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Air mattress

Abstract

According to embodiments, an air mattress includes an air cell unit including an air cell, and a controller that controls an internal pressure in the air cell. The controller conducts a first operation when the internal pressure in the air cell satisfies the second condition after having satisfied a first condition. The first condition includes the internal pressure becoming from a first value to a second value lower than the first value, a difference between the first value and the second value being equal to or more than a first threshold, and a change rate relative to time of the internal pressure from the first value to the second value being equal to or more than a second threshold. The second condition includes, after the internal pressure has lowered from the first value to the second value, the internal pressure becoming a third value lower than the second value, and a difference between the second value and the third value being equal to or more than a third threshold. In the first operation, the controller changes the internal pressure toward the second value.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation of U.S. patent application Ser. No. 17/055,865, filed Nov. 16, 2020, which is a national stage application, filed under 35 U.S.C. § 371, of International Patent Application No. PCT/JP2019/023865, filed Jun. 17, 2019, which is based upon and claims the benefit of priority from Japanese Patent Application No. 2019-004776, filed Jan. 15, 2019 and Japanese Patent Application No. 2019-100244, filed May 29, 2019, each of which is incorporated by reference herein in its entirety.

TECHNICAL FIELD
(1) Embodiments of the present invention relate to an air mattress.
BACKGROUND ART
(2) There are air mattresses in which air cells are used. The air mattresses are desired to be more comfortable.
CITATION LIST
Patent Literature
(3) PTL 1: JP-A-2008-307249
SUMMARY OF INVENTION
Technical Problem
(4) Embodiments of the present invention provide a more comfortable air mattress.
Solution to Problem
(5) According to embodiments, an air mattress includes an air cell unit including an air cell, and a controller that controls an internal pressure in the air cell. The controller conducts a first operation when the internal pressure in the air cell satisfies a second condition after having satisfied a first condition. The first condition includes the internal pressure becoming from a first value to a second value lower than the first value, a difference between the first value and the second value being equal to or more than a first threshold, and a change rate relative to time of the internal pressure from the first value to the second value being equal to or more than a second threshold. The second condition includes, after the internal pressure has lowered from the first value to the second value, the internal pressure becoming a third value lower than the second value, and a difference between the second value and the third value being equal to or more than a third threshold. In the first operation, the controller changes the internal pressure toward the second value.
Advantageous Effects of Invention
(6) The embodiments of the present invention can provide a more comfortable air mattress.

Description

BRIEF DESCRIPTION OF DRAWINGS
(1) FIGS. **1**(*a*) to **1**(*c*) are schematic views exemplifying an air mattress according to a first embodiment.
(2) FIG. **2** is a schematic diagram exemplifying an operation of the air mattress according to the first embodiment.
(3) FIG. **3** is a schematic diagram exemplifying an operation of an air mattress in a reference

example.
(4) FIGS. **4**(*a*) and **4**(*b*) are schematic views exemplifying the operation in the air mattress according to the embodiment.
(5) FIG. **5** is a graph exemplifying the operation in the air mattress according to the embodiment.
(6) FIG. **6** is a flowchart exemplifying the operation in the air mattress according to the embodiment.
(7) FIGS. **7**(*a*) to **7**(*c*) are schematic diagrams exemplifying an operation of an air mattress according to a third embodiment.

DESCRIPTION OF EMBODIMENTS

(8) Hereinafter, embodiments of the invention will be described with reference to the drawings.
(9) The drawings are schematic or conceptual, and the relation between the thickness and the width in each portion, and the ratio of the sizes between portions, and the like are not necessarily the same as actual ones. Even when the same portion is illustrated, the same portion is illustrated mutually differently in the size and the ratio depending on the drawing in some cases.
(10) In the specification of the present application and the respective drawings, the similar elements having been described related to the already described drawing are assigned with the same reference numerals, and detailed explanations thereof are omitted as appropriate.

First Embodiment

(11) FIGS. **1**(*a*) to **1**(*c*) are schematic views exemplifying an air mattress according to a first embodiment.
(12) FIG. **1**(*a*) is a perspective view exemplifying an air mattress **110** according to the embodiment. FIG. **1**(*b*) is a plan view exemplifying a user interface device **60** of the air mattress **110**. FIG. **1**(*c*) is a function block diagram of the air mattress **110**.
(13) As illustrated in FIG. **1**(*a*), the air mattress **110** according to the embodiment includes a plurality of air cells **11**. As illustrated in FIG. **1**(*c*), the air mattress **110** according to the embodiment further includes a controller **72**.
(14) As illustrated in FIG. **1**(*a*), the plurality of the air cells **11** are included in an air cell unit **10**. The plurality of the air cells **11** each are, for example, tubular.
(15) The plurality of the air cells **11** are arranged along a first direction. An X axis direction is set as the first direction. One direction perpendicular to the X axis direction is set as a Z axis direction. A direction perpendicular to the X axis direction and the Z axis direction is set as a Y axis direction.
(16) The first direction corresponds to, for example, a direction from the head to the legs when a user is laid on the air mattress **110**. The Y axis direction corresponds to a right-and-left direction. The Z axis direction corresponds to a direction from a lower surface to an upper surface of the air mattress **110**.
(17) As illustrated in FIG. **1**(*a*), in this example, an upper layer cushion unit **40** is provided on the air cell unit **10** (on the air cells **11**). The upper layer cushion unit **40** includes, for example, a polymeric foam. The polymeric foam includes, for example, an urethane foam. The polymeric foam includes a plurality of holes.
(18) When the air mattress **110** according to the embodiment is in use, the air cell unit **10** may be covered with a cover part or the like. The cover part or the like includes, for example, a material such as polyester.
(19) As illustrated in FIG. **1**(*a*), the air mattress **110** further includes a pump unit **31**. The pump unit **31** is connected to the plurality of the air cells **11** respectively through tubes **11***p*. The pump unit **31** performs supply and exhaust of air to and from the plurality of the air cells **11**.
(20) In an example illustrated in FIG. **1**(*a*), the controller **72** is provided in a housing of the pump unit **31**. The controller **72** may, for example, include a processor. The controller **72** may be provided at a position different from that of the housing. The controller **72** may be of a smartphone type (for example, a portable terminal type).
(21) As illustrated in FIG. **1**(*c*), the controller **72** is connected to the pump unit **31**. At least either

arbitrary method of wired and wireless methods is applicable to the connection (for example, communication) between the controller **72** and the pump unit **31**. The controller **72** controls the pump unit **31**. The internal pressures in the plurality of the air cells **11** are controlled by an operation of the pump unit **31**. In the embodiment, the “internal pressure” corresponds to a difference relative to the atmospheric pressure. For example, the “internal pressure” corresponds to the “gauge pressure”.

(22) As illustrated in FIG. **1**(*c*), for example, a pressure sensor **31***s* (sensor) may be provided. The pressure sensor **31***s* is provided, for example, in the housing of the pump unit **31**. For example, the pressure sensor **31***s* is capable of detecting the internal pressures in the plurality of the air cells **11**. In one example, the internal pressures in the tubes **11***p* that are respectively connected to the plurality of the air cells **11** are detected, so that the respective internal pressures in the plurality of the air cells **11** can be detected.

(23) As illustrated in FIGS. **1**(*a*) and **1**(*b*), the air mattress **110** may further include the user interface device **60**. The user interface device **60** receives an input by a user. The user interface device **60** is, for example, an operation switch (for example, a remote controller). The controller **72** controls the internal pressures in the plurality of the air cells **11** in accordance with the input received by the user interface device **60**. The user interface device **60** is connected to the controller **72** (or the pump unit **31**) by at least either arbitrary method of wired and wireless methods. In this example, the user interface device **60** is connected to the controller **72** (or the pump unit **31**) by a cable **68**.

(24) As illustrated in FIG. **1**(*b*), for example, various kinds of buttons (display input units **61** and **62**, and the like) are provided to the user interface device **60**. The user manipulates these buttons to control the respective internal pressures in the plurality of the air cells **11** to be in desired states.

(25) As illustrated in FIG. **1**(*c*), a memory **78** may be provided. An internal pressure that the user desires may be stored in the memory **78**. The controller **72** may control, on the basis of data stored in the memory **78**, the internal pressures in the plurality of the air cells **11**. The data may include a time change in the internal pressure. The controller **72** may control the respective internal pressures in the plurality of the air cells **11** (a plurality of blocks) so as to change in terms of time.

(26) The controller **72** may control the internal pressure in the air cell **11** so as to become uniform. For example, there is a case in which the air leaks from a clearance of a connection portion or the like between the tube **11***p* and the air cell **11**. Accordingly, for example, the internal pressure lowers by about 0.1 kPa to 0.5 kPa per day in some cases. For example, in order to recover the lowering of the internal pressure due to the leakage of air, the controller **72** may adjust the internal pressure on a regular basis. For example, when the internal pressure in the air cell **11** becomes lower than an allowable range of a set value, the controller **72** causes the pump unit **31** to supply air to the air cells **11**. Accordingly, the internal pressure is adjusted so as to be within the allowable range. The lowering of the internal pressure in the air cell **11** due to the leakage of air is slow.

(27) Meanwhile, when the user lies down on the air cell unit **10** including the air cells **11**, the internal pressure in the air cells **11** rises. Further, at the bed-departure (when the user is not present on the air cell unit **10**), the internal pressure in the air cells **11** suddenly lowers. In the occurrence of such sudden lowering of the internal pressure, if the internal pressure is raised so as to recover the lowering of the internal pressure, when the user again lies down on the air cell unit **10**, the internal pressure becomes higher than the desired internal pressure. Accordingly, it has been understood that discomfort feeling is generated in some cases. The discomfort feeling impairs the comfort in some cases.

(28) In the embodiment, as in the following, in the sudden change in the internal pressure as the above, an operation to recover the lowering of the internal pressure is not performed. Accordingly, a more comfortable air mattress can be provided. Hereinafter, an example of an operation according to the embodiment will be described. This operation is conducted by, for example, the controller **72**.

(29) FIG. **2** is a schematic diagram exemplifying an operation of the air mattress according to the first embodiment.
(30) The horizontal axis in FIG. **2** represents time tm. The longitudinal axis represents an internal pressure Pi in the air cell.
(31) As illustrated in FIG. **2**, the controller **72** conducts a first operation OP**1**. The first operation OP**1** is conducted when the internal pressure Pi in the air cell **11** satisfies a second condition below, after having satisfied a first condition below.
(32) The first condition includes: the internal pressure Pi becoming, from a first value P**1**, a second value P**2** lower than the first value P**1**; a difference ΔP**1** between the first value P**1** and the second value P**2** being equal to or more than a first threshold; and a change rate of the internal pressure Pi relative to the time tm from the first value P**1** to the second value P**2** being equal to or more than a second threshold.
(33) For example, in a case where the difference ΔP**1** of the internal pressure Pi that is equal to or more than the first threshold is generated at the steepness equal to or more than the second threshold, the first condition is satisfied.
(34) In the example in FIG. **2**, the first condition is satisfied at a first time t**1**. For example, the user departs from the air mattress **110** (bed-departure) at the first time t**1**. Accordingly, the first condition is satisfied. For example, in the length of from 5 minutes to 12 hours, when the difference ΔP**1** is equal to or more than 0.5 kPa, it is determined that the first condition is satisfied.
(35) In the example in FIG. **2**, the second condition is satisfied at a second time t**2**. The second condition includes: after the internal pressure Pi has lowered from the first value P**1** to the second value P**2**, the internal pressure Pi becoming a third value P**3** lower than the second value; and a difference ΔP**2** between the second value P**2** and the third value P**3** being equal to or more than a third threshold.
(36) For example, after the first time t**1**, the internal pressure Pi slowly lowers. This is due to, for example, leakage of air from the air cell **11**. Further, when the change amount (difference ΔP**2**) of the internal pressure Pi due to the leakage has become equal to or more than the threshold (third threshold) (the second time t**2**), the second condition is satisfied.
(37) When the second condition has been satisfied after the first condition in this manner, the controller conducts the first operation OP**1**. In the first operation OP**1**, the controller **72** changes the internal pressure Pi toward the second value P**2**.
(38) For example, when only the first condition has been satisfied (for example, at the bed-departure), the controller **72** does not raise the internal pressure Pi in the air cell **11**. Accordingly, when the user again has gotten on the air mattress **110** after the bed-departure state, the internal pressure Pi returns from the second value P**2** to the first value P**1**. The internal pressure Pi returns to the state before the bed-departure to suppress the discomfort feeling.
(39) On the other hand, after the first condition has been satisfied (at the bed-departure), when the second condition has been satisfied due to the leakage of air and the like, the controller **72** returns the internal pressure Pi to the second value P**2**. The second value P**2** is the internal pressure Pi at the bed-departure. Accordingly, when the user again has gotten on the air mattress **110** after the bed-departure state, the internal pressure Pi returns from the second value P**2** to the first value P**1**. The internal pressure Pi returns to the state before the bed-departure to suppress the discomfort feeling.
(40) With the first operation OP**1** as the above, a more comfortable air mattress can be provided.
(41) As illustrated in FIG. **2**, at a third time t**3**, the internal pressure Pi lowers due to the leakage of air and the like. At the third time t**3**, the change amount (difference ΔP**2**) of the internal pressure Pi is smaller than the threshold (third threshold). Therefore, at the third time t**3**, the controller **72** does not conduct the first operation OP**1**.
(42) The controller **72** may further conduct a second operation OP**2**, which will be described below. The second operation OP**2** is conducted when the internal pressure Pi in the air cell **11** satisfies a

third condition below.
(43) The third condition includes: the internal pressure Pi rising to a fourth value P**4** higher than the second value P**2**; and a difference ΔP**3** between the fourth value P**4** and the second value P**2** being equal to or more than a threshold (fourth threshold). The fourth threshold is, for example, approximately 0.4 kPa.
(44) In the example in FIG. **2**, at a fourth time t**4**, the third condition is satisfied. For example, at the fourth time t**4**, the user lies down on the air mattress **110**. Accordingly, the internal pressure Pi in the air cell **11** rises. The rise in the internal pressure Pi is caused by the body weight of the user.
(45) When the rise amount (difference ΔP**3**) of the internal pressure Pi is equal to or more than the threshold (fourth threshold), the controller **72** conducts the second operation OP**2**. In the second operation OP**2**, the controller **72** changes the internal pressure Pi toward the first value P**1** or a set fifth value P**5**. Accordingly, when the user again has gotten on the air mattress **110**, the internal pressure Pi becomes the desired value (the first value P**1** or the fifth value P**5**). Accordingly, the state of hardness (softness) that the user prefers can be provided to the user.
(46) With the second operation OP**2** as the above, a more comfortable air mattress can be provided.
(47) The first value P**1** may be a value detected immediately before the time when the first condition was satisfied at the first time t**1**. For example, the first value P**1** may be a value used for the determination as to whether the first condition is satisfied. The detection is performed by, for example, the pressure sensor **31***s*. The detected value (first value P**1**) may be stored in the memory **78** and the like.
(48) The fifth value P**5** is set, for example, when the user manipulates the user interface device **60** (see FIG. **1**(*b*)) and the like. As illustrated in FIG. **2**, before the first time t**1**, the internal pressure Pi may gradually lower from the fifth value P**5**. This lowering of the internal pressure Pi is due to, for example, the leakage of air and the like. Further, at the first time t**1**, the internal pressure Pi suddenly changes. The first value P**1** may be substantially the same as the fifth value P**5**. At least either of the first value P**1** and the fifth value P**5** may be stored in, for example, the memory **78** or the like.
(49) At the time (in this example, a fifth time t**5**) after the second time t**2** illustrated in FIG. **2**, the internal pressure Pi becomes higher than the second value P**2** in some cases. For example, when an object (an article, a child, or the like) lighter than the user gets on the air mattress **110**, such the rise in the internal pressure Pi occurs. At the fifth time t**5**, the rise amount (difference ΔP**3**) of the internal pressure Pi is smaller than the threshold (third threshold). Therefore, at the fifth time t**5**, the controller **72** does not conduct the second operation OP**2**. In this example, after the fifth time t**5**, the "light object" is removed, and the internal pressure Pi becomes, for example, substantially the second value P**2**. Thereafter, as described as the above, at the fourth time t**4**, the rise amount (difference ΔP**3**) of the internal pressure Pi becomes equal to or more than the fourth threshold, and the controller **72** conducts the second operation OP**2**.
(50) The second value P**2** is a value detected, for example, when the first condition was satisfied at the first time t**1**. The detection is performed by, for example, the pressure sensor **31***s*. The detected value (second value P**2**) may be stored in the memory **78** or the like.
(51) The controller **72** may conduct the abovementioned operation, on the basis of the first value P**1**, the second value P**2**, and the fifth value P**5**, stored in the memory **78**.
(52) As has been already described, the user interface device **60** (see FIG. **1**(*b*)) that receives an input by the user may be provided. At this time, when the user interface device **60** receives an input to change the internal pressure Pi in the air cell **11**, at least either of the first value P**1** and the second value P**2**, stored in the memory **78**, may be reset. When the user interface device **60** receives an input to change the internal pressure Pi in the air cell **11**, the fifth value P**5** stored in the memory **78** may be reset.
(53) In the embodiment, the air mattress **110** may further include the sensor (pressure sensor **31***s*) that detects the first value P**1** and the second value P**2**.

(54) FIG. **3** is a schematic diagram exemplifying an operation of an air mattress in a reference example.
(55) The horizontal axis in FIG. **3** represents time tm. The longitudinal axis represents the internal pressure Pi in the air cell.
(56) In an air mattress **119** of a reference example illustrated in FIG. **3**, the internal pressure Pi in the air cell **11** suddenly lowers at the first time t**1**, from the first value P**1** to the second value P**2**. This sudden lowering is due to, for example, the bed-departure of the user and the like. Thereafter, at a sixth time t**6**, the internal pressure Pi further lowers from the second value P**2** to a value less than the threshold. In the reference example, at the sixth time t**6**, the internal pressure Pi is raised to, for example, the first value P**1**. In the reference example, the slow lowering of the internal pressure Pi due to the leakage of air and the sudden lowering of the internal pressure Pi due to the bed-departure and the like are not distinguished. Therefore, when the user lay down on the air mattress **119** at a seventh time t**7**, the internal pressure Pi further rises from the first value P**1**. Therefore, the air mattress **119** becomes harder than the hardness that the user desires. A state that the user desires is not provided.
(57) In this example, at the seventh time t**7** and the subsequent time, the internal pressure Pi exceeds the allowable range of the set internal pressure. Therefore, for example, the controller **72** lowers the internal pressure Pi at an eighth time, and in this example, the internal pressure Pi becomes the first value P**1**.
(58) In comparison with such a reference example, the air mattress **110** according to the embodiment can suppress the discomfort feeling. In the embodiment, a more comfortable air mattress can be provided.
(59) In the first embodiment, for example, when the internal pressure Pi suddenly lowers, the controller **72** determines the bed-departure. The internal pressure Pi (second value P**2**) at this time corresponds to, for example, an “internal pressure at the bed-departure”. For example, a set allowable value is provided to a difference of the internal pressure Pi from the internal pressure at the bed-departure. For example, in a case where a natural leakage has occurred, the controller **72** supplies air up to the internal pressure at the bed-departure. Meanwhile, when the internal pressure Pi rises to equal to or more than the threshold, exceeding the internal pressure at the bed-departure, the controller **72** may determine staying-in-bed. Thereafter, a set allowable value may be provided relative to the original set internal pressure, and the internal pressure at the bed-departure may be reset. In a case where the internal pressure Pi is changed by a manual manipulation or a program, the set internal pressure (fifth value P**5**), the internal pressure before the bed-departure (first value P**1**), and the internal pressure at the bed-departure (second value P**2**) may be reset.
(60) In the first embodiment, for example, the internal pressure Pi is adjusted so as to become a value at the bed-departure. Therefore, the discomfort feeling when the user again lies down is suppressed. The discomfort feeling is suppressed, so that a manipulation of setting the internal pressure Pi (setting of hardness) becomes unnecessary, which is convenient. A comfortable air mattress can be provided.
Second Embodiment
(61) In a second embodiment, the controller **72** further conducts, in addition to the first operation OP**1**, the second operation OP**2**, and the like, which are mentioned above, a third operation, which will be described below.
(62) For example, the controller **72** may further conduct the third operation after the internal pressure Pi in the air cell **11** has satisfied the abovementioned first condition.
(63) In the third operation, the controller **72** conducts at least either of an energy-saving operation and a maintenance operation.
(64) The time when the first condition has been satisfied corresponds to, for example, the bed-departure. When the first condition has been satisfied, the air mattress **110** automatically becomes under the energy-saving operation. Alternatively, when the first condition has been satisfied, the air

mattress **110** becomes under the maintenance operation. In the maintenance operation, the controller **72** operates, for example, the pump unit **31** at high output to dry the air cell unit **10**. The output in the maintenance operation is higher than, for example, that in the second operation OP**2** or the like. In the maintenance operation, for example, noise is larger than that in the second operation OP**2** or the like.
(65) In the second embodiment, for example, when the second value P**2** is stored in the memory **78**, the third operation different from the second operation OP**2** is performed. In the second embodiment, a more comfortable and more convenient air mattress can be provided. The third operation is conducted, for example, at a fixed time or the like. For example, the conduct of the third operation may be started by a timer or the like.
(66) In the embodiment, the pump unit **31** may include a DC pump **31***d* (see FIG. **1**(*c*)). By using the DC pump **31***d*, for example, pulse width modulation (PWM) control may be conducted. Hereinafter, an example of the PWM control will be described.
(67) FIGS. **4**(*a*) and **4**(*b*) are schematic views exemplifying an operation in the air mattress according to the embodiment. The horizontal axis in these drawings represents time tm. The longitudinal axis exemplifies strength SigC of the PWM control signal. FIG. **4**(*a*) corresponds to a case where a duty ratio Dt is 65%. FIG. **4**(*b*) corresponds to a case where the duty ratio Dt is 35%. The PWM control signal is supplied, for example, from the controller **72** or a drive circuit controlled by the controller **72**, to the DC pump **31***d*. The amount of supply and exhaust of air to and from the air cells **11** by the DC pump **31***d* can be controlled from a ratio of a period in a high state of the strength SigC of the PWM control signal and a period in a low state of the strength SigC thereof.
(68) FIG. **5** is a graph exemplifying the operation in the air mattress according to the embodiment.
(69) The horizontal axis in FIG. **5** represents the duty ratio Dt. The longitudinal axis represents a pressure Pr (kPa) in the supply and exhaust of air. As illustrated in FIG. **5**, when the duty ratio Dt is high, the pressure Pr in the supply and exhaust of air becomes high. The duty ratio Dt in the PWM control is controlled to allow the amount of the supply and exhaust of air to and from the pump to be controlled.
(70) In the embodiment, the pump unit **31** may include an AC pump. The internal pressure in the air cell **11** can be controlled by an operation of the AC pump. In this case, for example, by an applied voltage to the AC pump, an output (for example, the pressure Pr in the supply and exhaust of air) from the AC pump is controlled. In the AC pump, the applied voltage can be switched by phase control. In the phase control, a desired operation is unlikely to be obtained because an influence of the fluctuation in the frequency is received in some cases.
(71) With the PWM control that uses the DC pump, for example, the output can be controlled with high accuracy in accordance with the pressure of the necessary supply and exhaust of air without substantially receiving an influence due to the variation of the AC power supply (for example, including the fluctuation in the frequency and the like). For example, the output can be minimized. With the PWM control that uses the DC pump, for example, compared with the case where the AC pump is used, sound to be generated can be made low. For example, the sound to be generated can be minimized. Accordingly, for example, better sleep comfort can be provided.
(72) Hereinafter, an example of an operation of the air mattress **110** will be described.
(73) FIG. **6** is a flowchart exemplifying the operation in the air mattress according to the embodiment.
(74) As illustrated in FIG. **6**, a power supply is turned on (Step S**101**). Accordingly, for example, the operation is shifted to an initialization mode (Step S**102**). In the initialization mode, for example, the internal pressure (the pressure Pr) of the air cells **11** is set to a fixed value (for example, 5 kPa and the like). In the initialization mode, a user gets on the air cell unit **10**. For example, in this state, the internal pressure (pressure Pr) is set to a fixed value.
(75) The operation is shifted to a normal mode (Step S**103**). For example, on the basis of a state of

the user or on the basis of the reception of a manipulation by the user interface device **60**, the operation may be shifted to a falling asleep mode (Step S**131**). In the falling asleep mode (Step S**131**), on the basis of the reception of a manipulation of an "end", on the basis of a state of the user, or on the basis of the reception of a manipulation by the user interface device **60**, the operation returns to the normal mode (Step S**103**).

(76) In the normal mode, for example, a sensor check is conducted (Step S**104**). The internal pressure is checked (detected) (Step S**105**). In addition, at this time, it is determined whether a set (stored) state is "bed-departure" or "staying-in-bed" (Step S**106**). The "set (stored) state" is, for example, a state when a previous operation has ended (for example, Step S**111**, which is described later). For example, a state of the air mattress **110** that is set (stored) at the beginning may be "staying-in-bed", for example. At Step S**106**, if the state is "bed-departure", the operation proceeds to Step S**121**, which is described later. If the state is "staying-in-bed", the operation proceeds to Step S**107**.

(77) At Step S**107**, it is determined whether the internal pressure has been significantly lowered. If it has been determined that the internal pressure has been significantly lowered, "bed-departure" is presumed, and the internal pressure at that time is stored as a "bed-departure internal pressure" (Step S**109**). Thereafter, for example, the operation waits for a fixed time (for example, 12 hours), (Step S**111**).

(78) At Step S**107**, if it has been determined that the internal pressure has not significantly lowered, it is determined whether the internal pressure has lowered (Step S**108**). If it has been determined that the internal pressure has not lowered, the operation proceeds to Step S**111**.

(79) If it has been determined that the internal pressure has lowered at Step S**108**, supply of air up to the set internal pressure is performed (Step S**110**). Thereafter, the operation proceeds to Step S**111**.

(80) At Step S**106**, if it has been determined as "bed-departure", it is determined whether the internal pressure has lowered at Step S**121**. If it has been determined that the internal pressure has not lowered, it is determined whether the internal pressure has increased (Step S**122**). If it has been determined that the internal pressure has not increased, the operation proceeds to Step S**111**. If it has been determined that internal pressure has increased, "staying-in-bed" is presumed, and the "bed-departure internal pressure" is cleared (Step S**124**, for example, the memory is initialized). Thereafter, the operation proceeds to Step S**111**.

(81) At Step S**121**, if it has been determined that the internal pressure has lowered, supply of air up to the "bed-departure internal pressure" is performed (Step S**123**). Thereafter, the operation proceeds to Step S**111**.

(82) Such an operation is performed by, for example, a control device **70** (or the controller **72**) or the like.

(83) At Steps S**106** to S**110**, Steps S**121** to S**124**, and the like, the operation described related to FIG. **2** may be applied.

(84) With the embodiment, a more comfortable air mattress can be provided.

Third Embodiment

(85) An air mattress (for example, the air mattress **110**: see FIGS. **1**(*a*) to **1**(*c*)) according to a third embodiment includes the air cell unit **10** including the air cells **11**, and the controller **72** that controls the internal pressure Pi in the air cell **11**. Hereinafter, an example of an operation of the controller **72** according to the third embodiment will be described. In the following explanation, the internal pressure Pi in the air cell **11** is detected, for example, by the pressure sensor **31***s*. The controller **72** acquires data (a signal can also be applicable) related to the internal pressure Pi detected by the pressure sensor **31***s*.

(86) FIGS. **7**(*a*) to **7**(*c*) are schematic diagrams exemplifying an operation of the air mattress according to the third embodiment.

(87) The horizontal axis in FIGS. **7**(*a*) to **7**(*c*) represents time tm. The longitudinal axis represents

the internal pressure Pi in the air cell **11**.
(88) As illustrated in FIG. **7**(*a*), in one example, at a time ta**0**, the internal pressure Pi is a value Pax**2**, which is high. At the time ta**0**, the user is present on the air mattress **110**. At a time tx, the internal pressure Pi suddenly lowers. At the time tx, the user departs from the bed. At a first time ta**1**, the controller **72** acquires data (internal pressure Pa**1**) related to the internal pressure Pi. At this time, when data related to the internal pressure Pi is not abnormal, the controller **72** does not conduct an operation, which is described later, and the time tm is elapsed. In this example, at a time ty, the internal pressure Pi suddenly rises. At the time ty, a state where the user is present on the air mattress **110** is started. In this example, at a second time ta**2**, the controller **72** acquires data related to the internal pressure Pi. At this time, when data related to the internal pressure Pi is not abnormal, the controller **72** does not conduct an operation, which is described later, and the time tm is elapsed. Such an operation is repeatedly performed.
(89) In other words, the respective times (the time ta**0**, the first time ta**1**, and the second time ta**2**) at the first cycle become respective times (a time tb**0**, a first time tb**1**, and a second time tb**2**) at the second cycle, and such an operation is repeated. For example, the time tm from the time ta**0** to the second time ta**2** corresponds to a cycle T. The cycle T is, for example, 24 hours. The time from the time ta**0** to the first time ta**1** is ½ of the cycle T, which is 12 hours. The time from the first time ta**1** to the second time ta**2** is ½ of the cycle T, which is 12 hours.
(90) In one example, the time ta**0** is, for example, at 22:00 on the first day. The first time ta**1** is at 10:00 on the second day. The second time ta**2** is at 22:00 on the second day.
(91) In this example, for every the time duration of ½ of the cycle T, the controller **72** conducts an operation SO to acquire data related to the internal pressure Pi. The operation SO is a monitoring operation of the internal pressure Pi.
(92) When an acquired internal pressure Pi (internal pressure P**1**) is less than a fixed value, the controller **72** may conduct an air-supplying operation PO to the air cells **11**. For example, the controller **72** controls the pump unit **31** so as to supply the air to the air cells **11**. At this time, for example, in a case where the time of the operation SO is during the daytime, the air-supplying operation PO is performed. For example, in a case where the time of the operation SO is during the night, the air-supplying operation PO may be omitted.
(93) In the example in FIG. **7**(*a*), the internal pressure Pa**1** at the first time ta**1** is the substantially same as a value Pax**1** (reference value). For example, an absolute value of a difference ΔQ**1** between the internal pressure Pa**1** and the value Pax**1** at the first time ta**1** is smaller than a “fixed value related to the difference”. In this case, the air-supplying operation PO is not performed. The value Pax**1** is, for example, an “internal pressure at the bed-departure”. The “internal pressure at the bed-departure” may be stored in the memory **78** or the like. FIG. **7**(*a*) corresponds to a state where no abnormality is present in the air cells **11**.
(94) As illustrated in FIG. **7**(*a*), the controller **72** may conduct an operation SC to acquire data related to sudden change in the internal pressure Pi. In FIGS. **7**(*b*) and **7**(*c*), for easy recognition of the drawings, illustration of the operation SC is omitted.
(95) As illustrated in FIG. **7**(*b*), in another example, at the time ta**0**, the internal pressure Pi is the value Pax**2**. At the time tx, the internal pressure Pi suddenly lowers. At the first time ta**1**, the controller **72** acquires the data (internal pressure Pa**1**) related to the internal pressure Pi. In this example, the internal pressure Pa**1** at the first time ta**1** is significantly lower than the value Pax**1** (for example, the “internal pressure at the bed-departure”). For example, there is a case in which the abnormality such as a hole is present in the air cell **11**, and the internal pressure Pi abnormally lowers.
(96) For example, the absolute value of the difference ΔQ**1** between the internal pressure Pa**1** and the value Pax**1** at the first time ta**1** is equal to or more than a “fixed value related to the difference”. In this case, the controller **72** shortens the interval of the monitoring operation (operation SO) of the internal pressure Pi. In the example in FIG. **7**(*b*), after the first time ta**1** at which the internal

pressure Pi has been monitored, a next internal pressure Pi is monitored at the second time ta**2**, which is earlier than that in the example in FIG. **7**(*a*). Accordingly, the state of the air cells **11** can be more accurately grasped. For example, in a case where abnormality such as a hole is present in the air cell **11**, the abnormality can be grasped more rapidly. The air cell **11** can be caused to recover to an adequate state more rapidly.
(97) For example, as for the internal pressure Pa**1** at the first time ta**1**, a threshold (first threshold Pt**1**) is fixed. The first threshold Pt**1** is, for example, a value lower than the “internal pressure at the bed-departure” by a “fixed difference”. The internal pressure Pa**1** at the first time ta**1** is compared with the first threshold Pt**1**, and in accordance with a result thereof, the controller **72** changes the second time ta**2** of the next monitoring.
(98) In this manner, in the third embodiment, the controller **72** acquires the internal pressure Pa**1** at the first time ta**1**, and acquires an internal pressure Pa**2** at the second time ta**2** after the first time ta**1**. The time from the first time ta**1** to the second time ta**2** in a case where the internal pressure Pa**1** at the first time ta**1** is equal to or more than the first threshold Pt**1** is set as a first time period tp**1** (see FIG. **7**(*a*)). The time from the first time ta**1** to the second time ta**2** in a case where the internal pressure Pa**1** at the first time ta**1** is less than the first threshold Pt**1** is set as a second time period tp**2** (see FIG. **7**(*b*)). In the embodiment, the second time period tp**2** in a case where the internal pressure Pa**1** is less than the first threshold Pt**1** is shorter than the first time period tp**1** in a case where the internal pressure Pa**1** is equal to or more than the first threshold Pt**1**. Accordingly, for example, the state of the air cells **11** can be more accurately grasped. An abnormal state of the air cells **11** can be rapidly detected, and the air cells **11** can be caused to recover more rapidly to an adequate state. A more comfortable air mattress can be provided.
(99) As illustrated in FIG. **7**(*b*), for example, the controller **72** conducts the air-supplying operation PO to the air cells **11** in a case where the internal pressure Pa**1** at the first time ta**1** is less than the first threshold Pt**1**.
(100) A threshold (second threshold Pt**2**) may be fixed as for the internal pressure Pa**1** at the second time ta**2**. The second threshold Pt**2** is, for example, a value lower than the “internal pressure at the bed-departure” by the “fixed difference”. The second threshold Pt**2** may be the same as the first threshold Pt**1**. In a case where the internal pressure Pa**2** at the second time ta**2** is less than the second threshold Pt**2**, the controller **72** may conduct the air-supplying operation PO to the air cells **11**.
(101) As illustrated in FIG. **7**(*b*), the controller **72** acquires the internal pressure Pi at a third time ta**3** after the second time ta**2**. In the example in FIG. **7**(*b*), the third time ta**3** is the time tb**0**.
(102) In the embodiment, the internal pressure Pa**2** at the second time ta**2** may be compared with the second threshold Pt**2**, and in accordance with a result of the comparison, the third time ta**3** may be changed. In the example illustrated in FIG. **7**(*b*), the internal pressure Pa**2** at the second time ta**2** is equal to or more than the second threshold Pt**2**. On the other hand, in a case where the internal pressure Pa**2** at the second time ta**2** is less than the second threshold Pt**2**, an operation of FIG. **7**(*c*), which will be described below, may be performed.
(103) As illustrated in FIG. **7**(*c*), in still another example, at the time ta**0**, the internal pressure Pi is the value Pax**2**. At the time tx, the internal pressure Pi suddenly lowers. At the first time ta**1**, the controller **72** acquires data related to the internal pressure Pi. In this example, the internal pressure Pa**1** at the first time ta**1** is less than the first threshold Pt**1**, and the time from the first time ta**1** to the second time ta**2** is the second time period tp**2**. In the example in FIG. **7**(*c*), the internal pressure Pa**2** at the second time ta**2** is less than the second threshold Pt**2**. In this case, the controller **72** sets the third time ta**3** at the next monitoring so as to be earlier than the third time ta**3** in the case of FIG. **7**(*b*). Accordingly, the state of the air cells **11** can be more accurately grasped. For example, the air cell **11** can be recovered more rapidly to the adequate state. A more comfortable air mattress can be provided.
(104) The time from the second time ta**2** to the third time ta**3** in a case where the internal pressure

Pa**2** at the second time ta**2** is equal to or more than the second threshold Pt**2** is set as a third time period tp**3** (see FIG. **7**(*b*)). The time from the second time ta**2** to the third time ta**3** in a case where the internal pressure Pa**2** at the second time ta**2** is less than the second threshold Pt**2** is set as a fourth time period tp**4** (see FIG. **7**(*c*)). The fourth time period tp**4** in a case where the internal pressure Pa**2** is less than the second threshold Pt**2** is shorter than the third time period tp**3** in a case where the internal pressure Pa**2** is equal to or more than the second threshold Pt**2**. For example, the air cell **11** can be recovered more rapidly to the adequate state. A more comfortable air mattress can be provided.
(105) For example, the fourth time period tp**4** is shorter than the second time period tp**2**. For example, the fourth time period tp**4** is equal to or more than 0.3 times and equal to or less than 0.8 times the second time period tp**2**. For example, the fourth time period tp**4** is equal to or more than 0.45 times and equal to or less than 0.55 times the second time period tp**2**. For example, the fourth time period tp**4** is substantially ½ of the second time period tp**2**.
(106) For example, the fourth time period tp**4** is equal to or more than 0.3 times and equal to or less than 0.8 times the third time period tp**3**. For example, the fourth time period tp**4** is equal to or more than 0.45 times and equal to or less than 0.55 times the third time period tp**3**. For example, the fourth time period tp**4** is substantially ½ of the third time period tp**3**.
(107) For example, the second time period tp**2** is equal to or more than 0.3 times and equal to or less than 0.8 times the first time period tp**1**. For example, the second time period tp**2** is equal to or more than 0.45 times and equal to or less than 0.55 times the first time period tp**1**. For example, the second time period tp**2** is substantially ½ of the first time period tp**1**.
(108) For example, the first time period tp**1** is 12 hours. For example, the second time period tp**2** is 6 hours. The third time period tp**3** is 6 hours. For example, the fourth time period tp**4** is 3 hours.
(109) By setting such relations, for example, the first time ta**1** at which the internal pressure Pi is monitored is likely to be set during the daytime. When abnormality is present, the second time ta**2** at which the internal pressure Pi is monitored can be likely to be the time before going-to-bed (FIG. **7**(*b*)).
(110) The controller **72** may conduct an operation of making notification when the internal pressure Pa**1** at the first time ta**1** is less than the first threshold Pt**1**. The controller **72** may make notification when the internal pressure Pa**2** at the second time ta**2** is less than the second threshold Pt**2**. The notification may include, for example, at least either of display and sound waves. The notification may include, for example, a "message" by a display unit of the user interface device **60**.
(111) As has been already described, the air mattress **110** includes the pressure sensor **31***s* that detects the internal pressure Pi. The controller **72** acquires the internal pressure Pi detected by the pressure sensor **31***s*. The acquisition of the internal pressure Pi may include the control by the controller **72** of the detection operation of the pressure sensor **31***s*.
(112) In the third embodiment, the operations having been described related to the first embodiment and the second embodiment may be further conducted.
(113) With the first to third embodiments, a more comfortable air mattress can be provided.
(114) The embodiments may include the following configurations.
Configuration 1
(115) An air mattress provided with: an air cell unit including an air cell; and a controller that controls an internal pressure in the air cell, in which the controller conducts a first operation when the internal pressure in the air cell satisfies a second condition after having satisfied a first condition, the first condition includes the internal pressure becoming from a first value to a second value lower than the first value, a difference between the first value and the second value being equal to or more than a first threshold, and a change rate relative to time of the internal pressure from the first value to the second value being equal to or more than a second threshold, the second condition includes, after the internal pressure has lowered from the first value to the second value, the internal pressure becoming a third value lower than the second value, and a difference between

the second value and the third value being equal to or more than a third threshold, and in the first operation, the controller changes the internal pressure toward the second value.

Configuration 2

(116) The air mattress according to Configuration 1, in which the controller conducts a second operation when the internal pressure in the air cell has satisfied a third condition, the third condition includes the internal pressure rising to a fourth value higher than the second value, and a difference between the fourth value and the second value being equal to or higher than a fourth threshold, and in the second operation, the controller changes the internal pressure toward the first value or a set fifth value.

Configuration 3

(117) The air mattress according to Configuration 1 or 2, further provided with a memory that stores therein the first value and the second value.

Configuration 4

(118) The air mattress according to Configuration 3 further provided with a user interface device that receives an input by a user, in which when the user interface device has received an input to change the internal pressure in the air cell, the first value and the second value stored in the memory are reset.

Configuration 5

(119) The air mattress according to any one of Configurations 1 to 4, further provided with a sensor that detects the first value and the second value.

Configuration 6

(120) The air mattress according to any one of Configurations 1 to 5, in which the controller further conducts a third operation after the internal pressure in the air cell has satisfied the first condition, and in the third operation, the controller conducts at least either of an energy-saving operation and a maintenance operation.

Configuration 7

(121) An air mattress provided with: an air cell unit including an air cell; and a controller that controls an internal pressure in the air cell, in which the controller acquires the internal pressure at a first time, and acquires the internal pressure at a second time after the first time, and a second time period from the first time to the second time in a case where the internal pressure at the first time is less than a first threshold is shorter than a first time period from the first time to the second time in a case where the internal pressure at the first time is equal to or more than the first threshold.

Configuration 8

(122) The air mattress according to Configuration 7, in which the controller supplies air to the air cell in a case where the internal pressure at the first time is less than the first threshold.

Configuration 9

(123) The air mattress according to Configuration 7 or 8, in which the controller supplies air to the air cell in a case where the internal pressure at the second time is less than a second threshold.

Configuration 10

(124) The air mattress according to Configuration 7 or 8, in which the controller acquires the internal pressure at a third time after the second time, and a fourth time period from the second time to the third time in a case where the internal pressure at the second time is less than a second threshold is shorter than a third time period from the second time to the third time in a case where the internal pressure at the second time is equal to or more than the second threshold.

Configuration 11

(125) The air mattress according to Configuration 10, in which the fourth time period is shorter than the second time period.

Configuration 12

(126) The air mattress according to Configuration 11, in which the fourth time period is equal to or

more than 0.3 times and equal to or less than 0.8 times the second time period.
Configuration 13
(127) The air mattress according to any one of Configurations 10 to 12, in which the fourth time period is equal to or more than 0.3 times and equal to or less than 0.8 times the third time period.
Configuration 14
(128) The air mattress according to any one of Configurations 7 to 13, in which the second time period is equal to or more than 0.3 times and equal to or less than 0.8 times the first time period.
Configuration 15
(129) The air mattress according to any one of Configurations 9 to 14, in which the controller makes notification when the internal pressure at the second time is less than the second threshold.
Configuration 16
(130) The air mattress according to any one of Configurations 7 to 15, in which the controller makes notification when the internal pressure at the first time is less than the first threshold.
Configuration 17
(131) The air mattress according to any one of Configurations 7 to 16, in which the first time period is 12 hours, and the second time period is 6 hours.
Configuration 18
(132) The air mattress according to any one of Configurations 7 to 17, further provided with a sensor that detects the internal pressure, in which the controller acquires the internal pressure detected by the sensor.
(133) In the foregoing, the embodiments of this disclosure have been described with reference to the specific examples. However, the present invention is not limited to these specific examples. For example, the specific configurations of the respective elements such as the air cell unit and the controller, which are included in the air mattress, can be included in the scope of the present invention, as long as those skilled in the art can similarly implement the present invention by the appropriate selection from the publicly known range, and obtain the similar effects.
(134) The combination of any two or more elements in the specific examples within a technically possible range is included in the scope of the present invention as long as the gist of the present invention is included.
(135) In addition, all the control devices and the air mattresses that can be implemented through the design changes as appropriate by those skilled in the art based on the control devices and the air mattresses described above as the embodiments of the present invention belong to the scope of the present invention as long as the gist of the present invention is included.
(136) In addition, within the spirit of the present invention, those skilled in the art can conceive of various changes and modifications, and it is understood that these changes and modifications also belong to the scope of the present invention.
REFERENCE SIGNS LIST
(137) **10** . . . air cell unit, **11** . . . air cell, **11***p* . . . tube, **31** . . . pump unit, **31***d* . . . DC pump, **31***s* . . . pressure sensor, **40** . . . upper layer cushion unit, **60** . . . user interface device, **61**, **62** . . . display input unit, **68** . . . cable, **70** . . . control device, **72** . . . controller, **78** . . . memory, ΔP**1** to ΔP**3** . . . difference, ΔQ**1** . . . difference, **110**, **119** . . . air mattress, Dt . . . duty ratio, OP**1**, OP**2** . . . first, second operation, P**1** to P**5** . . . first to fifth value, PO . . . air-supplying operation, Pa**1**, Pa**2** . . . internal pressure, Pax**1**, Pax**2** . . . value, Pi . . . internal pressure, Pr . . . pressure, Pt**1**, Pt**2** . . . first, second threshold, Q**1** . . . absolute value, SC . . . operation, SO . . . operation, SigC . . . strength, T . . . cycle, t**1** to t**7** . . . first to seventh time, ta**0** . . . time, ta**1** to ta**3** . . . first to third time, tb**0** . . . time, tb**1**, tb**2** . . . first, second time, tm . . . time, tp**1** to tp**4** . . . first to fourth time period, tx, ty . . . time.

Claims

1. An air mattress comprising: an air cell unit; a memory; and a controller configured to: monitor an internal pressure of the air cell unit; determine a state of the air mattress to be an unoccupied state based on the internal pressure of the air cell unit; store, in the memory, the internal pressure of the air cell unit monitored at a timing at which the state of the air mattress is determined to be the unoccupied state, as an unoccupied internal pressure; detect an air leakage from the air cell unit based on a decrease of the internal pressure of the air cell unit from the unoccupied internal pressure while the determined state of the air mattress is the unoccupied state; and perform a first operation to increase the internal pressure of the air cell unit to the stored unoccupied internal pressure upon detecting the air leakage from the air cell unit.
2. The air mattress according to claim 1, wherein the controller is configured to determine the air mattress to have turned into the unoccupied state when a first condition is satisfied, the first condition including a decrease of the internal pressure of the air cell unit, which is from a first value to a second value lower than the first value, being equal to or greater than a first threshold value and a rate of the decrease being equal to or greater than a second threshold value, the second value being the unoccupied internal pressure stored in the memory.
3. The air mattress according to claim 2, wherein the controller is configured to detect the air leakage from the air cell unit when a second condition is satisfied after the first condition is satisfied, the second condition including a further decrease of the internal pressure of the air cell unit, which is from the second value to a third value lower than the second value, being equal to or greater than a third threshold value.
4. The air mattress according to claim 3, wherein the controller is configured to perform a second operation to set the internal pressure of the air cell unit to the first value or a fifth value that is preset when a third condition is satisfied, the third condition including an increase of the internal pressure of the air cell unit, which is from the second value to a fourth value higher than the second value, being equal to or greater than a fourth threshold value.
5. The air mattress according to claim 3, wherein the controller is configured to clear the unoccupied internal pressure stored in the memory in response to increase of the monitored internal pressure of the air cell unit.
6. The air mattress according to claim 5, further comprising: a user interface device, wherein upon the user interface device receiving a user input to change the internal pressure of the air cell unit, the unoccupied internal pressure stored in the memory is cleared.
7. The air mattress according to claim 3, further comprising: a sensor configured to measure the internal pressure of the air cell unit, wherein the controller monitors the internal pressure of the air cell unit measured by the sensor.
8. The air mattress according to claim 3, wherein the controller is configured to perform a third operation when the first condition is satisfied, the third operation including a maintenance operation.
9. The air mattress according to claim 3, wherein the controller is configured to perform a third operation when the first condition is satisfied, the third operation including an energy-saving operation.
10. An air mattress comprising: an air cell unit; and a controller configured to: monitor an internal pressure of the air cell unit; determine a state of the air mattress to be an unoccupied state when the internal pressure of the air cell unit satisfies a first condition, the first condition including a decrease of the internal pressure of the air cell unit, which is from a first value to a second value lower than the first value, being equal to or greater than a first threshold value and a rate of the decrease being equal to or greater than a second threshold value; detect an air leakage from the air cell unit when the internal pressure of the air cell unit satisfies a second condition while the determined state of the air mattress is the unoccupied state, the second condition including a further decrease of the internal pressure of the air cell unit, which is from the second value to a third value

lower than the second value, being equal to or greater than a third threshold value; and perform a first operation to set the internal pressure of the air cell unit to the first value or a fifth value that is preset when a third condition is satisfied, the third condition including an increase of the internal pressure of the air cell unit, which is from the second value to a fourth value higher than the second value, being equal to or greater than a fourth threshold value.

11. The air mattress according to claim 10, wherein the controller is configured to perform a second operation to increase the internal pressure of the air cell unit upon detecting the air leakage from the air cell unit.

12. The air mattress according to claim 10, further comprising: a memory in which the first value and the second value are stored.

13. The air mattress according to claim 12, further comprising: a user interface device, wherein upon the user interface device receiving a user input to change the internal pressure of the air cell unit, the first value and the second value stored in the memory are cleared.

14. The air mattress according to claim 10, further comprising: a sensor configured to measure the internal pressure of the air cell unit, wherein the controller monitors the internal pressure of the air cell unit measured by the sensor.

15. The air mattress according to claim 10, wherein the controller is configured to perform a third operation when the first condition is satisfied, the third operation including a maintenance operation.

16. The air mattress according to claim 10, wherein the controller is configured to perform a third operation when the first condition is satisfied, the third operation including an energy-saving operation.
