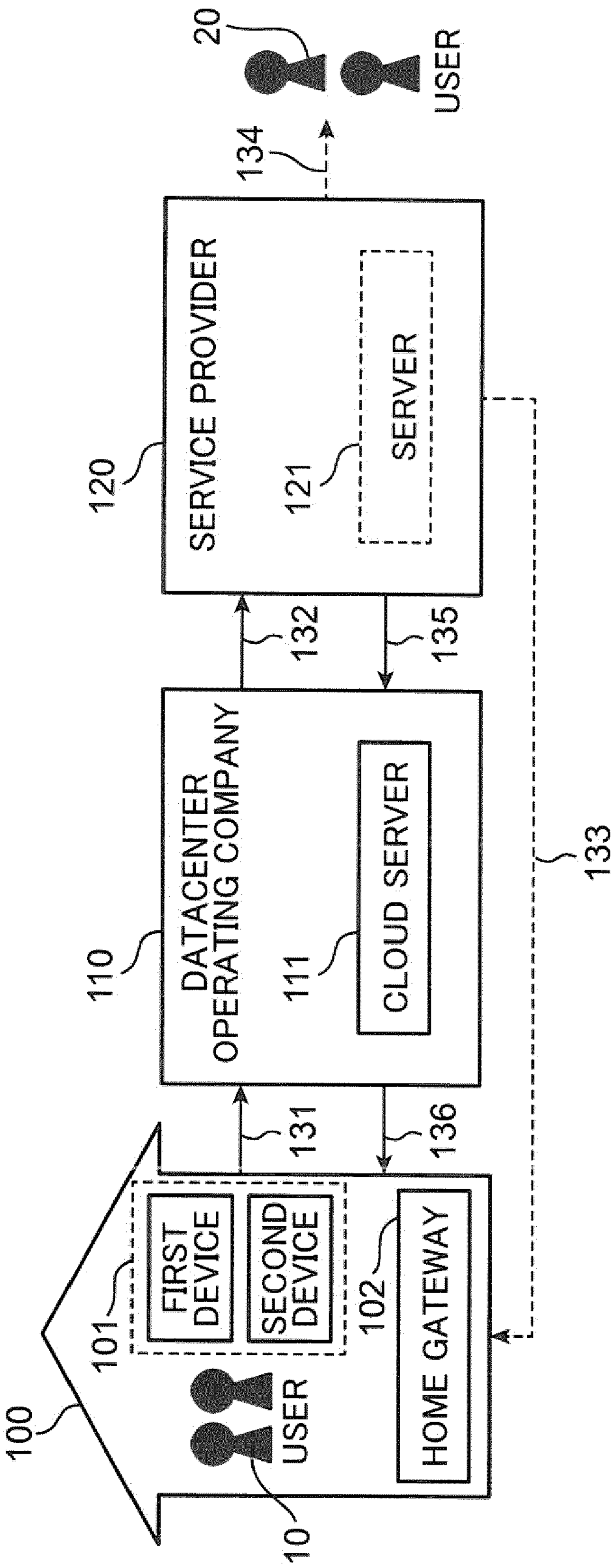

100
10
USER
101
FIRST DEVICE
SECOND DEVICE
102
HOME GATEWAY
131
136
110
DATACENTER OPERATING COMPANY
111
CLOUD SERVER
132
135
120
SERVICE PROVIDER
121
SERVER
133
134
20
USER

FIG.2

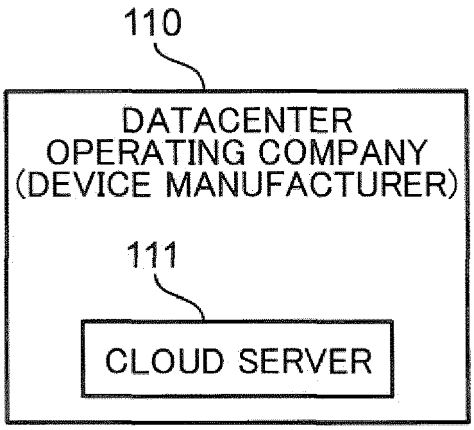

110
DATACENTER
OPERATING COMPANY
(DEVICE MANUFACTURER)
111
CLOUD SERVER

FIG.3

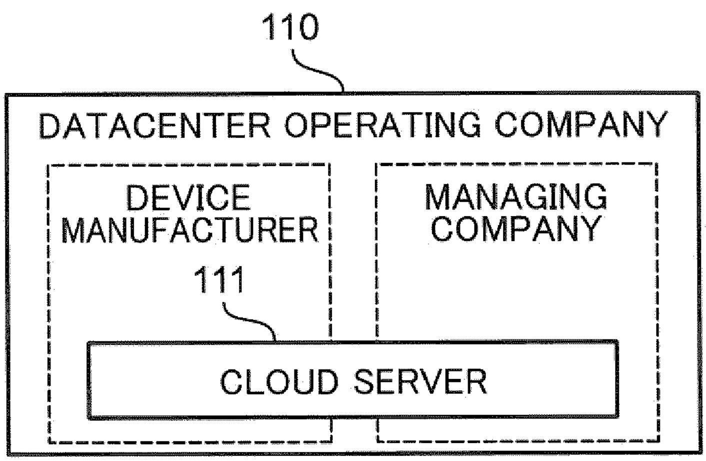

110
DATACENTER OPERATING COMPANY
DEVICE MANUFACTURER
MANAGING COMPANY
111
CLOUD SERVER

FIG.4

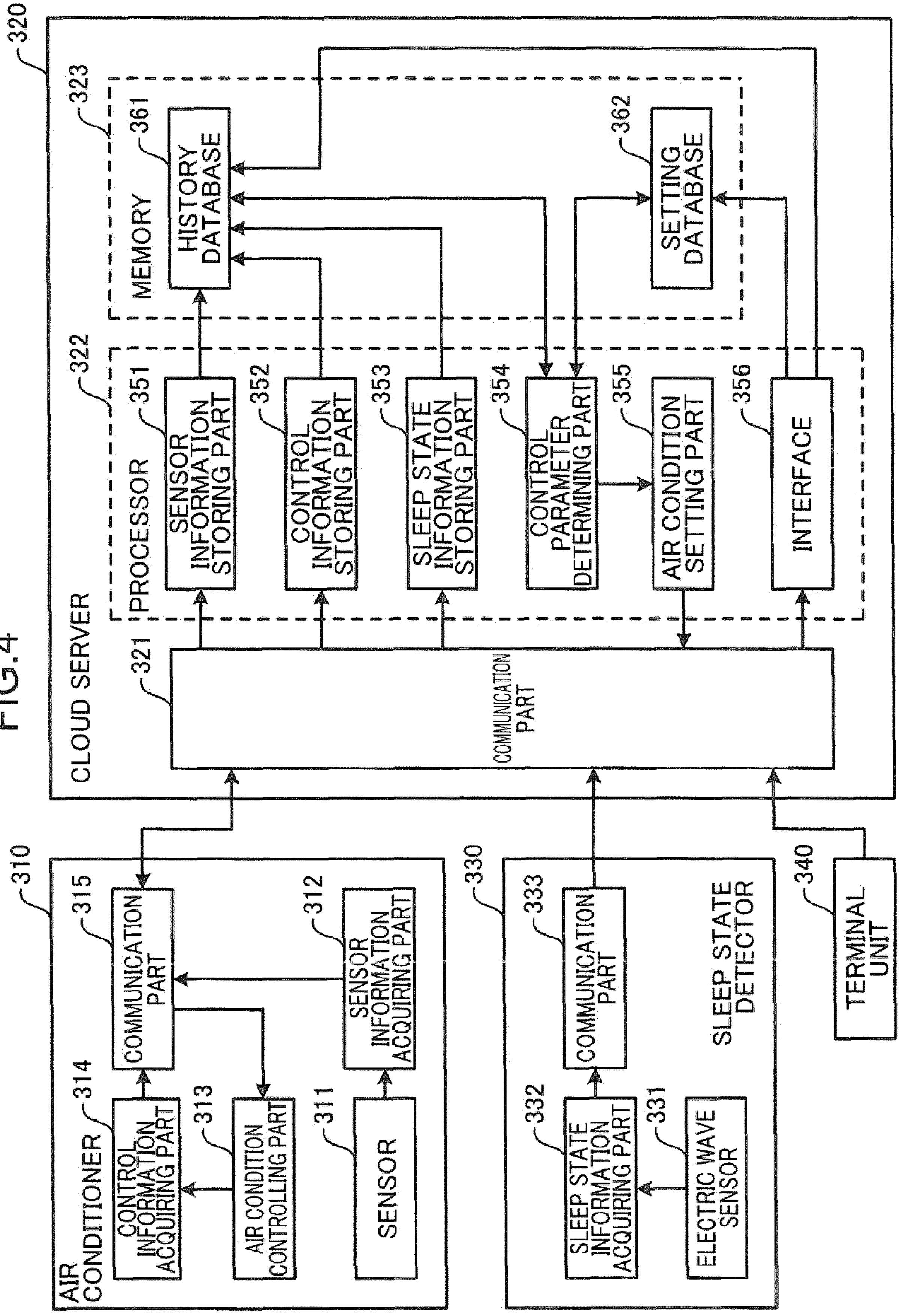

320
CLOUD SERVER
323
MEMORY
361
HISTORY DATABASE
362
SETTING DATABASE
322
PROCESSOR
351
SENSOR INFORMATION STORING PART
352
CONTROL INFORMATION STORING PART
353
SLEEP STATE INFORMATION STORING PART
354
CONTROL PARAMETER DETERMINING PART
355
AIR CONDITION SETTING PART
356
INTERFACE
321
COMMUNICATION PART
310
AIR CONDITIONER
315
COMMUNICATION PART
314
CONTROL INFORMATION ACQUIRING PART
313
AIR CONDITION CONTROLLING PART
312
SENSOR INFORMATION ACQUIRING PART
311
SENSOR
330
SLEEP STATE DETECTOR
333
COMMUNICATION PART
332
SLEEP STATE INFORMATION ACQUIRING PART
331
ELECTRIC WAVE SENSOR
340
TERMINAL UNIT

FIG.5

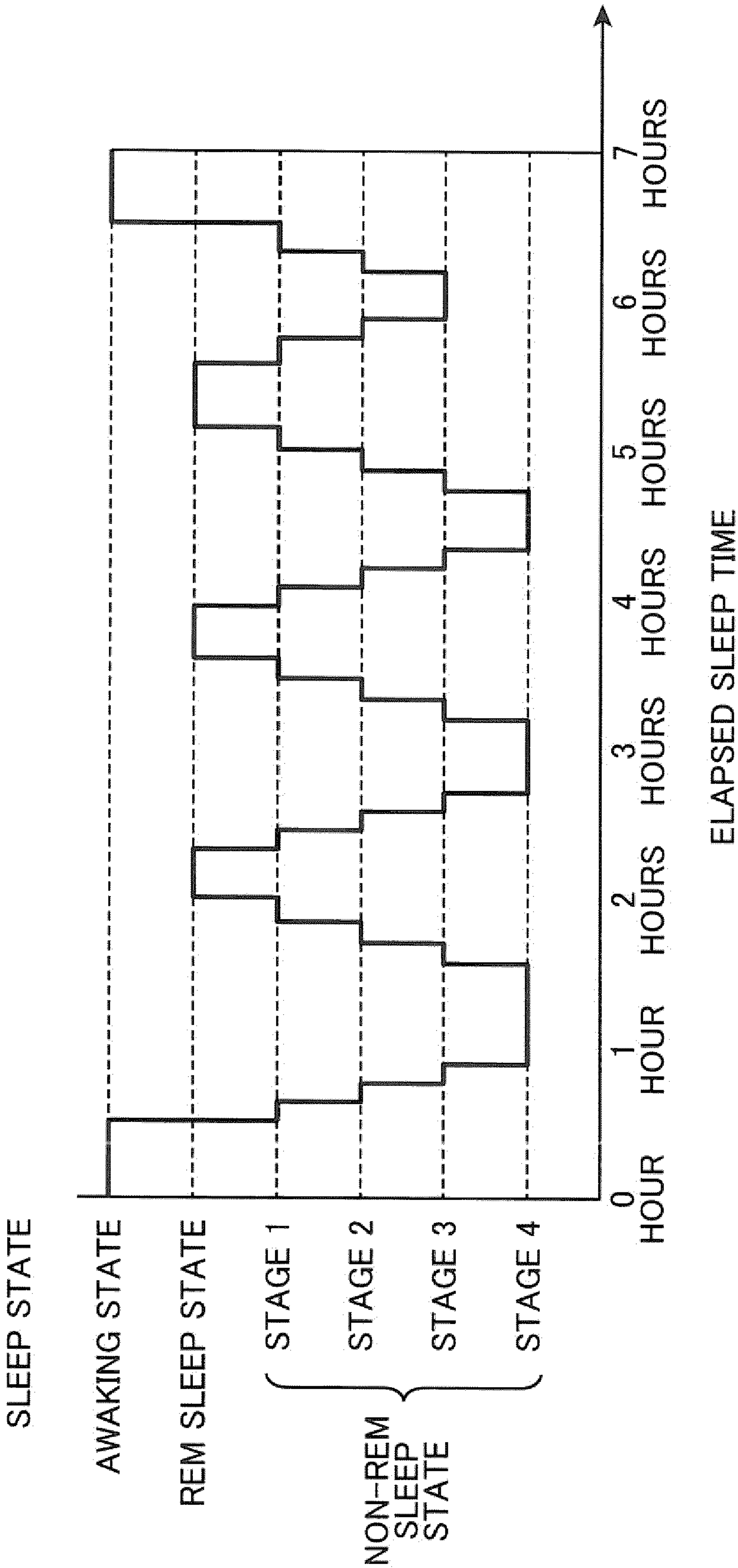

SLEEP STATE
AWAKING STATE
REM SLEEP STATE
STAGE 1
STAGE 2
STAGE 3
STAGE 4
NON-REM SLEEP STATE
0 HOUR
1 HOUR
2 HOURS
3 HOURS
4 HOURS
5 HOURS
6 HOURS
7 HOURS
ELAPSED SLEEP TIME

FIG.6

ID	TIME	ACQUISITION BY SENSOR INFORMATION ACQUIRING PART						ACQUISITION BY CONTROL INFORMATION ACQUIRING PART				
		INDOOR TEMPERATURE (°C)	INDOOR HUMIDITY (%)	OUTDOOR TEMPERATURE (°C)	TEMPERATURE OF AIR BLOW (°C)	EXISTENCE /ABSENCE INFORMATION	POWER AMOUNT (wh)	OPERATIONAL STATUS	OPERATIONAL MODE	SET TEMPERATURE (°C)	AIRFLOW AMOUNT	AIRFLOW DIRECTION
...	...	...	...	...	...	...	...	...	...	...	...	...
100	SUN., AUG. 14, 2016 10:00	30.0	50	32.9	–	ABSENCE	0	OFF	–	–	–	–
102	SUN., AUG. 14, 2016 10:01	30.1	50	33.0	–	ABSENCE	0	OFF	–	–	–	–
103	SUN., AUG. 14, 2016 10:02	30.2	51	33.0	–	EXISTENCE	0	OFF	–	–	–	–
104	SUN., AUG. 14, 2016 10:03	30.2	50	32.8	28.0	EXISTENCE	100	ON	COOLING MODE	25	Lv5	Dir1
105	SUN., AUG. 14, 2016 10:04	30.0	49	32.7	26.0	EXISTENCE	60	ON	COOLING MODE	25	Lv5	Dir1
106	SUN., AUG. 14, 2016 10:05	29.7	49	32.6	24.0	EXISTENCE	40	ON	COOLING MODE	25	Lv5	Dir1
...	...	...	...	...	...	...	...	...	...	...	...	...

FIG.7

ID	TIME	ACQUISITION BY SLEEP STATE INFORMATION ACQUIRING PART				
		SLEEP STATE	HEART RATE (bpm)	BREATHING RATE (brpm)	BODY MOTION AMOUNT	...
...	...	...	...	...	...	...
200	SUN., AUG. 14, 2016 23:00	WAKE	66.28	13.16	20	...
202	SUN., AUG. 14, 2016 23:01	WAKE	64.98	13.68	5	...
203	SUN., AUG. 14, 2016 23:02	STAGE1	67.45	13.2	0	...
204	SUN., AUG. 14, 2016 23:03	STAGE1	66.63	13.2	0	...
205	SUN., AUG. 14, 2016 23:04	STAGE1	65.66	13.31	0	...
206	SUN., AUG. 14, 2016 23:05	STAGE2	65.36	12.3	0	...
...	...	...	...	...	...	...

FIG.8

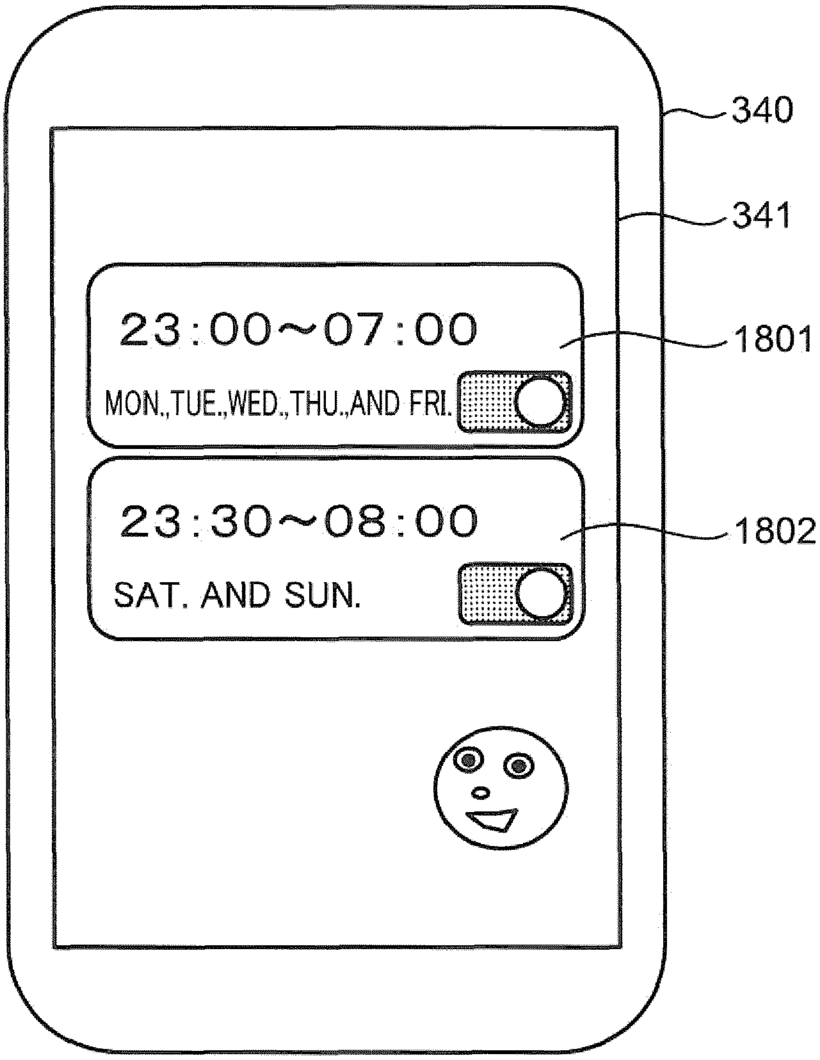

340
341
1801
1802
23:00~07:00
MON.,TUE.,WED.,THU.,AND FRI.
23:30~08:00
SAT. AND SUN.

FIG.9

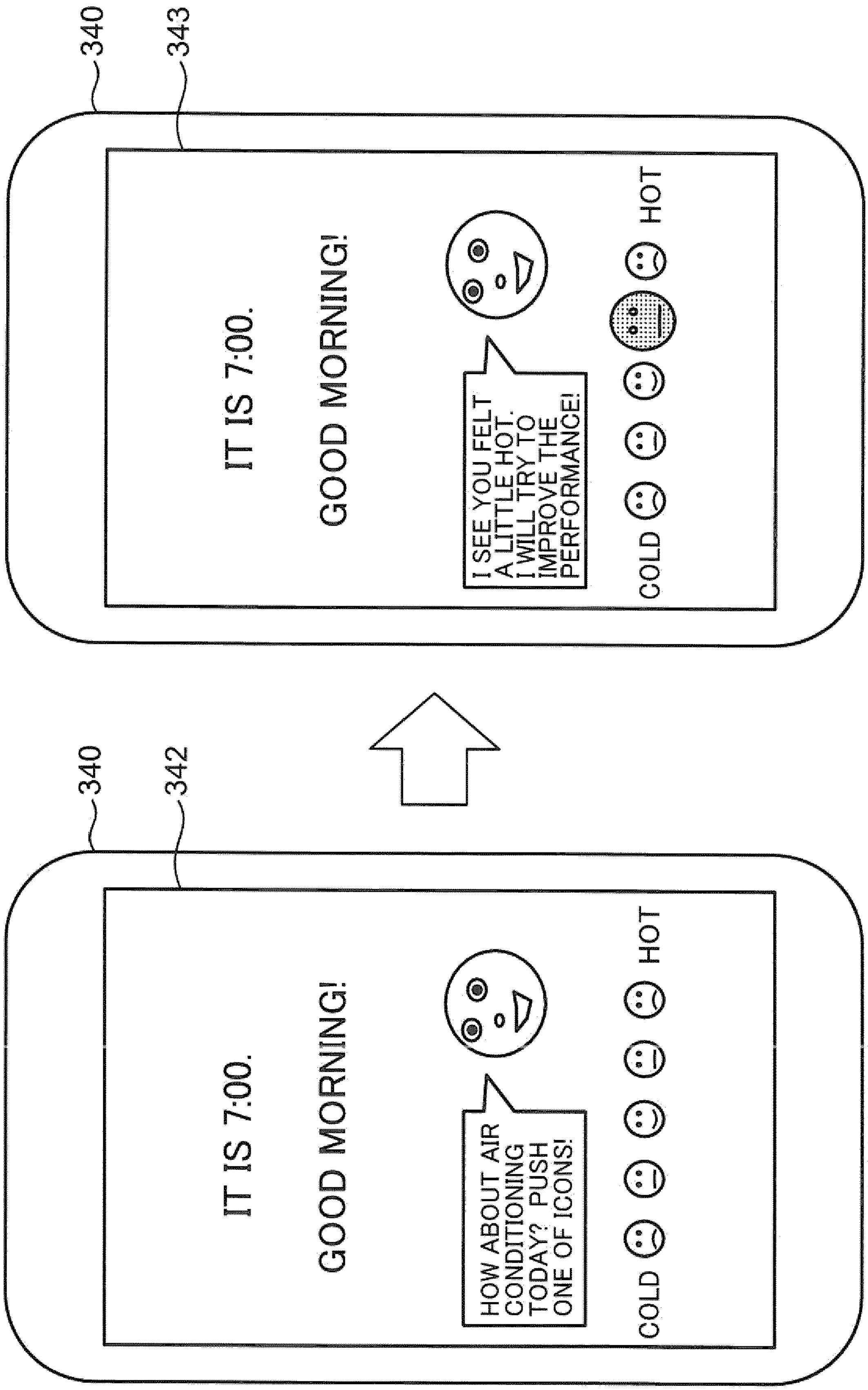

340
342
IT IS 7:00.
GOOD MORNING!
HOW ABOUT AIR CONDITIONING TODAY? PUSH ONE OF ICONS!
COLD
HOT
340
343
IT IS 7:00.
GOOD MORNING!
I SEE YOU FELT A LITTLE HOT. I WILL TRY TO IMPROVE THE PERFORMANCE!
COLD
HOT

FIG.10

ID	ACTUAL SLEEP STARTING TIME	ACTUAL AWAKING TIME	THERMAL CONDITION ENVIRONMENT SUBJECTIVE EVALUATION
400	AUG. 14, 2018 23:04	AUG. 14, 2018 7:00	1 : COLD
401	AUG. 14, 2018 23:20	AUG. 14, 2018 7:05	4: A LITTLE HOT

FIG.11

ID	ESTIMATED SLEEP STARTING TIME	ESTIMATED AWAKING TIME	DAY OF WEEK	AWAKING TIME THERMAL CONDITION INDICATION
300	23:00	07:00	MON.,TUE.,WED.,THU.,AND FRI.	77.5
302	23:30	08:00	SAT. AND SUN.	78.0

FIG.12

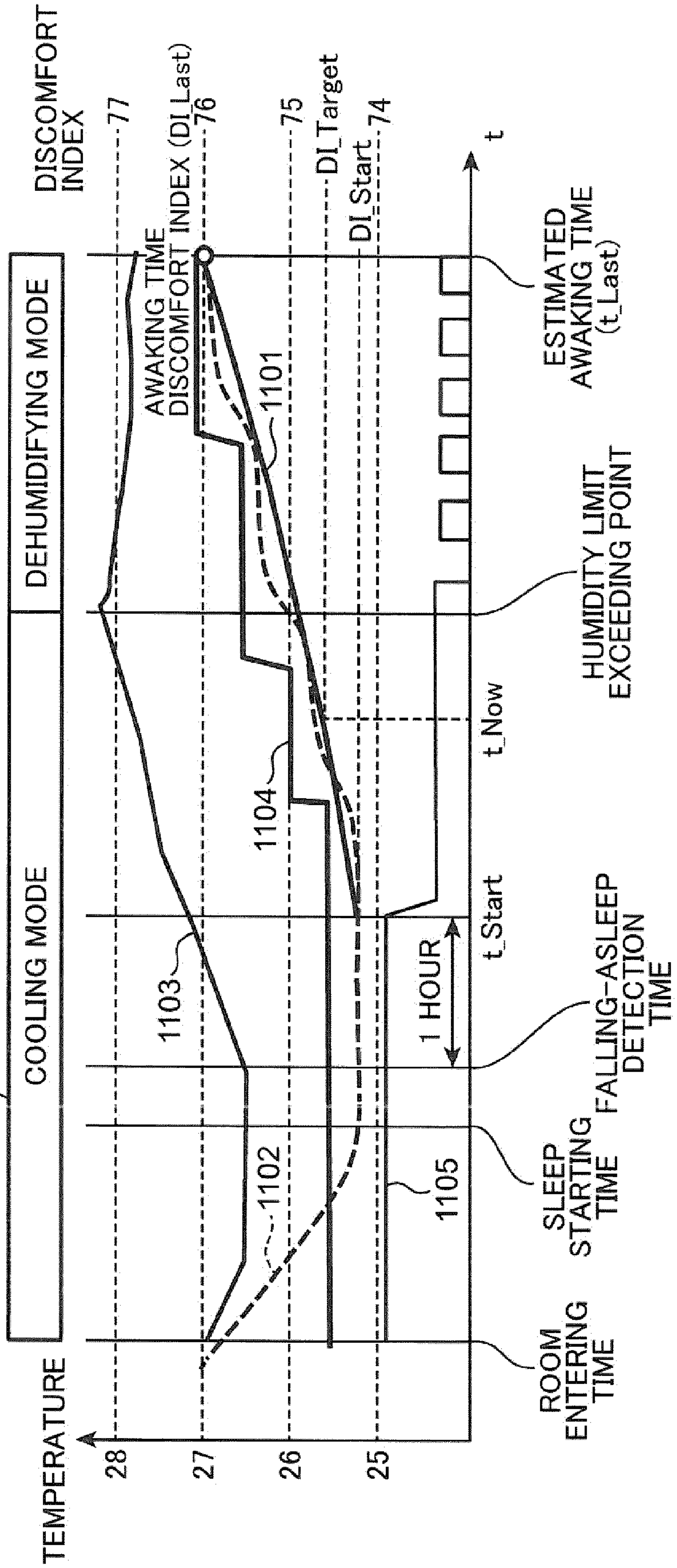

TEMPERATURE
28
27
26
25
DISCOMFORT INDEX
77
76
75
74
DI_Target
DI_Start
t
AWAKING TIME DISCOMFORT INDEX (DI_Last)
1107
COOLING MODE
DEHUMIDIFYING MODE
1101
1102
1103
1104
1105
1 HOUR
t_Start
t_Now
ROOM ENTERING TIME
SLEEP STARTING TIME
FALLING-ASLEEP DETECTION TIME
HUMIDITY LIMIT EXCEEDING POINT
ESTIMATED AWAKING TIME (t_Last)

FIG.13

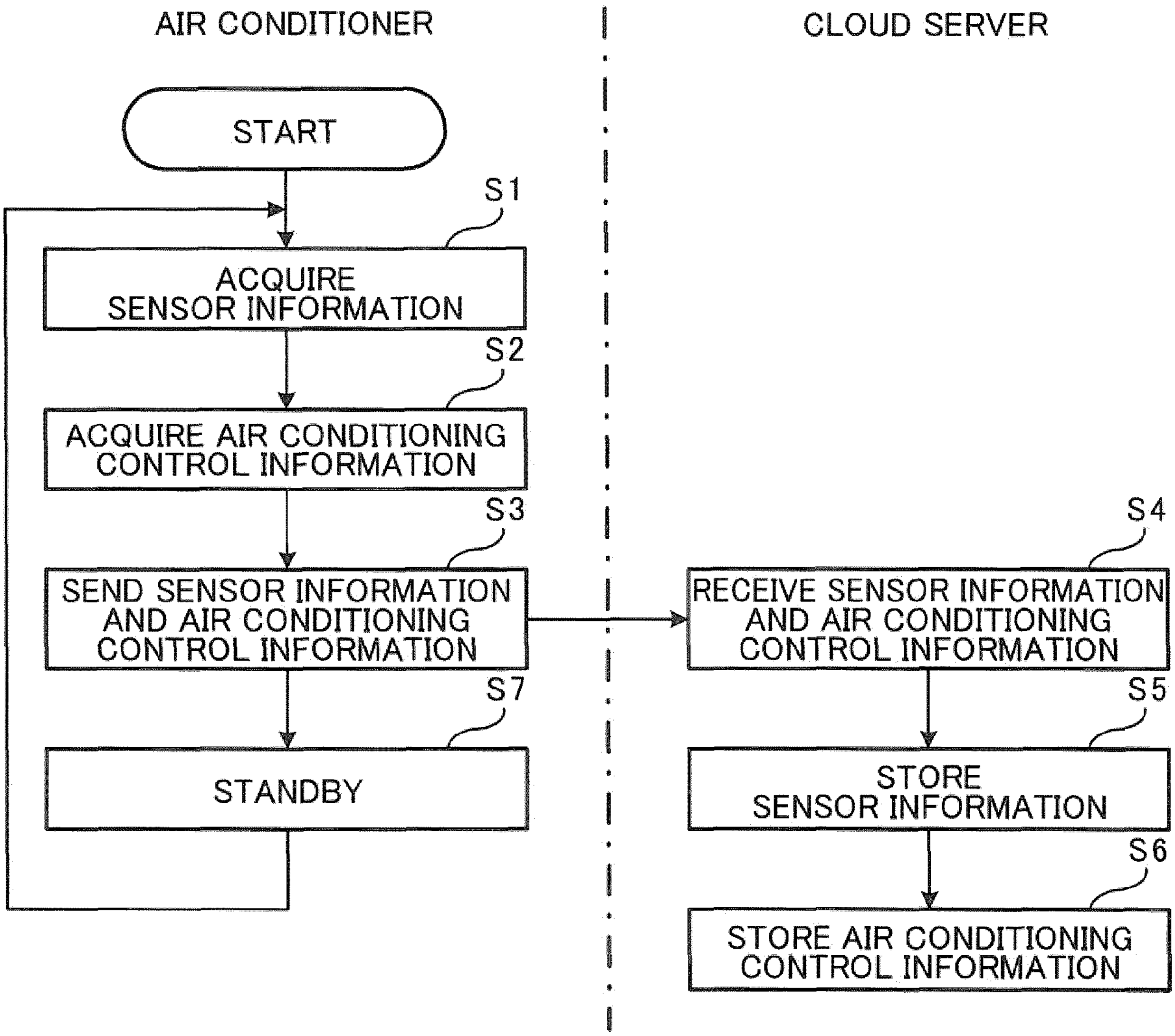

AIR CONDITIONER
CLOUD SERVER
START
S1
ACQUIRE SENSOR INFORMATION
S2
ACQUIRE AIR CONDITIONING CONTROL INFORMATION
S3
SEND SENSOR INFORMATION AND AIR CONDITIONING CONTROL INFORMATION
S7
STANDBY
S4
RECEIVE SENSOR INFORMATION AND AIR CONDITIONING CONTROL INFORMATION
S5
STORE SENSOR INFORMATION
S6
STORE AIR CONDITIONING CONTROL INFORMATION

FIG.14

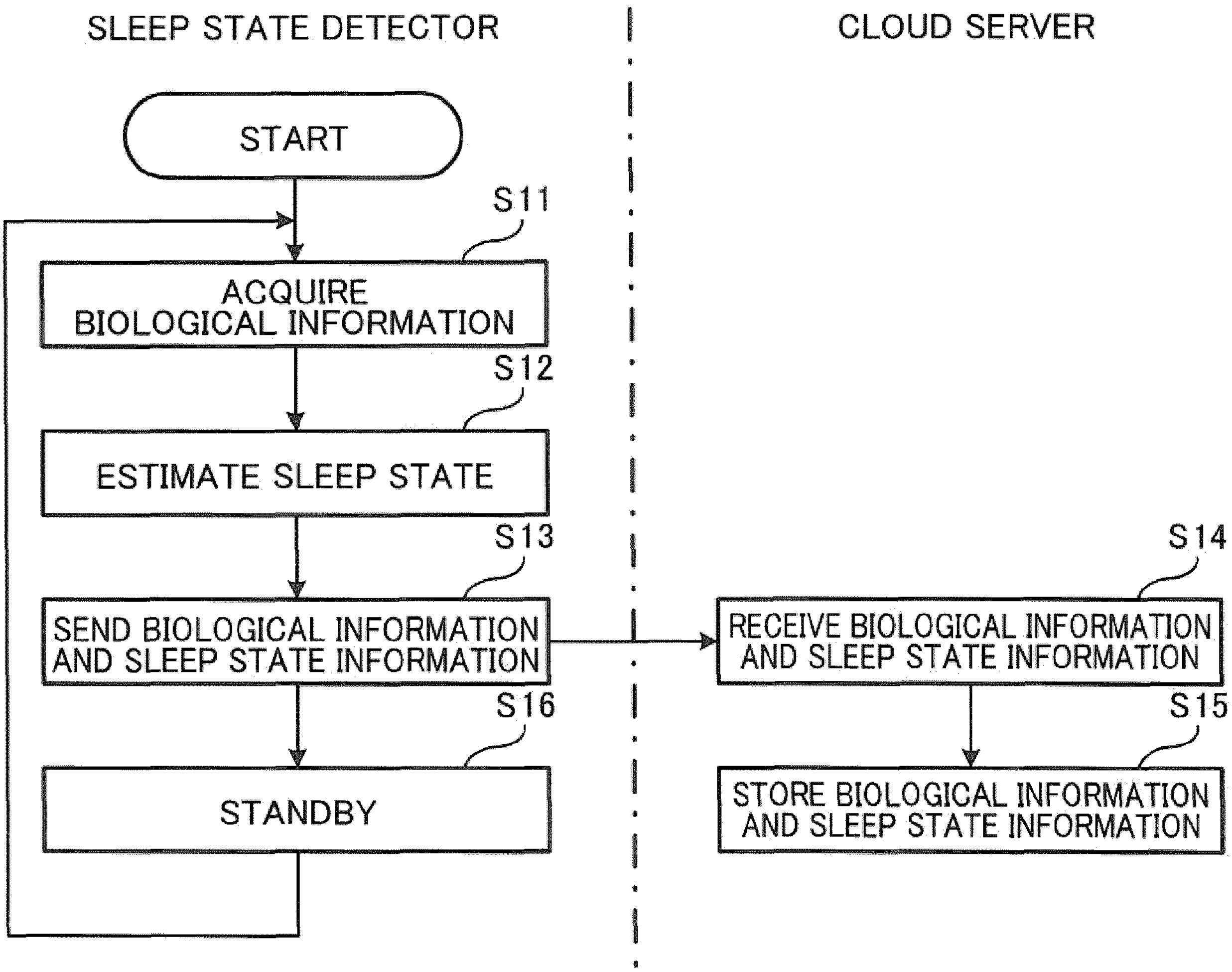

SLEEP STATE DETECTOR
CLOUD SERVER
START
S11
ACQUIRE BIOLOGICAL INFORMATION
S12
ESTIMATE SLEEP STATE
S13
SEND BIOLOGICAL INFORMATION AND SLEEP STATE INFORMATION
S16
STANDBY
S14
RECEIVE BIOLOGICAL INFORMATION AND SLEEP STATE INFORMATION
S15
STORE BIOLOGICAL INFORMATION AND SLEEP STATE INFORMATION

FIG.15

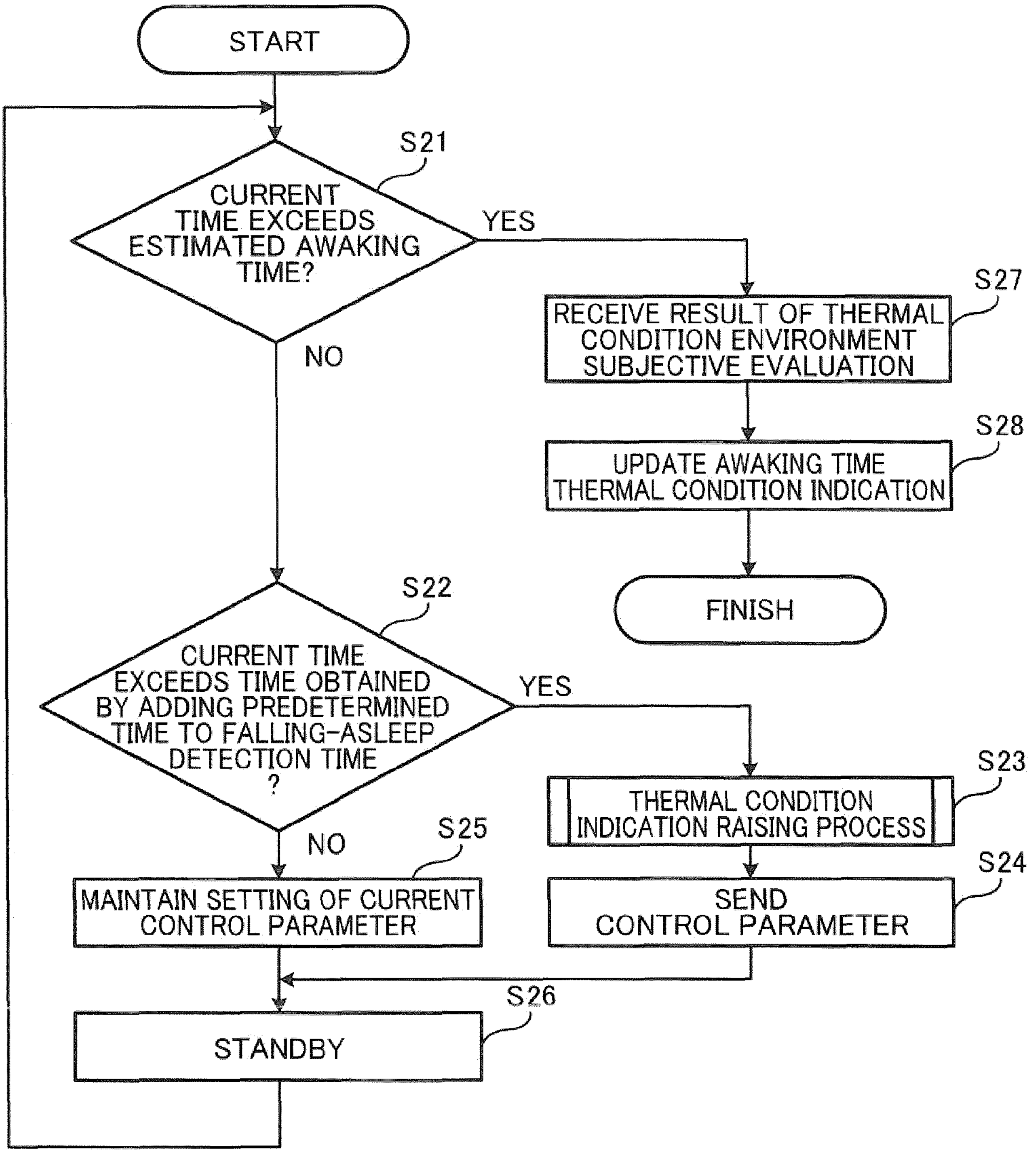

START
S21
CURRENT TIME EXCEEDS ESTIMATED AWAKING TIME?
YES
NO
S27
RECEIVE RESULT OF THERMAL CONDITION ENVIRONMENT SUBJECTIVE EVALUATION
S28
UPDATE AWAKING TIME THERMAL CONDITION INDICATION
FINISH
S22
CURRENT TIME EXCEEDS TIME OBTAINED BY ADDING PREDETERMINED TIME TO FALLING-ASLEEP DETECTION TIME ?
YES
NO
S23
THERMAL CONDITION INDICATION RAISING PROCESS
S24
SEND CONTROL PARAMETER
S25
MAINTAIN SETTING OF CURRENT CONTROL PARAMETER
S26
STANDBY

FIG.16

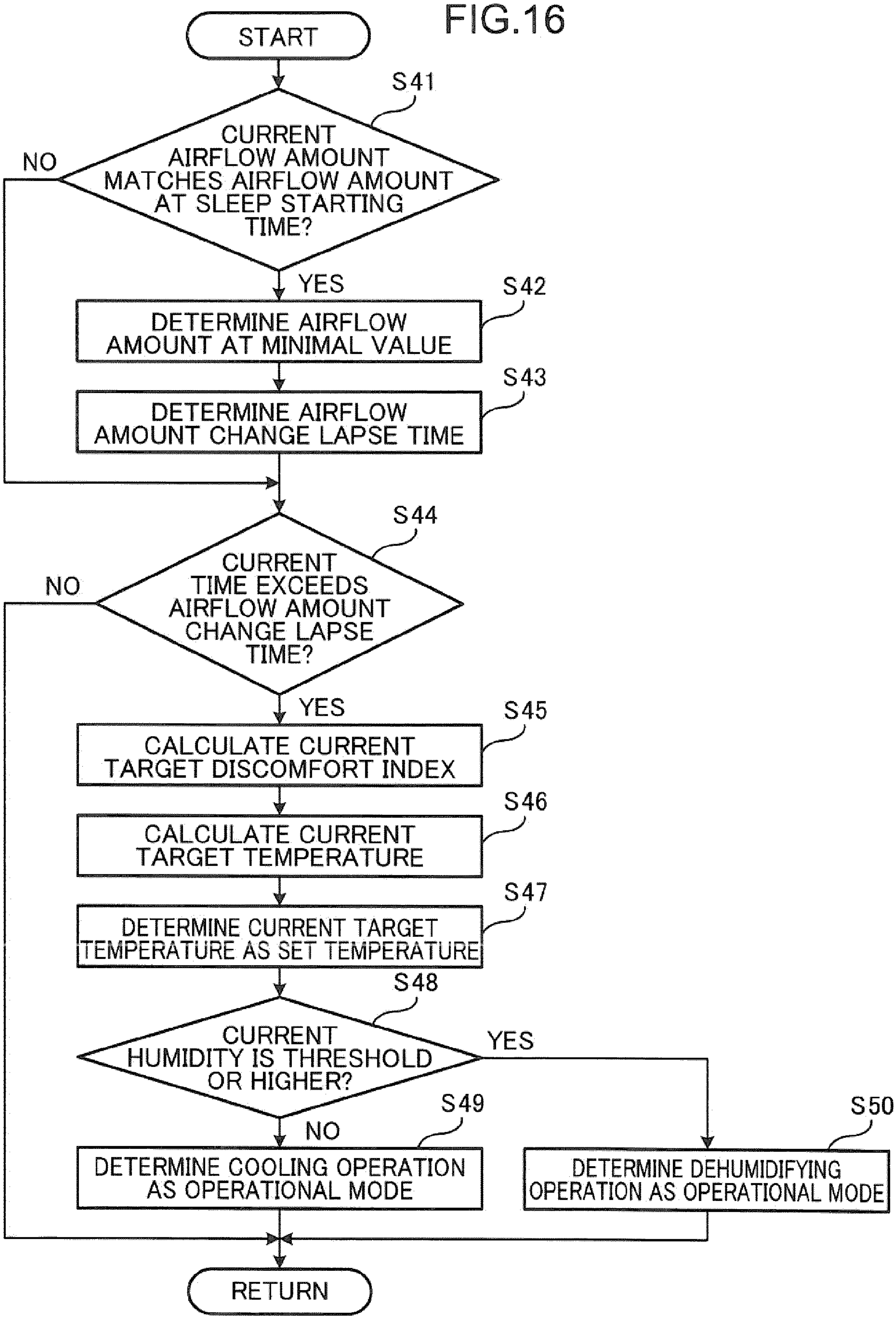

START
S41
CURRENT AIRFLOW AMOUNT MATCHES AIRFLOW AMOUNT AT SLEEP STARTING TIME?
NO
YES
S42
DETERMINE AIRFLOW AMOUNT AT MINIMAL VALUE
S43
DETERMINE AIRFLOW AMOUNT CHANGE LAPSE TIME
S44
CURRENT TIME EXCEEDS AIRFLOW AMOUNT CHANGE LAPSE TIME?
NO
YES
S45
CALCULATE CURRENT TARGET DISCOMFORT INDEX
S46
CALCULATE CURRENT TARGET TEMPERATURE
S47
DETERMINE CURRENT TARGET TEMPERATURE AS SET TEMPERATURE
S48
CURRENT HUMIDITY IS THRESHOLD OR HIGHER?
YES
NO
S49
DETERMINE COOLING OPERATION AS OPERATIONAL MODE
S50
DETERMINE DEHUMIDIFYING OPERATION AS OPERATIONAL MODE
RETURN

FIG.17

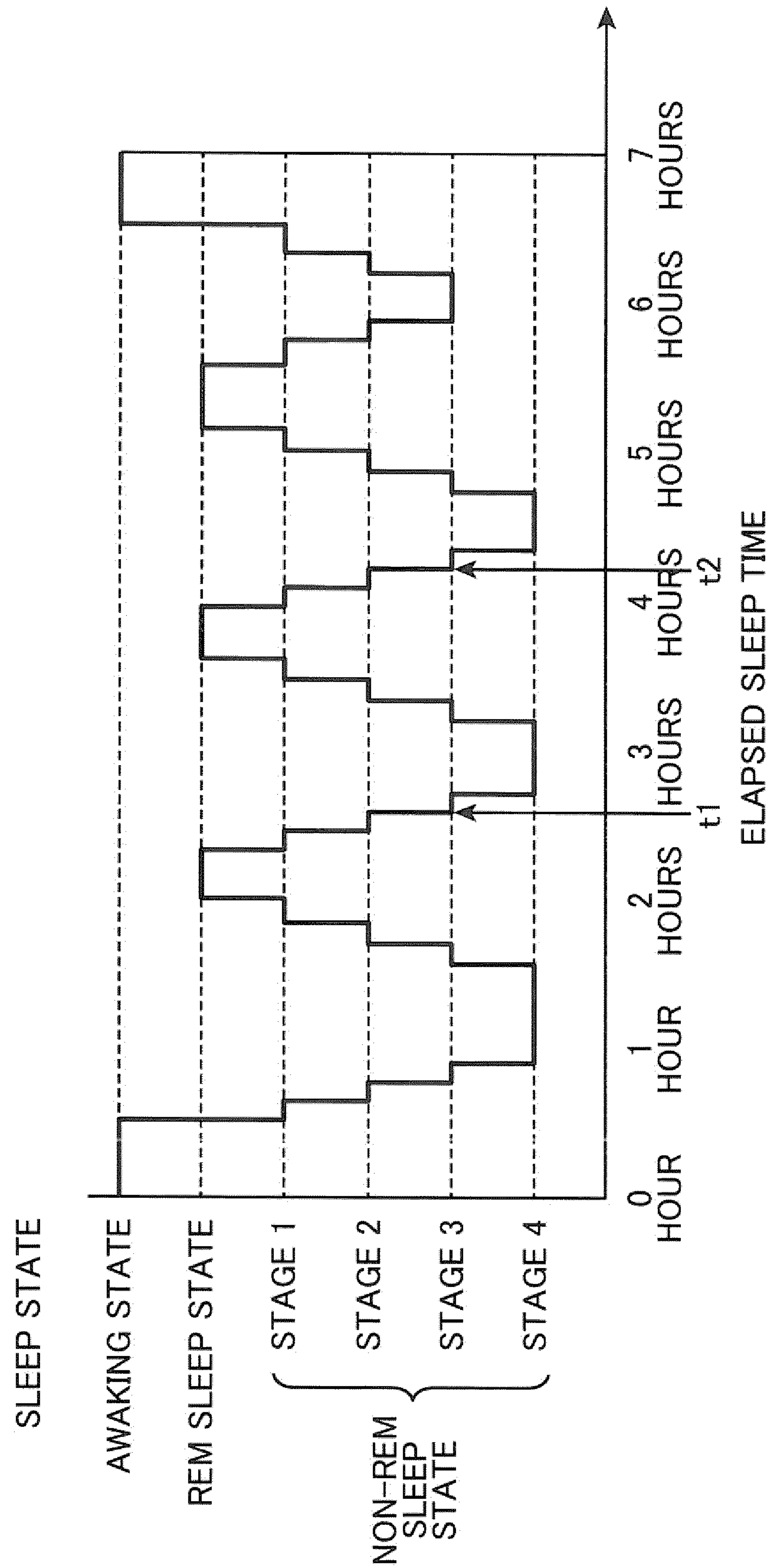

SLEEP STATE
AWAKING STATE
REM SLEEP STATE
STAGE 1
STAGE 2
STAGE 3
STAGE 4
NON-REM SLEEP STATE
0 HOUR
1 HOUR
2 HOURS
3 HOURS
4 HOURS
5 HOURS
6 HOURS
7 HOURS
t1
t2
ELAPSED SLEEP TIME

FIG.18

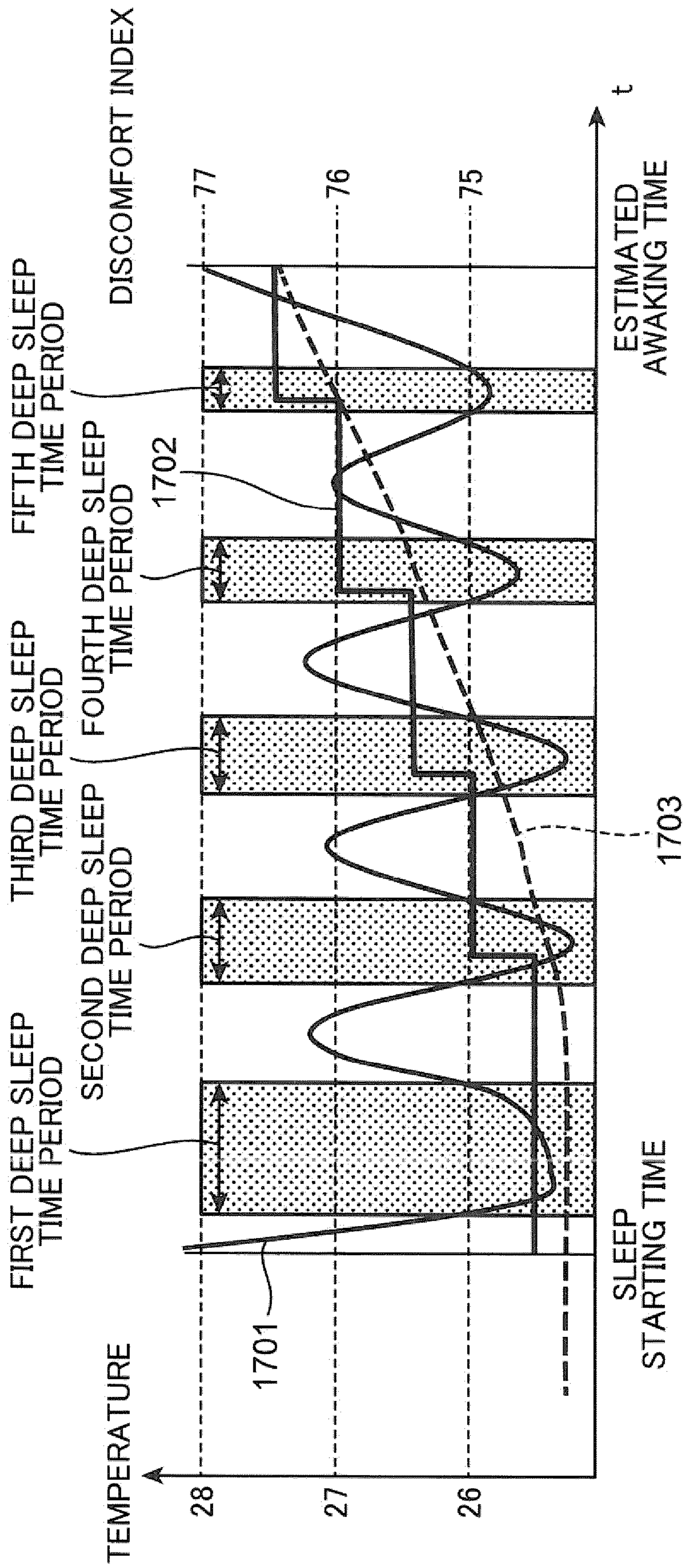
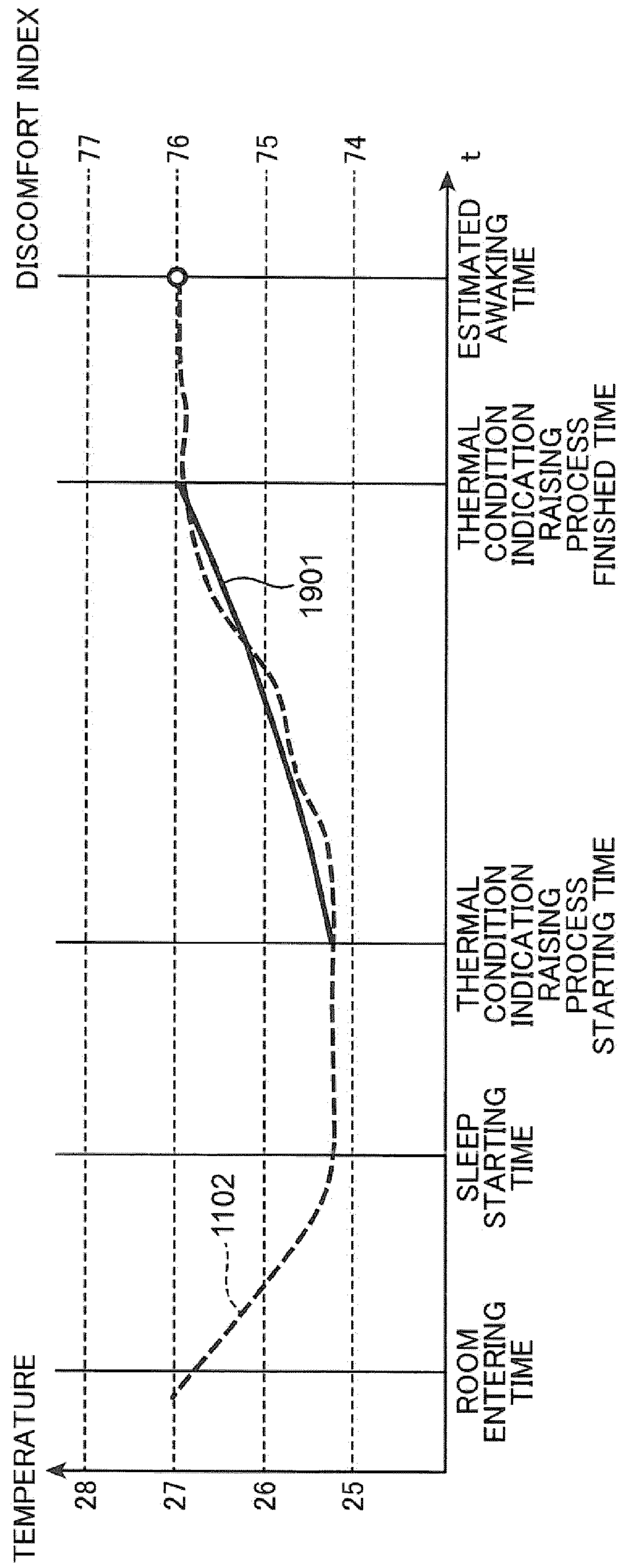

TEMPERATURE
28
27
26
DISCOMFORT INDEX
77
76
75
t
1701
1702
1703
FIRST DEEP SLEEP TIME PERIOD
SECOND DEEP SLEEP TIME PERIOD
THIRD DEEP SLEEP TIME PERIOD
FOURTH DEEP SLEEP TIME PERIOD
FIFTH DEEP SLEEP TIME PERIOD
SLEEP STARTING TIME
ESTIMATED AWAKING TIME

FIG.19



TEMPERATURE
28
27
26
25
DISCOMFORT INDEX
77
76
75
74
t
1102
1901
ROOM ENTERING TIME
SLEEP STARTING TIME
THERMAL CONDITION INDICATION RAISING PROCESS STARTING TIME
THERMAL CONDITION INDICATION RAISING PROCESS FINISHED TIME
ESTIMATED AWAKING TIME

FIG.20

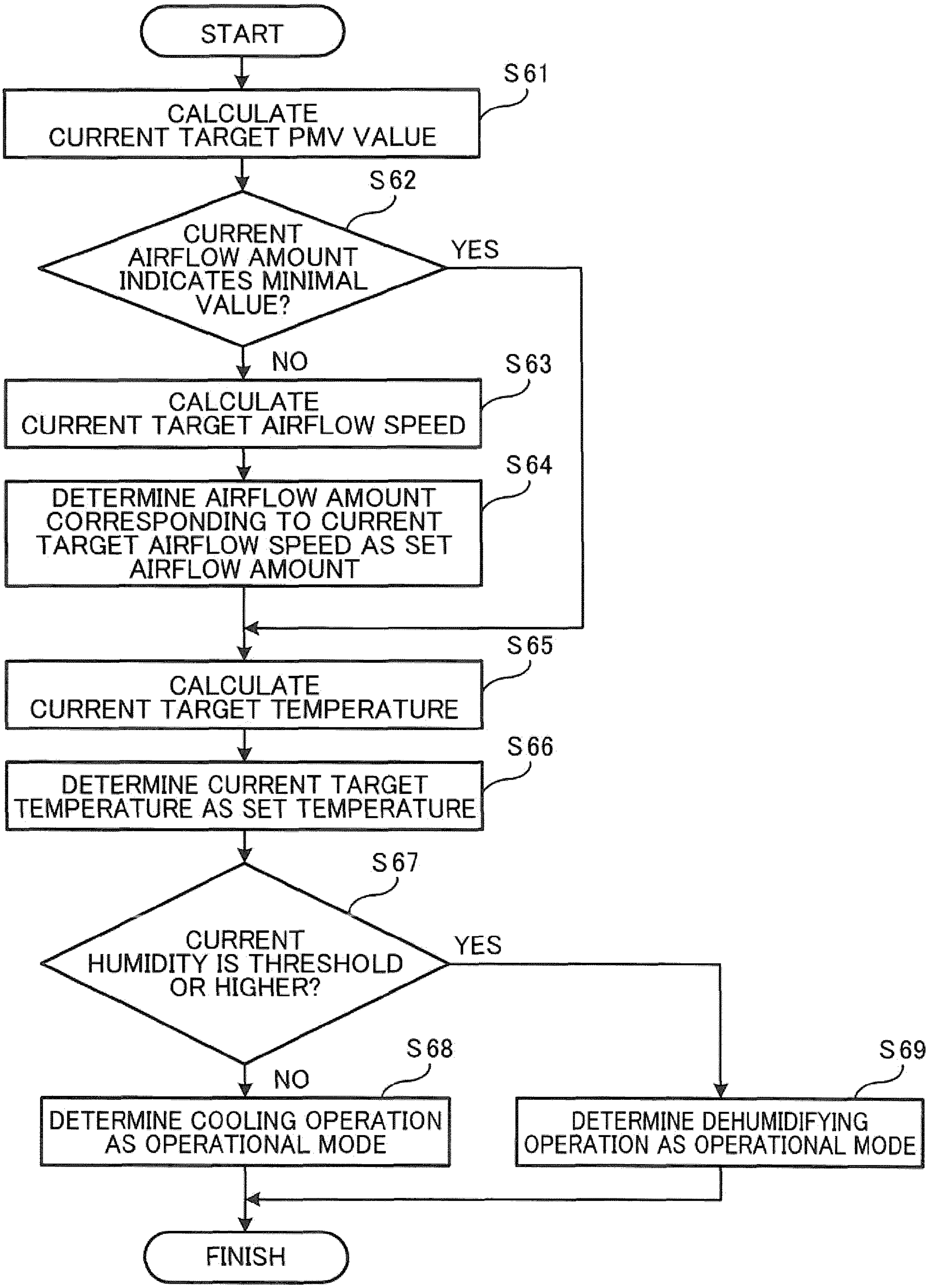

START
S61
CALCULATE CURRENT TARGET PMV VALUE
S62
CURRENT AIRFLOW AMOUNT INDICATES MINIMAL VALUE?
YES
NO
S63
CALCULATE CURRENT TARGET AIRFLOW SPEED
S64
DETERMINE AIRFLOW AMOUNT CORRESPONDING TO CURRENT TARGET AIRFLOW SPEED AS SET AIRFLOW AMOUNT
S65
CALCULATE CURRENT TARGET TEMPERATURE
S66
DETERMINE CURRENT TARGET TEMPERATURE AS SET TEMPERATURE
S67
CURRENT HUMIDITY IS THRESHOLD OR HIGHER?
YES
NO
S68
DETERMINE COOLING OPERATION AS OPERATIONAL MODE
S69
DETERMINE DEHUMIDIFYING OPERATION AS OPERATIONAL MODE
FINISH

FIG.21

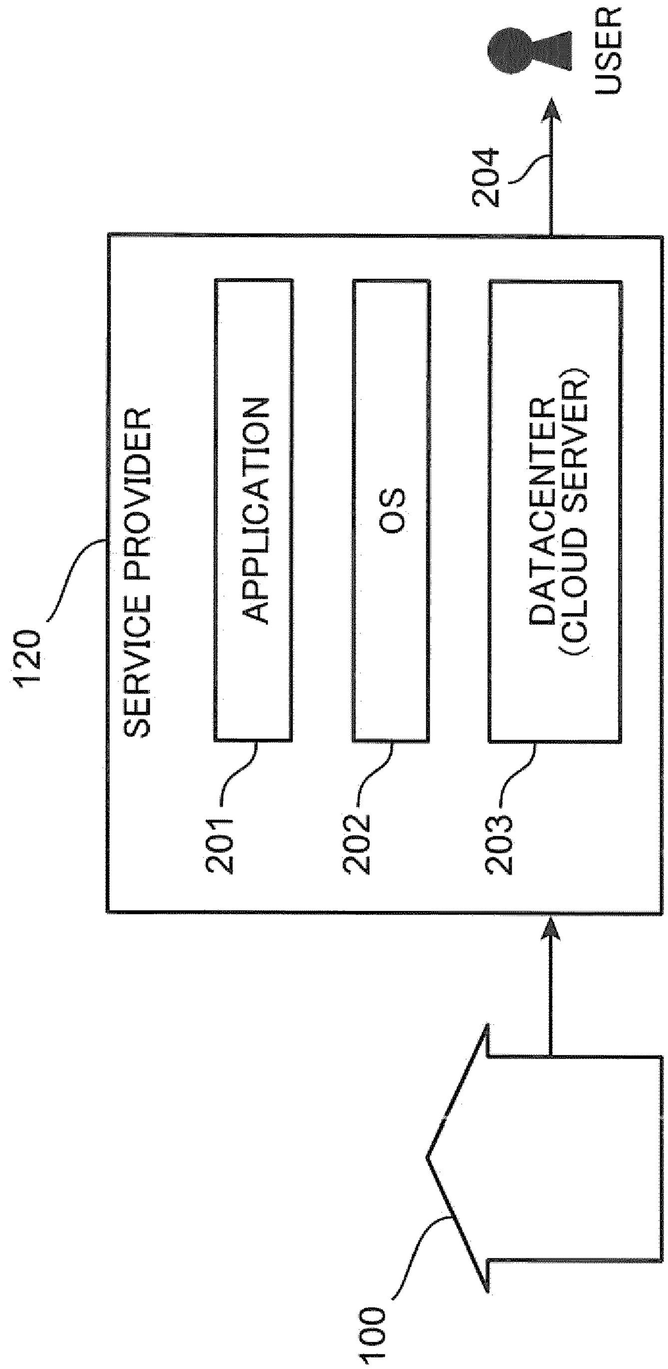

120
SERVICE PROVIDER
APPLICATION
OS
DATACENTER
(CLOUD SERVER)
201
202
203
204
USER
100

FIG.22

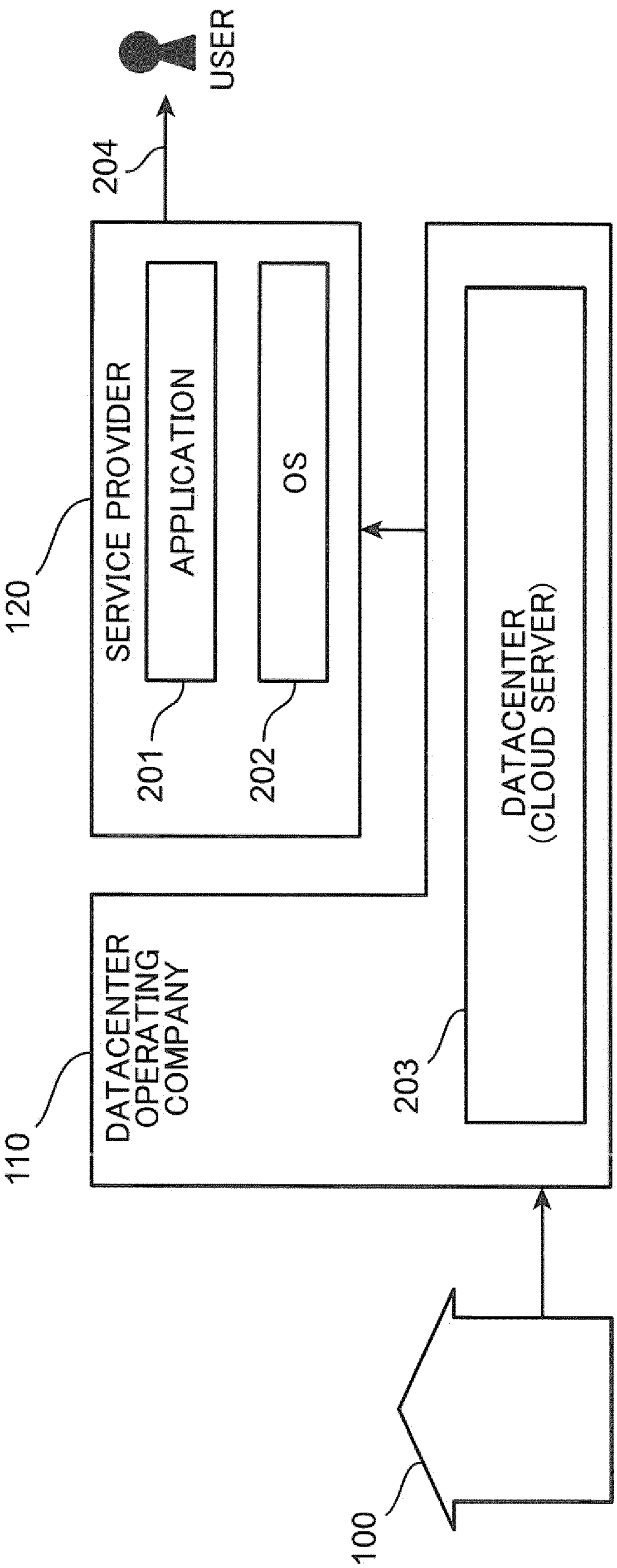

USER
204
120
SERVICE PROVIDER
APPLICATION
OS
201
202
110
DATACENTER
OPERATING
COMPANY
203
DATACENTER
(CLOUD SERVER)
100

FIG.23

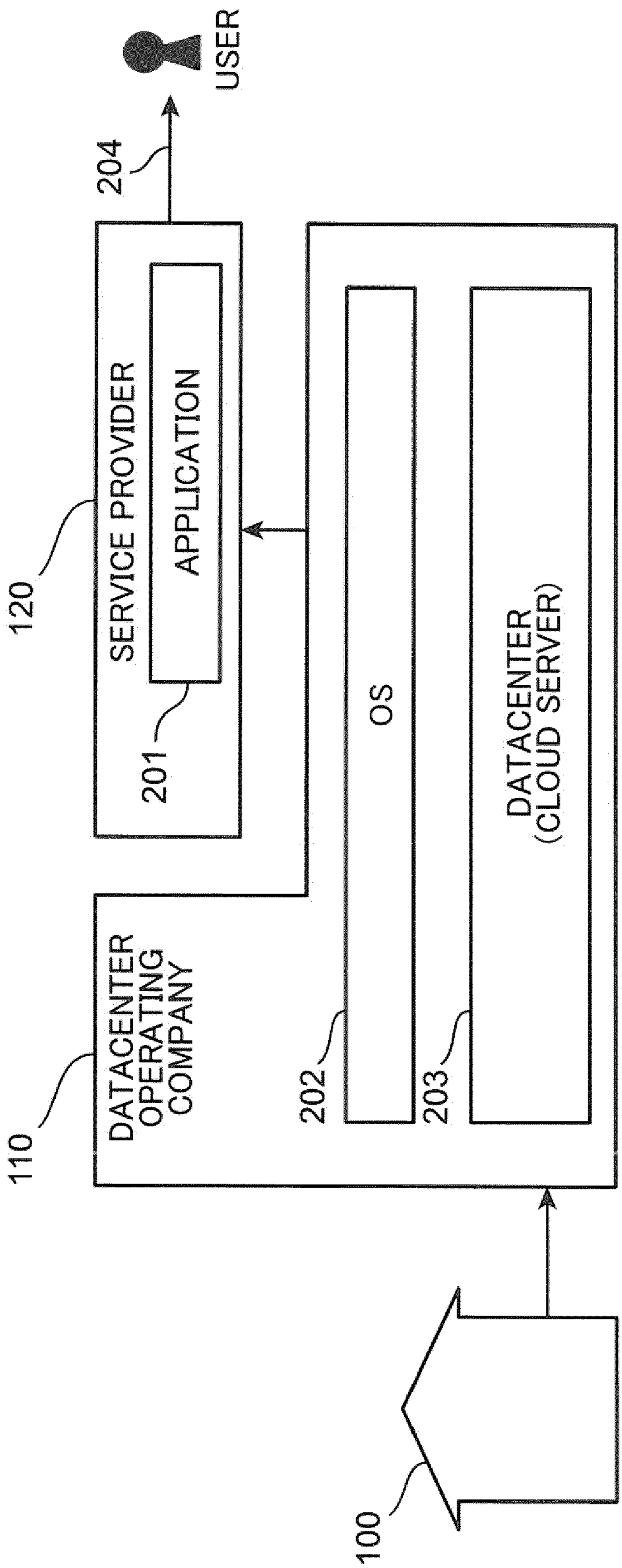
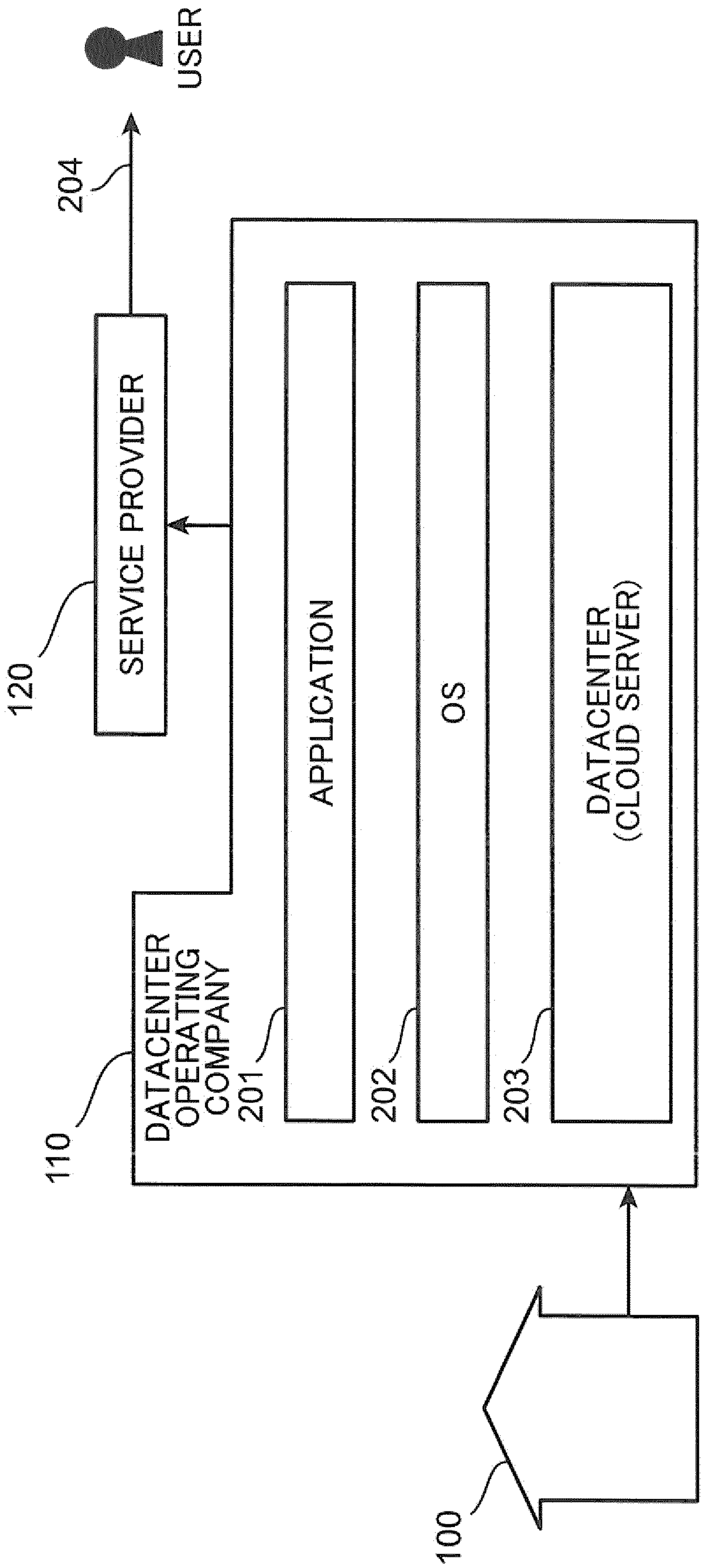

USER
204
120
SERVICE PROVIDER
APPLICATION
201
110
DATACENTER OPERATING COMPANY
OS
202
DATACENTER (CLOUD SERVER)
203
100

FIG.24


USER
204
120
SERVICE PROVIDER
110
DATACENTER OPERATING COMPANY
201
APPLICATION
202
OS
203
DATACENTER (CLOUD SERVER)
100

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 19 21 5202

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	US 2018/271299 A1 (HARADA MASAAKI [JP] ET AL) 27 September 2018 (2018-09-27) * page 10, paragraph 129 - page 12, paragraph 142; figure 6 * * page 8, line 106 - page 10, line 127; figure 5 * * page 14, paragraph 167; claims 1,2,4,6,9,12 * -----	1-10	INV. F24F11/74 F24F11/66 F24F110/10 F24F120/00 F24F110/20 F24F120/14 F24F120/20
X	US 5 299 428 A (KAWAGURI MARIKO [JP] ET AL) 5 April 1994 (1994-04-05) * column 2, line 30 - column 6, line 17; figures 1-2 * -----	1-10	
X	JP 2007 132581 A (TOSHIBA CORP) 31 May 2007 (2007-05-31) * the whole document * -----	1-4,7-10	
X	JP 2018 066547 A (MITSUBISHI ELECTRIC CORP) 26 April 2018 (2018-04-26) * the whole document * -----	1-10	

TECHNICAL FIELDS SEARCHED (IPC)

F24F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	20 May 2020	Hoffmann, Stéphanie

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons
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20-05-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		US 2018271299 A1	27-09-2018
US 5299428 A	05-04-1994	JP 2876882 B2	31-03-1999
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JP 2007132581 A	31-05-2007	JP 4435070 B2	17-03-2010
		JP 2007132581 A	31-05-2007
JP 2018066547 A	26-04-2018	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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Patent documents cited in the description

- JP 4538941 B **[0002]**
- JP 2018237479 A **[0219]**
- JP 2019156296 A **[0219]**

Non-patent literature cited in the description

- Optimal Thermal Conditions during Night Sleep in Summer. **YOH KAWASHIMA ; NAOSHI KAKITSUBA.** Human and Living Environment. Japanese Society of Human-Environment System, 2004, vol. 11, 17-23 **[0004]**