(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 361 515 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
01.05.2024 Bulletin 2024/18

(21) Application number: **22845892.3**

(22) Date of filing: **15.07.2022**

(51) International Patent Classification (IPC):
F24F 11/64 *(2018.01)* ***F24F 11/80*** *(2018.01)*

(52) Cooperative Patent Classification (CPC):
F24F 11/46; F24F 11/64; F24F 11/80

(86) International application number:
PCT/JP2022/027924

(87) International publication number:
WO 2023/002958 (26.01.2023 Gazette 2023/04)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **19.07.2021 JP 2021119044**

(71) Applicant: **Daikin Industries, Ltd.**
Osaka-shi, Osaka 530-0001 (JP)

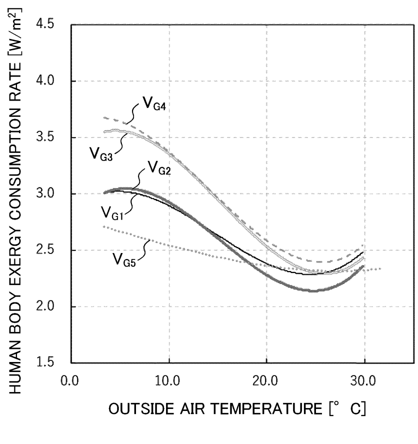
(72) Inventors:
- **EMOTO, Shiori**
Osaka-shi, Osaka 530-8323 (JP)
- **HORI, Shouta**
Osaka-shi, Osaka 530-8323 (JP)
- **NISHINO, Atsushi**
Osaka-shi, Osaka 530-8323 (JP)

(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(54) AIR-CONDITIONING DEVICE AND CONTROL SYSTEM

(57) An air-conditioning device includes: an information acquisition unit (101) configured to acquire first information indicating environmental information on an environment in which a target person (H) has been placed in a past or biological information of the target person (H); and a control unit (100) configured to grasp a habitual behavior pattern of the target person (H) in the first information. A target value of a first index, which is an index related to a thermal environment, is set based on the first information acquired by the information acquisition unit (101) and the grasped behavior pattern.

FIG.4



EP 4 361 515 A1

Description

Technical Field

[0001] The present disclosure relates to an air-conditioning device and a control system.

Background Art

[0002] PTL 1 discloses an air-conditioning device for air-conditioning an indoor space, the air-conditioning device controlling air-conditioning such that the indoor space becomes a comfortable thermal environment while suppressing a load of thermal stress applied to a person in the space.

Citation List

Patent Literature

[0003] PTL 1: Japanese Unexamined Patent Application Publication No. 2020-41755

Summary of Invention

Technical Problem

[0004] The strength of air-conditioning and the amount of clothing in a room vary among individuals. For example, some people wear light clothing in summer and heavy clothing in winter with weaker air-conditioning throughout the year, and some people wear an average amount of clothing in both summer and winter with stronger air-conditioning throughout the year. In this way, each person feels the thermal comfort of the indoor space differently, and thus, it is preferable to perform air-conditioning according to the person in the space. However, with the air-conditioning device described in PTL 1, it is not possible to perform air-conditioning for each person (person in the space). The present disclosure provides an air-conditioning device that controls air-conditioning according to a person.

Solution to Problem

[0005] A first aspect is an air-conditioning device including: an information acquisition unit (101) configured to acquire first information indicating environmental information on an environment in which a target person (H) has been placed in a past or biological information of the target person (H); and a control unit (100) configured to grasp a habitual behavior pattern of the target person (H) in the first information, in which the control unit (100) is configured to set a target value of a first index, which is an index related to a thermal environment, based on the first information acquired by the information acquisition unit (101) and the grasped behavior pattern.

[0006] In the first aspect, the control unit (100) controls air-conditioning such that the first index becomes the target value, based on the first information and the behavior pattern of the target person (H). The behavior pattern varies depending on the target person (H). Accordingly, the air-conditioning device can control air-conditioning according to the target person (H). In addition, in a case where the first information is an outside air temperature that is an experienced temperature, since the outside air temperature changes depending on the season, it is possible to control air-conditioning according to the target person (H) for each season.

[0007] According to a second aspect, in the first aspect,
the control unit (100) is configured to grasp the behavior pattern, based on a report from the target person (H), operation information on an operation performed by the target person (H) on the air-conditioning device, environmental information of a target space (S), a behavior of the target person (H) estimated from a camera image of the target space (S), an amount of clothing of the target person (H) estimated from the camera image of the target space (S), or a voice of the target person (H) in the target space (S).

[0008] In the second aspect, the control unit (100) can grasp the behavior pattern by the report (input) from the target person. In addition, the control unit (100) can grasp the behavior pattern of the target person (H), based on the operation information of the air-conditioning device, the environmental information, the camera image, or the like. Accordingly, it is possible to save time and effort for making a report (input).

[0009] According to a third aspect, in the first or second aspect,
the target value of the first index is in a thermal environment in which a target person group corresponding to one behavior pattern among a plurality of classified behavior patterns feels thermally neutral.

[0010] In the third aspect, the first index and the target value can be set based on a thermal environment in which a plurality of target persons (H) classified into the same behavior pattern feel thermally neutral. The thermal environment that is felt to be thermally neutral refers to, for example, the target space (S) that the target person (H) feels neither hot nor cold. The thermal environment includes an inside air temperature, an inside air humidity, airflow (wind speed), a radiation temperature, and the like in the target space (S).

[0011] According to a fourth aspect, in the first or second aspect,
the control unit (100) includes an individual recognition unit (102) configured to recognize an individual and a storage unit (101) configured to accumulate a behavior pattern for each recognized individual, and is configured to set the target value of the first index, based on a past behavior pattern of the target person (H).

[0012] In the fourth aspect, the behavior pattern can be specified for each individual. Accordingly, the target value of the first index can be set in accordance with each individual. Since the accumulated individual behavior patterns are used, it is possible to set the target value of the first index more suitable for the individual than in a case where the behavior patterns are classified into a plurality of behavior patterns in advance.

[0013] According to a fifth aspect, in any one of the first to fourth aspects,
the first index is an index based on a temperature in the target space (S), an index related to a human body exergy balance, a predicted mean vote (PMV), or the thermal environment.

[0014] In the fifth aspect, the first index can be an index based on the temperature in the target space (S), the index related to the human body exergy balance, the predicted mean vote (PMV), or the thermal environment.

[0015] According to a sixth aspect, in the fifth aspect,
the index related to the human body exergy balance indicates a human body exergy consumption rate.

[0016] In the sixth aspect, the first index may be the human body exergy consumption rate.

[0017] According to a seventh aspect, in the sixth aspect,
the control unit (100) is configured to control, if the first index is the human body exergy consumption rate, a temperature, a humidity, a wind speed, or a radiation temperature of the target space (S) so as to satisfy the target value.

[0018] In the seventh aspect, the human body exergy consumption rate can be brought to the target value by adjusting the temperature, the humidity, the wind speed, or the radiation temperature. If the target value is a value at which the target person (H) feels most comfortable, the target space can be made comfortable according to the target person (H) only by adjusting the temperature, the humidity, the wind speed, or the radiation temperature.

[0019] According to an eighth aspect, in the seventh aspect,
the control unit (100) is configured to set the target value of the human body exergy consumption rate to be lower than a predetermined value Va for the target person (H) for whom a set temperature of the target space (S) is set to be higher than a predetermined value Ta during a heating operation of the air-conditioning device.

[0020] In the eighth aspect, for example, if the predetermined value Ta is an average set temperature, air-conditioning of the target space can be controlled so as to achieve a human body exergy consumption rate suitable for a person who sets relatively strong air-conditioning in the heating operation.

[0021] According to a ninth aspect, in the seventh aspect, the control unit (100) is configured to set the target value of the human body exergy consumption rate to be higher than a predetermined value Va for the target person (H) for whom a set temperature of the target space (S) is set to be lower than a predetermined value Ta during a heating operation of the air-conditioning device.

[0022] In the ninth aspect, for example, if the predetermined value Ta is an average set temperature, air-conditioning of the target space can be controlled so as to achieve a human body exergy consumption rate suitable for a person who sets relatively weak air-conditioning in the heating operation.

[0023] According to a tenth aspect, in the seventh aspect,
the control unit (100) is configured to set the target value of the human body exergy consumption rate to be lower than a predetermined value Vb during a cooling operation of the air-conditioning device for the target person (H) whose amount of clothing is lower than a predetermined value Ca during the cooling operation.

[0024] In the tenth aspect, the target value of the human body exergy consumption rate is set based on the amount of clothing of the target person (H). Accordingly, the human body exergy consumption rate can be controlled according to the target person (H).

[0025] An eleventh aspect is a control system for an air-conditioning device including the control unit (100) according to any one of the first to ninth aspects.

Brief Description of Drawings

[0026]

Fig. 1 is a schematic configuration diagram of an air-conditioning device according to an embodiment.
Fig. 2 is a schematic piping diagram of the air-conditioning device according to the embodiment.
Fig. 3 is a block diagram of the air-conditioning device according to the embodiment.

Fig. 4 is a diagram illustrating an example of graph data included in a control unit of the air-conditioning device according to the embodiment.

Fig. 5 is a flowchart of an exergy control operation of the air-conditioning device according to the embodiment.

Fig. 6 is a block diagram of a first control device of an air-conditioning device according to Modification Example 5 of the embodiment.

Fig. 7 is a graph illustrating a relationship between an outside air temperature and a human body exergy consumption rate in relation to research results.

Fig. 8 is a graph illustrating an average value ± standard deviation of an air temperature and an amount of clothing for each week when a sense of cold and hot is "neither" in houses in the Kanto region in relation to research results.

Fig. 9 is a table illustrating adaptive behavior patterns to environmental changes in relation to research results.

Fig. 10 is a graph illustrating a relationship between the outside air temperature and the human body exergy consumption rate in a condition of a report that "it is neither hot nor cold" in relation to research results.

Fig. 11 is a graph illustrating a relationship between an indoor temperature, the human body exergy consumption rate, and a wetting rate in relation to research results. Description of Embodiments

[0027] Hereinafter, an embodiment of the present disclosure will be described in detail with reference to the drawings. Note that the present disclosure is not limited to the embodiment described below, and various changes can be made without departing from the technical idea of the present disclosure. Since the drawings are intended to conceptually explain the present disclosure, dimensions, ratios, or numbers may be exaggerated or simplified as necessary for ease of understanding.

<<Embodiment>>

(1) Overall Configuration of Air-Conditioning Device

[0028] An air-conditioning device (10) of the present disclosure performs air-conditioning of an indoor space (S), which is a target space. A person (H) is present in the indoor space (S). The person (H) is a target person (H) of the present disclosure. The air-conditioning device (10) of the present example has a function of adjusting the temperature of indoor air.

[0029] As illustrated in Figs. 1 and 2, the air-conditioning device (10) includes a heat source unit (20) and a utilization unit (30). The heat source unit (20) and the utilization unit (30) are connected to each other via two connection pipes (a liquid connection pipe (11) and a gas connection pipe (12)). Thus, a refrigerant circuit (R) is formed in the air-conditioning device (10). The refrigerant circuit (R) is filled with a refrigerant. The refrigerant circuit (R) performs a refrigeration cycle by circulating the refrigerant.

(1-1) Heat Source Unit

[0030] The heat source unit (20) is an outdoor unit disposed in an outdoor space (0). The heat source unit (20) includes a heat source fan (21). The heat source unit (20) includes, as elements connected to the refrigerant circuit (R), a compressor (22), a heat-source heat exchanger (23), a switching mechanism (24), and an expansion mechanism (25).

[0031] The compressor (22) compresses the sucked refrigerant. The compressor (22) discharges the compressed refrigerant. The compressor (22) is a rotary compressor such as a swing piston type compressor. The compressor (22) is of an inverter type. The number of revolutions (operating frequency) of a first motor (M1) of the compressor (22) is adjusted by an inverter device.

[0032] The heat-source heat exchanger (23) is a fin-and-tube type air heat exchanger. The heat-source heat exchanger (23) is an outdoor heat exchanger that exchanges heat between the refrigerant flowing therein and outdoor air.

[0033] The heat source fan (21) is disposed near the heat-source heat exchanger (23). The heat source fan (21) of the present example is a propeller fan. The heat source fan (21) conveys air that passes through the heat-source heat exchanger (23).

[0034] The switching mechanism (24) changes the flow path of the refrigerant circuit (R) so as to switch between a first refrigeration cycle as a cooling cycle and a second refrigeration cycle as a heating cycle. The switching mechanism (24) is a four-way switching valve. The switching mechanism (24) has a first port (P1), a second port (P2), a third port (P3), and a fourth port (P4). The first port (P1) of the switching mechanism (24) is connected to a discharge portion of the compressor (22). The second port (P2) of the switching mechanism (24) is connected to a suction portion of the compressor (22). The third port (P3) of the switching mechanism (24) is connected to a gas-side end of a utilization heat exchanger (33) through the gas connection pipe (12). The fourth port (P4) of the switching mechanism (24) is connected to a gas-side end of the heat-source heat exchanger (23).

[0035] The switching mechanism (24) is switched between a first state and a second state. The switching mechanism

(24) in the first state (the state indicated by the solid line in Fig. 2) allows the first port (P1) and the fourth port (P4) to communicate with each other and allows the second port (P2) and the third port (P3) to communicate with each other. The switching mechanism (24) in the second state (the state indicated by the broken line in Fig. 2) allows the first port (P1) and the third port (P3) to communicate with each other and allows the second port (P2) and the fourth port (P4) to communicate with each other.

[0036] One end of the expansion mechanism (25) is connected to a liquid-side end of the heat-source heat exchanger (23), and the other end is connected to a liquid-side end of the utilization heat exchanger (33) via the liquid connection pipe (11). The expansion mechanism (25) is an expansion valve. The expansion mechanism (25) is an electronic expansion valve whose opening degree is adjustable.

(1-2) Utilization Unit

[0037] The utilization unit (30) is installed on a wall surface of the indoor space (S). In other words, the utilization unit (30) is a wall-mounted indoor air conditioner. The utilization unit (30) includes a casing (31) and a utilization fan (32). The utilization unit (30) has the utilization heat exchanger (33) as an element connected to the refrigerant circuit (R).

[0038] The casing (31) houses the utilization fan (32) and the utilization heat exchanger (33). The casing (31) has an air inlet (30a) and an air outlet (30b). Inside the casing (31), an air passage (30c) is formed from the air inlet (30a) to the air outlet (30b).

[0039] The utilization heat exchanger (33) is a fin-and-tube type air heat exchanger. The utilization heat exchanger (33) is an air heat exchanger that exchanges heat between the air flowing therein and the refrigerant.

[0040] The utilization fan (32) is a cross-flow fan. The number of revolutions of a second motor (M2) of the utilization fan (32) is variable. In other words, the air volume of the utilization fan (32) is variable. The utilization fan (32) is disposed on the upstream side of the utilization heat exchanger (33) in the air passage (30c). The utilization fan (32) conveys air passing through the utilization heat exchanger (33).

(1-3) Sensors

[0041] As illustrated in Figs. 2 and 3, the air-conditioning device (10) includes a plurality of sensors. The air-conditioning device (10) of the present example includes an outside air temperature sensor (41), an outside air humidity sensor (42), and an inside air temperature sensor (43). The outside air temperature sensor (41) and the outside air humidity sensor (42) are disposed in the outdoor space (0). The outside air temperature sensor (41) detects the temperature of outdoor air.

[0042] The outside air humidity sensor (42) detects the humidity (strictly speaking, relative humidity) of outdoor air. The inside air temperature sensor (43) is disposed in the indoor space (S). The inside air temperature sensor (43) detects the temperature of indoor air.

[0043] The air-conditioning device (10) includes various refrigerant sensors (not illustrated) that detect high and low pressures, a condensation temperature, an evaporation temperature, and the like of the refrigerant circuit (R).

(1-4) Remote Controller

[0044] As illustrated in Figs. 1 to 3, the air-conditioning device (10) includes a remote controller (35). Predetermined information is input to the remote controller (35), based on an operation performed by the person (H). Specifically, the remote controller (35) includes an operation unit (36).

[0045] The operation unit (36) is a functional unit for inputting predetermined information. The predetermined information includes various instructions given by the person (H) to the air-conditioning device (10), behavior patterns, and the like. The remote controller (35) of the present example is configured to be able to select one from a plurality of kinds of behavior patterns, based on the operation performed by the person (H). Details of the behavior pattern will be described in (3).

[0046] The operation unit (36) includes a switch, a button, or a touch panel. By the person operating the operation unit (36), the operation of the air-conditioning device (10) is selected or a behavior pattern is selected. The operation of the air-conditioning device (10) includes a cooling operation and a heating operation. The person can change a set temperature by operating the operation unit (36). The set temperature is a target temperature of the indoor space (S).

(1-5) Control Unit

[0047] The air-conditioning device (10) includes a control unit (100). As illustrated in Figs. 2 and 3, the control unit (100) includes a first control device (C1), a second control device (C2), and a third control device (C3). The first control device (C1) is provided in the heat source unit (20). The second control device (C2) is provided in the utilization unit (30). The third control device (C3) is provided in the remote controller (35).

[0048] The first control device (C1) and the second control device (C2) are connected to each other by a first communication line (W1). The first communication line (W1) is wired or wireless. The second control device (C2) and the third control device (C3) are connected to each other by a second communication line (W2). The second communication line (W2) is wired or wireless.

[0049] Each of the first control device (C1), the second control device (C2), and the third control device (C3) includes a micro control unit (MCU), an electric circuit, and an electronic circuit. The MCU includes a central processing unit (CPU), a memory, and a communication interface. Various programs to be executed by the CPU are stored in the memory.

[0050] The first control device (C1) controls the compressor (22), the heat source fan (21), the switching mechanism (24), and the expansion mechanism (25). The first control device (C1) adjusts the number of revolutions of the first motor (M1) of the compressor (22). The second control device (C2) controls the utilization fan (32). The second control device (C2) adjusts the number of revolutions of the second motor (M2) of the utilization fan (32).

[0051] The control unit (100) grasps a habitual behavior pattern of the person (H) at the outside air temperature. Specifically, a plurality of kinds of behavior patterns are stored in the third control device (C3) of the remote controller (35). When one behavior pattern is selected based on a report (operation) from the person (H), the remote controller (35) transmits the information to the first control device (C1). In this way, the first control device (C1) grasps the behavior pattern selected by the person (H).

[0052] The control unit (100) includes a storage unit (101). The storage unit (101) of the present example is provided in the first control device (C1), but may be provided in the second control device (C2) or the third control device (C3). The storage unit (101) includes a hard disk drive (HDD), a random access memory (RAM), a solid state drive (SSD), and the like.

[0053] The storage unit (101) appropriately stores the outside air temperature detected by the outside air temperature sensor (41) and the outside air humidity detected by the outside air humidity sensor (42). The storage unit (101) is an information acquisition unit (101) of the present disclosure. The storage unit (101) acquires first information. The first information of the present embodiment is an experienced temperature that is environmental information on an environment in which the person (H) has been placed in the past. The experienced temperature is the outside air temperature in the present embodiment. In the present example, "placed in the past" refers to, for example, a certain period of time in the past. "Placed in the past" may be a certain period of time from the past to the present. In this way, the storage unit (101) stores the outside air temperature in a predetermined period as history data. The storage unit (101) stores the outside air temperature at predetermined intervals (for example, every 30 minutes). The storage unit (101) may store the outside air humidity as history data in the same manner as the outside air temperature. In this case, the storage unit (101) stores the outside air humidity at predetermined intervals (for example, every 30 minutes).

[0054] The storage unit (101) stores data in which a human body exergy consumption rate V and an index related thereto are associated with each other. The human body exergy consumption rate V is a first index of the present disclosure. The human body exergy consumption rate V is an index related to the thermal environment of the indoor space (S).

(2) Human Body Exergy Balance

[0055] The air-conditioning device (10) performs air-conditioning in consideration of the human body exergy consumption rate. The human body exergy consumption rate is included in the following equation for exergy balance.

[0056]

[Human Body Exergy Consumption Rate] = [Human Body Exergy Input] - [Human Body Exergy Accumulation] - [Human Body Exergy Output]

[0057] The human body exergy consumption rate is an index representing the rate of exergy consumption per body surface 1 m^2 of a human body. The human body exergy input is an index representing the rate of exergy generation per body surface 1 m^2 of a human body. The human body exergy accumulation is an index representing the rate of exergy accumulation per body surface 1 m^2 of a human body. The human body exergy output is an index representing the rate of exergy release per body surface 1 m^2 of a human body. The unit of these indices is W/m^2. Each of the human body exergy input, the human body exergy accumulation, and the human body exergy output is an index related to the human body exergy balance of the present disclosure. The index related to the human body exergy balance indicates the human body exergy consumption rate. In the present example, as illustrated in the above equation, the human body exergy consumption rate is obtained based on these three indices related to the human body exergy balance.

[0058] The human body exergy consumption rate is exergy consumed in the body. The human body exergy consumption rate is caused by thermal diffusion due to a temperature difference between the inside and the outside of the human body, thermal diffusion due to a temperature difference between the human body and clothing, and mutual diffusion of sweat and air due to a water vapor pressure difference between the human body and clothing.

[0059] The human body exergy input consists mainly of exergy generated by metabolism, exergy from inhalation, exergy from metabolic water, and exergy from radiant heat absorbed by clothing. The exergy generated by metabolism is exergy generated in the body as a result of the exergy stored in glucose taken into the human body by eating and drinking being consumed for cellular activity. The exergy from inhalation is exergy generated by diffusion of heat of inhalation, diffusion of water vapor contained in inhalation, and the like. The exergy from metabolic water is exergy generated by diffusion of heat of the metabolic water, diffusion of the metabolic water to the outside of the body, and the like. The metabolic water is water generated by metabolism, for example, water generated by combustion of glucose in the body.

[0060] The human body exergy accumulation is exergy accumulated in the body according to the surrounding environment. As the temperature of the surrounding environment increases, the human body exergy accumulation tends to increase.

[0061] The human body exergy output is exergy released from the body to the outside of the body. The human body exergy output consists mainly of exergy from inhalation, exergy generated by diffusion of moist air generated after evaporation of sweat, exergy from radiant heat emitted by clothing, and exergy from convection heat emitted by clothing. The exergy from inhalation is exergy generated by diffusion of heat of inhalation and diffusion of water vapor and the like contained in inhalation.

[0062] The human body exergy consumption rate is correlated with the degree of expansion and contraction of blood vessels of the human body. The lower the human body exergy consumption rate, the smaller the degree of expansion and contraction of the blood vessels of the human body, and the smaller the thermal stress load applied to the human body. That is, the human body exergy consumption rate is an index representing the thermal stress load of the human body.

[0063] The human body exergy consumption rate tends to be high in a cold environment and a hot environment, and low in an environment that is neither cold nor hot. The environment in which the human body exergy consumption rate is minimized is an environment in which, among 1) the thermal diffusion due to the temperature difference between the inside and the outside of the human body, 2) the thermal diffusion due to the temperature difference between the human body and clothing, and 3) the mutual diffusion of sweat and air due to the water vapor pressure difference between the human body and clothing, the ratio of item 3) is particularly small. The environment in which the human body exergy consumption rate is minimized is an environment in which the thermal stress load applied to the human body is the minimum.

(3) Behavior Patterns

[0064] The behavior patterns include a behavior style in the indoor space (S) in which the person (H) behaves based on the outside air temperature. The behavior patterns are classified into a plurality of kinds. Specifically, as illustrated in Table 1, five kinds of behavior patterns are set in the present example. These behavior patterns (first to fifth behavior patterns) are stored in the remote controller (35). The inside air temperature of the indoor space (S) and the amount of clothing are set for each behavior pattern of the present example.

[0065] The person (H) operates the remote controller (35) to report information on his/her own behavior pattern. For example, regarding the amount of clothing, in response to the inquiry "How much clothing do you wear in summer?" on an input screen of the remote controller (35), the person (H) selects one from among "A: light, B: normal, C: heavy". Similarly, in response to the inquiry "How much clothing do you wear in winter?", the person (H) selects one from among "A: light, B: normal, C: heavy". In addition, regarding the inside air temperature, in response to the inquiry "How is the air-conditioning in summer?" on the input screen of the remote controller (35), the person (H) selects one from among "A: weaker, B: normal, C: stronger". Similarly, in response to the inquiry "How is the air-conditioning in winter?", the person (H) selects one from among "A: weaker, B: normal, C: stronger".

[0066] Based on these pieces of information input to the remote controller (35), the control unit (100) grasps which behavior pattern the person (H) corresponds to. Alternatively, the person (H) may directly select (report) a behavior pattern the person (H) corresponds to from the first to fifth behavior patterns.

[0067]

[Table 1]

Behavior pattern	Assumed pattern	Inside air temperature	Amount of clothing
First behavior pattern	Spend averagely	T_{AVE}.	C_{AVE}.
Second behavior pattern	Spend on lighter clothing than average throughout year	T_{AVE}.	C~

(continued)

Behavior pattern	Assumed pattern	Inside air temperature	Amount of clothing
Third behavior pattern	Spend with weaker air-conditioning while changing clothing largely	Weaker air-conditioning	Change largely
Fourth behavior pattern	Spend with weaker air-conditioning while changing clothing averagely	Weaker air-conditioning	C_{AVE}.
Fifth behavior pattern	Spend with stronger air-conditioning while changing clothing averagely	Stronger air-conditioning	C_{AVE}.

[0068] The first behavior pattern is intended for a person who spends one year averagely. In the first behavior pattern, the room temperature is an average value (T_{AVE}. (°C)), and the amount of clothing is an average value (C_{AVE}, (clo)). Here, the "average value" is obtained based on, for example, data obtained by an experiment or data continuously accumulated from the past.

[0069] The second behavior pattern is intended for a person who spends on lighter clothing than average throughout the year. In the second behavior pattern, the air temperature is T_{AVE}. (°C) and the amount of clothing is C^- (clo) ($C^- < C_{AVE}$.).

[0070] The third behavior pattern is intended for a person who spends the year with weaker air-conditioning while changing clothing largely. In the third behavior pattern, the air temperature is "weaker air-conditioning", and the amount of clothing is "change largely". In the "weaker air-conditioning", for example, the indoor temperature is set to T^+ (°C) ($T^+ > T_{AVE}$.) when the average of the weekly maximum outside air temperatures is higher than the indoor temperature, such as in spring and summer, and the indoor temperature is set to T^- (°C) ($T^- < T_{AVE}$.) when the average of the weekly maximum outside air temperatures is lower than the indoor temperature, such as in autumn and winter. In the amount of clothing "change largely", for example, the amount of clothing is C^- (clo) when the average of the weekly maximum outside air temperatures is higher than the indoor temperature, such as in spring and summer, and the amount of clothing is C^+ (clo) ($C^+ > C_{AVE}$.) when the average of the weekly maximum outside air temperatures is lower than the indoor temperature, such as in autumn and winter.

[0071] The fourth behavior pattern is intended for a person who spends the year with weaker air-conditioning while changing clothing averagely. In the fourth behavior pattern, the indoor temperature is "weaker air-conditioning", and the amount of clothing is C_{AVE}. (clo) .

[0072] The fifth behavior pattern is intended for a person who spends the year with stronger air-conditioning while changing clothing averagely. In the fifth behavior pattern, the indoor temperature is "stronger air-conditioning", and the amount of clothing is C_{AVE}. (clo). In the "stronger air-conditioning", for example, the indoor temperature is set to T^- (°C) when the average of the weekly maximum outside air temperatures is higher than the indoor temperature, such as in spring and summer, and the indoor temperature is set to T^+ (°C) when the average of the weekly maximum outside air temperatures is lower than the indoor temperature, such as in autumn and winter.

(4) Operations

[0073] The air-conditioning device (10) performs a normal cooling operation, a normal heating operation, and an exergy control operation.

(4-1) Cooling Operation

[0074] During the cooling operation, the air-conditioning device (10) performs a refrigeration cycle (cooling cycle) in which the heat-source heat exchanger (23) functions as a radiator and the utilization heat exchanger (33) functions as an evaporator. Specifically, the refrigerant compressed by the compressor (22) radiates heat in the heat-source heat exchanger (23) and is decompressed by the expansion mechanism (25). The refrigerant decompressed by the expansion mechanism (25) is evaporated in the utilization heat exchanger (33) and sucked into the compressor (22).

[0075] In the utilization unit (30), the utilization fan (32) is in operation. The air in the indoor space (S) is sucked into the air passage (30c) through the air inlet (30a). The air in the air passage (30c) is cooled by the utilization heat exchanger (33) and then supplied to the indoor space (S) from the air outlet (30b).

(4-2) Heating Operation

[0076] During the heating operation, the air-conditioning device (10) performs a refrigeration cycle (heating cycle) in which the utilization heat exchanger (33) functions as a radiator and the heat-source heat exchanger (23) functions as an evaporator. Specifically, the refrigerant compressed by the compressor (22) radiates heat in the utilization heat exchanger (33) and is decompressed by the expansion mechanism (25). The refrigerant decompressed by the expansion mechanism (25) is evaporated in the heat-source heat exchanger (23) and sucked into the compressor (22).

[0077] In the utilization unit (30), the utilization fan (32) is in operation. The air in the indoor space (S) is sucked into the air passage (30c) through the air inlet (30a). The air in the air passage (30c) is heated by the utilization heat exchanger (33) and then supplied to the indoor space (S) from the air outlet (30b).

(4-3) Exergy Control Operation

[0078] In the exergy control operation, the control unit (100) sets a target value V_G of the human body exergy consumption rate V, based on the outside air temperature acquired by the outside air temperature sensor (41) and the behavior pattern selected by the person (H). In the exergy control operation, air-conditioning of the indoor space (S) is controlled so that the human body exergy consumption rate V becomes the target value V_G. In the present example, the outside air temperature indicates an average outside air temperature in a certain period (for example, 30 days).

[0079] Specifically, in the exergy control operation, the control unit (100) controls air-conditioning based on the graph data illustrated in Fig. 4. In this graph data, the relationship between the outside air temperature and the human body exergy consumption rate V when the person (H) feels comfortable is illustrated for each behavior pattern.

[0080] To "feel comfortable" refers to a case where a plurality of persons (H) corresponding to one behavior pattern among a plurality of classified behavior patterns (the first to fifth behavior patterns in the present example) feel that the thermal environment (inside air temperature, inside air humidity, airflow, wind speed, etc.) is thermally neutral. The term "thermally neutral" refers to a thermal environment in which the person (H) does not feel hot or cold. The "plurality of persons (H) corresponding to one behavior pattern" is a target person group of the present disclosure.

[0081] Specifically, for example, the range of the thermal environment in which the person who has selected the third behavior pattern feels thermally neutral is comfortable for the plurality of persons (H) who have selected the third behavior pattern. This means that the thermal environment in which the person (H) corresponding to a different behavior pattern feels thermally neutral is different even at the same outside air temperature. Therefore, target values V_{G1} to V_{G5} of the exergy consumption rate V when the person (H) feels comfortable are set for the respective behavior patterns.

[0082] The target value V_{G1} is a target value of the human body exergy consumption rate V in the first behavior pattern. The target value V_{G2} is a target value of the human body exergy consumption rate V in the second behavior pattern. The target value V_{G3} is a target value of the human body exergy consumption rate V in the third behavior pattern. The target value V_{G4} is a target value of the human body exergy consumption rate V in the fourth behavior pattern. The target value V_{G5} is a target value of the human body exergy consumption rate V in the fifth behavior pattern. Hereinafter, the target values V_{G1}, V_{G2}, V_{G3}, V_{G4}, and V_{G5} may be collectively referred to as a target value V_G.

[0083] The control unit (100) controls air-conditioning so as to satisfy the target value V_G of the human body exergy consumption rate V from the selected behavior pattern and the outside air temperature, based on the graph data.

[0084] The human body exergy consumption rate V is obtained based on the above-described equation related to the exergy balance. Specifically, the human body exergy consumption rate V is obtained using the outside air temperature and outside air humidity of the outdoor space (0), the inside air temperature and inside air humidity of the indoor space (S) in which the person (H) is present, the wall surface temperature (radiation temperature) of the indoor space (S) in which the person (H) is present, the flow rate of the airflow supplied to the person (H) from the air-conditioning device (10), the amount of clothing of the person (H), and the amount of activity of the person (H) as parameters.

[0085] In the exergy control operation of the present example, the inside air temperature among these parameters is set as a first parameter. The control unit (100) adjusts the inside air temperature to set the human body exergy consumption rate V to the target value V_G. Specifically, the control unit (100) sets the inside air temperature satisfying the target value V_G as a target inside air temperature. In other words, by performing air-conditioning so that the inside air temperature of the indoor space (S) becomes the target inside air temperature, the human body exergy consumption rate V becomes the target value V_G.

[0086] In the graph data of Fig. 4, the target value V_G of the human body exergy consumption rate V indicate specific values at the respective outside air temperatures, but the target value does not need to be a specific value and may be values within a predetermined range.

[0087] The exergy control operation includes a heating exergy operation corresponding to the heating operation and a cooling exergy operation corresponding to the cooling operation. Here, for example, an example of the heating exergy control operation performed in winter will be described with reference to Fig. 5.

[0088] When the exergy control operation is performed, in step S11, the outside air temperature sensor (41) acquires the outside air temperature of the outdoor space (O). The storage unit (101) appropriately stores the outside air temperature acquired by the outside air temperature sensor (41) as history data.

[0089] In step S12, the control unit (100) calculates an average value of the outside air temperature (average outside air temperature Ta) based on the history data stored in the storage unit (101). The control unit (100) calculates an average value of a plurality of outside air temperatures acquired in a predetermined period ΔT from a predetermined time before to the present. In the present example, the predetermined period ΔT is set to, for example, one month (about 30 days). The plurality of outside air temperatures are acquired every predetermined time t1 and stored in the storage unit (101). The predetermined time t1 is set to, for example, 30 minutes. In this way, by acquiring the outside air temperature from the past to the present in a relatively long period of time, the indoor space (S) can be air-conditioned in consideration of the seasonal adaptation of people.

[0090] In step S13, the control unit (100) determines which of the first to fifth behavior patterns has been input.

[0091] In step S14, the control unit (100) obtains the target value V_G of the human body exergy consumption rate V from the outside air temperature calculated in S12 and the behavior pattern determined in S13, based on the graph data.

[0092] In step S15, the control unit (100) acquires the outside air humidity of outdoor air detected by the outside air humidity sensor (42). The outside air humidity acquired here may be an average value of the outside air temperature in the predetermined period ΔT (for example, one month (about 30 days)), similarly to the outside air temperature acquired in steps S11 to S12.

[0093] In step S16, the control unit (100) acquires the amount of clothing of the person (H) in the indoor space (S). Here, the amount of clothing (unit: clo) may be a set value stored in the control unit (100) in advance. In this case, in the control unit (100), it is preferable to set the amount of clothing for each season or period in which the air-conditioning device (10) is operated. For example, the amount of clothing is relatively large in a cold season, and the amount of clothing is relatively small in a hot season. The person (H) may directly input the amount of clothing to the remote controller (35). In this case, the control unit (100) can acquire the current amount of clothing of the person (H) more accurately.

[0094] Here, the average outside air temperature Ta acquired in step S12 is used as the outside air temperature, and the outside air humidity acquired in step S15 is used as the outside air humidity.

[0095] In the present example, as the inside air humidity, a set value (for example, relative humidity of 50%) stored in the control unit (100) in advance is used. In this case, in the control unit (100), it is preferable to set the inside air humidity for each season or period in which the air-conditioning device (10) is operated. The utilization unit (30) may be provided with an inside air humidity sensor for detecting the inside air humidity to directly acquire the current inside air humidity.

[0096] As the wall surface temperature of the indoor space (S), the same temperature as the inside air temperature is used. In other words, the wall surface temperature is regarded as the same temperature as the target inside air temperature.

[0097] As the wind speed, a set value (for example, 0.1 m/s) stored in the control unit (100) in advance is used. The wind speed is preferably a set value corresponding to the current air volume (number of revolutions) of the utilization fan (32). The control unit (100) reads the set value corresponding to the current air volume of the utilization fan (32) and uses the set value as a parameter for obtaining the relationship. The current wind speed may be acquired by an anemometer or the like.

[0098] As described above, a set value (for example, 0.94 clo in a cold season) stored in the control unit (100) in advance is used as the amount of clothing.

[0099] As the amount of activity of the person (H), a set value (for example, 1.1 met) stored in the control unit (100) in advance is used.

[0100] In step S17, the control unit (100) obtains the target inside air temperature that satisfies V_G obtained in step S14.

[0101] In step S18, the control unit (100) controls air-conditioning so that the inside air temperature of the indoor space (S) becomes the target inside air temperature obtained in step S17. Specifically, the control unit (100) adjusts the air-conditioning capacity of the air-conditioning device (10) so that the inside air temperature detected by the inside air temperature sensor (43) approaches the target temperature. In the heating exergy control operation, the control unit (100) adjusts the high pressure (condensation pressure or condensation temperature) of the utilization heat exchanger (33) by adjusting the number of revolutions of the compressor (22). As a result, the inside air temperature of the indoor space (S) converges to an optimal inside air temperature.

[0102] After step S18, when a predetermined time elapses in step S19, the process proceeds to step S11 again, and the same process is performed. Here, the predetermined time in step S19 is set to, for example, 30 minutes.

(4) Features

(4-1) Feature 1

[0103] The control unit (100) of the air-conditioning device (10) of the present embodiment performs setting so that the human body exergy consumption rate (first index) becomes the target value, based on the outside air temperature (first information), which is the air temperature of the environment in which the person (H) has been placed in the past, and the habitual behavior pattern of the person (H) at the outside air temperature.

[0104] As described above, the behavior pattern for each season in the indoor space (S) varies from person to person. The target value V_G of the human body exergy consumption rate V of the present example is set for each behavior pattern. Accordingly, by setting the target value V_G of the human body exergy consumption rate V, based on the behavior pattern of each person (H), it is possible to control air-conditioning according to the person (person (H)) in the space.
[0105] In addition, the control unit (100) has graph data indicating the relationship between the outside air temperature throughout the year and the exergy consumption rate V when a person feels comfortable. Since the outside air temperature (strictly speaking, the average outside air temperature in a certain period of time) differs depending on the season, the control unit (100) can obtain the target value V_G of the human body exergy consumption rate V in consideration of the seasonal adaptation of the person, based on the graph data. In this way, by using the human body exergy consumption rate as an index, it is possible to control air-conditioning in consideration of the thermal stress applied to the person (H) from the environment. Furthermore, the thermal stress can be estimated without measuring a physiological quantity such as an increase or a decrease in the blood flow of the person (H) .

(4-2) Feature 2

[0106] The control unit (100) of the air-conditioning device (10) of the present embodiment grasps the behavior pattern, based on the report from the person (H). Accordingly, the person (H) can select the behavior pattern optimal for the person (H).

(4-3) Feature 3

[0107] The target value V_G of the human body exergy consumption rate V is in a thermal environment in which a plurality of persons (H) corresponding to one behavior pattern of the five kinds of behavior patterns feel thermally neutral. The thermal environment which is felt to be thermally neutral is a thermal environment in which a person feels comfortable, as described above. Therefore, the target value V_G is a value set for each behavior pattern so as to achieve a thermal environment in which the person (H) feels comfortable. Accordingly, if the target value V_G is set according to the behavior pattern, the indoor space (S) can be made comfortable according to the behavior pattern.

(4-4) Feature 4

[0108] The control unit (100) controls the inside air temperature of the indoor space (S) so as to satisfy the target value V_G of the human body exergy consumption rate V. Since the target value V_G can be satisfied only by controlling the inside air temperature, the indoor space (S) can be made comfortable relatively easily.

(5) Modification Examples

[0109] The above-described embodiment may have a configuration in the following modification examples. In principle, differences from the above-described embodiment will be described below.

(5-1) Modification Example 1 of Grasping of Behavior Pattern

[0110] The storage unit (101) of the present example stores the operation information on an operation performed by the person (H) on the air-conditioning device (10). The operation information includes past information such as an operation history of the air-conditioning device (10) and a setting history of the inside air temperature. The storage unit (101) stores the operation information corresponding to a certain period from the past to the present.
[0111] Based on the operation information stored in the storage unit (101), the control unit (100) of the present example grasps an appropriate behavior pattern. For example, among pieces of the operation information stored in the storage unit (101), if the inside air temperature set by the person (H) is an average temperature throughout the year, the control unit (100) selects the first behavior pattern or the second behavior pattern of the above embodiment. In addition, among pieces of the operation information stored in the storage unit (101), if the inside air temperature set by the person (H) is lower than the average set temperature in summer and higher than the average set temperature in winter, the control unit (100) selects the fifth behavior pattern of the above embodiment.
[0112] In this way, in the present example, even if the person (H) does not make a report, the control unit (100) selects a behavior pattern suitable for the person, and accordingly, it is possible to save time and effort for making a report by an operation performed by the person (H). In addition, since the control unit (100) selects the behavior pattern, based on the set temperature corresponding to a certain period from the past, the behavior pattern optimal for the person (H) can be selected, and as a result, it is possible to control air-conditioning such that the human body exergy consumption rate is optimal for the person (H).

(5-2) Modification Example 2 of Grasping of Behavior Pattern

[0113] The storage unit (101) of the present example stores the environmental information of the indoor space (S). The environmental information of the indoor space (S) includes information on the thermal environment of the indoor space (S). Specifically, the environmental information of the indoor space (S) includes the inside air temperature, the inside air humidity, the airflow (wind speed), or the radiation temperature (wall surface temperature) of the indoor space (S). The storage unit (101) stores the environmental information of the indoor space (S) corresponding to a certain period from the past to the present.

[0114] Based on the environmental information of the indoor space (S) stored in the storage unit (101), the control unit (100) of the present example grasps the behavior pattern. For example, if the inside air temperature in summer is substantially the same as the average set temperature in summer and the inside air temperature in winter is substantially the same as the average set temperature in winter, the control unit (100) selects the first behavior pattern or the second behavior pattern of the above embodiment. If the inside air temperature in summer is lower than the average set temperature in summer and the inside air temperature in winter is higher than the average set temperature in winter, the control unit (100) selects the fifth behavior pattern of the above embodiment.

[0115] As described above, also in the present example, without the person (H) making a report, the control unit (100) selects a behavior pattern suitable for the person (H), and accordingly, it is possible to save time and effort for making a report. In addition, since the control unit (100) selects the behavior pattern, based on the environmental information of the indoor space (S) corresponding to a certain period from the past, the behavior pattern optimal for the person (H) can be selected, and as a result, it is possible to control air-conditioning such that the human body exergy consumption rate is optimal for the person (H).

(5-3) Modification Example 3 of Grasping of Behavior Pattern

[0116] A camera (not illustrated) is installed in the indoor space (S) of the present example. The camera photographs the indoor space (S). Specifically, the camera photographs the amount of clothing of the person (H) in the indoor space (S). Based on the amount of clothing of the person (H) estimated from the camera image of the indoor space (S), the control unit (100) of the present example grasps the behavior pattern.

[0117] The captured image data is transmitted to the control unit (100). The storage unit (101) stores the image data transmitted to the control unit (100). The storage unit (101) stores the image data corresponding to a certain period from the past to the present.

[0118] Based on the image data stored in the storage unit (101), the control unit (100) recognizes the amount of clothing of the person (H) in the indoor space (S). Here, to "recognize the amount of clothing" includes not only simply to recognize the amount of clothing of the person (H), but also to recognize the kind of clothing (sweater, T-shirt, or the like) and to adjust the amount of clothing such as putting on or taking off clothing, for example. In addition, to "recognize the amount of clothing" may also include to determine the amount and kind of comforter during sleep. Based on the amount of clothing of the person (H) recognized based on the image data, the control unit (100) selects an appropriate behavior pattern from the first to fifth behavior patterns as described in the embodiment. When the present example is combined with Modification Example 1 or 2 described above, the behavior pattern can be selected in consideration of the set inside air temperature and the amount of clothing, and accordingly, the behavior pattern more suitable for the person (H) can be selected.

(5-4) Modification Example 4 of Grasping of Behavior Pattern

(5-4-1) Modification Example 4-1 of Grasping of Behavior Pattern

[0119] A camera (not illustrated) is installed in the indoor space (S) of the present example, as in Modification Example 3 described above. Specifically, the camera photographs the behavior of the person (H) in the indoor space (S). Based on the behavior of the person (H) estimated from the camera image, the control unit (100) of the present example grasps the behavior pattern.

[0120] The captured image data is transmitted to the control unit (100). The storage unit (101) stores the image data transmitted to the control unit (100). The storage unit (101) stores the image data corresponding to a certain period from the past to the present.

[0121] Based on the image data stored in the storage unit (101), the control unit (100) recognizes the behavior of the person (H) in the indoor space (S). Specifically, the control unit (100) recognizes how the person (H) behaves from the image data. The behavior includes, for example, actions such as "using a paper fan", "opening a window", "drinking a cold beverage", "drinking a hot beverage", "giving a frown", and "wiping sweat".

[0122] For example, it is assumed that the number of times the person (H) uses a paper fan is relatively large in the image data stored in the storage unit (101). The control unit (100) classifies the person (H) into a behavior pattern of "using a paper fan". Based on the behavior pattern, the control unit (100) performs the exergy control operation. In the behavior pattern of "using a paper fan", for example, the airflow (wind speed) and the inside air temperature are adjusted so as to satisfy the target value V_G of the human body exergy consumption rate. Thus, the person (H) can use the paper fan in a comfortable environment. The control unit (100) may recognize the degree of fanning of the person (H). Thus, based on the degree of fanning, the control unit (100) can adjust the wind speed and the inside air temperature. As a result, for the person (H) who likes to fan, the burden of fanning can be reduced, and thus, the person (H) can continue to fan for a long time.

[0123] In addition, for example, it is assumed that the number of times that the person (H) opens the window is relatively large in the image data stored in the storage unit (101). The control unit (100) classifies the person (H) into a behavior pattern of "opening a window". Based on the behavior pattern, the control unit (100) performs the exergy control operation. In the behavior pattern of "opening a window", for example, the airflow (wind speed), the inside air humidity, and the inside air temperature are adjusted so as to satisfy the target value V_G of the human body exergy consumption rate. Thus, the window can be opened appropriately in accordance with the person (H). The control unit (100) may recognize the degree of opening of the window by the person (H). In the behavior pattern of "opening a window", the information on the thermal environment when the air-conditioning device (10) is not in operation may be acquired. In this case, the information on the thermal environment is acquired by a sensor such as the indoor temperature sensor set separately from the air-conditioning device (10).

[0124] In addition, for example, it is assumed that the number of times the person (H) drinks a cold beverage is relatively large in the image data stored in the storage unit (101). The control unit (100) classifies the person (H) into a behavior pattern of "drinking a cold beverage". Based on the behavior pattern, the control unit (100) performs the exergy control operation. In the behavior pattern of "drinking a cold beverage", for example, the inside air humidity and the inside air temperature are adjusted so as to satisfy the target value V_G of the human body exergy consumption rate. Thus, the person (H) can appropriately adjust the amount of water to drink.

[0125] In this way, in the present example, since the behavior pattern of the person is grasped based on the image data instead of selection from a plurality of behavior patterns set in advance, it is possible to control air-conditioning such that the human body exergy consumption rate is optimal for the person (H).

(5-4-2) Modification Example 4-2 of Grasping of Behavior Pattern

[0126] A microphone (not illustrated) is installed in the indoor space (S) of the present example. Specifically, the microphone records the voice of the person (H) in the indoor space (S). Based on the behavior of the person (H) estimated from the voice, the control unit (100) of the present example grasps the behavior pattern.

[0127] The recorded voice data is transmitted to the control unit (100). The storage unit (101) stores the voice data transmitted to the control unit (100). The storage unit (101) stores the voice data corresponding to a certain period from the past to the present.

[0128] Based on the voice data stored in the storage unit (101), the control unit (100) recognizes the behavior of the person (H) in the indoor space (S). Specifically, the control unit (100) recognizes what kind of voice the person (H) is uttering, conversation details, and the like from the voice data. For example, the control unit (100) recognizes conversation details indicating comfort or discomfort with respect to the thermal environment, a change in the thermal environment, or adjustment of the thermal environment, a crying voice of an infant, and the like.

[0129] In this way, in the present example, since the behavior pattern of the person is grasped based on the voice data instead of selection from a plurality of behavior patterns set in advance, it is possible to control air-conditioning such that the human body exergy consumption rate is optimal for the person (H).

(5-4-3) Modification Example 4-3 of Grasping of Behavior Pattern

[0130] In the present example, in Modification Examples 4-1 and 4-2 described above, the behavior of the person (H) or the voice of the person (H) may be newly added as a parameter for obtaining the human body exergy consumption rate. For example, in addition to the "inside air temperature" and the "amount of clothing" of the first to fifth behavior patterns, at least one of "using a paper fan", "opening a window", "drinking water", "conversation details", and "crying voice" may be added as an item. By increasing the kinds of parameters, the models of behavior patterns can be increased. As a result, the human body exergy consumption rate can be controlled more finely, and an optimal thermal environment for each person (H) can be made.

(5-5) Modification Example 5 of Grasping of Behavior Pattern

[0131] As illustrated in Fig. 6, the control unit (100) of the present example includes an individual recognition unit (102).

The individual recognition unit (102) may be a device that recognizes a face of an individual from image data transmitted from a camera, or may be a reading device that reads individual information such as fingerprint authentication or an ID card. The storage unit (101) of the present example accumulates data of the behavior pattern of each individual recognized by the individual recognition unit (102).

[0132] The control unit (100) of the present example sets the target value V_G of the human body exergy consumption rate, based on the past behavior patterns of the individual (H) accumulated in the storage unit (101). Specifically, the "past behavior patterns" are behavior patterns of the individual stored in the storage unit (101) in a certain period from the past to the present. The behavior pattern may be specified based on the image data obtained by the camera or the voice data obtained by the microphone described in Modification Example 4, or may be based on the operation information of the air-conditioning device (10) or the thermal information (thermal environment) of the indoor space (S) as described in Modification Examples 1 to 3.

[0133] The storage unit (101) stores the individual behavior pattern and the thermal information representing the thermal environment when the behavior pattern is taken. In this way, a table or graph data in which a relationship between the individual behavior pattern and the thermal information is constructed is constructed in the storage unit (101).

[0134] Based on the table or graph data constructed in this way, the control unit (100) controls the human body exergy consumption rate. Since the table or graph data is updated day by day, a table or graph data more suitable for the person (H) is generated. Thus, the human body exergy consumption rate optimal for the person (H) can be controlled.

[0135] In addition, the control unit (100) of the present example can control the human body exergy consumption rate according to each person (H) in a custom-made manner by specifying the individual and recognizing the behavior pattern of the individual.

(5-6) Modification Example of First Index

[0136] The first index of the present disclosure may be the inside air temperature of the indoor space (S). The air-conditioning device (10) may control air-conditioning according to the behavior pattern so as to set the inside air temperature at which the person in the space (person (H)) feels comfortable.

[0137] The first index of the present disclosure may be an index related to the human body exergy balance. In this case, the first index may be any one of the human body exergy input, the human body exergy accumulation, and the human body exergy output, or may be a combination of two or more thereof.

[0138] The first index of the present disclosure may be a PMV. The PMV (predicted mean vote) is calculated from a total of six elements including four elements on the environment side of the room temperature, the radiation temperature, the relative humidity, and the wind speed, and two elements on the human body side of the amount of clothing and the amount of activity. The PMV is a parameter representing the degree of comfort related to thermal sensation of a person. The PMV can range from -3 to +3. The PMV is rated on seven levels of comfort: -3 (fairly cold), -2 (cold), -1 (slightly cold), 0 (neutral), +1 (slightly hot), +2 (hot), and +3 (fairly hot). In general, the PMV when a person feels comfortable is -0.5 to +0.5.

[0139] The first index of the present disclosure may be an index based on the thermal environment. The index based on the thermal environment includes, for example, a PPD, an SET*, or a WBGT.

[0140] The PPD (predicted percentage of dissatisfied) indicates the percentage of people who feel dissatisfied or uncomfortable in the thermal environment. The PPD is used to indicate, for example, which percentage of a plurality of persons in the indoor space (S) in a hot or cold state is dissatisfied.

[0141] The SET* (standard new effective temperature) is an index indicating a comfortable range of the indoor space, which is obtained in consideration of the inside air temperature, the radiation temperature, the inside air humidity, the airflow, the amount of clothing, and the amount of activity. What is different from the PMV described above is that the SET* is a value obtained by incorporating a new effective temperature ET* into the PMV. The ET* (Effective Temperature, new effective temperature) is an index represented by the inside air temperature when the inside air temperature is the same as the wall surface temperature, the airflow is a quiet airflow, and the inside air humidity is 50 %. Note that the comfortable temperature range when the amount of clothing is 0.6 clo and the person is seated and at rest is 22.2 to 22.6 °CET*. The first index may be ET*.

[0142] The WBGT (wet bulb globe temperature) is also referred to as heat index. The WBGT is an index focusing on the exchange of heat (heat balance) between the human body and the outside air, and is an index that takes into account the three of humidity, thermal environment such as solar radiation (radiation), and air temperature, which have a large effect on the heat balance of the human body.

(5-7) Modification Example of Target Value of First Index

[0143] The target value of the first index of the present disclosure may not be based on the degree of comfort felt by the target person (H) in the indoor space (S). The target value of the first index may be set based on the degree of comfort and thermal stress load felt by the person (H) in the indoor space (S), or may be freely set by the person (H).

(5-8) Modification Example of First Parameter

[0144] If the first index of the present disclosure is the human body exergy consumption rate V, the first parameter may be the inside air humidity (relative humidity), the wind speed, or the radiation temperature of the indoor space (S). In addition, the first parameter is not limited to one kind, and two or more kinds may be combined.

(6) Modification Example of Control Unit

[0145] The control unit (100) of the present disclosure is provided in the air-conditioning device (10). However, the control unit (100) may be a control system provided in a portion different from the air-conditioning device (10). The control unit (100) may be provided in a server device connected to the air-conditioning device (10) via a network. The control unit (100) may be provided in, for example, a terminal device owned by the person (H). The terminal device includes a smartphone, a personal computer, a tablet, and the like.

(7) Modification Example of First Information

[0146] The first information of the present disclosure may be biological information of the person (H). Specifically, the biological information of the person (H) may be a body temperature (including a core body temperature), a skin temperature, an eardrum temperature, a rectal temperature, an axillary temperature, a sublingual temperature, a surface temperature (including clothing), a heart rate, a blood flow rate, a blood pressure, an autonomic index, a sweat rate, or tremor. These pieces of biological information are appropriately measured by predetermined sensors.

[0147] These pieces of biological information are also information placed in the past as in the above embodiment. That is, the storage unit (101) acquires the biological information of the person (H) corresponding to a certain period in the past or a certain period from the past to the present.

(8) Other Embodiments

[0148] The above-described embodiment and the above-described modification examples may be configured as follows.

[0149] The control unit (100) may control the human body exergy consumption rate V not based on the first to fifth behavior patterns. In the first to fifth behavior patterns, the behavior patterns are classified based on the relationship between the strength of air-conditioning as the inside air temperature and the amount of clothing, but the present disclosure is not limited thereto. Examples will be described below.

[0150] For example, for the person (H) for whom the set temperature of the indoor space (S) during the heating operation is set to be higher than the predetermined value Ta, the control unit (100) may set the target value V_G of the human body exergy consumption rate during the heating operation to be lower than the predetermined value Va. The predetermined value Ta is, for example, an average set temperature during the heating operation. The predetermined value Ta is obtained based on the operation history of the air-conditioning device (10) accumulated so far. The predetermined value Va is set to any value, and may be an average value of the target values V_G at respective outside air temperatures (experienced temperatures) of the plurality of kinds of behavior patterns. The target values V_G may be determined in consideration of the set temperature during the cooling operation.

[0151] In addition, for example, for the person (H) for whom the set temperature of the indoor space (S) during the heating operation is set to be lower than the predetermined value Ta, the control unit (100) may set the target value V_G of the human body exergy consumption rate during the heating operation to be higher than the predetermined value Va. The target values V_G may be determined in consideration of the set temperature during the cooling operation.

[0152] In addition, for example, for the person (H) whose amount of clothing is lower than the predetermined value C_{AVE}. during the cooling operation, the control unit (100) may set the target value V_G of the human body exergy consumption rate to be lower during the cooling operation. In this case, the target value V_G may be obtained in consideration of the amount of clothing during the heating operation. C_{AVE}. is the predetermined value Ca of the present disclosure.

[0153] The person (H) of the embodiment is not limited to one person. The number of persons (H) may be two or more. In addition, the person (H) may be any person in the indoor space (S), and the person (H) may not be identified.

[0154] The outside air temperature (experienced temperature) in the above embodiment may be an air temperature measured at a measurement point closest to the position indicated by the position information of the person (H) among a plurality of measurement points by acquiring the position information indicating the position of the person (H). Such measurement of the air temperature may be acquired from a predetermined weather server by communication.

[0155] The experienced temperature in the above embodiment may be the air temperature of the environment. The environment may be the indoor space (S). In this case, the experienced temperature is the inside air temperature of the indoor space (S) .

[0156] The information acquisition unit (101) of the present disclosure may also be the outside air temperature sensor (41) .

[0157] The experienced temperature in the above embodiment may be acquired from a temperature sensor (not illustrated) carried by the person (H). In this case, for example, the temperature is acquired at predetermined time intervals for one week. When the person (H) carries the temperature sensor, the temperature exposed to the person (H) can be acquired both indoors and outdoors.

[0158] The environmental information (first information) on the environment in which the target person (H) of the present disclosure has been placed in the past may be the humidity, wind speed, radiation temperature, PMV, WBGT, SET*, discomfort index, or PPD. In this case, the storage unit (101) acquires the humidity, wind speed, radiation temperature, PMV, WBGT, SET*, discomfort index, or PPD. The humidity, the wind speed, and the radiation temperature of the first information may be those of the indoor space (S), those of the outdoor space, or those of the place where the person (H) is present. For example, the position information indicating the position of the person (H) is acquired, and the place where the person (H) is present is measured at the measurement point closest to the position indicated by the position information of the person (H) among the plurality of measurement points. Note that the discomfort index is expressed based on the temperature and the humidity.

[0159] The environmental information (first information) on the environment in which the target person (H) of the present disclosure has been placed in the past may be a report on the thermal environment by the person (H). The thermal environment includes the indoor space (S), the outdoor space, or the position where the person (H) is present.

[0160] The environmental information (first information) on the environment in which the target person (H) of the present disclosure has been placed in the past may be the set temperature, a set humidity, a set wind speed, or a set radiation temperature of the air-conditioning device (10). The set temperature, the set humidity, the set wind speed, or the set radiation temperature may be set based on an operation performed by the person (H).

[0161] The behavior pattern of the person (H) may be grasped by any one of the first control device (C1), the second control device (C2), or the third control device (C3).

[0162] The control unit (100) may have different kinds of graph data for each season. It is possible to obtain the target value V_G of the human body exergy consumption rate V which is more adapted to the season. For example, although the outside air temperature is close in spring and autumn, by selectively using the graph data for spring and the graph data for autumn, a more comfortable indoor space (S) corresponding to the behavior pattern can be provided.

[0163] The target value of the first index may be a target range having a predetermined width.

[0164] The behavior pattern may be any behavior style in the indoor space (S) in which the person (H) behaves based on the first information of the present disclosure. For example, the behavior pattern may be a behavior style in the indoor space (S) in which the person (H) behaves based on the thermal environment.

[0165] Although the embodiments and modification examples have been described above, it should be understood that various changes can be made for forms or details without departing from the spirit and scope of the claims. In addition, the above-described embodiment, modification examples, and other embodiments may be appropriately combined or replaced as long as the functions of the object of the present disclosure are not impaired.

[0166] The above terms "first," "second," and "third" ... are used to distinguish between the terms to which they refer, and are not intended to limit the number or order of the terms.

<Research Work Related to Present Disclosure>

[0167] Research work related to the present disclosure will be described below.

1. Introduction

[0168] In the last report and the second to the last report, in order to examine the necessity of environment control in accordance with the adaptation to the fluctuation of the outside air temperature, the difference between the subjective sense of cold and hot and the physiological data is considered between the case where the indoor temperature and humidity condition is set by applying the adaptive model and the case where the conventional standard temperature and humidity condition is set. As a result, it is confirmed that the temperature and humidity condition based on the adaptive model is more comfortable. In addition, a model for discriminating the sense of cold and hot by using a blood flow rate, which is one item of the physiological data is considered.

[0169] The aim of this series of reports is to provide a human-friendly space, that is, an environment with low thermal stress. Here, the thermal stress refers to stress applied for body temperature regulation of a human body in a hot or cold environment. In the present research, the authors wish to develop a new air-conditioning control method and to derive a thermal stress evaluation method in consideration of seasonal adaptation by combining the human body exergy balance theory and the adaptive model.

[0170] The influence of the seasonal change in the outside air temperature on the comfort can be expressed by the adaptive model, but further examination is required in order to consider the thermal stress on the human body. Therefore, this paper reports results of calculating the human body exergy balance in consideration of the influence of the seasonal fluctuation in the outside air temperature on the comfortable temperature and the amount of clothing, and particularly examining the seasonal change of the human body exergy consumption rate.

2. Adaptive Model Theory

[0171] Since a person has a characteristic of seasonal adaptation, thermal perception is different between summer and winter even if the environmental temperature is instantaneously the same. In order to perform human-friendly environmental control, it is essential to incorporate this knowledge. An adaptive model has been proposed by ASHRAE and CEN as a formulation of a human neutral temperature (a temperature value that is perceived as comfortable, not hot or cold), which fluctuates due to a change in environmental temperature. According to the adaptive model, the human neutral temperature is determined by the history of experienced temperatures for the past week.

[0172] The authors believe that such adaptation, that is, a change in the neutral temperature, is caused by characteristics such as seasonal fluctuations in human basal metabolic rate. In the adaptive model, the physiological and behavioral adaptation of the human is grasped by reflecting the results of the on-site measurements, but the correspondence with the physiological state of the human and the mechanism such as the thermal stress applied to the human body by the thermal environment is unknown.

3. Human Body Exergy Balance Theory

3.1. Summary of Human Body Exergy Balance

[0173] Previous studies on environment control have been based on the thermal energy balance of the human body. However, in addition to this, when the human body exergy balance is also taken into consideration, there is a possibility that a human-friendly method of environment control can be newly found.

[0174] The human body exergy balance theory is a model that can calculate consumption involved in convection, radiation, and evaporation. The blood flow rate, the wetting rate, and the like are calculated as intermediate calculations. The human body exergy consumption rate calculated by this model can be expressed by the following equation, and it is considered to possibly correspond to stress (fatigue) derived from a thermal environment.

[0175]

[Human Body Exergy Consumption Rate] = [Warm Exergy Generated in Metabolism] + [Warm (Cool) Wet (Dry) Exergy of Inhalation] + [Warm Wet Exergy of Metabolic Water (Lungs)] + [Warm (Cool) Wet (Dry) Exergy of Metabolic Water (Skin) and Dry Air] + [Warm (Cool) Radiant Exergy Absorbed by Clothing] - [Accumulation of Warm Exergy] - [Warm Wet Exergy of Exhalation] - [Heat/Separation Exergy of Moist Air Produced After Evaporation of Sweat] - [Warm (Cool) Radiant Exergy from Clothing] - [Warm (Cool) Exergy Convected out of Clothing]

[0176] In the human body exergy balance theory, different forms of heat and moisture transfer, such as convection, radiation, and evaporation, can be uniformly expressed by a quantity (exergy) indicating a diffusion capacity. Although there are many conditions in which the balance between input/output and accumulation of energy is the same even if the ratio of heat transfer of radiation, convection, and evaporation is different, a difference in consumption appears in the case of the exergy balance.

[0177] In order to derive the human body exergy balance, the outside air temperature is required, and therefore, unlike in the energy balance, a difference in season may appear. Therefore, it is considered important to examine the correspondence with the comfortable temperature of the adaptive model in which the outside air temperature is used as a variable.

3.2. Human Body Exergy Balance at Various Outside Air Temperatures

[0178] Fig. 7 illustrates how the human body exergy consumption rate changes according to the outside air temperature. In this graph, the air temperature and the wall surface temperature are equally 25 °C, the relative humidity is 50%, the wind speed is 0.1 m/s, the amount of clothing is 1 clo, the amount of activity is 1.1 met, and the outside air humidity is 50%. Even when the indoor environment is the same, if the outside air temperature is different, the exergy consumption rate is different, and it can be seen that the degree of diffusion with respect to the outdoor environment state is reflected.

However, the human body exergy balance does not include the thermal environment experience (past outside air temperature history) of the human. Therefore, this report will consider how the human body exergy consumption rate changes by fusing the data of the adaptive model to the human body exergy balance theory.

4. Seasonal Adaptation and Human Body Exergy Consumption Rate

4.1. Human Body Exergy Consumption Rate According to Seasonal Adaptation

[0179] As the calculation conditions, the average indoor air temperature and standard deviation, and the average amount of clothing and standard deviation for each week are used when the report of sense of cold and hot is "neither (neither hot nor cold)" (n = 7,333) using data of environmental measurements and subjective reports for houses in the Kanto region as examination targets. The values are illustrated in Fig. 8. The radiation temperature is equal to the air temperature, and the relative humidity, the wind speed, and the amount of activity are fixed to 50%, 0.1 m/s, and 1.1 met, respectively. For the outside air temperature and humidity, data disclosed by the Japan Meteorological Agency in the same region at the same time as the above-described examination data is used. Considering individual differences in the method of adjusting the indoor air temperature and the amount of clothing according to fluctuations in the outside air temperature, five kinds of adaptive behavior patterns are assumed as illustrated in Fig. 9 and used as input conditions for the human body exergy balance calculation. The details of each pattern will be described below.

[0180] As an average pattern, the average values illustrated in Fig. 8 are used for both the air temperature and the amount of clothing on the assumption that an average adaptive behavior to an environmental change is always performed. In pattern A, a person who feels hot easily is assumed. On the assumption that the air temperature is average but the clothing is always light throughout the year, the average value is used as the air temperature, and the average value - standard deviation is used as the amount of clothing. In pattern B, a person who does not use air-conditioning so much and changes clothing largely is assumed. The air temperature is the average value + standard deviation in a cooling operation period and the average value - standard deviation in a heating operation period to express weaker air-conditioning (hereinafter referred to as weaker air-conditioning condition). Here, the cooling operation period is the case where the average of the weekly maximum outside air temperatures > air temperature, and the heating operation period is the case where the average of the weekly maximum outside air temperatures ≤ air temperature (the same applies hereinafter). On the other hand, the amount of clothing is the average value - standard deviation in the cooling operation period, and the average value + standard deviation in the heating operation period. In pattern C, a person who does not use air-conditioning so much and changes clothing averagely is assumed. For the air temperature, the same weaker air-conditioning condition as in B is used, and for the amount of clothing, the average value is used. In pattern D, a person who positively uses air-conditioning and changes clothing averagely is assumed. Contrary to B and C, the air temperature is the average value - standard deviation in the cooling operation period, and the air temperature is the average value + standard deviation in the heating operation period to express stronger air-conditioning. The average value is used for the amount of clothing. The relationship between the human body exergy consumption rate and the outside air temperature calculated using the above values is illustrated in Fig. 10.

[0181] First, looking at the whole, even if the report of sense of cold and hot is "neither", the human body exergy consumption rate is low in summer when the outside air temperature is high, and the human body exergy consumption rate is high in winter when the outside air temperature is low. This indicates that the lower the outside air temperature is, the more easily heat escapes from the human body, and it can be seen that the environment is such that heat easily escapes from the human body in winter. In any of the patterns, the human body exergy consumption rate is the lowest throughout the year when the outside air temperature is around 20 °C. This corresponds to an intermediate period around May or October, which coincides with a comfortable time without air-conditioning. Furthermore, the variation in the human body exergy consumption rate is large in winter and small in summer. This is due to environmental and clothing conditions. Since the standard deviation of the air temperature and the amount of clothing tends to vary more in winter than in summer, when the input values of each pattern are set using the average value and the standard deviation as illustrated in Fig. 9, the fact that the divergence of the input values is larger in winter is reflected in the calculation results, and it is considered that the human body exergy consumption rate varies even at the same outside air temperature. The reason why the variation in environmental conditions is larger in winter than in summer is that there are more environment adjusting methods in winter than in summer, such as a Kotatsu (a table covered with a comforter), a knee rug, and electric heater, which are not reflected in input values of air temperatures and humidities.

[0182] Next, the calculation results of patterns A, B, C, and D simulating the individual environment adjustment will be considered. Among the four patterns, B and C have a difference in human body exergy consumption rate particularly between summer and winter. This is because the human body exergy consumption rate in winter is high. A common point between B and C is to simulate a space in which the air-conditioning is weaker in both summer and winter, the temperature is higher in summer, and the temperature is lower in winter. That is, particularly in winter, even in a case where clothing is changed largely to maintain a comfortable state, the human body exergy consumption rate is high, and thermal stress is applied to the body as compared to a case where the environmental control is actively performed as in A or D. Therefore, it is considered that the stress on the body can be reduced more by performing the environmental control to some extent at the same time than by controlling the temperature only with clothing.

4.2. Estimation of Optimal Set Temperature in Consideration of Seasonal Adaptation

[0183] The results of 4.1 illustrate that the target value of the human body exergy consumption rate is not constant, and there are appropriate values depending on the environmental conditions such as the history of the outside air temperature and the amount of clothing of the person. Therefore, in this section, a method of setting the air temperature using the human body exergy consumption rate when the wall surface temperature is the same as the air temperature in a case where environmental conditions other than the air temperature and the wall surface temperature, the amount of activity, and the amount of clothing are given will be described. A method for determining the set air temperature assuming specific environmental conditions will be described below.

[0184] Fig. 11 illustrates a relationship between the indoor temperature, the human body exergy consumption rate, and the wetting rate when the outside air temperature is 5.5 °C, the outside relative humidity is 45%, the indoor relative humidity is 50%, the wind speed is 0.1 m/s, the amount of clothing is 0.94 clo, and the amount of activity is 1.1 met, assuming a winter environment. Note that the air temperature and the wall surface temperature are the same, and the two are collectively referred to as the room temperature. The human body exergy consumption rate rapidly decreases to about 2.6 w/m^2 at indoor temperatures of 14 to 21 °C, the rapid decrease stops at 21 °C, and the human body exergy consumption rate gradually decreases while forming a mountain-like curve. The optimal indoor temperature is around 21 °C, which is the inflection point of the human body exergy consumption rate.

[0185] The reason why the optimal indoor temperature is set around the inflection point will be described. It is considered that the inflection point appears because perspiration exceeding insensible perspiration appears. In fact, the wetting rate illustrated in Fig. 11 rises from 0.06, which indicates insensible perspiration, at 21 °C, which is the same as the inflection point of the human body exergy consumption rate, and indicates that sweating has started. Considering a real environment where perspiration occurs in winter, for example, a state where heating is turned on but the air temperature becomes too high and perspiration occurs can be cited as an example, and such a state is obviously uncomfortable. In addition, since the human body exergy consumption rate is proportional to the amount of heat dissipated, for the human body constantly dissipating heat, the human body exergy consumption rate needs to be at or above a certain level. In particular, at a room temperature of 28 °C or higher, the human body exergy consumption rate decreases in spite of perspiration, which indicates that even if perspiration occurs, the sweat does not evaporate and heat is not dissipated. When this state continues, heat continues to accumulate in the body, the core temperature rises, and eventually heatstroke occurs. From the above, it is considered that 21 °C or lower at which perspiration does not occur is appropriate in winter as an environment when the person is seated at home and wants to relax.

[0186] Next, at 21 °C or lower in Fig. 11, the human body exergy consumption rate is extremely high as the temperature is low. The human body exergy consumption rate needs to be at least a certain level for constant heat dissipation of the human body, but if it is too high, heat that is to be in the body is also lost due to excessive heat dissipation, that is, thermal stress is applied to the body, and the body feels cold and uncomfortable. From the above, it is considered that indoor temperatures of 20 to 21 °C at which the human body exergy consumption rate is not too high are optimal in the environment assumed here.

[0187] As described above, by determining the environment other than the indoor temperature, it is possible to derive the indoor temperature at which the thermal stress on the person is small in the environment. In the next section, a system using the above calculation method will be described.

5. Idea of Air Conditioner Control based on Human Body Exergy Balance

5.1. Overview

[0188] As described in the last report and the second to the last report, the present system aims at a human-friendly environment control system. This paper will describe a system having a function of determining a set temperature using the method of deriving an indoor temperature with less thermal stress on a person described in Section 4.2.

[0189] By using this system, it is possible to automatically set a temperature with less burden on the body in accordance with the condition of the person and the season.

5.2. System Configuration

[0190] In order to derive the optimal indoor temperature, the current outside air temperature and humidity, indoor humidity, wind speed, amount of clothing, and amount of activity are required. A main use scene of the present system is a state in which the person is seated at home and relaxed, and it is considered that the wind speed may be 0.1 m/s and the amount of activity may be 1.1 met. However, there is a possibility that the set value of the wind speed is changed by acquiring operation state data of an electric fan from spring to autumn. The outside air temperature and humidity are acquired from a temperature and humidity sensor provided in the outdoor unit, and the indoor humidity is acquired from a temperature and humidity sensor provided in the indoor unit. The amount of clothing is fixed in each of summer, intermediate season, and winter. However, the amount of clothing may be directly input by the person. The present system is an air-conditioning control system having the above configuration to apply the indoor temperature derived using the calculation method described in Section 4 to the environment.

Industrial Applicability

[0191] As described above, the present disclosure is useful for an air-conditioning device and a control system.

Reference Signs List

[0192]

S indoor space (target space)
H person (target person (H))
100 control unit
101 storage unit (information acquisition unit)

Claims

1. An air-conditioning device comprising:

   an information acquisition unit (101) configured to acquire first information indicating environmental information on an environment in which a target person (H) has been placed in a past or biological information of the target person (H); and
   a control unit (100) configured to grasp a habitual behavior pattern of the target person (H) in the first information, wherein
   the control unit (100) is configured to
   set a target value of a first index, which is an index related to a thermal environment, based on the first information acquired by the information acquisition unit (101) and the grasped behavior pattern.

2. The air-conditioning device according to claim 1, wherein the control unit (100) is configured to grasp the behavior pattern, based on a report from the target person (H), operation information on an operation performed by the target person (H) on the air-conditioning device, environmental information of a target space (S), a behavior of the target person (H) estimated from a camera image of the target space (S), an amount of clothing of the target person (H) estimated from the camera image of the target space (S), or a voice of the target person (H) in the target space (S).

3. The air-conditioning device according to claim 1 or 2, wherein the target value of the first index is in a thermal environment in which a target person group corresponding to one behavior pattern among a plurality of classified behavior patterns feels thermally neutral.

4. The air-conditioning device according to claim 1 or 2, wherein the control unit (100) includes an individual recognition unit (102) configured to recognize an individual and a storage unit (101) configured to accumulate a behavior pattern for each recognized individual, and
   is configured to set the target value of the first index, based on a past behavior pattern of the target person (H).

5. The air-conditioning device according to claim 1 or 2, wherein the first index is an index based on a temperature in the target space (S), an index related to a human body exergy balance, a predicted mean vote (PMV), or the thermal environment.

6. The air-conditioning device according to claim 5, wherein the index related to the human body exergy balance indicates a human body exergy consumption rate.

7. The air-conditioning device according to claim 6, wherein the control unit (100) is configured to control, if the first index is the human body exergy consumption rate, a temperature, a humidity, a wind speed, or a radiation temperature of the target space (S) so as to satisfy the target value.

8. The air-conditioning device according to claim 7, wherein the control unit (100) is configured to set the target value of the human body exergy consumption rate to be lower than a predetermined value Va for the target person (H) for whom a set temperature of the target space (S) is set to be higher than a predetermined value Ta during a heating operation of the air-conditioning device.

9. The air-conditioning device according to claim 7, wherein the control unit (100) is configured to set the target value of the human body exergy consumption rate to be higher than a predetermined value Va for the target person (H) for whom a set temperature of the target space (S) is set to be lower than a predetermined value Ta during a heating operation of the air-conditioning device.

10. The air-conditioning device according to claim 7, wherein the control unit (100) is configured to set the target value of the human body exergy consumption rate to be lower than a predetermined value Vb during a cooling operation of the air-conditioning device for the target person (H) whose amount of clothing is lower than a predetermined value Ca during the cooling operation.

11. A control system for an air-conditioning device comprising the control unit (100) according to claim 1 or 2.

FIG.1

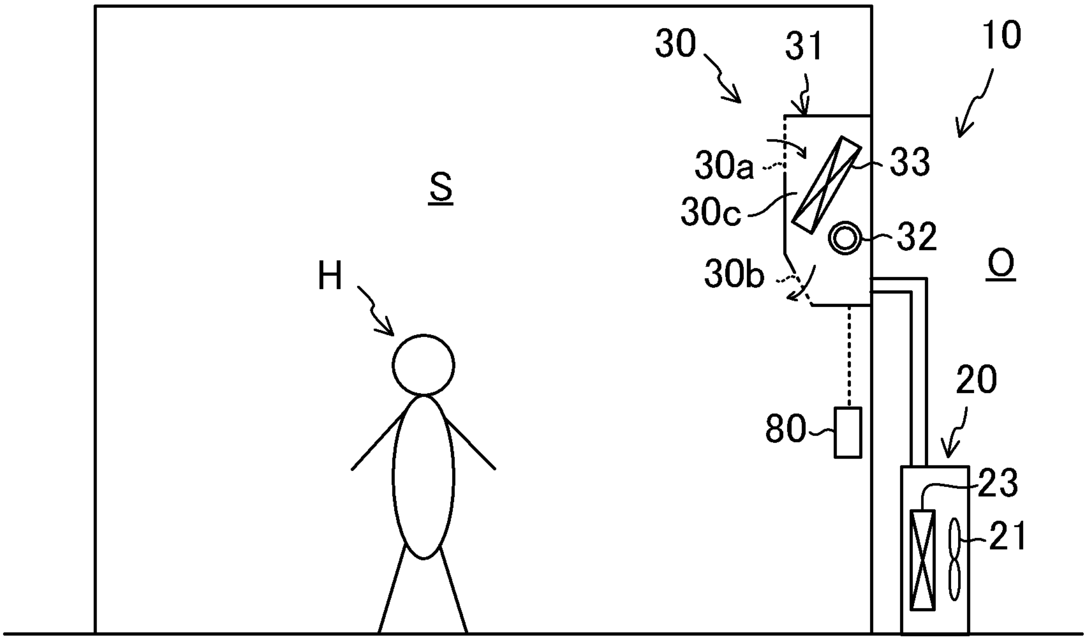

30
31
10
30a
33
S
30c
32
O
30b
H
20
80
23
21

FIG.2

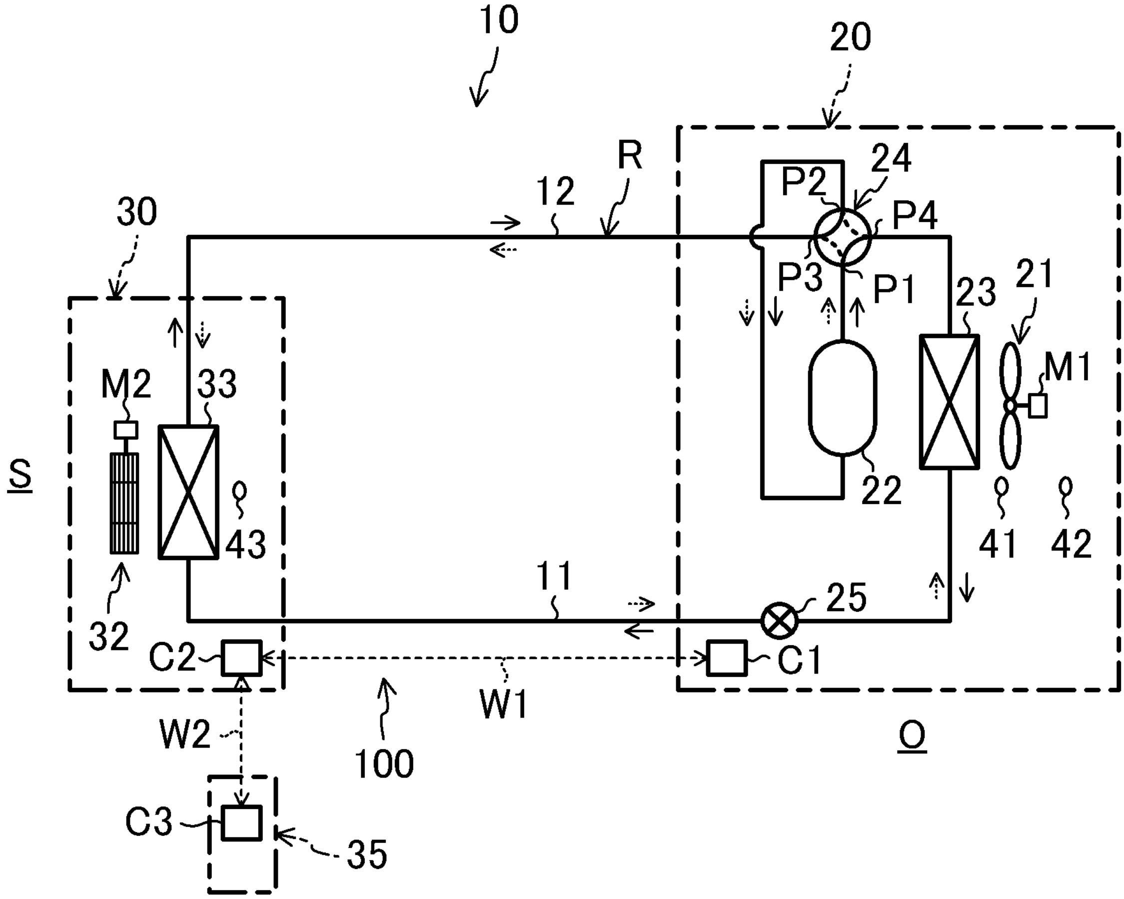

10
20
R
24
12
P2
30
P4
P3
P1
21
23
M1
M2
33
S
22
43
41
42
11
25
32
C2
C1
W1
W2
O
100
C3
35

FIG.3

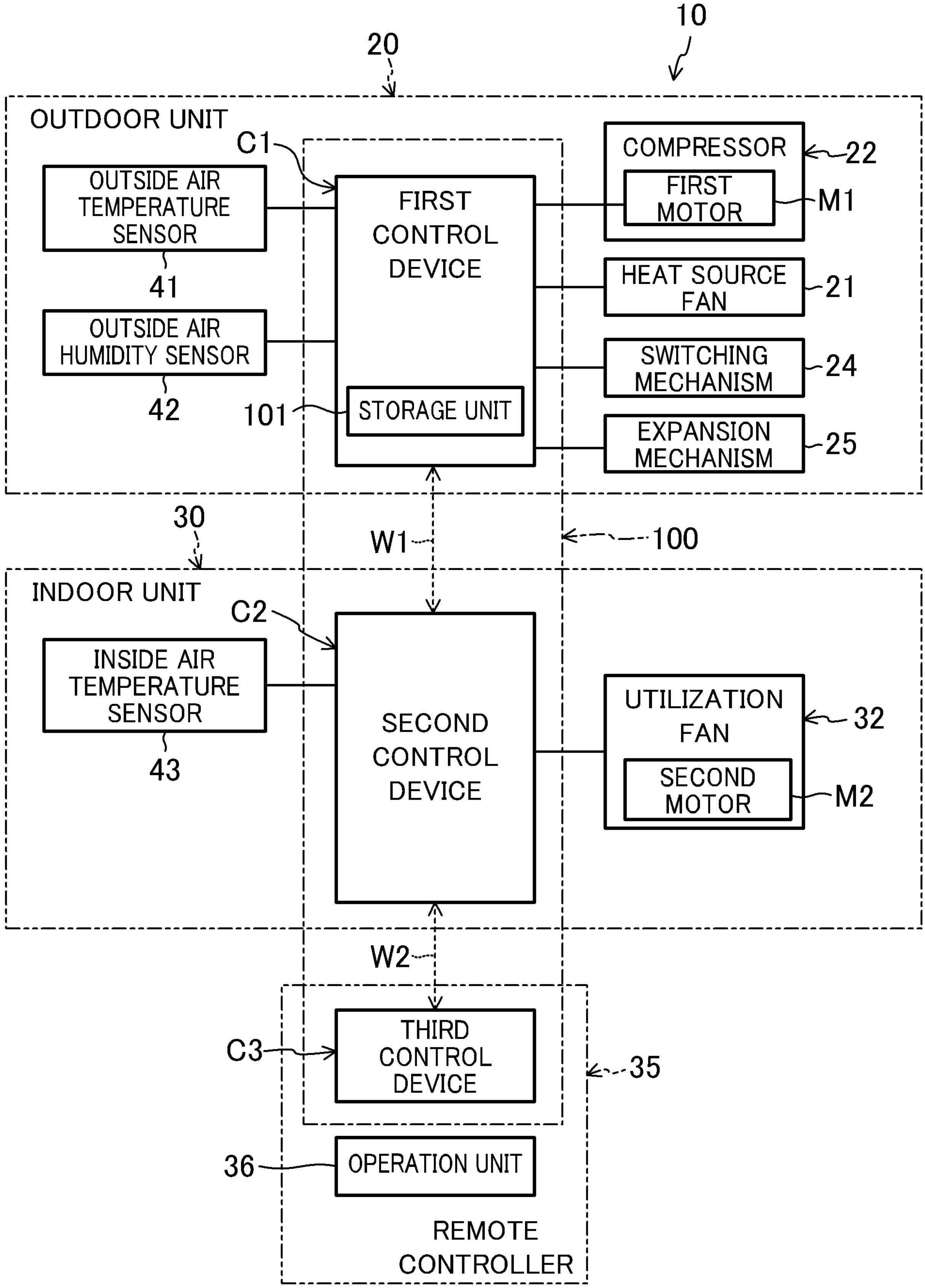

20
10
OUTDOOR UNIT
C1
OUTSIDE AIR TEMPERATURE SENSOR
41
OUTSIDE AIR HUMIDITY SENSOR
42
FIRST CONTROL DEVICE
STORAGE UNIT
101
COMPRESSOR
FIRST MOTOR
22
M1
HEAT SOURCE FAN
21
SWITCHING MECHANISM
24
EXPANSION MECHANISM
25
30
W1
100
INDOOR UNIT
C2
INSIDE AIR TEMPERATURE SENSOR
43
SECOND CONTROL DEVICE
UTILIZATION FAN
32
SECOND MOTOR
M2
W2
C3
THIRD CONTROL DEVICE
35
36
OPERATION UNIT
REMOTE CONTROLLER

FIG.4

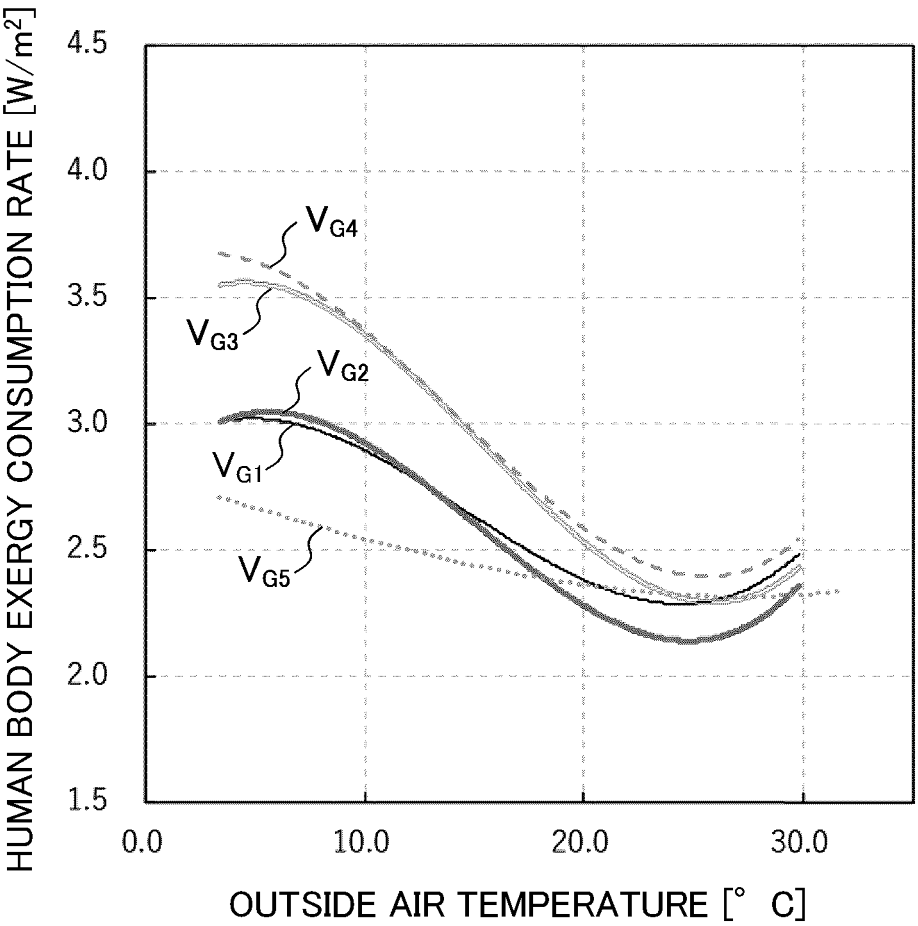

HUMAN BODY EXERGY CONSUMPTION RATE [W/m2]
4.5
4.0
3.5
3.0
2.5
2.0
1.5
0.0
10.0
20.0
30.0
OUTSIDE AIR TEMPERATURE [° C]
VG4
VG3
VG2
VG1
VG5

FIG.5

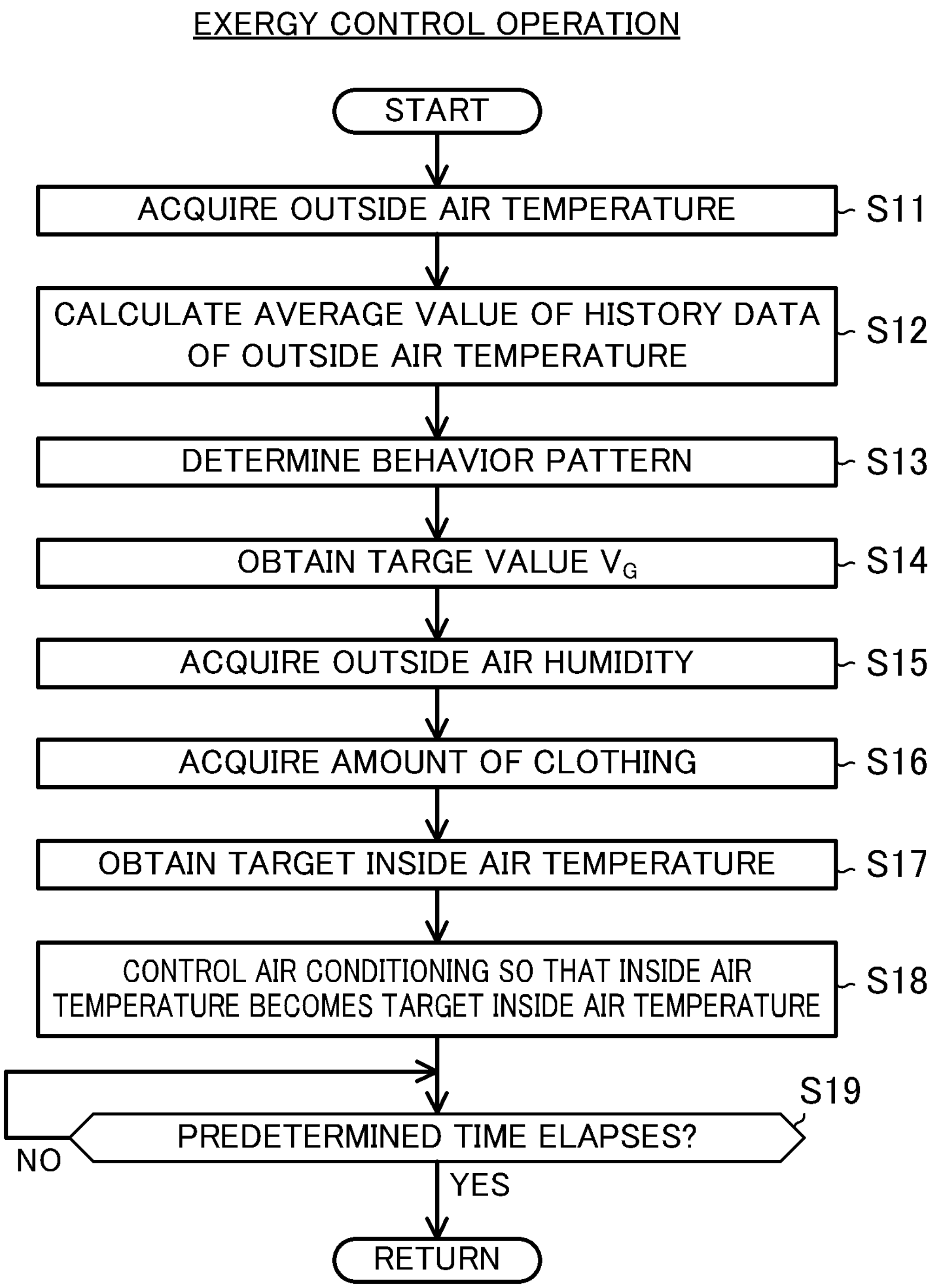

EXERGY CONTROL OPERATION
START
ACQUIRE OUTSIDE AIR TEMPERATURE
S11
CALCULATE AVERAGE VALUE OF HISTORY DATA OF OUTSIDE AIR TEMPERATURE
S12
DETERMINE BEHAVIOR PATTERN
S13
OBTAIN TARGE VALUE V_G
S14
ACQUIRE OUTSIDE AIR HUMIDITY
S15
ACQUIRE AMOUNT OF CLOTHING
S16
OBTAIN TARGET INSIDE AIR TEMPERATURE
S17
CONTROL AIR CONDITIONING SO THAT INSIDE AIR TEMPERATURE BECOMES TARGET INSIDE AIR TEMPERATURE
S18
S19
PREDETERMINED TIME ELAPSES?
NO
YES
RETURN

FIG.6

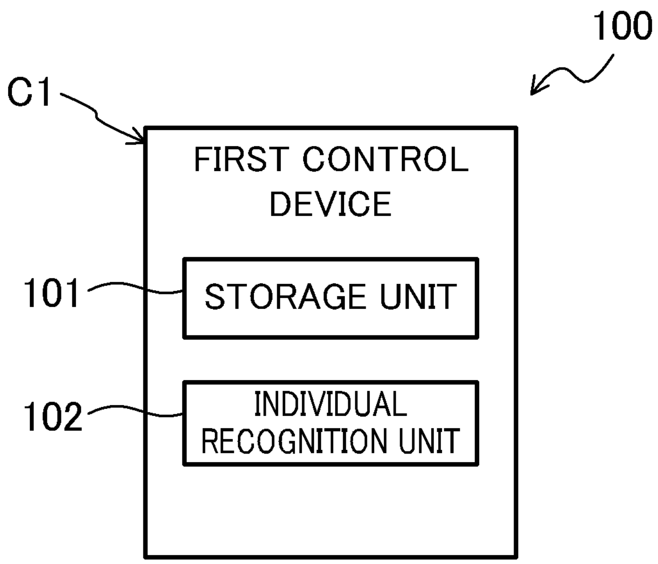

100
C1
FIRST CONTROL DEVICE
101
STORAGE UNIT
102
INDIVIDUAL RECOGNITION UNIT

FIG.7

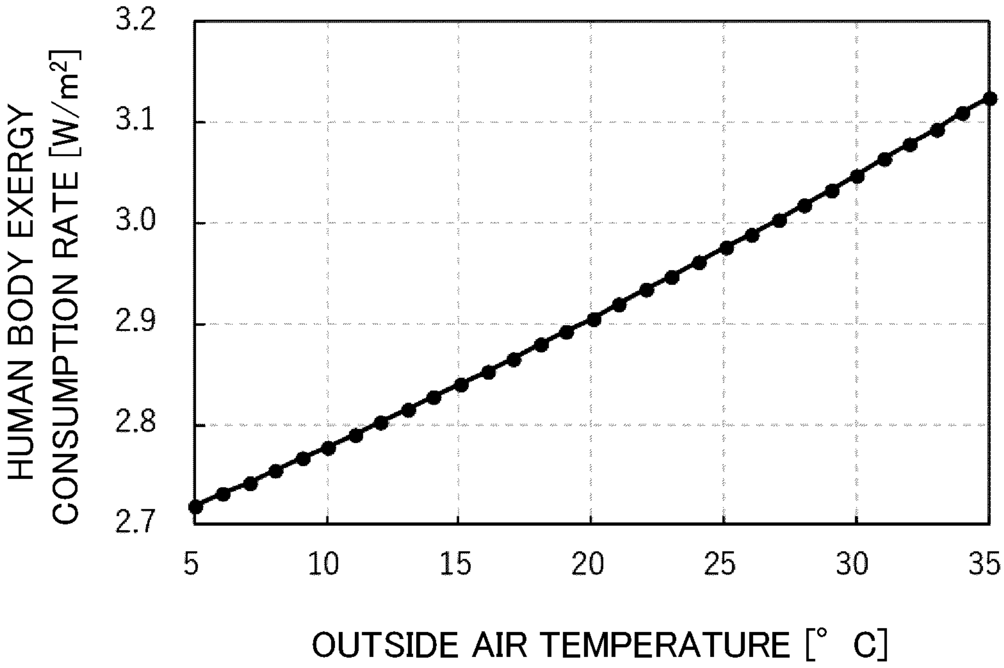

HUMAN BODY EXERGY CONSUMPTION RATE [W/m2]
3.2
3.1
3.0
2.9
2.8
2.7
5
10
15
20
25
30
35
OUTSIDE AIR TEMPERATURE [° C]

FIG.8

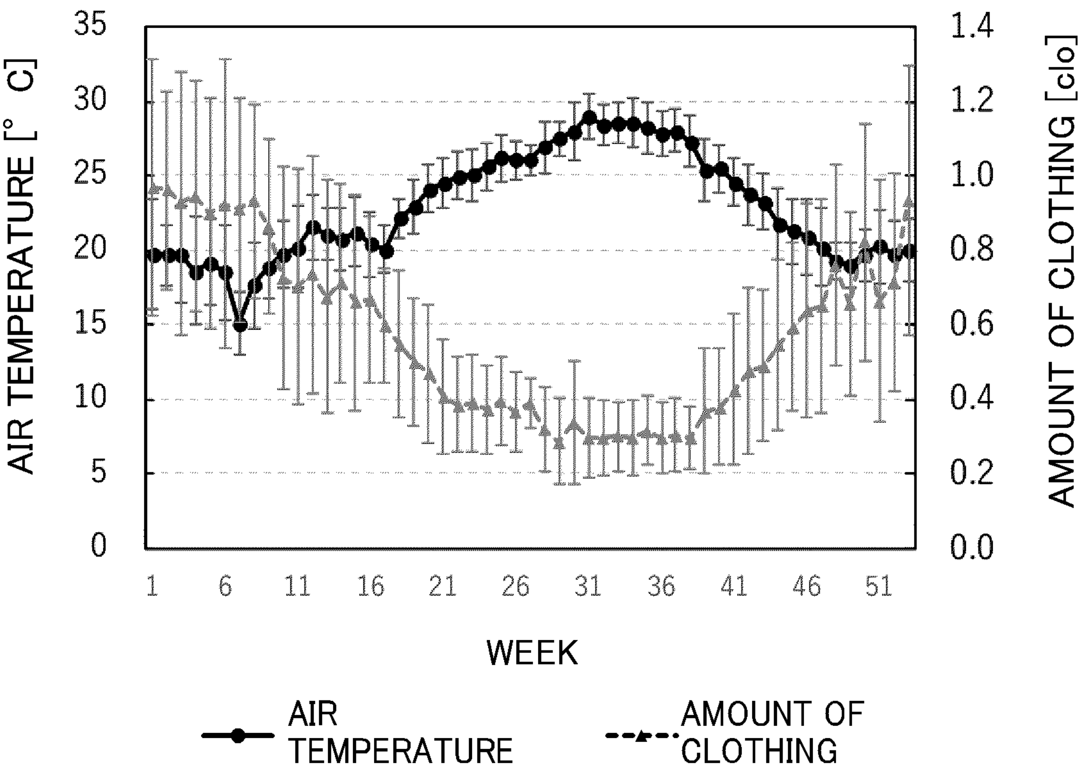

AIR TEMPERATURE [° C]
35
30
25
20
15
10
5
0
AMOUNT OF CLOTHING [clo]
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1
6
11
16
21
26
31
36
41
46
51
WEEK
AIR TEMPERATURE
AMOUNT OF CLOTHING

FIG.9

PATTERN	ASSUMED PATTERN	AIR TEMPERATURE	AMOUNT OF CLOTHING
AVERAGE	SPEND AVERAGELY	μ (AVERAGE VALUE)	μ (AVERAGE VALUE)
A	SPEND ON LIGHTER CLOTHING THAN AVERAGE THROUGHOUT YEAR	μ (AVERAGE VALUE)	$\mu - \sigma$
B	SPEND WITH WEAKER AIR-CONDITIONING WHILE CHANGING CLOTHING LARGELY	WEAKER AIR-CONDITIONING	CHANGE LARGELY
C	SPEND WITH WEAKER AIR-CONDITIONING WHILE CHANGING CLOTHING AVERAGELY	WEAKER AIR-CONDITIONING	μ (AVERAGE VALUE)
D	SPEND WITH STRONGER AIR-CONDITIONING WHILE CHANGING CLOTHING AVERAGELY	STRONGER AIR-CONDITIONING	μ (AVERAGE VALUE)

ITEM	CLASSIFICATION	DESCRIPTION
AMOUNT OF CLOTHING	CHANGE LARGELY	SET AMOUNT OF CLOTHING = $\mu - \sigma$ WHEN AVERAGE OF WEEKLY MAXIMUM OUTSIDE AIR TEMPERATURES > AIR TEMPERATURE, AND SET AMOUNT OF CLOTHING = $\mu + \sigma$ WHEN AVERAGE OF WEEKLY MAXIMUM OUTSIDE AIR TEMPERATURES ≤ AIR TEMPERATURE.
AIR TEMPERATURE	WEAKER AIR-CONDITIONING	SET AIR TEMPERATURE = $\mu + \sigma$ WHEN AVERAGE OF WEEKLY MAXIMUM OUTSIDE AIR TEMPERATURES > AIR TEMPERATURE, AND SET AIR TEMPERATURE = $\mu - \sigma$ WHEN AVERAGE OF WEEKLY MAXIMUM OUTSIDE AIR TEMPERATURES ≤ AIR TEMPERATURE.
	STRONGER AIR-CONDITIONING	SET AIR TEMPERATURE = $\mu - \sigma$ WHEN AVERAGE OF WEEKLY MAXIMUM OUTSIDE AIR TEMPERATURES > AIR TEMPERATURE, AND SET AIR TEMPERATURE = $\mu + \sigma$ WHEN AVERAGE OF WEEKLY MAXIMUM OUTSIDE AIR TEMPERATURES ≤ AIR TEMPERATURE.

* WEEKLY AVERAGE VALUE = μ, STANDARD DEVIATION = σ ARE SET.

* WALL SURFACE TEMPERATURE IS ALWAYS EQUAL TO AIR TEMPERATURE.

FIG.10

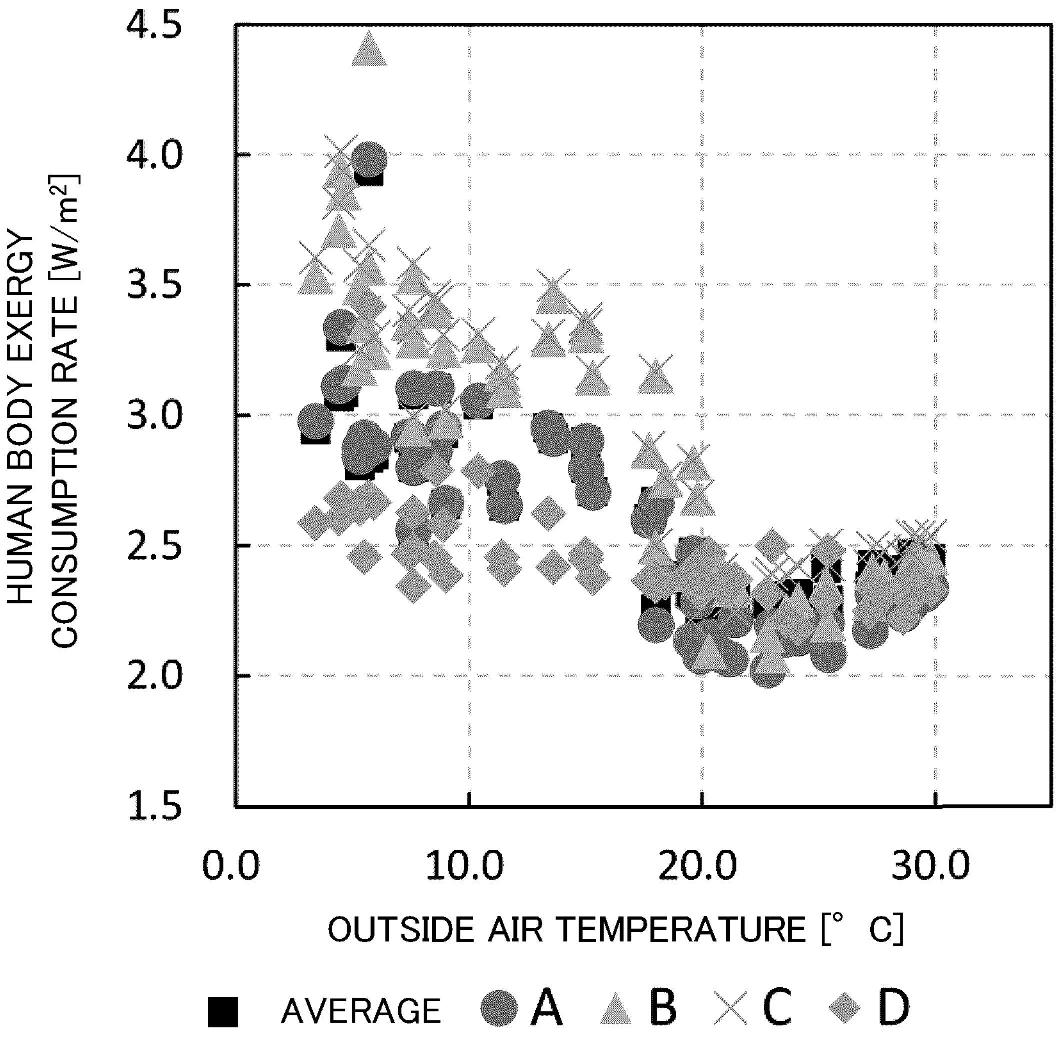
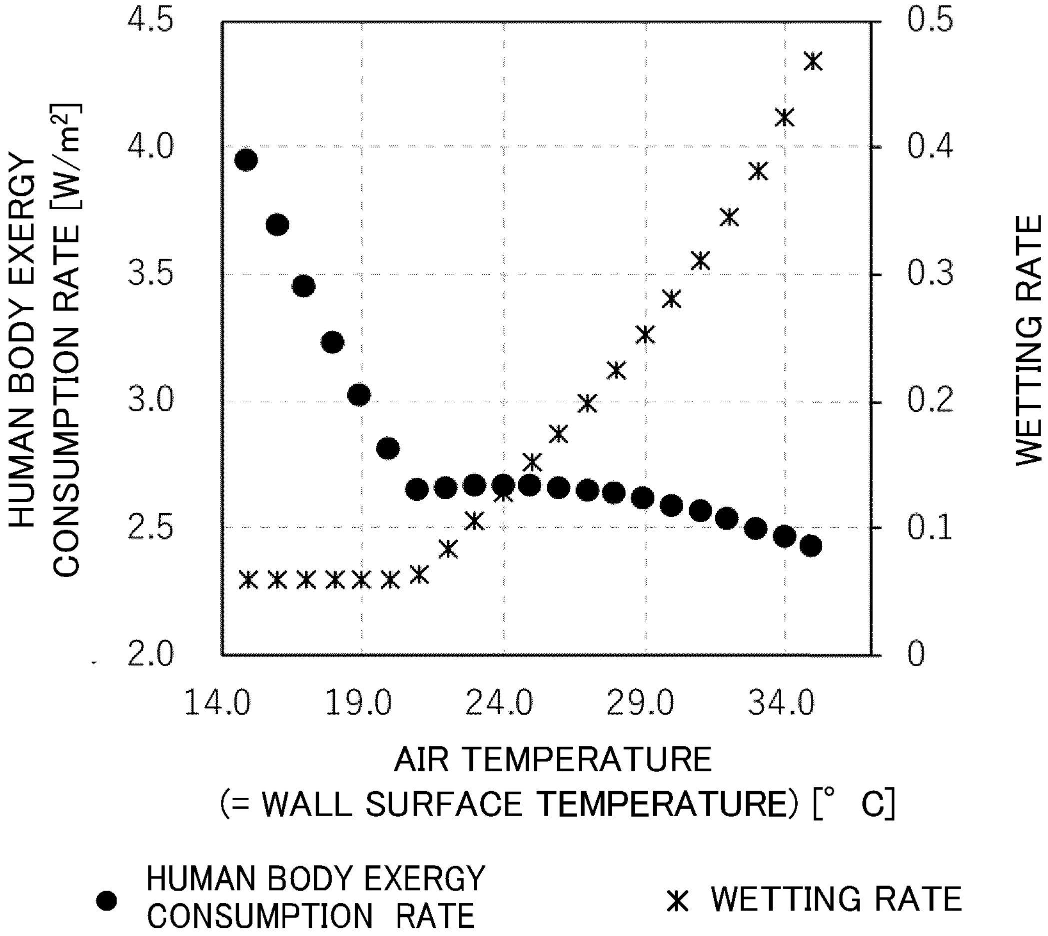

4.5
4.0
3.5
3.0
2.5
2.0
1.5
HUMAN BODY EXERGY CONSUMPTION RATE [W/m2]
0.0
10.0
20.0
30.0
OUTSIDE AIR TEMPERATURE [° C]
AVERAGE
A
B
C
D

FIG.11



4.5
4.0
3.5
3.0
2.5
2.0
HUMAN BODY EXERGY
CONSUMPTION RATE [W/m2]
0.5
0.4
0.3
0.2
0.1
0
WETTING RATE
14.0
19.0
24.0
29.0
34.0
AIR TEMPERATURE
(= WALL SURFACE TEMPERATURE) [° C]
HUMAN BODY EXERGY CONSUMPTION RATE
WETTING RATE

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/027924

A. CLASSIFICATION OF SUBJECT MATTER

F24F 11/64(2018.01)i; ***F24F 11/80***(2018.01)i
FI: F24F11/64; F24F11/80

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F24F11/64; F24F11/80

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 9-269145 A (SHARP CORP) 14 October 1997 (1997-10-14) paragraphs [0001]-[0054]	1-2, 4-5, 11
Y	paragraphs [0001]-[0054]	3, 5-7
A	paragraphs [0001]-[0054]	8-10
Y	JP 2020-41755 A (DAIKIN IND LTD) 19 March 2020 (2020-03-19) paragraphs [0001]-[0094]	3, 5-7
A	paragraphs [0001]-[0094]	8-10

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 September 2022	**27 September 2022**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/027924

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 9-269145 A	14 October 1997	(Family: none)	
JP 2020-41755 A	19 March 2020	(Family: none)	

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2020041755 A **[0003]**