



(11)

EP 4 772 153 A1

(12)

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

(43) Date of publication:
08.07.2026 Bulletin 2026/28

(21) Application number: **24859893.0**

(22) Date of filing: **29.08.2024**

(51) International Patent Classification (IPC):
A61G 7/018 ^(2006.01) **A47C 19/04** ^(2006.01)
A47C 27/00 ^(2006.01) **A61G 7/008** ^(2006.01)
A61G 7/057 ^(2006.01)

(52) Cooperative Patent Classification (CPC):
A47C 19/04; A47C 27/00; A61G 7/008;
A61G 7/018; A61G 7/057

(86) International application number:
PCT/JP2024/030934

(87) International publication number:
WO 2025/047864 (06.03.2025 Gazette 2025/10)

(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 ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(30) Priority: **31.08.2023 JP 2023140925**

(71) Applicant: **Nakatsugawa, Shigekazu**
Tokyo, 134-0083 (JP)

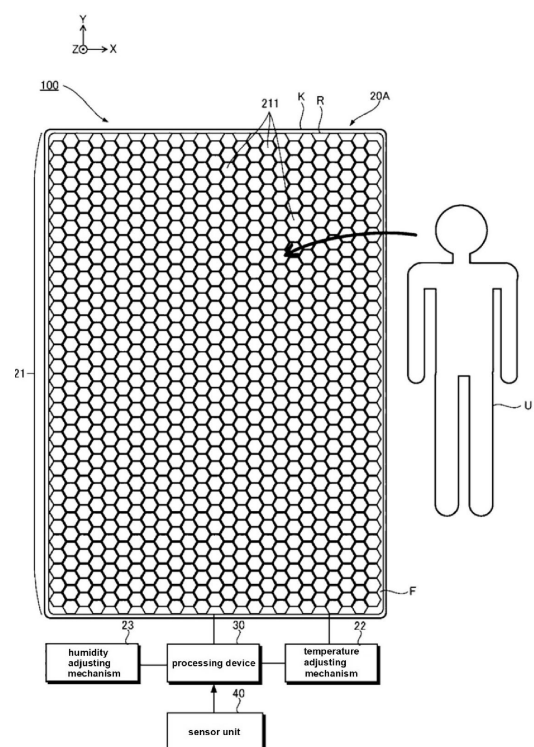
(72) Inventor: **Nakatsugawa, Shigekazu**
Tokyo, 134-0083 (JP)

(74) Representative: **Dehns**
10 Old Bailey
London EC4M 7NG (GB)

(54) **AUXILIARY SYSTEM**

(57) An auxiliary system comprising a housing including a contact surface on which a user places a body and filled with a liquid whose temperature is adjustable, and an auxiliary mechanism that is housed in the housing and assists a change in posture of the user, the auxiliary mechanism including a plurality of column members each extending in a direction intersecting the contact surface and being movable along the direction, wherein each of the column members has a hollow interior and includes a first portion whose cross-sectional size decreases toward an end opposite to the contact surface, the liquid is filled in gaps between the column members, and the liquid is not filled inside the column members.

Fig.1



Description

[Technical Field]

[0001] The present invention relates to an auxiliary system for assisting a change in a body position of a user.

[Background Art]

[0002] In recent years, due to the effects of climate change and global conditions, it has become considerably difficult for people to maintain sleep having good quality and quantity in order to maintain mental stability and physical health. On the other hand, sleep is subject to changes due to aging, similarly to a decrease in the amount of exercise and other functions essential for sustaining life. It has been considered unavoidable that sleep time, which strongly correlates with cognitive function, becomes shorter, that light sleep increases, and that deep sleep decreases. That is, it has been considered that, as aging progresses, the risk of dementia increases and a shortening of healthy life expectancy is unavoidable.

[0003] A person's life (daily activities) consists, in terms of time, of social activities outside the home accounting for about 34 to 50%, home life accounting for about 17 to 33%, and the remaining approximately 33% being sleep time, and is regulated by a biological clock. During sleep, memory is consolidated, and sleep also plays a significant role in maintenance of visceral functions, and it has become clear that sleep is indispensable for improving productivity. In a sense, activities other than sleep are supported by psychological and physical conditions, that is, water intake, nutrition (reflecting digestion, absorption, metabolism, excretion, and the like), exercise, sleep, lifestyle habits, memory, and a sense of purpose in life. In contrast, sleep reflects physical or psychological fatigue, stress, mental state, other social activities, nutrition, exercise, lifestyle habits, and the like, and its quality and quantity are influenced thereby.

[0004] Further, sleep exhibits significant individual differences in terms of a balance among changes in body temperature, heat generation (such as amount of exercise and dietary content), and heat dissipation (such as perspiration capability). It is also known that sleep is greatly affected by environmental factors of a region in which a person resides, that is, temperature, humidity, sound, light, oxygen saturation, carbon dioxide concentration, carbon monoxide concentration, and the like. With respect to individual differences, large variations arise depending on a person's body composition, in particular muscle mass related to heat generation, cardiovascular and nervous systems related to skeletal structure, heat dissipation and perspiration, the degree of development and aging of internal organs, combinations of lifestyle-related diseases, balance of immune and endocrine systems, and also the quantity and content of work. In addition, in practice, perceived comfort

table temperature is greatly influenced by humidity, even when viewed from wet-bulb globe temperature.

[0005] Incidentally, the temperature of each part of the body is defined by, first, factors leading to an increase in temperature:

1. inflow of heat (mainly due to arterial blood);
2. heat production (mainly in muscles and internal organs (for example, the liver), as well as congestion and inflammatory responses);
3. heat convection (transfer of heat from a gas or liquid having a high temperature passing over exposed skin to the skin);
4. heat conduction (transfer of heat from a surface (solid) having a temperature higher than the body temperature and in direct contact to a body surface having a lower temperature); and
5. suppression of convective heat transfer (obesity (reduction in body surface area), heavy clothing, wind shielding).

[0006] Next, factors leading to a decrease in temperature include:

6. heat release by radiation (mainly infrared radiation for reducing a temperature difference with the surrounding environment, influenced by body surface area (leanness) and balance of the autonomic nervous system);
7. evaporation (for example, sweat, cooling due to vaporization of moisture);
8. heat convection (transfer of heat to a gas or liquid having a low temperature passing over exposed skin, for example, ventilation);
9. heat conduction (conduction of heat from the body surface to a surface (solid) having a temperature lower than the body surface temperature, or transfer of heat from a high-temperature surface in direct contact to a low-temperature surface (for example, an ischemic site)); and
10. outflow of heat (mainly due to venous blood, cutaneous veins, capillaries, and ischemia),

and the temperature is determined by a balance among these factors.

[0007] Heat production is caused by muscle activity (60%) and metabolism of internal organs (40%). In addition, body temperature increases due to excitation of the sympathetic nervous system, hyperthyroidism, severe obesity, and the like. On the other hand, body temperature decreases under dominance of the parasympathetic nervous system, hypothyroidism, and emaciation.

[0008] Conventionally, 30 minutes has been physiologically assumed as one unit of sleep, and this is consid-

ered to possibly correlate with a turning-over rhythm that is said to occur approximately once every 30 minutes. On the other hand, in addition to conventional sleep disorders associated with childcare, in recent years, 24-hour operations, such as medical care, nursing care, production, distribution, commerce, transportation, security, and global operations, which cannot be regulated by the biological clock at all, have become widespread, and together with shift work, have become causes of serious sleep disorders.

[0009] Further, at least a part of various lifestyle-related diseases, frailty, associated with extreme eating disorders, emaciation, and severe obesity, which are problems in developed countries, correlates with problems such as quality and quantity of sleep. It has also been found that sleep disorders are related, in addition to depression and the like, to obesity and exacerbation of a part of lifestyle-related diseases. For example, in sleep apnea syndrome, even when AHI (apnea hypopnea index) is the same, there may be extremely serious symptoms even in cases where there are no subjective symptoms at all, and it is also known that subjective symptoms related to sleep exhibit very large individual differences.

[0010] In Japan, where stressful work environments are not uncommon, and which has a long north-south landmass with four seasons and in which a stable environment is difficult to obtain, it is said that sleep duration is the shortest among developed countries and that the proportion of people who are not satisfied with sleep, including those with sleep disorders, is higher than in other countries. In monsoon regions such as Japan, humidity is originally high except during periods such as winter, and it is considered that the range of temperatures comfortable for sleep is extremely narrow, even when viewed from wet-bulb globe temperature, which is also a cause of the occurrence of sleep disorders. Further, with aging, progression of degenerative spondylosis in addition to arteriosclerosis is unavoidable, and various influences are exerted on regulation of the balance of the autonomic nervous system. In particular, the head and neck region is not only a region in which central nerves such as the brain and spinal cord including a sleep center are present, but also a region in which sensory nerves are densely distributed, and is also the most sensitive region. Further, the carotid sinus has a central role of monitoring various changes in blood, and thus the particularity of the neck region with respect to sleep is remarkable.

[0011] Furthermore, in emaciation and severe obesity associated with lack of exercise in the context of aging as described above, it is difficult to support body weight due to insufficient muscle mass (sarcopenia), and the number of people who cannot freely turn over, which is important for preventing muscle pain upon waking and local circulatory insufficiency, is increasing. As described above, the above-described autonomic thermoregulation function decreases with aging. In addition, when remaining in a supine position during sleep, particularly after alcohol

consumption, the base of the tongue tends to fall backward, and the airway tends to become narrow, whereas in a lateral position the airway is more easily secured, and thus turning over without awakening is essential for comfortable sleep. Awakening during sleep leads to fragmentation of sleep and mid-sleep awakening, and re-initiation of sleep thereafter may not be easy, resulting in a decrease in sleep quality. Further, in obesity, subcutaneous fat deposition progresses also in the neck region, increasing a distance between the skin surface and arteries and veins, thereby reducing heat dissipation, and the skin is stretched and a distribution of sweat glands per unit area decreases, resulting in a decrease in perspiration capability of the neck region and hindering a decrease in brain temperature necessary for sleep. Under such circumstances, sudden death due to arrhythmia caused by sleep apnea syndrome and pulmonary embolism due to economy class syndrome is also increasing.

[0012] Here, techniques for improving a quality of sleep of a user have been conventionally proposed. For example, Patent Literature 1 discloses a bed system for assisting a change in a body position of a user during sleep. Specifically, in Patent Literature 1, a bed bottom is divided into a left half and a right half, and both the left half and the right half are inclined so as to assist the user to assume a lateral position.

[0013] In the technique of Patent Literature 1, the bed bottom can only be inclined in a planar manner (over an entire surface) for each of a left half region and a right half region. That is, the bed bottom cannot be moved for each subdivided region. In addition, since the body is not kept straight during sleep, a configuration in which the bed bottom is inclined in a planar manner (over an entire surface) can only achieve incomplete distribution of body weight load and does not match a body surface shape of each part of the body. Therefore, in a case where the bed bottom is inclined in a planar manner, the body is first returned to a straight state at once and then inclined while remaining straight, whereby a large nonuniformity in body weight load occurs for each part, and each time the center of gravity moves, discomfort caused by body weight load of several times to ten times or more being applied to limited parts of the body, or awakening, cannot be avoided. As described above, in the technique of Patent Literature 1, it is difficult to appropriately assist a change in a body position of a user during sleep without discomfort and without awakening.

[0014] Accordingly, the inventor of the present invention has developed, in Patent Literature 2, a bedding system for facilitating falling asleep, subsequent deep sleep, and re-initiation of sleep by achieving equalization of body weight load and a condition of cool head and warm feet for a user during sleep, and for appropriately assisting a change in body position (specifically, comfortable turning over). Specifically, in the technique of Patent Literature 2, each of a plurality of column members incorporated in the bedding is individually movable.

Further, an interior of a container accommodating the column members is filled with an adjustment liquid whose temperature is adjustable, thereby promoting comfortable sleep of the user.

[Prior Art Documents]

[Patent Literature]

[0015]

[Patent Literature 1] JP 2016-67429 A
[Patent Literature 2] WO 2022/145346 A1

[Summary of the Invention]

[Problem to be Solved by the Invention]

[0016] However, in the technique of Patent Literature 2, since the bedding includes a plurality of column members, there has been room for improvement from a viewpoint of weight reduction. Further, since the plurality of column members are provided adjacent to each other, the adjustment liquid tends to be difficult to flow, and the temperature may be difficult to adjust uniformly. In view of the above circumstances, an object of the present invention is to provide an auxiliary system that enables weight reduction and improves fluidity of the adjustment liquid.

[Means for Solving the Problem]

[0017]

[1] An auxiliary system comprising a housing including a contact surface on which a user places a body and filled with a liquid whose temperature is adjustable, and an auxiliary mechanism that is housed in the housing and assists a change in posture of the user, the auxiliary mechanism including a plurality of column members each extending in a direction intersecting the contact surface and being movable along the direction, wherein each of the column members has a hollow interior and includes a first portion whose cross-sectional size decreases toward an end opposite to the contact surface.

[2] The auxiliary system according to [1], wherein each of the column members includes a second portion having a constant cross-sectional size at an end on the contact surface side, and the first portion is formed from an end of the second portion opposite to the contact surface toward a side opposite to the contact surface.

[3] The auxiliary system according to [2], wherein a length of the first portion is 1/2 or more of a length of the column member, and a length of the second portion is 1/10 or more and less than 1/2 of the length

of the column member.

[4] The auxiliary system according to [3], wherein the housing includes a housing body having a hollow interior on a side opposite to the contact surface, an end of each of the column members on a side opposite to the contact surface is located inside the housing body, and a driving mechanism is installed inside the housing body.

[5] The auxiliary system according to any one of [1] to [4], further comprising a detection unit that detects a pressure value from the user for each of a plurality of regions on the contact surface, wherein the plurality of column members move such that the pressure values in the respective regions become closer to each other.

[6] The auxiliary system according to [2], wherein the auxiliary mechanism includes, for each of the plurality of column members, a movable portion having a bottom portion and a side wall portion provided over an entire circumference of the bottom portion, the second portion is fitted inside the side wall portion of the movable portion such that an end of the second portion opposite to the first portion faces the bottom portion, and the movable portion moves toward the first portion side when a load from the user is applied to the bottom portion.

[7] The auxiliary system according to any one of [1] to [6], wherein a gas having a density smaller than a density of the liquid is filled inside the column members.

[Advantageous Effects of the Invention]

[0018] According to the auxiliary system of the present invention, since the column member includes a first portion whose cross-sectional size decreases toward an end portion on a side opposite to a contact surface, weight reduction is possible, and fluidity of the adjustment liquid can be improved.

[Brief Description of the Drawings]

[0019]

[FIG. 1] A schematic view of an auxiliary system according to a first embodiment.

[FIG. 2] A side view of a mattress.

[FIG. 3] A block diagram illustrating functions of the auxiliary system.

[FIG. 4] A cross-sectional view illustrating one column member.

[FIG. 5] An explanatory view illustrating movement of the column members.

[FIG. 6] An explanatory view illustrating movement of

the column members.

[FIG. 7] An explanatory view illustrating movement of the column members.

[FIG. 8] An explanatory view illustrating movement of the column members.

[FIG. 9] A schematic view of an auxiliary system according to a second embodiment.

[FIG. 10] A side view of a pillow member.

[FIG. 11] An explanatory view illustrating movement of the column members.

[FIG. 12] An explanatory view illustrating movement of the column members.

[FIG. 13] An explanatory view illustrating movement of the column members.

[FIG. 14] An explanatory view illustrating movement of the column members.

[FIG. 15] A side view of a pillow according to another aspect of the second embodiment.

[FIG. 16] A configuration diagram of a humidity adjustment mechanism according to a modification.

[FIG. 17] A side view of an auxiliary system according to a modification.

[FIG. 18] A side view of a mattress according to a modification.

[FIG. 19] A cross-sectional view of a column member according to a modification.

<First Embodiment>

[0020] FIG. 1 is a schematic view of an auxiliary system 100 according to a first embodiment. In the first embodiment, an auxiliary system 100 of a bedding type (bed type) used by a user U during sleep is assumed. As illustrated in FIG. 1, the auxiliary system 100 includes a mattress 20A, an auxiliary mechanism 21, a temperature adjustment mechanism 22, a humidity adjustment mechanism 23, a processing device 30, a sensor unit 40, and a drive mechanism 50.

[0021] The mattress 20A is a mat on which the user U lies during sleep. In the following description, a thickness direction of the mattress 20A is referred to as a Z direction, a direction orthogonal to the Z direction is referred to as an X direction, and a direction orthogonal to the Z direction and the X direction is referred to as a Y direction. In FIG. 1, a lateral direction of the mattress 20A is defined as the X direction, a longitudinal direction of the mattress 20A is defined as the Y direction, and the thickness direction of the mattress 20A is defined as the Z direction. FIG. 1 is a plan view of the mattress 20A as viewed from the Z direction. FIG. 2 is a side view of the mattress 20A as viewed from the Y direction.

[0022] The mattress 20A includes, for example, a container R and a housing portion K. An interior of the container R is filled with an adjustment liquid L whose temperature is adjustable, and the auxiliary mechanism 21 is provided therein. The container R is, for example, a bag-shaped structure formed of a waterproof material (for example, a resin or the like). The container R is

preferably elastic. An outer peripheral surface of the container R may be further covered with a fabric. The container R includes a surface F on which the user U places a body (hereinafter referred to as a "contact surface"). In the mattress 20A, the contact surface F is a surface on which the user U lies. The contact surface F is a surface on a positive side in the Z direction of the container. In practice, the auxiliary mechanism 21 cannot be visually recognized from outside the mattress 20A; however, in FIGS. 1 and 2, the auxiliary mechanism 21 is illustrated for convenience.

[0023] As illustrated in FIG. 2, the housing portion K is connected to the container R on a side opposite to the contact surface F of the container R. Specifically, the housing portion K is a hollow structure. An interior of the housing portion K is set to a size that can accommodate a drive mechanism 50 described later. As illustrated in FIG. 1, in a plan view from the Z direction, the housing portion K has a size equal to or larger than that of the container R.

[0024] As illustrated in FIG. 1, in the first embodiment, the temperature adjustment mechanism 22 is connected to an exterior of the mattress 20A. However, the temperature adjustment mechanism 22 and the humidity adjustment mechanism 23 may be provided inside the housing portion K.

<Sensor Unit 40>

[0025] FIG. 3 is a block diagram illustrating functions of the auxiliary system 100 according to the first embodiment. As illustrated in FIG. 3, the sensor unit 40 is a detection device that generates detection signals S (S1, S2, S3) for specifying information related to a living body of the user U (hereinafter referred to as "biological information"). The sensor unit 40 of the first embodiment includes a first acquisition unit 41, a second acquisition unit 42, and a third acquisition unit 43.

[0026] The first acquisition unit 41 is a sensor that generates a detection signal S1 that varies in accordance with a load of the user U (pressure from the user U) on the contact surface F. That is, the detection signal S1 is a signal representing a load value (pressure value). For example, a pressure sensor (for example, a piezoelectric element) is exemplified as the first acquisition unit 41. The detection signal S1 is used to specify a position of the user U (hereinafter referred to as a "body position") on the mattress 20A (contact surface F) and a period elapsed since the user U most recently changed a body position (hereinafter referred to as a "change period"). For example, a plurality of first acquisition units 41 are provided at predetermined intervals in a region on the contact surface F side inside the mattress 20A (container R). However, the number of the first acquisition units 41 is arbitrary.

[0027] Among the plurality of first acquisition units 41, a detected value of the detection signal S1 generated by the first acquisition unit 41 corresponding to a region of the contact surface F on which the user U is present

(lying) varies. Therefore, the body position can be estimated based on the detection signal S1. Further, since the detection signal S1 generated by the first acquisition unit 41 varies when the user U moves, a change in body position of the user U can also be detected. The body position and the change period are examples of biological information.

[0028] Any sensor may be used as the first acquisition unit 41 as long as the body position and the change period can be specified. The first acquisition unit 41 continuously generates the detection signal S1 at predetermined intervals. That is, a temporal change in the load of the user U is detected.

[0029] The second acquisition unit 42 is a sensor that generates a detection signal S2 representing a body temperature of the user U. The detection signal S2 is used to specify the body temperature of the user U (an example of biological information). For example, any known body temperature sensor (for example, an infrared sensor) is used as the second acquisition unit 42. The second acquisition unit 42 is, for example, attached (affixed) to body surfaces at a plurality of locations of the user U (such as a torso, both hands, both feet, a head, and a neck). Note that a non-contact body temperature sensor may be used as the second acquisition unit 42 as long as it can generate the detection signal S2 representing the body temperature of the user U. The second acquisition unit 42 continuously generates the detection signal S2 at predetermined intervals.

[0030] The third acquisition unit 43 is a sensor that generates a detection signal S3 representing humidity of a body surface of the user U. The detection signal S3 is used to specify the humidity of the body surface of the user U (an example of biological information). For example, any known humidity sensor is used as the third acquisition unit 43. The third acquisition unit 43 is, for example, attached to the same positions on the body surface of the user U as the second acquisition unit 42. Note that a non-contact humidity sensor may be used as the third acquisition unit 43 as long as it can generate the detection signal S3 representing the humidity of the body surface of the user U. Further, an integrated device including the second acquisition unit 42 and the third acquisition unit 43 may be used. The third acquisition unit 43 continuously generates the detection signal S3 at predetermined intervals. The numbers of the second acquisition unit 42 and the third acquisition unit 43 are arbitrary.

<Auxiliary Mechanism 21>

[0031] The auxiliary mechanism 21 of the first embodiment is a mechanism for assisting a change in a body position of the user U lying on the mattress 20A (typically, turning over of the user U during sleep). Specifically, the auxiliary mechanism 21 includes a plurality of column members 211. Each column member 211 is an elongated columnar member extending along the Z direction (a

thickness direction of the mattress 20A). The Z direction can also be expressed as a direction intersecting (orthogonal to) the contact surface F. The plurality of column members 211 are arranged closely so as to be parallel to each other. The plurality of column members 211 are arranged so as to extend over an entire area of the mattress 20A in a plan view. Inside the container R, the adjustment liquid L is filled so as to fill gaps between the column members 211. A distance between adjacent column members 211 is preferably 1 mm to 1 cm, and more preferably 2 to 8 mm, from a viewpoint of achieving both weight reduction and buoyancy.

[0032] As illustrated in FIG. 1, the column member 211 is, for example, a regular hexagonal prism. A diameter of the column member 211 (a length of a diagonal of a regular hexagon) is, for example, 20 to 60 mm. The column member 211 is not limited to a regular hexagonal prism. For example, a column member 211 may be a cylinder or a polygonal prism other than a regular hexagonal prism (for example, a quadrangular prism).

[0033] FIG. 4 is a cross-sectional view focusing on one column member 211. As illustrated in FIG. 4, the column member 211 of the first embodiment is hollow. Specifically, the column member 211 is composed of a top surface portion, a bottom surface portion, and a side surface portion. The side surface portion is a tubular portion, and the top surface portion is positioned so as to close an opening at an upper part (a positive side in the Z direction) of the side surface portion, and the bottom surface portion is positioned so as to close an opening at a lower part (a negative side in the Z direction) of the side surface portion. A surface (end portion J) of the column member 211 on the contact surface F side is preferably formed of, for example, a flexible material (for example, silicone or rubber) so as to reduce discomfort when the user U lies on the container R. A thickness of a wall portion constituting the column member 211 is not particularly limited, but is assumed to be, for example, about 5 mm to 1.5 cm from a viewpoint of achieving both sufficient strength and weight reduction, and a configuration in which the thickness increases from the positive side toward the negative side in the Z direction is preferable. For example, the column member 211 is formed of a resin such as polyoxymethylene, polyphenylene sulfide, polystyrene, or polypropylene.

[0034] The plurality of column members 211 are individually movable along the Z direction. Specifically, each column member 211 is movable within a predetermined range toward a positive side and a negative side in the Z direction (upward and downward directions). Each column member 211 is movable so as to change a body position of the user U. The column members 211 are formed of any material that enables weight reduction and has durability.

[0035] The column members 211 are moved along the Z direction by the drive mechanism 50. The drive mechanism 50 is, for example, an electric or hydraulic actuator (cylinder). Any type of the drive mechanism

50 may be used as long as the column members 211 can be moved along the Z direction. As illustrated in FIG. 2, the drive mechanism 50 is provided inside the housing portion K. In the present embodiment, two or more drive mechanisms 50 are provided for the plurality of column members 211. Although one drive mechanism 50 may be provided for one column member 211, in the present embodiment, from viewpoints of miniaturization and weight reduction, it is preferable that one drive mechanism 50 moves two or more column members 211 adjacent to each other. The number of the two or more column members 211 moved by one drive mechanism 50 is arbitrary, and is, for example, assumed to be two or more and ten or less. On the other hand, in a configuration in which one column member 211 is controlled by one drive mechanism 50, each column member 211 can be moved so as to follow a body of the user U, and therefore the user U can comfortably change a body position. A configuration in which a part of the drive mechanism 50 communicates with an interior of the column member 211 may also be adopted. In the above configuration, a part of the drive mechanism 50 is provided so as to penetrate the bottom surface portion of the column member 211.

[0036] As illustrated in FIGS. 2 and 4, an end portion of the column member 211 on a side opposite to the contact surface F (an end portion on a negative side in the Z direction) penetrates a surface of the container R on a side opposite to the contact surface F (a surface on the negative side in the Z direction) and is positioned inside the housing portion K. The end portion of the column member 211 on the negative side in the Z direction is connected to the drive mechanism 50 provided inside the housing portion K. Accordingly, the column member 211 becomes movable along the Z direction via the drive mechanism 50. Since the end portion of the column member 211 on the side opposite to the contact surface F is positioned inside the housing portion K, the drive mechanism 50 can be provided in a space outside the container R filled with the adjustment liquid L (an internal space of the housing portion K). The column member 211 and the drive mechanism 50 may be connected directly or indirectly. In the example illustrated in FIG. 4, a configuration is shown in which a cushioning material D is provided between the end portion of the column member 211 on the negative side in the Z direction and the drive mechanism 50. The cushioning material D is provided to absorb an impact from the drive mechanism 50, and is designed, for example, such that an area on the negative side in the Z direction of the column member 211 is large.

[0037] The housing portion K in which the drive mechanism 50 is accommodated is preferably composed of a plurality of layers from viewpoints of sound insulation and vibration isolation. Each layer of the housing portion K is made of, for example, plastic or polyurethane. When the drive mechanism 50 is hydraulic, it is preferable to provide a deodorizing agent (for example, charcoal) in the housing portion K.

[0038] As illustrated in FIG. 4, the column member 211

of the first embodiment includes a first portion 213 and a second portion 215. The second portion 215 is located on a positive side in the Z direction, and the first portion 213 is located on a negative side in the Z direction. The second portion 215 is a portion having a constant cross-sectional size at an end portion of the column member 211 on the contact surface F side. The first portion 213 is a portion whose cross-sectional size decreases toward an end portion on a side opposite to the contact surface F. In the first embodiment, the first portion 213 is provided from an end portion on the negative side in the Z direction of the second portion 215 (an end portion on a side opposite to the contact surface F) to an end portion on the negative side in the Z direction of the column member 211.

[0039] Here, a cross-sectional size of the column member 211 (the first portion 213 and the second portion 215) is an area of a shape formed by an outer edge in a cross section obtained by cutting the column member 211 along a plane parallel to an X-Y plane. The cross-sectional size of the column member 211 (the first portion 213 and the second portion 215) can also be expressed as a cross-sectional area obtained by cutting a structure, assuming that the column member 211 has a non-hollow structure, along a plane parallel to the X-Y plane.

[0040] As illustrated in FIG. 4, the first portion 213 is provided so as to extend over, for example, 1/2 or more (preferably 2/3 or more, more preferably 4/5 or more) of a length of the column member 211 along the Z direction, from viewpoints of weight reduction of the column member 211 and fluidity of the adjusting liquid L. On the other hand, the second portion 215 is provided so as to extend over, for example, 1/10 or more and less than 1/2 (preferably 1/8 or more and 1/3 or less, more preferably 1/7 or more and 1/4 or less) of the length of the column member 211 along the Z direction, from a viewpoint of strength of the column member 211.

[0041] However, a shape of the column member 211 is arbitrary as long as it includes the first portion 213. For example, a configuration in which an entire column member 211 is composed of the first portion 213, and a configuration including, in addition to the first portion 213 and the second portion 215, another portion (for example, a portion protruding from an end portion on the negative side in the Z direction of the first portion 213) are also included. In order to prevent the adjustment liquid L from leaking from the inside of the container R when the column member 211 moves, a waterproof structure is appropriately employed in a through hole of the container R through which the column member 211 penetrates. When the drive mechanism 50 is waterproof, the container R and the housing portion K may communicate with each other, and the adjustment liquid L may be filled in the housing portion K. However, from a viewpoint of weight reduction, a configuration in which only the container R is filled with the adjustment liquid L is preferable.

[0042] Since the column member 211 includes the first

portion whose cross-sectional size decreases toward an end portion on a side opposite to the contact surface F, weight reduction is possible, for example, as compared with a configuration in which a cross-sectional size of the column member 211 is constant along a longitudinal direction. Further, a sufficient gap is formed between the first portion 213 of one column member 211 and the first portion 213 of another adjacent column member 211. Therefore, fluidity of the adjustment liquid can be improved. In addition, since the column member includes, in addition to the first portion 213, the second portion 215 having a constant cross-sectional size, there is an advantage that sufficient strength can also be maintained.

[0043] Movement of each of the column members 211 of the auxiliary mechanism 21 of the first embodiment is controlled in accordance with biological information. Specifically, movement of the column members 211 is controlled by controlling the drive mechanism 50 in accordance with the biological information. In the first embodiment, movement of the column members 211 is controlled in accordance with a body position and a change period. That is, in the first embodiment, the auxiliary mechanism 21 is controlled in accordance with two types of biological information. A change in body position is typically turning over.

<Temperature Adjustment Mechanism 22>

[0044] The temperature adjustment mechanism 22 is a mechanism for adjusting (cooling or heating) a temperature of the adjustment liquid L in the container R. The temperature adjustment mechanism 22 is, for example, a circulation-type temperature adjustment device. The temperature adjustment mechanism 22 and the container R are connected by tubes through which the adjustment liquid L can be conveyed. The container R is provided with a discharge port for conveying the adjustment liquid L to the temperature adjustment mechanism 22 and a supply port for conveying the adjustment liquid L whose temperature has been adjusted by the temperature adjustment mechanism 22 to the container R. The discharge port and the temperature adjustment mechanism 22, and the supply port and the temperature adjustment mechanism 22, are respectively connected by tubes. The temperature adjustment mechanism 22 includes, for example, a pump for conveying the adjustment liquid L, a cooling unit capable of cooling the adjustment liquid L, and a heating unit capable of heating the adjustment liquid L. The cooling unit and the heating unit may be integrated or separate devices, and any known device (for example, a heat exchanger, a chiller, a heater, a heat pump, or a combination thereof) is appropriately used. The temperature of the adjustment liquid L is adjusted, for example, within a range of 18 to 26°C.

[0045] From a viewpoint of rapidly changing the temperature of the adjustment liquid L, it is preferable, for

example, to provide a plurality of temperature adjustment mechanisms 22 respectively corresponding to a plurality of temperature ranges. For example, within a range of 18 to 26°C, temperature adjustment mechanisms 22 corresponding to a low temperature range (for example, 18 to 19°C), a medium temperature range (20 to 21°C), and a high temperature range (22 to 26°C) are provided.

[0046] Each element constituting the temperature adjustment mechanism 22 (a pump, a cooling unit, and a heating unit) is preferably accommodated in a box-shaped housing portion composed of a plurality of layers. The housing portion preferably includes, for example, an innermost layer made of a heat-resistant plastic capable of fire prevention and prevention of chemical reactions, an outermost layer made of polyurethane capable of sound insulation and vibration isolation, and an intermediate layer made of plastic and functioning as a cushioning material, the intermediate layer being provided between the outermost layer and the innermost layer.

[0047] The temperature adjustment mechanism 22 is controlled in accordance with biological information. In the first embodiment, the temperature adjustment mechanism 22 is controlled in accordance with the body temperature of the user U.

<Humidity Adjustment Mechanism 23>

[0048] The humidity adjustment mechanism 23 is a mechanism for dehumidifying or humidifying. Specifically, the humidity adjustment mechanism 23 includes a plurality of air blowing devices (for example, compressors or fans) capable of sending air whose humidity has been adjusted (dehumidified or humidified). The humidity adjustment mechanism 23 is, for example, appropriately provided at positions around the mattress 20A such that air is blown onto the user U. Therefore, the humidity of the body surface of the user U can be adjusted by air blown from the humidity adjustment mechanism 23.

[0049] The humidity adjustment mechanism 23 is controlled in accordance with biological information. In the first embodiment, the humidity adjustment mechanism 23 is controlled in accordance with the humidity of the body surface of the user U.

<Processing Device 30>

[0050] The processing device 30 illustrated in FIG. 3 is a device that controls the drive mechanism 50, the temperature adjustment mechanism 22, and the humidity adjustment mechanism 23. The processing device 30 of the first embodiment is implemented by a computer system including a control device 31 and a storage device 32. For example, an information terminal such as a personal computer or a tablet is used as the processing device 30.

[0051] The control device 31 is composed of one or more processing circuits such as a CPU (Central Processing Unit), and comprehensively controls respective ele-

ments of the processing device 30. The storage device 32 is one or more memories composed of known recording media such as magnetic recording media or semiconductor recording media, and stores programs executed by the control device 31 and various data used by the control device 31. As illustrated in FIG. 3, the control device 31 of the first embodiment functions as a determination unit 311, a first control unit 321, a second control unit 322, and a third control unit 323.

[0052] The determination unit 311 determines whether the change period exceeds a predetermined threshold Z. That is, it is determined whether a predetermined period (threshold Z) has elapsed since the user U last changed a body position (turned over). The change period is specified from the detection signal S1 generated by the first acquisition unit 41.

[0053] The first control unit 321 controls the drive mechanism 50 in accordance with biological information (the change period and the body position) to move each of the column members 211 in the auxiliary mechanism 21. That is, movement of the column members 211 is controlled via the drive mechanism 50. Specifically, a timing at which each column member 211 moves and a position to which each column member 211 moves are controlled in accordance with the biological information.

[0054] First, the first control unit 321 controls a timing at which each of the column members 211 moves in accordance with the change period. Specifically, the first control unit 321 moves each of the column members 211 when the determination unit 311 determines that the change period exceeds the threshold Z. That is, when a body position has not been changed for a predetermined period, each of the column members 211 moves (the body position of the user U is changed). The threshold Z is set to, for example, 20 to 30 minutes from a viewpoint that turning over approximately every 30 minutes is effective for preventing snoring, sleep apnea, congestion, muscle stiffness, and the like.

[0055] Second, the first control unit 321 controls a position to which each of the column members 211 moves in accordance with the body position. The body position is estimated based on the detection signal S1 generated by the first acquisition unit 41. The body position is, for example, a position of a body axis of the user U. For example, it is estimated that the body position of the user U is located in a region of the contact surface F where the detection signal S1 indicating a load value exceeding a predetermined threshold is detected. Specifically, the first control unit 321 controls positions of the column members 211 such that the user turns over to a position different from the current body position.

[0056] Hereinafter, an example of movement of the plurality of column members 211 in the auxiliary mechanism 21 will be described. FIGS. 5 to 8 are explanatory views illustrating an example of movement of the column members 211 as viewed from the Y direction. In FIGS. 5 to 8, a state of the column members 211 when the user U changes a body position (turns over) from a supine

position to a lateral position is described.

[0057] As illustrated in FIGS. 5 to 8, for example, movement of the column members 211 is controlled so as to transition from a state A1 to a state A2, to a state A3, and to a state A4. As a result, the user U changes a body position (turns over) from a supine position to a lateral position. The body position is continuously specified during a period from the state A1 to the state A4. Movement of the column members 211 from the state A1 to the state A4 is performed by specifying the body position.

[0058] In general, the user U is caused to turn over by lowering tip ends (end portions on a positive side in the Z direction) of one or more column members 211 corresponding to either a left side or a right side of the user U as viewed from the Y direction among the plurality of column members 211.

[0059] A state A1 in FIG. 5 is a state of the column members 211 when the user U is in a supine position. As illustrated in FIG. 5, in the state A1, for example, positions in the Z direction of tip ends of all the column members 211 are the same. In FIG. 5, a case in which the positions in the Z direction of the tip ends of all the column members 211 are the same is illustrated as the state A1. However, in the state A1, for example, the tip ends of the column members 211 may be located at different positions such that no burden is imposed according to a body of the user U.

[0060] In a state A2 of FIG. 6, among the plurality of column members 211, one or more column members 211 corresponding to a predetermined width (a length in the X direction) on both left and right sides (a negative side and a positive side in the X direction) of the body position of the user U are lowered (moved to a negative side in the Z direction). As illustrated in FIG. 6, for example, the column members 211 are moved so as to be inclined from the body position side toward an end portion on the positive side and an end portion on the negative side in the X direction. Among the plurality of column members 211, the column members 211 located at the end portion on the positive side and the end portion on the negative side in the X direction are lowered at their tip ends by, for example, about 50 mm, as compared with the column member 211 corresponding to the body position. In the state A1, when the determination unit 311 determines that the change period exceeds the threshold Z, an operation of moving the plurality of column members 211 so as to transition from the state A2 to the state A4 is executed.

[0061] In a state A3 of FIG. 7, among the plurality of column members 211, one or more column members 211 located on either a left side or a right side of the user U are further lowered. Specifically, after setting the state A2, the column members 211 on a side to which the user U has voluntarily moved are further lowered. In FIG. 7, a case in which one or more column members 211 located on a right side (a positive side in the X direction) of the user U are further lowered from the state A2 is illustrated as an example. For example, an end portion on the positive

side in the X direction is lowered by about 50 mm from the state A2.

[0062] As illustrated in FIG. 7, the column members 211 may be moved such that a position corresponding to a right shoulder of the user U becomes lowest. On the other hand, one or more column members 211 located on a left side (a negative side in the X direction) of the user U are raised from the state A2 (for example, raised by about 100 mm). The distance by which the column members are lowered is arbitrary as long as the end portion on the positive side in the X direction is within 60 mm from the state A2. Similarly, the distance by which the column members are raised is arbitrary as long as the end portion on the positive side in the X direction is within 60 mm from the state A2.

[0063] In a state A4 of FIG. 8, from the state A3, one or more column members 211 located on the right side of the user U are further lowered, and one or more column members 211 located on the left side of the user U are further raised. For example, in the state A4, from the state A1, one or more column members 211 located on the right side of the user U are lowered by about 60 to 100 mm, and one or more column members 211 located on the left side of the user U are raised by about 60 to 100 mm. That is, a height difference of about 120 to 200 mm is generated among the plurality of column members 211.

[0064] By movement from the state A1 to the state A4, among the plurality of column members 211, one or more column members 211 on one side (on the right side in the first embodiment) of the user U as viewed from the Y direction move so as to be lowered, and one or more column members 211 on the other side (on the left side in the first embodiment) move so as to be raised. That is, a slope from one side to the other side of the user U as viewed from the Y direction among the plurality of column members 211 is made to have a gentle gradient. Since the body position of the user U changes in accordance with movement of the plurality of column members 211, it becomes possible to change the body position (turn over) from a supine position to a lateral position.

[0065] Among the plurality of column members 211, one or more column members 211 on a side to be lowered (a left side or a right side) are lowered over a width (about 400 mm) exceeding a shoulder width on the side to be lowered as viewed from the Y direction. On the other hand, among the plurality of column members 211, a side to be raised as viewed from the Y direction preferably has a width (a length in the X direction) as small as possible.

[0066] The above-described example of movement of the column members 211 when changing the body position of the user U from a supine position to a lateral position is not limited thereto. As long as the user U can be caused to turn over by lowering tip ends of one or more column members 211 on either a left side or a right side of the user U as viewed from the Y direction among the plurality of column members 211, a method of moving the column members 211 is arbitrary.

[0067] In the first embodiment, a case in which the

body position of the user U is changed from a supine position to a lateral position has been described as an example; however, the change in body position is not limited to the above example. For example, the column members 211 may be moved so that the user U changes from a supine position to a lateral position, or may be moved so that the user U changes from one supine position to another supine position.

[0068] The second control unit 322 controls the temperature adjustment mechanism 22 in accordance with the body temperature (biological information) of the user U. An example of a method by which the second control unit 322 controls the temperature adjustment mechanism 22 is described below; however, the method of controlling the temperature adjustment mechanism 22 is not limited to the above example.

[0069] The second control unit 322 controls the temperature adjustment mechanism 22 such that temperatures of respective body parts (a trunk, limbs, a neck, and a head) are maintained at target temperatures (hereinafter referred to as "target temperatures"). The temperatures of the respective body parts are specified from the detection signal S2 acquired by the second acquisition unit 42. For example, when there are no lesions such as inflammation in the respective body parts, the second control unit 322 controls the temperature adjustment mechanism 22 such that the target temperature of the trunk and the limbs is 26.0°C, that of the neck is 25.0°C, and that of the head is 18.0°C, and thereafter controls the temperature adjustment mechanism 22 such that the target temperatures of the respective body parts increase over time (+0.25 to 0.5°C/hour). However, it is not essential to control the temperature adjustment mechanism 22 such that the target temperatures change over time. When the body temperature specified by the detection signal S2 is lower than the target temperature, the temperature of the adjustment liquid L of the temperature adjustment mechanism 22 is controlled to be higher, and when the body temperature specified by the detection signal S2 is higher than the target temperature, the temperature of the adjustment liquid L of the temperature adjustment mechanism 22 is controlled to be lower.

[0070] The third control unit 323 controls the humidity adjustment mechanism 23 in accordance with the humidity of the body surface of the user U. An example of a method by which the third control unit 323 controls the humidity adjustment mechanism 23 is described below; however, the method of controlling the humidity adjustment mechanism 23 is not limited to the above example.

[0071] The third control unit 323 controls the humidity adjustment mechanism 23 such that humidity of body surfaces of respective body parts (a trunk, limbs, a neck, and a head) is maintained at a target humidity (hereinafter referred to as "target humidity"). The humidity of the respective body parts is specified from the detection signal S3 acquired by the third acquisition unit 43. For example, when there are no lesions such as inflammation in the respective body parts, the third control unit 323

controls the humidity adjustment mechanism 23 such that the target humidity of the respective body parts is 50% or less. When the humidity of the body surface specified by the detection signal S3 is lower than the target humidity, the humidity adjustment mechanism 23 is controlled to blow humid air, and when the humidity specified by the detection signal S3 is higher than the target humidity, the humidity adjustment mechanism 23 is controlled to blow dry air.

[0072] A method of setting the target temperature and the target humidity is arbitrary. For example, the user U may set the target temperature and the target humidity for each body part by input via an input device (not illustrated) of the processing device 30. Further, the target temperature and the target humidity may be changed over time.

[0073] As understood from the above description, in the first embodiment, each of the plurality of column members 211 moves independently, and therefore the mattress 20A can be moved for each region corresponding to each column member 211. That is, the mattress 20A can be moved in units of subdivided regions. Therefore, it is possible to appropriately assist a change in body position of the user U during sleep. As a result, the body position of the user U can be changed without causing the user U to take an unnatural posture.

[0074] In the auxiliary system 100 of the first embodiment, in particular, since movement of the plurality of column members 211 is controlled based on biological information, it is possible to assist a change in body position according to the user U. That is, it is possible to provide sleep optimized for each user U.

[0075] In the first embodiment, since movement of the plurality of column members 211 is controlled in accordance with the body position and the change period, it is possible to individually assist an optimal change in body position for each user.

[0076] Further, since the temperature adjustment mechanism 22 and the humidity adjustment mechanism 23 are incorporated in the mattress 20A, for example, even when it is difficult to appropriately maintain temperature and humidity in a room, it is possible to appropriately maintain the body temperature and humidity of the user U. That is, while adjusting temperature and humidity, it is possible to appropriately assist a change in body position of the user during sleep at any time. As understood from the above description, according to the auxiliary system 100 of the first embodiment, it is possible to provide comfortable sleep to the user.

[0077] In the first embodiment, from a viewpoint of achieving comfortable sleep of the user, it is preferable that pressure (load) from the user is uniform on the contact surface F. For example, a pressure value (load value) from the user is detected for each predetermined region on the contact surface F, and each column member 211 is moved such that the pressures in the respective regions become closer to each other. For example, the first acquisition unit 41 (an example of a "detection

unit") is provided for each region on the contact surface F. The pressure value from the user for each predetermined region on the contact surface F is detected as the detection signal S1 using the first acquisition unit 41. Then, the column members 211 are moved such that the pressure values indicated by the detection signals S1 obtained for the respective regions become closer to each other. That is, the column members 211 are moved such that variations in pressure values are eliminated within the plurality of regions.

[0078] For example, when a value of the detection signal S1 obtained from a specific first acquisition unit 41 is greater than a predetermined threshold, it can be said that a load from the user is large in a region of the contact surface F corresponding to the first acquisition unit 41. Therefore, one or more column members 211 located at a position corresponding to the first acquisition unit 41 are moved to a negative side in the Z direction. Further, when the value of the detection signal S1 obtained from a specific first acquisition unit 41 is smaller than the predetermined threshold, one or more column members 211 located at the position corresponding to the first acquisition unit 41 may be moved to a positive side in the Z direction. As long as the column members 211 can be moved such that the values of the detection signals S1 obtained for the respective regions approach each other, a specific method of controlling the column members 211 is not limited to the above example. Further, a sheet-shaped pressure distribution sensor capable of grasping pressure for each predetermined region of the contact surface F may be used as the first acquisition unit 41.

<Second Embodiment>

[0079] A second embodiment of the present invention will be described. In the following embodiments, elements having functions or operations similar to those of the first embodiment are denoted by the same reference numerals as those used in the first embodiment, and detailed descriptions thereof will be omitted as appropriate.

[0080] In the second embodiment, a pillow-type auxiliary system 100 is exemplified. In the second embodiment, a configuration other than a shape of the auxiliary system 100 is the same as that of the first embodiment.

[0081] FIG. 9 is a plan view of bedding according to the second embodiment. The auxiliary system 100 according to the second embodiment includes a pillow 20B, an auxiliary mechanism 21, a temperature adjustment mechanism 22, a humidity adjustment mechanism 23, a processing device 30, a sensor unit 40, and a drive mechanism 50.

[0082] FIG. 10 is a side view of the pillow 20B (a side view as viewed from a positive side in the X direction). The pillow 20B, similarly to the mattress 20A, includes the container R and the housing portion K. The container R includes a surface (contact surface F) on which a head is placed when the user U lies down. In the second embodi-

ment, illustration of the housing portion K is omitted; however, similarly to the first embodiment, the housing portion K is connected to the container R on a side opposite to the contact surface F of the container R. The drive mechanism 50 is provided inside the housing portion K similarly to the first embodiment.

[0083] As illustrated in FIG. 10, similarly to the first embodiment, the auxiliary mechanism 21 is provided inside the pillow 20B. The auxiliary mechanism 21 according to the second embodiment includes a plurality of column members 211, similarly to the first embodiment. In the second embodiment, a diameter of the column member 211 (a length of a diagonal of a regular hexagon) is, for example, 10 to 20 mm. Since a length of the column in the pillow, particularly in a portable pillow, is limited, an upper portion of the column is formed in a double structure, and when realizing turning over, in a column that becomes lower, the upper portion of the column is formed in a double structure so that a difference in length of the columns is maximized, thereby realizing turning over without awakening.

[0084] The temperature adjustment mechanism 22 of the second embodiment is a mechanism for adjusting a temperature of the pillow 20B. Therefore, it is possible to adjust a temperature of a head of the user U. The temperature adjustment mechanism 22 preferably has a configuration capable of adjusting temperature for each of a plurality of regions corresponding to a plurality of parts of the head of the user U in the pillow 20B.

[0085] It is preferable that, due to buoyancy of the adjustment liquid L, positions of end portions on a positive side in the Z direction of the respective column members 211 follow a shape of a body surface in accordance with a difference in distribution of body load. A similar configuration may also be employed in the first embodiment.

[0086] The humidity adjustment mechanism 23 is, similarly to the first embodiment, a mechanism for dehumidifying or humidifying. The humidity adjustment mechanism 23 is provided around the user U. The humidity adjustment mechanism 23 includes a plurality of air blowing devices (for example, compressors or fans) capable of sending air whose temperature and humidity have been adjusted. For example, the humidity adjustment mechanism 23 is provided at a position such that the air sent therefrom hits a head of the user U (particularly a neck) from the contact surface. Therefore, it is possible to adjust the humidity of the head of the user U by the air blown from the humidity adjustment mechanism 23.

[0087] The sensor unit 40 of the second embodiment includes the first acquisition unit 41, the second acquisition unit 42, and the third acquisition unit 43, similarly to the first embodiment.

[0088] The first acquisition unit 41 is, similarly to the first embodiment, a sensor used to specify a body position and a change period. In the second embodiment, the body position is a position of a head (for example, a center of gravity) of the user U on the contact surface.

[0089] The first acquisition unit 41, similarly to the first

embodiment, generates a detection signal S1 that varies in accordance with a load of the head of the user U on the contact surface F. The detection signal S1 is used to specify the body position and the change period, similarly to the first embodiment. For example, a plurality of first acquisition units 41 are provided at predetermined intervals in a region on the contact surface F side inside the pillow 20B (the container R).

[0090] The second acquisition unit 42 is, similarly to the first embodiment, a sensor that generates a detection signal S2 representing a body temperature of the user U. The second acquisition unit 42 is, for example, attached (affixed) to a plurality of positions on a head and a neck of the user U.

[0091] The third acquisition unit 43 is, similarly to the first embodiment, a sensor that generates a detection signal S3 representing humidity of a body surface of the user U. The third acquisition unit 43 is, for example, attached to positions on the body surface of the user U that are the same as those of the second acquisition unit 42.

[0092] The first control unit 321 controls movement of each of the column members 211 in the auxiliary mechanism 21 in accordance with the change period and the body position, similarly to the first embodiment. First, the first control unit 321 controls a timing at which each of the column members 211 moves in accordance with the change period. Specifically, the first control unit 321 moves each of the column members 211 when the determination unit 311 determines that the change period exceeds the threshold Z. Second, the first control unit 321 controls a position to which each of the column members 211 moves in accordance with the body position.

[0093] The second control unit 322 controls the temperature adjustment mechanism 22 in accordance with the body temperature (biological information) of the user U, similarly to the first embodiment. The third control unit 323 controls the humidity adjustment mechanism 23 in accordance with the humidity of the body surface of the head of the user U, similarly to the first embodiment.

[0094] Hereinafter, an example of movement of the plurality of column members 211 in the auxiliary mechanism 21 according to the second embodiment will be described. FIGS. 12 to 14 are explanatory views illustrating an example of movement of the column members 211 as viewed from the Y direction. In FIGS. 12 to 14, a state of the column members 211 when the user U changes a body position (turns over) from a supine position to a lateral position is described.

[0095] As illustrated in FIGS. 12 to 14, for example, movement of the column members 211 is controlled so as to transition from a state B1 to a state B2, to a state B3, and to a state B4. As a result, the user U changes a body position (turns over) from a supine position to a lateral position. The body position is continuously specified during a period from the state B1 to the state B4. Movement of the column members 211 from the state B1 to the state B4 is performed by specifying the body position.

The states B1 to B4 correspond to the states A1 to A4 in the first embodiment.

[0096] In general, the user U is caused to turn over by lowering tip ends (end portions on a positive side in the Z direction) of one or more column members 211 on either a left side or a right side of the user U as viewed from the Y direction among the plurality of column members 211.

[0097] A state B1 in FIG. 11 is a state of the column members 211 when the user U is in a supine position. In a state B2 of FIG. 12, among the plurality of column members 211, one or more column members 211 corresponding to a predetermined width on both left and right sides (a negative side and a positive side in the X direction) of the head of the user U are lowered (moved to a negative side in the Z direction). As illustrated in FIG. 12, for example, the column members 211 are moved so as to be inclined from the body position side toward an end portion on the positive side and an end portion on the negative side in the X direction. Among the plurality of column members 211, the column members 211 located at the end portion on the positive side and the end portion on the negative side in the X direction are lowered at their tip ends by, for example, about 15 mm, as compared with the column member 211 corresponding to the body position. In the state B1, when the determination unit 311 determines that the change period exceeds the threshold Z, an operation of moving the plurality of column members 211 so as to transition from the state B2 to the state B4 is executed.

[0098] In a state B3 of FIG. 13, among the plurality of column members 211, one or more column members 211 corresponding to a predetermined width located on either a left side or a right side of the head of the user U are further lowered. Specifically, after setting the state B2, the column members 211 on a side to which the head of the user U has voluntarily moved are further lowered. In FIG. 13, a case in which one or more column members 211 located on a right side (a positive side in the X direction) of the head are further lowered from the state B2 is illustrated as an example. For example, an end portion on the positive side in the X direction is lowered by about 15 mm from the state B2.

[0099] On the other hand, one or more column members 211 corresponding to a predetermined width located on a left side (a negative side in the X direction) of the user U are raised from the state B2 (for example, raised by about 15 mm). The distance by which the column members are lowered is arbitrary as long as the end portion on the positive side in the X direction is within 15 mm from the state B2. Similarly, the distance by which the column members are raised is arbitrary as long as the end portion on the positive side in the X direction is within 15 mm from the state B2.

[0100] In a state B4 of FIG. 14, from the state B3, one or more column members 211 located on a right side of the head of the user U are further lowered, and one or more column members 211 located on a left side of the user U are further raised. For example, in the state B4, from the

state B1, one or more column members 211 located on the right side of the user U are lowered by about 30 to 60 mm, and one or more column members 211 located on the left side of the user U are raised by about 30 to 60 mm.

That is, a height difference of about 60 to 120 mm is generated among the plurality of column members 211.

[0101] By movement from the state B1 to the state B4, among the plurality of column members 211, one or more column members 211 on one side (on the right side in the first embodiment) of the user U as viewed from the Y direction move so as to be lowered, and one or more column members 211 on the other side (on the left side in the first embodiment) move so as to be raised. That is, a slope from one side to the other side of the user U as viewed from the Y direction among the plurality of column members 211 is made to have a gentle gradient. Since the body position of the user U changes in accordance with movement of the plurality of column members 211, it becomes possible to change the body position (turn over) from a supine position to a lateral position.

<Modifications>

[0102] The embodiments described above can be modified in various ways. Specific modes of modification are exemplified below. Two or more modes arbitrarily selected from the following examples may be appropriately combined.

(1) In the above embodiments, the change period is used to control a timing of moving the column members 211; however, the biological information used to control the timing of moving the column members 211 is not limited to the above example. For example, various types of information described below are used to control the timing of moving the column members 211.

[Information on Snoring]

[0103] The information on snoring is, for example, a volume of snoring of the user U. The first acquisition unit 41 (for example, a microphone) collects the snoring of the user U and generates a detection signal S1 corresponding to the sound. The determination unit 311 specifies the volume of the snoring represented by the detection signal S1 and compares the volume with a predetermined threshold. The first control unit 321 moves the column members 211 when the determination unit 311 determines that the volume of the snoring exceeds the predetermined threshold. The information on snoring is not limited to the volume of snoring. For example, a frequency of snoring may also be used as the information on snoring.

[Information on Respiration]

[0104] The information on respiration is, for example, a

respiration rate of the user U. The first acquisition unit 41 is any sensor capable of detecting respiration of the user U, and generates a detection signal S1 representing the respiration of the user U. The determination unit 311 specifies the respiration rate in a predetermined period from the detection signal S1 and compares the respiration rate with a predetermined threshold. The first control unit 321 moves the column members 211 when the determination unit 311 determines that the respiration rate is lower than the predetermined threshold.

[0105] The period of apnea may also be used as the information on respiration. The determination unit 311 specifies the period of apnea from the detection signal S1 and compares the period with a predetermined threshold. The first control unit 321 moves the column members 211 when the determination unit 311 determines that the period exceeds the predetermined threshold. The information on respiration is not limited to the respiration rate and the period of apnea.

[Information on Heartbeat]

[0106] The information on heartbeat is, for example, a heart rate of the user U. The first acquisition unit 41 is any sensor capable of detecting the heart rate of the user U, and generates a detection signal S1 representing the heart rate of the user U. The determination unit 311 specifies the heart rate in a predetermined period from the detection signal S1 and compares the heart rate with a predetermined threshold. The first control unit 321 moves the column members 211 when the determination unit 311 determines that the heart rate exceeds (or falls below) the predetermined threshold.

[0107] The occurrence of arrhythmia may also be used as the information on heartbeat. The determination unit 311 detects the occurrence of arrhythmia from the detection signal S1. The first control unit 321 moves the column members 211 when the determination unit 311 detects arrhythmia.

[0108] As understood from the above description, the biological information used to control the timing of moving the column members 211 is arbitrary. The biological information used to control the timing of moving the column members 211 is not limited to the above examples. For example, various types of information such as body temperature, body movement, and humidity of the body surface are exemplified as biological information used to control the timing of moving the column members 211. A plurality of types of biological information may be combined and used to control the timing of moving the column members 211.

[0109] (2) The biological information used to control a position to which each of the column members 211 moves is not limited to the body position. For example, various types of information such as body temperature, body movement, and humidity of the body surface are exemplified as biological information used to control the position to which the column members 211 move. A

plurality of types of biological information may be combined and used to control the position to which the column members 211 move. As understood from the above description, the biological information is a general term for information used to control the auxiliary mechanism 21. Sensors corresponding to types of biological information are appropriately employed for the first acquisition unit 41.

[0110] (3) The biological information used to control the temperature adjustment mechanism 22 is not limited to the body temperature of the user U. For example, various other types of biological information may be used to control the temperature adjustment mechanism 22. Similarly, the biological information used to control the humidity adjustment mechanism 23 is not limited to the humidity of the body surface of the user U.

[0111] (4) In the above embodiments, for example, a configuration may be adopted in which the user U evaluates a degree of comfortable sleep (for example, on a 10-point scale) at the time of waking after sleeping using the auxiliary system 100. The user U inputs the evaluation using an input device. The second control unit 322 may set the target temperature in consideration of the evaluation by the user U. Similarly, the third control unit 323 may set the target humidity in consideration of the evaluation by the user U. That is, the second control unit 322 and the third control unit 323 may perform feedback control of the temperature adjustment mechanism 22 and the humidity adjustment mechanism 23 based on the evaluation by the user U.

[0112] In the above configuration, the second control unit 322 may set the target temperature (a target temperature estimated to enable the user U to achieve the most comfortable sleep) using a trained model that has learned a relationship between a degree of comfortable sleep and the target temperature. A trained model that has learned a relationship between the degree of comfortable sleep, various other parameters (such as ambient temperature, body temperature, humidity, psychological state, bowel movement, urination, atmospheric pressure, season, etc.), and the target temperature may also be used. Similarly, the third control unit 323 may set the target humidity (a target humidity estimated to enable the user U to achieve the most comfortable sleep) using a trained model that has learned a relationship between the degree of comfortable sleep and the target humidity. A trained model that has learned a relationship between the degree of comfortable sleep, various other parameters (such as ambient temperature, body temperature, humidity, psychological state, bowel movement, urination, atmospheric pressure, season, etc.), and the target humidity may also be used. Similarly, the first control unit 321 may control the plurality of column members 211 using a trained model that has learned a relationship between the degree of comfortable sleep and various other parameters (such as physical condition, ambient temperature, body temperature, humidity, psychological state, bowel movement, urination,

atmospheric pressure, season, etc.), and control of the plurality of column members 211 (the drive mechanism 50).

[0113] The trained model is a statistical estimation model generated by machine learning. For example, various statistical estimation models such as decision trees or neural networks are suitably used as the trained model. The trained model is implemented by a combination of a program (for example, a program module constituting artificial intelligence software) that causes the control device 31 to execute an operation of generating output data from input data, and a plurality of coefficients applied to the operation. The plurality of coefficients are set by machine learning (in particular, deep learning) using a large amount of training data and are stored in the storage device 32.

[0114] For a user U who uses the auxiliary system 100 of the present invention for the first time, when there is no lesion in each body part, such as inflammation or chronic fatigue, the target humidity is set to 50% or less (43% to 50%), and the target temperatures are set to, for example, 26.0°C for the trunk and limbs, 25.0°C for the neck, and 18.0°C for the head. Then, the user U evaluates the degree of comfortable sleep upon waking when the humidity is set over time such that, in each body part, the target humidity is always maintained at 50% or less while the target temperature is set to rise at 0.25 to 0.5°C/hour. As described above, a configuration may also be adopted in which an evaluation for each body part is input. However, it is not essential to control the humidity adjusting mechanism 23 and the temperature adjusting mechanism 22 for each body part.

[0115] The first control unit 321 may control movement of the column member 211 of the auxiliary mechanism 21 in consideration of an evaluation by the user U. For example, the first control unit 321 controls movement of the column member 211 by using a trained model that has learned a relationship between a degree of comfortable sleep and movement of the column member 211 (for example, timing and a movement position).

[0116] According to a configuration in which the temperature adjusting mechanism 22 and the humidity adjusting mechanism 23 are controlled using a trained model, it is possible to individually optimize a target temperature and a target humidity for each user U. As a result, it is possible to promote comfortable sleep for the user U.

[0117] (5) In each of the above embodiments, bedding in which the mattress 20A and the pillow 20B are integrated may be used in the auxiliary system 100. Also in the bedding in which the mattress and the pillow 20B are integrated, the constituent elements and control methods of the auxiliary mechanism 21, the temperature adjusting mechanism 22, and the humidity adjusting mechanism 23 are the same as those in the above embodiments.

[0118] (6) In the second embodiment, the bedding is portable (and may be used with a storage battery). A material of the housing R of the bedding is washable.

Several types of the pillow 20B are prepared, ranging from a large one to a small portable one, and in a case of a combination with the mattress 20A, the number is limited to two small types. In a case where the pillow 20B is used alone, for the largest type, a length is longer than a distance from a top of the head to below a scapula and is about 700 to 900 mm, and a width is similarly about 700 to 900 mm. In a case of the combination and also in a case of a portable type usable alone, a length is from the top of the head to an upper portion of the neck and is about 250 to 350 mm, and a width exceeds a shoulder width and is about 450 to 600 mm. A height is determined so as to facilitate turning over from a lateral position, and is obtained by subtracting, from the shoulder width, a length from a body axis (rotation) center to a side temporal region via a center of the neck (with a certain allowance in consideration of individual comfort). In a case of turning over from a supine position, the height is set slightly lower than that in the lateral position, based on a distance from a body axis center and a head center to an end of an occipital region. Since a length of the column in the pillow is particularly limited in a portable pillow, an upper portion of the column is formed in a double structure. When turning over is realized, for a column that becomes lower, the upper portion of the column is formed in a double structure so as to maximize a difference in column length and to realize turning over without awakening. As described above, as long as an overall weight is within a portable range, a certain allowance is provided in accordance with an individual body size.

[0119] (7) In each of the above embodiments, the auxiliary mechanism 21, the temperature adjusting mechanism 22, and the humidity adjusting mechanism 23 may be controlled in consideration of a weight, height, age, sex, and medical history of the user U.

[0120] (8) In each of the above embodiments, the first control unit 321 may move the column member 211 at predetermined intervals in accordance with biological information.

[0121] (9) In each of the above embodiments, a material of the bedding (particularly the housing R) is preferably a hygroscopic material, and is further selected with particular consideration given to measures against condensation and static electricity that accompany a case where the target temperature of the temperature adjusting mechanism 22 is lowered.

[0122] (10) In each of the above embodiments, a method for controlling the auxiliary mechanism 21, the temperature adjusting mechanism 22, and the humidity adjusting mechanism 23 may be as follows.

<Mattress 20A>

[0123] The second control unit 322 controls the temperature adjusting mechanism 22 such that, based on the finding that comfortable cooling of the head helps to lower a brain temperature elevated due to daytime overheating and thereby makes sleep more comfortable, at the time of

falling asleep the head and the neck are set to 20 to 24°C, which is 10°C or more lower than a body temperature, and even in the morning when the body temperature rises endocrinologically toward waking, the temperature is set to 28°C, which is 7°C or less lower than a trunk body temperature.

[0124] Comfortable sleep is greatly influenced by meals, particularly a timing and content of dinner. In addition, a state of sympathetic nervous system excitation caused by coffee intake or smoking after dinner, excessive fluid intake, or intense exercise may also interfere with sleep, and thus requires attention. In recent years, it has become known that various hormone-like substances produced by an intestinal microbiota, which is estimated to exceed 100 trillion microorganisms, including neurotransmitters such as serotonin, interact with bioactive polypeptides, the central nervous system, and immune systems inside and outside the intestinal tract. It has also been clarified that sleep and an intestinal environment (a balance between the intestinal microbiota and intestinal immunity) have significant mutual influences. For example, it is important for comfortable sleep whether dietary fiber, which serves as food for so-called beneficial bacteria in the intestinal microbiota, is sufficiently ingested, and also important are secretion of various hormones in relation to a biological clock, as well as meal timing and sleep timing.

[0125] That is, although it depends on a degree of obesity, an accumulation of visceral fat, elevation of the diaphragm, and presence or absence of a hiatal hernia, it is well known that, when a time from dinner to falling asleep is short, within 1 to 2 hours, gastroesophageal reflux is very likely to occur, and sleep is often disturbed by heartburn, coughing, and the like. Furthermore, in the case of a meal rich in meat and fat, digestion takes time, and an interval of 3 to 4 hours is required. In the case of a vegetable-centered meal, since a burden on the stomach is light, an interval of 2 to 3 hours is considered sufficient. Therefore, for a late dinner, a salad and soup are preferable. Recently, a relationship between the intestinal microbiota and sleep has also been discussed, and a vegetable-centered diet containing sufficient dietary fiber is also better in relation to bowel movements.

[0126] From the above viewpoints, in order to prevent gastroesophageal reflux and also to reduce a burden on the heart, the column members 211 of the auxiliary mechanism 21 may be controlled such that an upper body portion of the bedding at the time of falling asleep is raised by about 10 to 20 degrees, and thereafter, including turning over, the angle is reduced over 1 to 3 hours after falling asleep in accordance with a sleep state, so as to be lowered to 0 to 5 degrees.

[0127] An interval between a bathing time and a sleep onset time also has significant importance. That is, after bathing for about 5 to 10 minutes in a lukewarm half-body bath at 39 to 40°C, a body temperature decreases and drowsiness tends to occur, and it is preferable to go to bed after about 1.5 hours, if possible. Such daily information is

also required to be input in order to achieve comfortable sleep. In addition, depending on a time until falling asleep, when the time is short, an initial set temperature of a portion of the temperature adjusting mechanism 22 corresponding to an upper body portion (adjusting liquid L) may be set lower than usual, in order to enhance drowsiness, when it is difficult to adjust a room temperature.

[0128] It is aimed to eliminate intermediate awakenings occurring 2 to 5 times, which most disturb a feeling of comfortable sleep and tend to cause a depressed mood, and early morning awakenings occurring from 1:00 to 5:00 a.m. In particular, when intermediate awakening or early morning awakening occurs, such as in shift work, whether re-sleep is possible is also an important point. Therefore, when a load of a head or a body weight, for example, disappears for 1 minute or more, it is regarded as an awakened state, and the state is brought closer to that at the time of falling asleep. That is, for example, when the awakened state continues for 10 minutes or more, a target body temperature of the temperature adjusting mechanism 22 and a target humidity of the humidity adjusting mechanism 23 are reset to states at the time of falling asleep to facilitate re-sleep. Further, when falling asleep cannot be smoothly achieved, each time, an initial temperature setting is set lower than an initially set temperature by 1 to 2°C or more, for example, 20 to 22°C for a head and neck, 22 to 24°C for a chest portion, and 24 to 26°C for a lower body portion, and temporal changes in a target body temperature and a target humidity up to a scheduled wake-up time are reset, thereby achieving comfortable sleep and comfortable awakening at an initially set wake-up temperature.

[0129] In order to make awakening comfortable, toward a scheduled wake-up time, the temperature of the temperature adjusting mechanism 22 is increased, and at the same time, awakening is promoted also from aspects of light and sound by indirect illumination that becomes brighter with passage of time from 30 to 60 minutes before waking, by a lighting device provided on a side surface of the auxiliary system 100. In addition, a function serving also as an alarm clock by sound without discomfort is provided by an audio system provided in the auxiliary system 100. Further, when the user does not wake up even after the scheduled time (when a body weight load on the bedding does not disappear), a vibration device that increases with time is also activated to promote awakening.

<Pillow 20B>

[0130] First, for comfortable sleep, not only ease of falling asleep but also whether a proportion of deep sleep (a proportion of NREM stage 3) can be secured at 20 to 25% or more, whether turning over is easy, whether awakening is natural at the time of waking, and whether there are a feeling of recovery from fatigue and a feeling of comfortable and satisfying sleep are important. In

addition, it is also important that there are no symptoms such as a heavy head, headache, pain in various parts of the body, fever, fatigue, malaise, or a mentally or psychologically depressive tendency, and that there is a positive feeling toward work.

[0131] As understood from the above description, the target body temperature and the target humidity are not always constant values, and may be changed over time or may be changed depending on various factors.

[0132] (11) Not limited to novel coronavirus, counter-measures against infectious diseases caused by microorganisms such as viruses, bacteria, and fungi are required. Therefore, in the humidity adjusting mechanism 23 according to a modified example, a configuration relating to infection control is adopted. FIG. 16 is a configuration diagram of the humidity adjusting mechanism 23 according to the modified example. As illustrated in FIG. 16, the humidity adjusting mechanism 23 includes a compressor, an ultraviolet irradiation device, a moisture absorption layer, and an activated carbon layer. Air discharged from the compressor is supplied to the bedding 20 (20A, 20B) via a tube. The ultraviolet irradiation device, the moisture absorption layer, and the activated carbon layer are provided between the compressor and the bedding.

[0133] Air discharged from the compressor (for example, having a wind speed of 0.05 to 0.1 m/s) first passes through the ultraviolet irradiation device. The ultraviolet irradiation device includes, for example, a constant temperature chamber and a UVC lamp (germicidal lamp). A tube is disposed in the constant temperature chamber set to a predetermined temperature (for example, settable at each 1°C within a range of 18°C to 28°C), and the tube is irradiated with the UVC lamp. For example, irradiation with the UVC lamp is performed for 10 seconds or more, which exhibits a sufficient effect of killing and eliminating microorganisms such as viruses and bacteria. Further, in the ultraviolet irradiation device, a predetermined humidity (for example, settable at each 2% within a range of 40% to 52%) can be set.

[0134] Air that has passed through the ultraviolet irradiation device further passes through a moisture absorption layer (for example, silica gel) capable of adjusting humidity, and is then supplied to an activated carbon layer. In the activated carbon layer, ozone generated in the ultraviolet irradiation device is captured. Then, the air that has passed through the activated carbon layer is supplied to positions corresponding to respective parts of the bedding. Note that the moisture absorption layer is not essential.

[0135] An ultraviolet irradiation device may also be provided for each part of the body. The humidity adjusting mechanism 23 may be entirely provided inside the bedding, or a part thereof may be provided outside the bedding. In FIG. 16, a configuration in which the humidity adjusting mechanism includes one ultraviolet irradiation device is illustrated as an example; however, the number of ultraviolet irradiation devices is arbitrary and may be

appropriately changed depending on a length of the tube. Regardless of the number of ultraviolet irradiation devices, from a viewpoint of obtaining a sufficient effect of killing and eliminating microorganisms, a configuration that enables irradiation with the UVC lamp for 10 seconds or more in total is preferable.

[0136] It is expected that the temperature and humidity in the humidity adjusting mechanism 23 will change before reaching respective parts of the body. Therefore, a relationship between the temperature and humidity in the humidity adjusting mechanism 23 and the temperature and humidity at respective parts may be learned by machine learning in a trained model for each air volume and air velocity, including factors such as an outside air temperature and humidity, weather, a body temperature of the user, and a physical condition including inflammation at respective parts. Then, the temperature and humidity in the humidity adjusting mechanism 23 may be set using the trained model.

[0137] (12) In the auxiliary system 100 according to each of the above embodiments, movement of the external auxiliary mechanism 21 (column members 211) that excessively restricts voluntary movement of the user may, to a certain extent, interfere with comfortable sleep. Therefore, first, for a purpose of detecting voluntary movement of a body axis, a center of gravity, or breathing of the user U, under an arbitrary initial setting of a target temperature and a target humidity, for 1 (normal) to 2 (in cases such as shift work) weeks after use, the system is kept in a flat state, and movements such as limbs movement, body movement, and turning over of the user under conditions of atmospheric pressure, temperature, and humidity are monitored and recorded over time using various parameters such as body weight, heart rate, respiration, snoring, and body temperature change. Then, sleeping posture, body movement, and turning over are accurately recorded and grasped as temporal changes on a three-dimensional coordinate axis in terms of temporal, physical, or spatial changes, and are utilized for conditions at a next use or for realization of induced turning over.

[0138] Further, before use and during a period of 1 (normal) to 2 (in cases such as shift work) weeks during use, the user U may check a comfortable sleep checklist, and a feeling of comfortable sleep and satisfaction may be used for setting the target temperature and the target humidity. Movements such as limbs movement, body movement, and turning over of the user U may be monitored and recorded over time using various parameters such as body weight, respiration, snoring, and body temperature change, and sleeping posture, body movement, and turning over may be recorded as temporal changes on a three-dimensional coordinate axis in terms of temporal, physical, or spatial changes, and may be utilized for initial conditions or for assisting a change in body position. As the comfortable sleep checklist, for example, treatment may be changed in multiple stages as follows.

8 points or less: no change

9 to 14 points: adjustment by a device operator is required

15 to 20 points: instructions such as a change in prescription by an attending physician are required

21 points or more: consultation with a sleep specialist or a neuropsychiatric specialist is required

[0139] (13) In each of the above embodiments, at the time of explanation before use, the auxiliary mechanism 21, the humidity adjusting mechanism 23, and the temperature adjusting mechanism 22 may be controlled in consideration of the following various types of information.

[0140] A cohabiting family composition (including presence or absence of stress and caregiving status), height and weight (BMI), medical history (particularly cerebrovascular disease such as stroke and heart disease such as arrhythmia), complications (including nasal and oral conditions such as chronic tonsillitis and sinusitis), current conditions (including hypertension, diabetes, heart disease such as heart failure, cerebrovascular disorders, asthma, emphysema, liver disease, and depression), family history, lifestyle history (sleep habits (sleeping posture (mainly supine position, right lateral position, left lateral position), sleep time (including naps and returning to sleep)), bathing (time and temperature, including sauna), coffee (time (daytime, after evening), amount), etc.), smoking (past smoking, current smoking, passive smoking), alcohol consumption (frequency, amount, presence or absence of flushing), preferences, allergy history (including hay fever and asthma), usual blood pressure, pulse rate, and body temperature, recent symptoms, usual meal time, meal contents, presence or absence of snacks (contents), work content (presence or absence of stress (including interpersonal relationships)) and time zone (including night shifts and shift work), and an AHI value at a time of diagnosis of sleep apnea syndrome are input by the user U via an input device.

[0141] Further, if possible, on a daily basis, during a period from dinner to before sleep, the user U is caused to input a physical condition of the day, stress at work, exercise time and content, meal time and content, presence or absence and amount of alcohol consumption, bathing time and content, and the like. In addition, after waking, the user U is also caused to input sleep time and content (including the number of awakenings and the number of times of going to the toilet during the night), a physical condition at waking, symptoms such as a feeling of comfortable sleep, headache, and dryness, and a state and malfunction of the device.

[0142] In addition, it is possible to pursue better comfort by reviewing on a 1- to 4-week basis or by comparison with a conventional average or a previous week/period. Further, as items relating to subjective symptoms, situa-

tions in which daytime drowsiness occurs (for example, dozing off almost always, when sitting and reading a newspaper or book, when sitting and watching TV, when sitting quietly during a meeting or in a movie theater or theater, when riding in a car driven by another person for one hour continuously, when lying down and resting in the afternoon, when sitting and talking with another person, when sitting quietly after lunch without drinking alcohol, when driving by oneself, when stopped for several minutes due to traffic congestion, etc.) are input, and it is also input whether or not the following symptoms are present: frequent snoring, awakening due to breathing difficulty, awakening due to urge to urinate two or more times during the night, feeling of decreased memory or concentration, feeling of fatigue and inability to recover from fatigue, being told by a family member that breathing stops or apnea for several minutes occurs during sleep, light sleep at night or frequent awakenings, heaviness of the head or headache at the time of waking or in the morning, lack of a feeling of deep sleep at the time of waking and feeling of chronic sleep deprivation, and drinking alcohol daily as a substitute for sleeping medication.

[0143] (14) In each of the above embodiments, a case where bedding (the mattress 20A and the pillow 20B) is used as the auxiliary system 100 has been described as an example; however, for example, as illustrated in FIG. 17, a chair-type auxiliary system 100 may also be adopted. The auxiliary system 100 includes a chair 20C instead of the bedding (the mattress 20A and the pillow 20B). Except for including the chair 20C instead of the bedding (the mattress 20A and the pillow 20B), the configuration is the same as in each of the above embodiments. The chair 20C includes the housing R and a housing body K (not shown). The housing R is formed so as to have a shape of a chair on which the user U sits. The housing R is configured to include, for example, a seat portion and an armrest portion. For example, by adjusting a height of the seat portion and a height of the armrest portion by the column members 211, it is possible to facilitate standing up of the user U. Also in the chair, particularly in a reclining type, rather than dispersing a body weight load, leveling thereof is possible, and a more comfortable sitting feeling can be realized. As understood from the above description, in the present invention, the housing R is a portion on which the whole body or a part of the body of the user U is placed (a portion to which a load is applied). The auxiliary system 100 is not limited to a bedding type or a chair type, and may be any structure having a function of supporting the whole body or a part of the body of the user U and in which a change in body position is assumed. A shape of the housing R may be appropriately changed according to the application.

[0144] (15) Sweating observed over time during sleep increases body surface humidity and also causes a decrease in body surface temperature. Therefore, control of temperature and humidity during sleep is required to be performed in accordance with passage of time, including

physical and mental conditions such as changes in body temperature, humidity, and sweating at respective parts of the body.

[0145] In consideration of the above circumstances, in the auxiliary system 100, a configuration is preferably adopted in which the second control unit 322 controls the temperature adjusting mechanism 22 such that the temperature of the bedding (particularly the mattress 20A) changes over time while the user U is sleeping. In the above configuration, it is preferable that the auxiliary system 100 includes any known sensor capable of measuring whether the user has fallen asleep and a time elapsed after falling asleep.

[0146] Specifically, before falling asleep, the second control unit 322 lowers the temperature of the temperature adjusting mechanism 22 so that a deep body temperature of a trunk portion together with a head and neck portion decreases, thereby calming excitation of the sympathetic nervous system and enabling smooth sleep onset. On the other hand, if the deep body temperature of the trunk portion continues to decrease during sleep, a hypothermic state may occur, causing deterioration of functions of internal organs and tissues such as the viscera, and also making it difficult to recover from fatigue, which may result in a feeling of malaise or fatigue after waking and a lack of refreshment or positive mood. Therefore, the second control unit 322 gradually increases the temperature of the temperature adjusting mechanism 22 with passage of time from after falling asleep to before waking. An increase in the deep body temperature consequently raises a temperature of blood flow to the brain. In addition, in order to prevent heaviness of the head or headache and to obtain a refreshed feeling, it is also preferable to increase the temperature of the head and neck portion, for example, from 30 minutes before waking, thereby reliably ensuring comfortable sleep.

[0147] In the above configuration, it is further preferable to adopt a configuration in which a temperature is individually controlled for a portion corresponding to the head and neck and a portion corresponding to the trunk (a portion below the neck) in the bedding. The second control unit 322 controls the temperature adjusting mechanism 22 such that the temperature of portions (regions) of the bedding corresponding to body parts changes so that the deep body temperature of the user U described above changes over time. Further, the second control unit 322 controls the temperature adjusting mechanism 22 such that the portion of the bedding corresponding to the head and neck does not significantly reduce brain function or cerebral circulation and allows sufficient deep sleep (non-REM sleep stage 3) to be obtained.

[0148] The second control unit 322 may also control the temperature adjusting mechanism 22 in accordance with a depth of sleep of the user U. For example, when the user U is in a state of intermediate awakening due to nocturnal urination or early morning awakening, or when

the user U is in non-REM sleep stage 1 or 2, or in a REM sleep state before one hour prior to a scheduled wake-up time after falling asleep, the second control unit 322 controls the temperature adjusting mechanism 22 such that the deep body temperature decreases to increase deeper sleep (non-REM sleep stage 3) and to improve a balance of the autonomic nervous system. On the other hand, when the user U is in a REM sleep state within one hour before the scheduled wake-up time, the second control unit 322 controls the temperature adjusting mechanism 22 such that the deep body temperature increases.

[0149] In the above configuration, it is preferable that the auxiliary system 100 includes a sensor that detects a sleep state of the user U, and that a degree of comfortable sleep at the time of waking is input and fed back to be learned by AI for improvement. It is known that a growth hormone, most of which is secreted during deep sleep within three hours after falling asleep, plays an important role in maintenance of internal organs and also in maintenance of hair; therefore, it is necessary to secure deep sleep time within three hours after falling asleep.

[0150] Further, in addition to control of the temperature adjusting mechanism 22 over time, the second control unit 322 may control the temperature adjusting mechanism 22 in accordance with individual circumstances such as a physical and mental condition of the user U before sleep (for example, environment such as work and home, overwork, stress, etc.), a lifestyle condition (for example, bathing, exercise, presence or absence of intake of preferences, etc.), and presence or absence of disease.

[0151] Similarly, in the auxiliary system 100, a configuration is preferably adopted in which the third control unit 323 controls the humidity adjusting mechanism 23 such that humidity of the bedding changes over time while the user U is sleeping.

[0152] (16) Temperature control of the trunk and limbs is insufficient if only the temperature of the head and brain is controlled; therefore, from a viewpoint of reducing the deep body temperature necessary for falling asleep and allowing natural turning over, the auxiliary system 100 may adopt the following configuration.

[0153] Perceived temperature is closely related to humidity. Specifically, temperature and humidity that change over time during sleep are greatly influenced, in addition to external humidity, by an amount of perspiration of the user (which is affected by factors such as perspiration ability, water intake, and amount of exercise). Therefore, in order to achieve comfortable sleep, it is preferable to control humidity and airflow, together with temperature, in addition to controlling temperature during sleep.

[0154] Perceived temperature of respective parts of the body during sleep, humidity around the body, and turning over also vary depending on daytime physical and mental conditions, physical activity, meals, water intake, and temperature and humidity of an environment in which the user has spent time. Therefore, it is prefer-

able to adopt a configuration using AI for control of temperature and humidity during sleep. It is further preferable to adopt a configuration in which feedback control is performed using information on whether a feeling of comfortable sleep has been obtained.

[0155] Further, a temporal course of sweating associated with humidity changes during sleep is also affected by a room temperature and humidity, an amount of exercise during the day, caloric intake from meals, water intake, an amount and frequency of coffee consumption, and a physical condition.

[0156] Furthermore, even temperature and humidity vary due to heat retention effects caused by a thickness of subcutaneous fat associated with obesity and due to differences in humidity changes caused by sweating.

[0157] For comfortable sleep, it is necessary to have smooth sleep onset in a short time, to have as few nocturnal awakenings for urination as possible, to have no intermediate awakening or early morning awakening, to be able to turn over naturally without awakening, for example once every 20 to 30 minutes, to have no nightmares, to have a feeling of comfort and refreshment at natural waking, to have no fatigue or feeling of fatigue, headache or heaviness of the head at waking, and to have no muscle pain, stiff shoulders, or lower back pain, and to be able to maintain a positive feeling.

[0158] Conditions necessary and sufficient for comfortable sleep, such as temperature, humidity, a height of the column members 211, and height differences between adjacent regions or among respective regions, are stored for each natural environment (such as season, weather, and atmospheric pressure) and for each physical and mental condition of the individual, or for each time period before and after falling asleep. Then, by reproducing the stored conditions, whether comfortable sleep can be obtained is re-verified by input of a subjective feeling of comfortable sleep, and conditions for further enhancing the feeling of comfortable sleep are stored. By reproducing such conditions when comfortable sleep is required, reliable comfortable sleep can be achieved regardless of region, season, weather, atmospheric pressure, and individual physical and mental condition.

[0159] (17) The auxiliary system 100 according to the present invention can be suitably used, for example, for a bedridden user. By causing the user to turn over using the auxiliary system 100, it is also possible to prevent bedsores and economy class syndrome.

[0160] (18) In each of the above embodiments, a movement mechanism (for example, a hydraulic pump) for moving each column member 211 in a vertical direction and a lateral direction may be provided. In particular, in a case where the user is severely obese or suffers from sarcopenia, it is preferable to provide the movement mechanism. In a configuration in which the movement mechanism is provided, by adjusting positions of the column members 211 in the vertical direction and the lateral direction by the movement mechanism to change a shape of the bedding 20, it is possible not only to

achieve smoother turning over leading to better comfortable sleep and to correct a posture leading to light sleep during sleep, for example, correction of a stooped posture, but also to assist movement from a sleeping state to waking, that is, from a recumbent position to a sitting position and further to a standing position.

[0161] For example, when the bedding is the mattress 20A, the shape is changed as follows. By adjusting positions of the column members 211 in the vertical direction and the lateral direction, a portion corresponding to a center of gravity (hip portion) of the mattress 20A is recessed, and a body direction is changed from a longitudinal axis direction of the mattress 20A to a direction perpendicular toward a getting-out-of-bed portion, thereby facilitating a sitting posture. At the same time, a portion of the mattress 20A from the center of gravity to a portion away from the mattress 20A (for example, toward a wheelchair or a standby position of a caregiver) is recessed to deform the mattress 20A into a shape like a chair with armrests. Therefore, it is possible to facilitate waking and getting up of the user. As a result, it is possible to reduce a burden on a caregiver.

[0162] Conversely, also when moving from a standing position to the mattress 20A, the mattress 20A is deformed into a shape like a chair with armrests to reduce a burden of assistance, and further, a portion corresponding to a center of gravity (hip portion) is further recessed, and a body direction is oriented toward a longitudinal axis direction of the mattress 20A. Therefore, it is possible to reduce the burden of assistance also when going to bed.

[0163] (19) The auxiliary system 100 according to the present invention is also suitably used for promoting comfortable sleep of a user U located in extreme environments such as a spacecraft or a deep-sea submersible.

[0164] (20) FIG. 18 is a side view of an interior of a mattress 10A according to a modified example. For convenience, illustration of the column members 211 and the driving mechanism 50 is omitted; however, in practice, the column members 211 and the driving mechanism 50 are installed inside the mattress 10A as in FIG. 2. As illustrated in FIG. 18, an interior of the housing R may be divided into a plurality of regions W respectively corresponding to a plurality of body parts of the user U. Each region W is partitioned by a partition wall 90. For example, in FIG. 18, the interior of the housing R is divided into three regions W1 to W3 corresponding respectively to a head, a trunk, and lower limbs of the user U. The three regions W1 to W3 are partitioned by two partition walls 90. Each region W (W1 to W3) is provided with a discharge port O1 for transporting an adjusting liquid L to the temperature adjusting mechanism 22 and a supply port O2 for transporting the adjusting liquid L, whose temperature has been adjusted by the temperature adjusting mechanism 22, to the housing R. The discharge port O1 and the temperature adjusting mechanism 22, and the supply port O2 and the temperature adjusting mechanism 22 are respectively connected by tubes. Note that

positions at which the discharge port O1 and the supply port O2 are provided are not limited to portions of the housing R that face the housing body K.

[0165] (21) In each of the above embodiments, it is not essential to control the temperature adjusting mechanism 22 in accordance with the detection signal S2. For example, an acquisition unit that detects a temperature of the adjusting liquid L may be provided inside the housing R, and the temperature adjusting mechanism 22 may be controlled in accordance with the temperature of the adjusting liquid L detected by the acquisition unit. For example, the temperature adjusting mechanism 22 is controlled such that the temperature of the adjusting liquid L becomes a desired temperature. The acquisition unit may be provided, for example, at an upper portion (an end on a contact surface F side) and a lower portion (an end on a housing body K side) of a portion of each column member 211 located inside the housing R. When a significant temperature difference occurs in the temperature of the adjusting liquid L detected in each column member 211, an alarm or the like may be issued.

[0166] (22) FIG. 19 is a cross-sectional view of a column member 211 according to a modified example. The auxiliary mechanism 21 includes a movable portion 217 for each of the plurality of column members 211. That is, the auxiliary mechanism 21 includes the same number of movable portions 217 as the number of column members 211. The movable portion 217 includes a bottom portion 171 and a side wall portion 173. The side wall portion 173 is provided over an entire circumference of the bottom portion 171. That is, the side wall portion 173 has a cylindrical shape. A second portion 215 is fitted inside the side wall portion 173 of the movable portion 217. An end portion 151 of the second portion 215 opposite to the first portion 213 faces the bottom portion 171 of the movable portion 217. The movable portion 217 is movable in a positive Z direction and a negative Z direction in a state in which the second portion 215 is fitted into the side wall portion 173. Specifically, when a load from the user U is applied to the bottom portion 171 (that is, when the user U is placed on the contact surface F), the movable portion 217 moves toward the first portion 213 (negative Z direction). When the load from the user U is applied, it is preferable that the movable portion 217 moves toward the first portion 213 by, for example, 2 to 15 cm. When the user U is separated from the contact surface F, the movable portion 217 moves in the positive Z direction due to buoyancy. By including the movable portion 217 in the column member 211, a position (height) of the column member 211 can be adjusted so as to conform to the body of the user U. Therefore, the user U can comfortably rest the body on the contact surface F.

[0167] In the above configuration, two movable portions 217 adjacent to each other may be connected by a string-like connecting member. By connecting the two movable portions 217 with the connecting member, the two movable portions 217 can move in conjunction with each other along the Z direction. The length of the con-

necting member is set such that a difference between positions of the two movable portions 217 (end portions on the positive Z direction side) is, for example, within a range of 10 cm. By connecting two adjacent movable portions 217 with the connecting member, it is possible to suppress occurrence of a large step at the contact surface F. Therefore, the user U can more comfortably rest the body on the contact surface F.

[0168] (23) It is preferable that a gas such as air or a nonflammable gas is filled in an interior (hollow portion) of the column member 211 in order to reduce an overall weight and to utilize buoyancy. A density of the gas is preferably sufficiently smaller than a density of the adjusting liquid L. The column member 211 is preferably made of a hard plastic that is resistant to pressure changes, bias, and temperature changes due to body weight load and center-of-gravity movement. The adjusting liquid L is preferably a nonflammable liquid having a relatively large specific heat. The partition wall 90 in FIG. 18 is preferably made of a plastic having elasticity and being resistant to pressure changes and temperature changes associated with expansion and contraction. The housing R is preferably made of a resin having airtightness and water resistance, and also having softness, elasticity, and durability. Further, it is preferable that a cushioning material made of plastic such as a soft plastic or urethane is provided on the contact surface F of the housing R in order to alleviate discomfort.

[Description of Reference Signs]

[0169]

20A: mattress
 20B: pillow
 20C: chair
 21: auxiliary mechanism
 22: temperature adjusting mechanism
 23: humidity adjusting mechanism
 30: processing device
 31: control device
 32: storage device
 40: sensor unit
 50: drive mechanism
 41: first acquisition unit
 42: second acquisition unit
 43: third acquisition unit
 90: partition wall
 100: auxiliary system
 211: column member
 213: first portion
 215: second portion
 217: movable portion
 311: determination unit
 321: first control unit
 322: second control unit
 323: third control unit
 F: contact surface

R: housing
 K: housing body
 S1: detection signal
 S2: detection signal
 S3: detection signal
 T: tube
 U: user
 L: adjusting liquid

Claims

1. An auxiliary system comprising:

a housing including a contact surface on which a user places a body, and filled with a liquid whose temperature is adjustable; and
 an auxiliary mechanism that is housed in the housing and assists a change in posture of the user, the auxiliary mechanism including a plurality of column members each extending in a direction intersecting the contact surface and being movable along the direction, wherein each of the column members has a hollow interior and includes a first portion whose cross-sectional size decreases toward an end opposite to the contact surface, and the liquid is filled in gaps between the column members, and the liquid is not filled inside the column members.

2. The auxiliary system according to claim 1,

wherein each of the column members includes a second portion having a constant cross-sectional size at an end on the contact surface side, and
 the first portion is formed from an end of the second portion opposite to the contact surface toward the side opposite to the contact surface.

3. The auxiliary system according to claim 2,

wherein a length of the first portion is $1/2$ or more of a length of the column member, and
 a length of the second portion is $1/10$ or more and less than $1/2$ of the length of the column member.

4. The auxiliary system according to claim 3,

wherein the housing includes a housing body having a hollow interior on a side opposite to the contact surface,
 an end of each of the column members on a side opposite to the contact surface is located inside the housing body, and
 a driving mechanism is installed inside the hous-

ing body.

5. The auxiliary system according to claim 1,

further comprising a detection unit that detects a pressure value from the user for each of a plurality of regions on the contact surface, wherein the plurality of column members move such that the pressure values in the respective regions become closer to each other.

6. The auxiliary system according to claim 2,

wherein the auxiliary mechanism includes, for each of the plurality of column members, a movable portion having a bottom portion and a side wall portion provided over an entire circumference of the bottom portion, the second portion is fitted inside the side wall portion of the movable portion such that an end of the second portion opposite to the first portion faces the bottom portion, and the movable portion moves toward the first portion side when a load from the user is applied to the bottom portion.

7. The auxiliary system according to claim 1, wherein a gas having a density smaller than a density of the liquid is filled inside the column members.

Fig.1

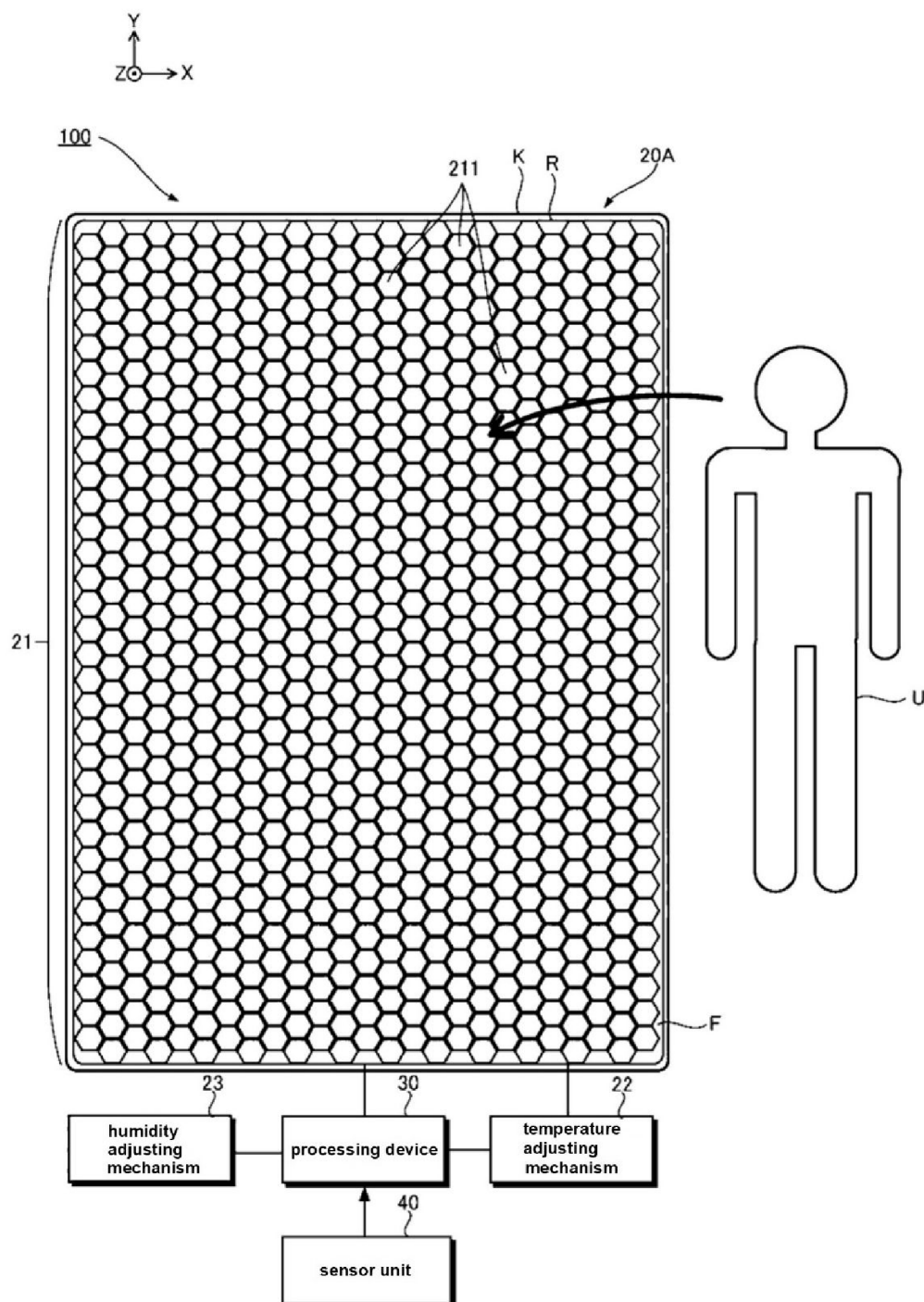


Fig.2

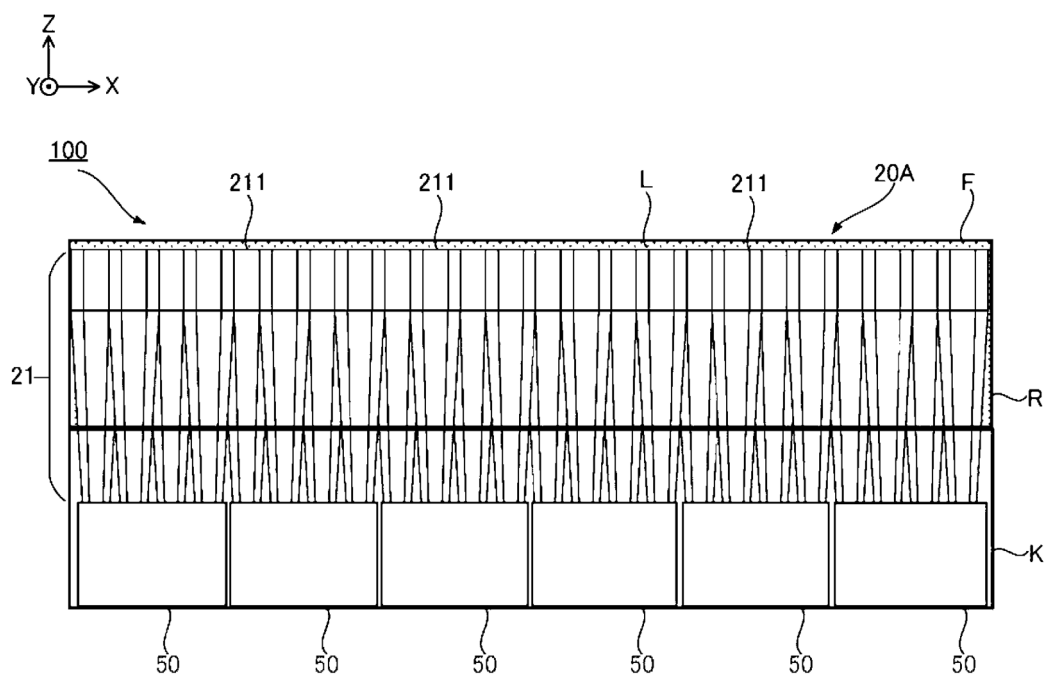


Fig.3

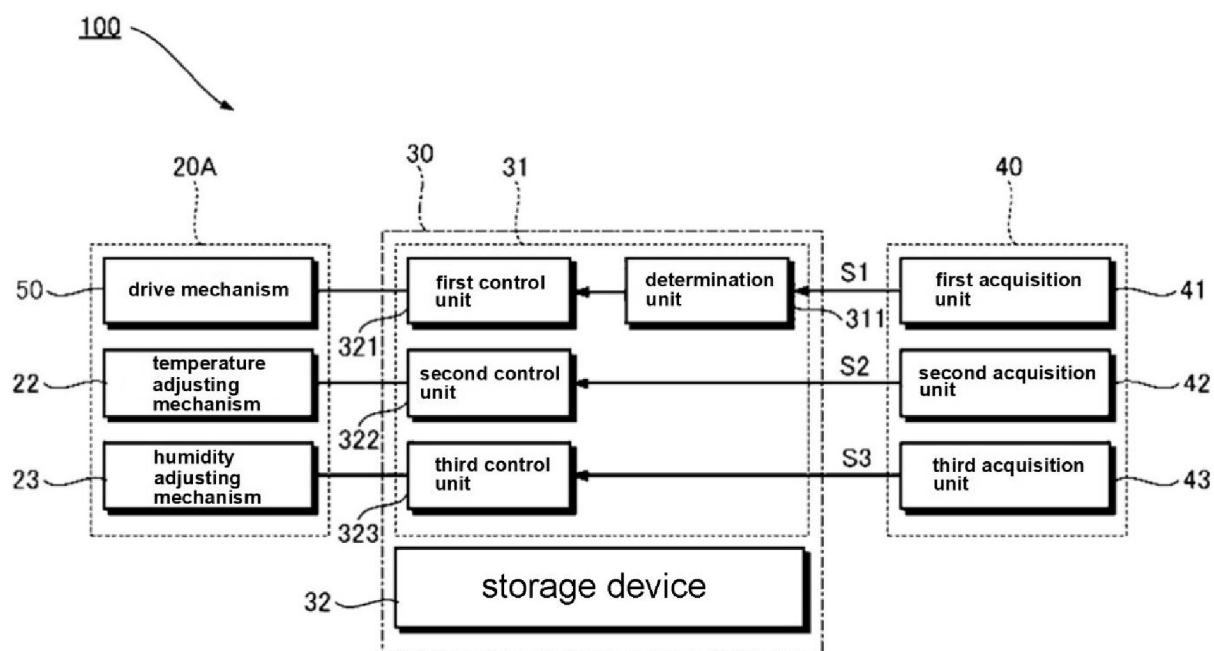


Fig.4

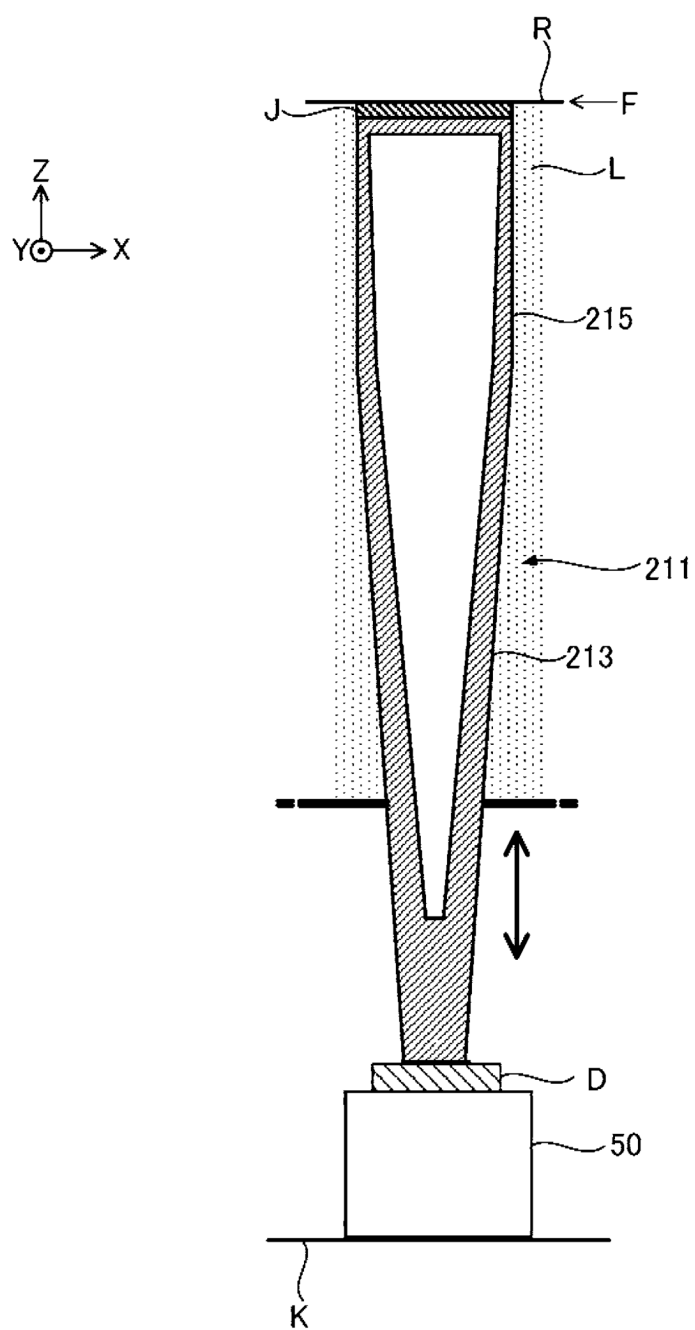


Fig.5

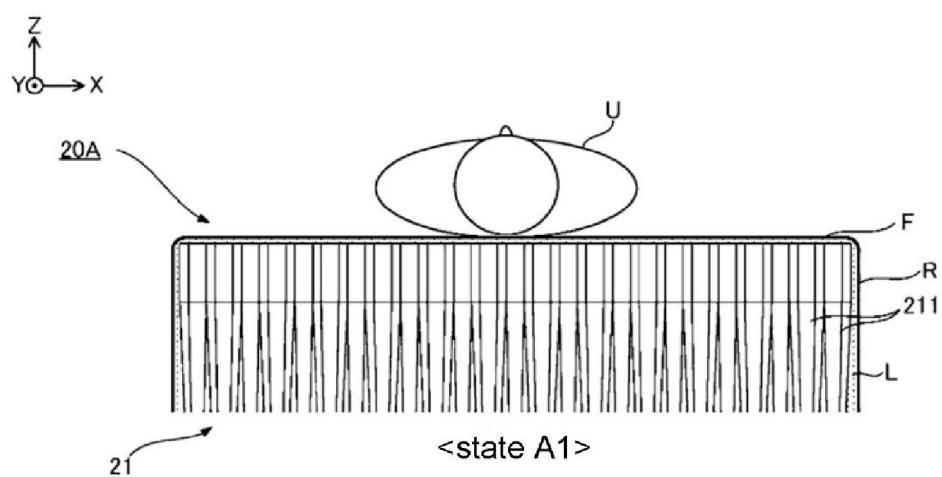


Fig.6

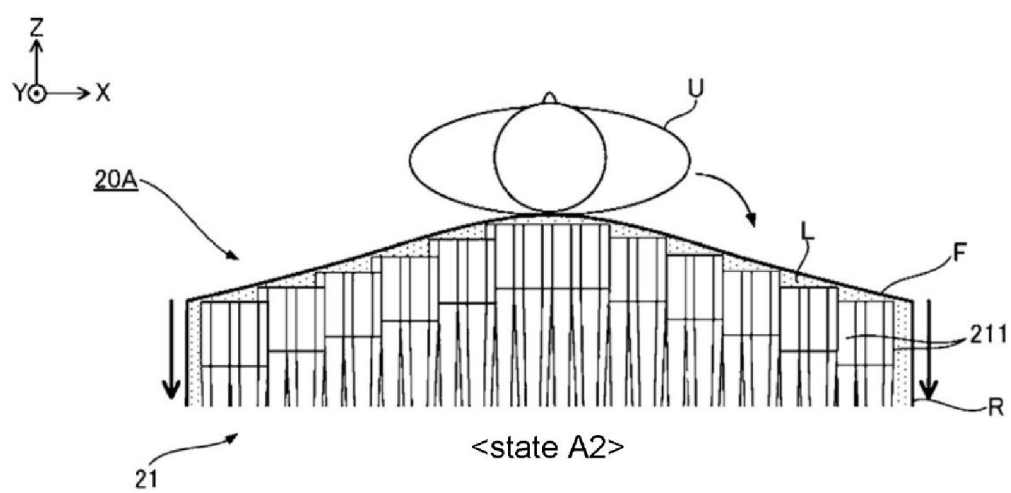


Fig.7

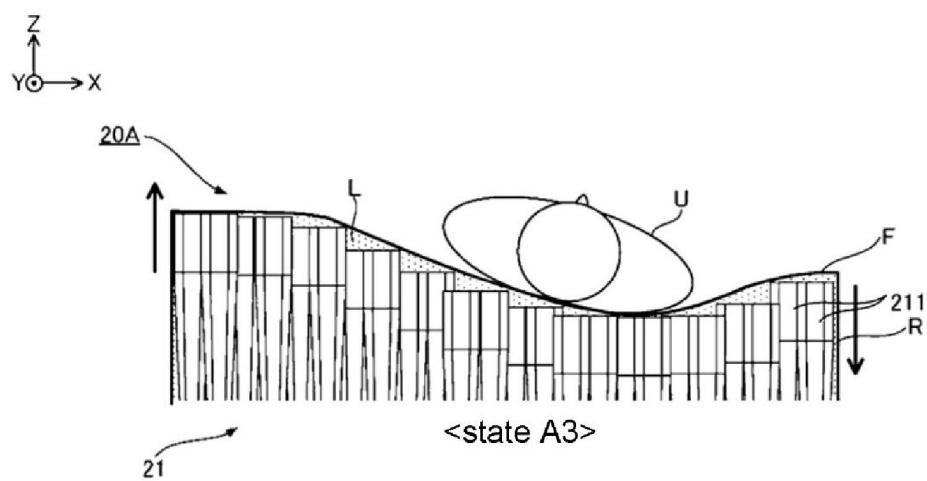


Fig.8

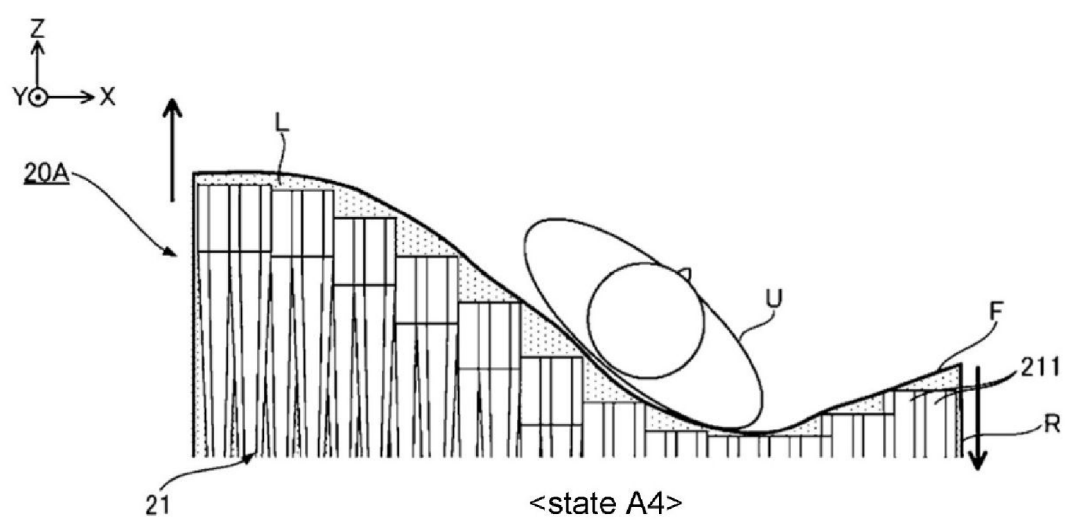


Fig.9

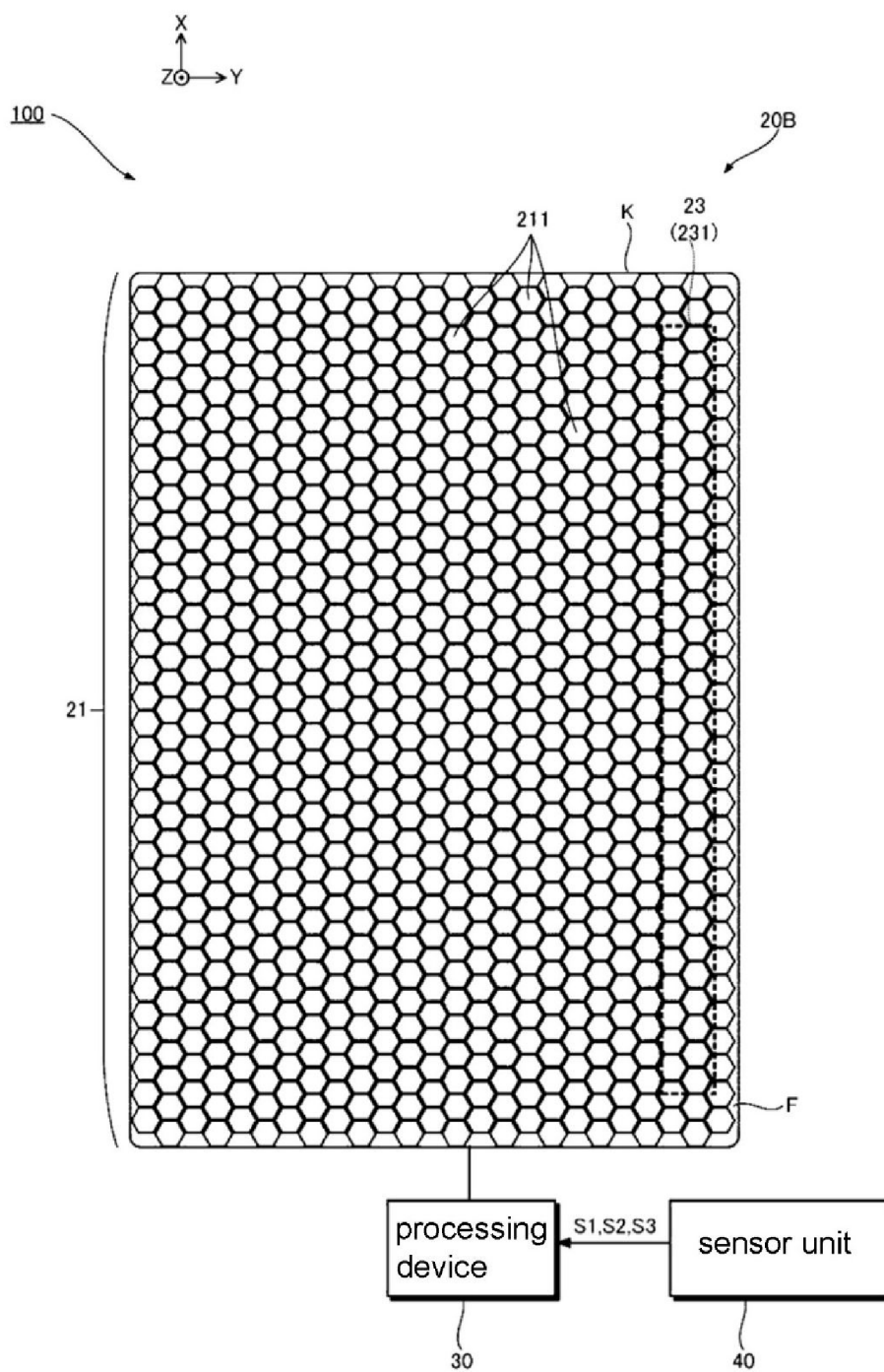


Fig.10

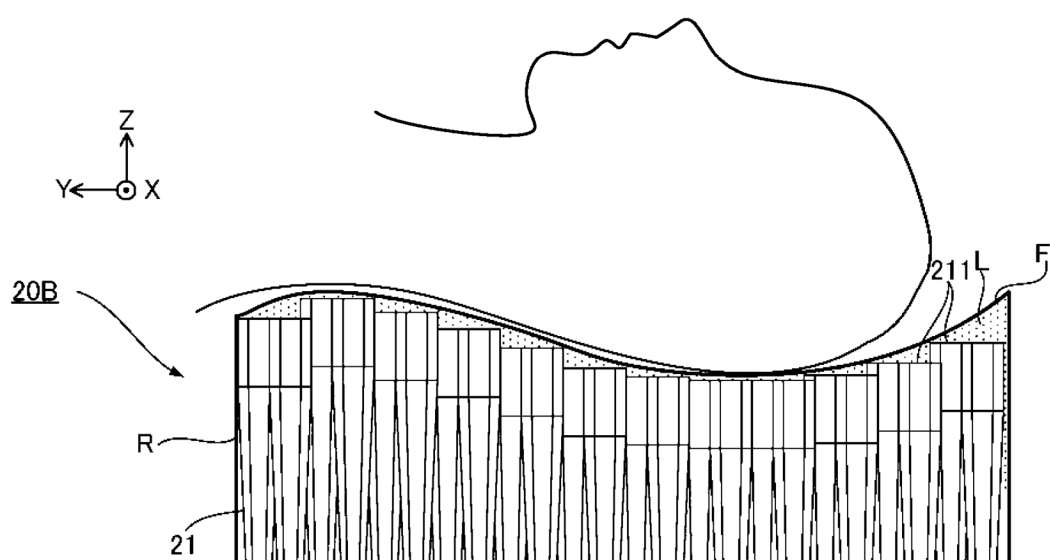


Fig.11

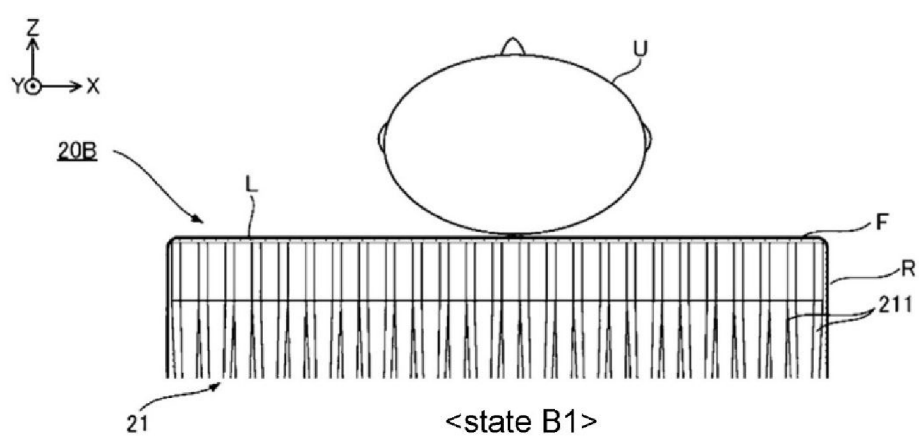


Fig.12

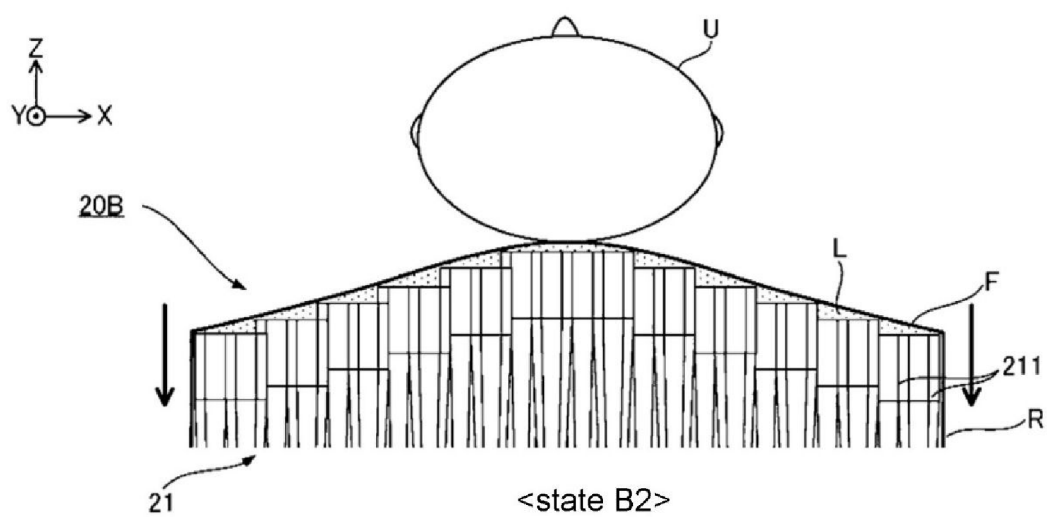


Fig.13

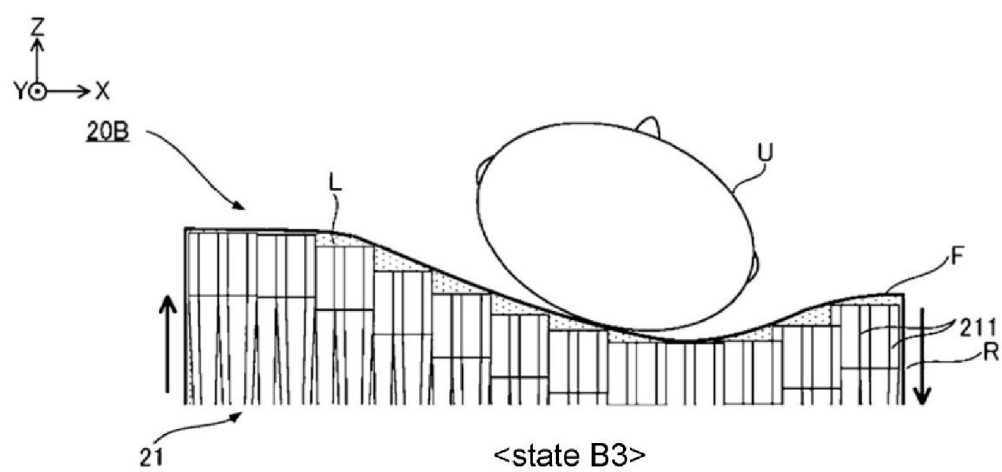


Fig.14

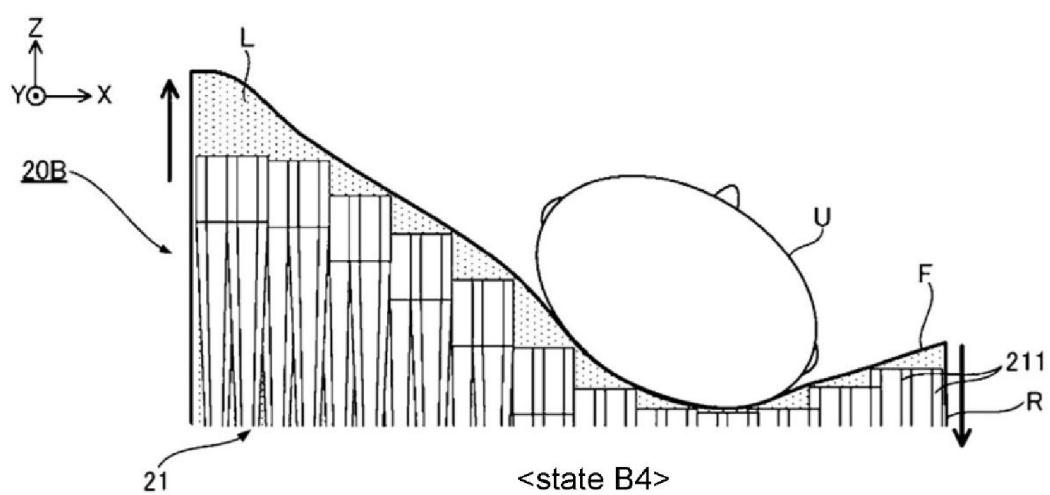


Fig.15

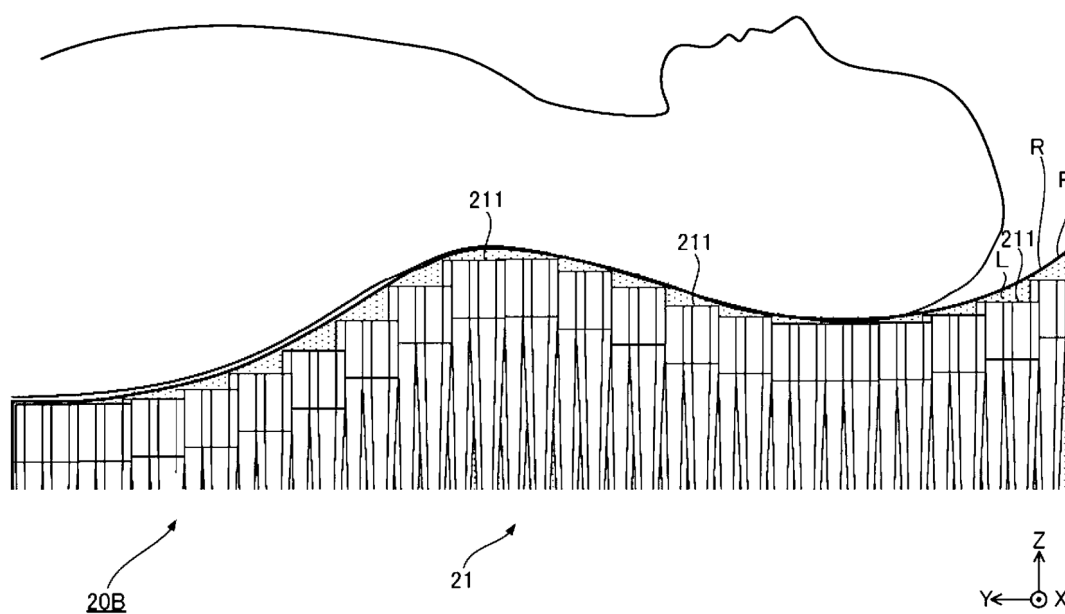


Fig.16

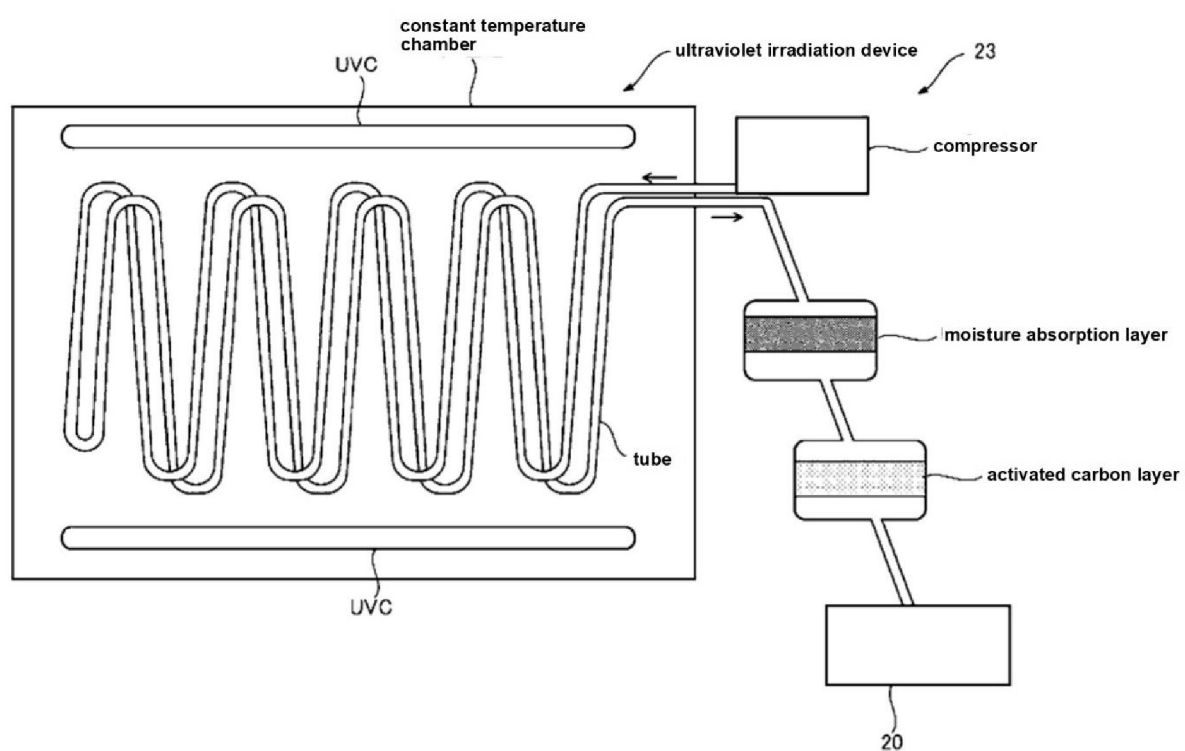


Fig.17

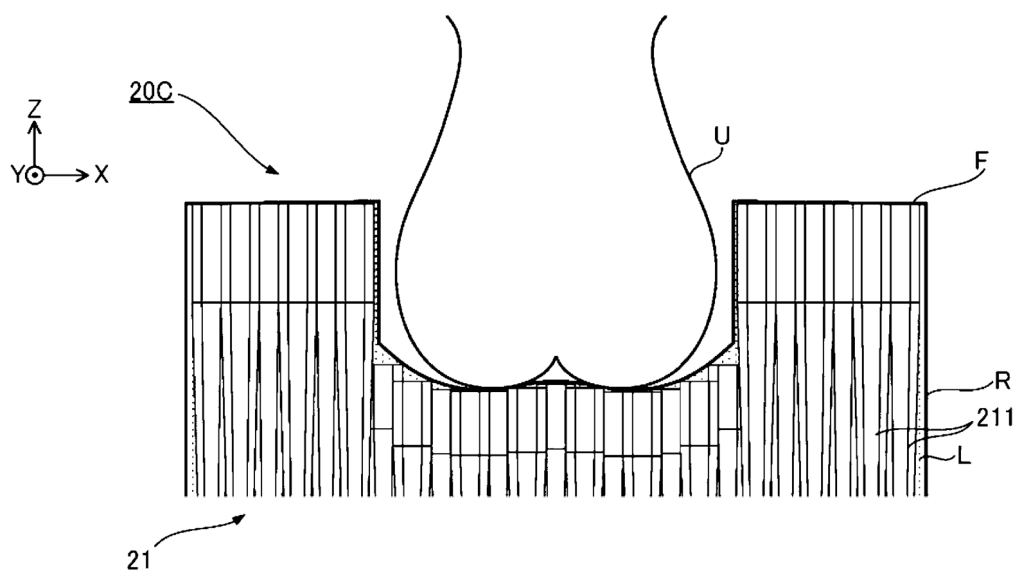


Fig.18

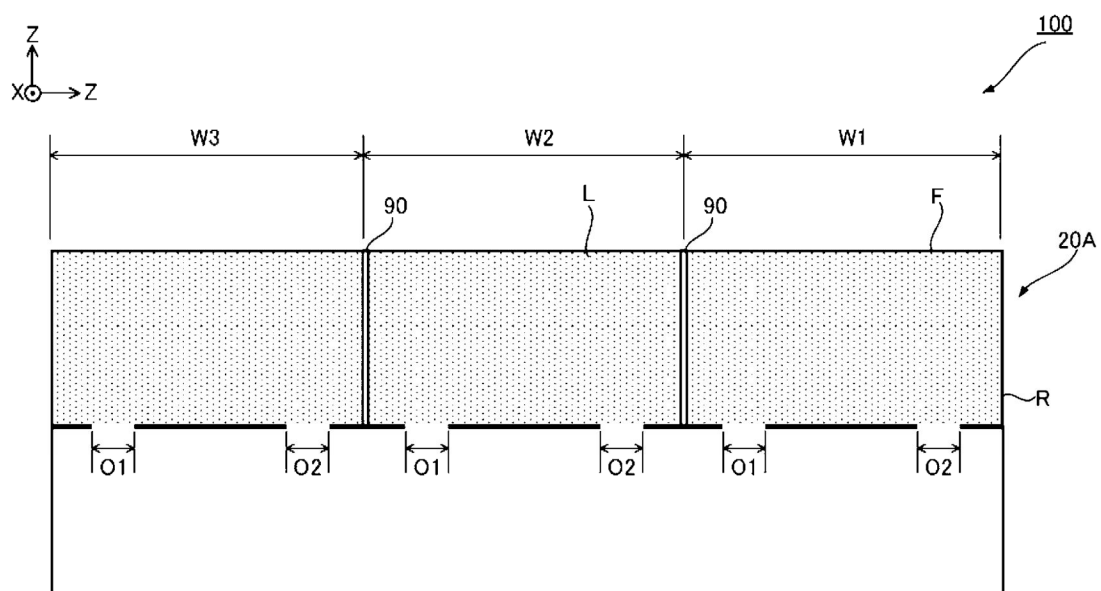
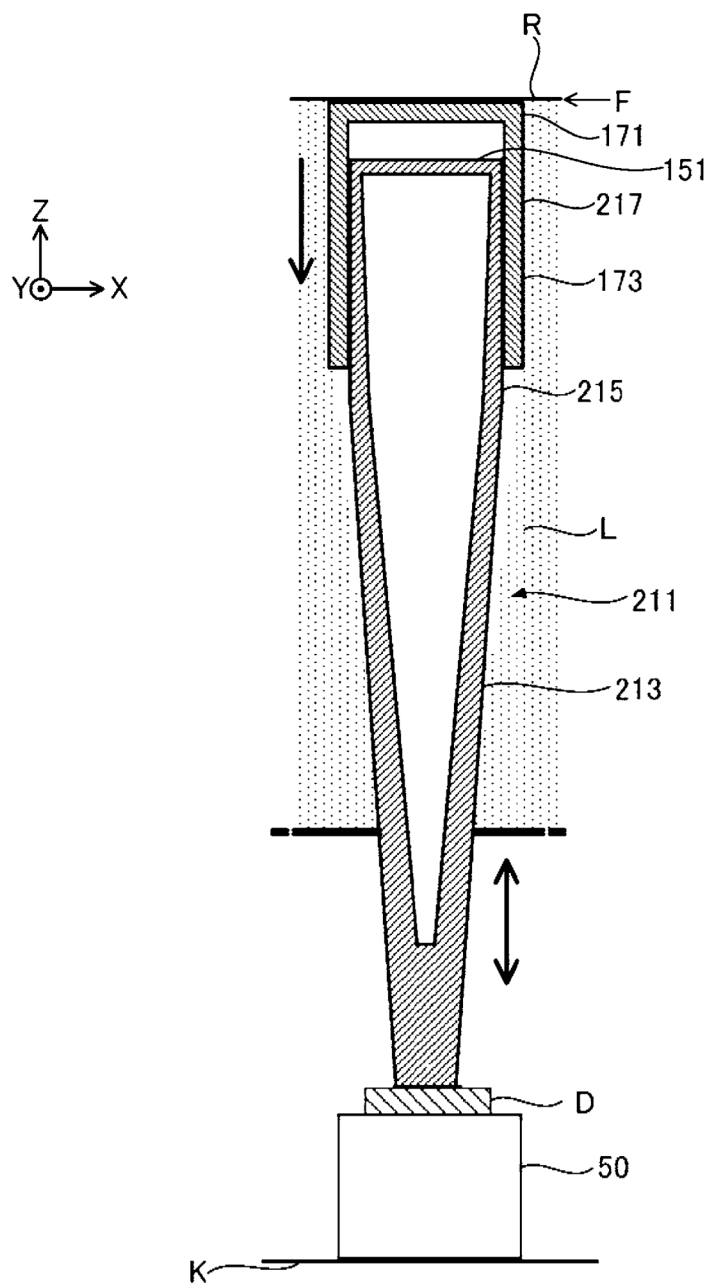


Fig.19



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2024/030934

A. CLASSIFICATION OF SUBJECT MATTER

A61G 7/018(2006.01)i; **A47C 19/04**(2006.01)i; **A47C 27/00**(2006.01)i; **A61G 7/008**(2006.01)i; **A61G 7/057**(2006.01)i
 FI: A61G7/018; A61G7/008; A61G7/057; A47C27/00 A; A47C27/00 D; A47C27/00 E; A47C19/04 Z

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)

A61G7/018; A47C19/04; A47C27/00; A61G7/008; A61G7/057

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 1971-2024
 Registered utility model specifications of Japan 1996-2024
 Published registered utility model applications of Japan 1994-2024

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.
Y	WO 2022/145346 A1 (NAKATSUGAWA, Shigekazu) 07 July 2022 (2022-07-07) paragraphs [0020]-[0108], fig. 1-6	1-7
Y	JP 2020-175115 A (AONO, Ryuji) 29 October 2020 (2020-10-29) paragraphs [0022], [0042], fig. 1-2	1-7

☐ 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

“D” document cited by the applicant in the international application

“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

28 October 2024

Date of mailing of the international search report

12 November 2024

Name and mailing address of the ISA/JP

**Japan Patent Office (ISA/JP)
 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915
 Japan**

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2024/030934

5

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2022/145346 A1	07 July 2022	US 2024/0042164 A1 paragraphs [0048]-[0146], fig. 1-6 EP 4268675 A1	
JP 2020-175115 A	29 October 2020	(Family: none)	

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 2016067429 A [0015]
- WO 2022145346 A1 [0015]