

DESCRIPTION

TITLE

AIR COMPOSITION ADJUSTMENT APPARATUS, REFRIGERATION APPARATUS, AND STORAGE

5

TECHNICAL FIELD

[0001]

The present disclosure relates to an air composition adjustment apparatus, a refrigeration apparatus, and a storage.

10

BACKGROUND ART

[0002]

Patent Document 1 discloses an inside air control apparatus for controlling a composition of inside air in a transportation container. In order to maintain freshness of fruits, vegetables, and the like stored in the transportation container which is a storage, the inside air control apparatus adjusts a concentration of oxygen and a concentration of carbon dioxide in inside air. The inside air control apparatus processes outside air to generate a treated gas having a composition different from that of the outside air, and supplies the treated gas to the inside space. The inside air control apparatus also operates to supply outside air to the inside space.

20

CITATION LIST

PATENT DOCUMENT

[0003]

25 Patent Document 1: Japanese Unexamined Patent Publication No. 2018-148877

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0004]

30 Respiration amounts of fruits and vegetables stored in the storage vary depending on kinds and states of the fruits and vegetables. For example, when the respiration amounts of fruits and vegetables are small, the amount of carbon dioxide generated by breathing of the fruits and vegetables is also small. Thus, the carbon dioxide concentration of the inside air cannot be increased to a target value by operation of the inside air control apparatus, and there

is a possibility that the inside air cannot be adjusted to a composition suitable for keeping freshness of the fruits and vegetables.

[0005]

5 An object of the present disclosure is to appropriately adjust the composition of inside air.

SOLUTION TO THE PROBLEM

[0006]

10 A first aspect of the present disclosure is directed to an air composition adjustment apparatus (90) that adjusts a composition of inside air inside a storage (2), the air composition adjustment apparatus including a composition adjustment unit (100) that generates a treated gas having a composition different from a composition of outside air by treating the outside air, and supplies the treated gas to the storage (2), an air supply unit (40) that supplies the outside air to the storage (2) and is capable of changing a flow rate of the outside air supplied
15 to the storage (2), a detector (160) that detects a concentration of one or more components of the inside air, and a controller (110) that adjusts the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) based on a value detected by the detector (160).

[0007]

20 In the first aspect, controller (110) adjusts the flow rate of the outside air supplied to the storage (2) by air supply unit (40) based on a value detected by detector (160). Thus, the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) can be extremely reduced as necessary. As a result, even when the flow rate of the outside air supplied to the storage (2) is too large to appropriately set the composition of the inside air, the controller (110) adjusts the flow rate of the outside air supplied to the storage (2) by the air
25 supply unit (40), so that the composition of the inside air can be appropriately set.

[0008]

A second aspect of the present disclosure is an embodiment of the first aspect. In the second aspect, the controller (110) executes a first control mode in which the controller (110) controls an operation of the composition adjustment unit (100) based on the value detected by
30 the detector (160) in a state in which supply of the outside air to the storage (2) by the air supply unit (40) is stopped, and a second control mode in which the controller (110) adjusts the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) based on the value detected by the detector (160) in a state where the composition adjustment unit (100) is stopped.

[0009]

In the second aspect, the controller (110) performs a first control mode and a second control mode. In the first control mode, the controller (110) controls the composition adjustment unit (100) in a state where supply of the outside air to the storage (2) by the air supply unit (40) is stopped. In the second control mode, the controller (110) adjusts the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) with the composition adjustment unit (100) stopped.

[0010]

A third aspect of the present disclosure is an embodiment of the second aspect. In the third aspect, the detector (160) includes an oxygen sensor (161) that detects an oxygen concentration of the inside air and a carbon dioxide sensor (162) that detects a carbon dioxide concentration of the inside air, and the controller (110) ends the first control mode and executes the second control mode when a detection value of the oxygen sensor (161) is lower than a first predetermined value and a detection value of the carbon dioxide sensor (162) is lower than a second predetermined value during execution of the first control mode.

[0011]

In the third aspect, when the detection value of the oxygen sensor (161) is lower than the first predetermined value and the detection value of the carbon dioxide sensor (162) is lower than the second predetermined value, the controller (110) switches the control mode to be executed from the first control mode to the second control mode.

[0012]

A fourth aspect of the present disclosure is an embodiment of the third aspect. In the fourth aspect, the controller (110) reduces the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) when a rising speed of the detection value of the oxygen sensor (161) is higher than a third predetermined value during execution of the second control mode.

[0013]

When the rising speed of the detection value of the oxygen sensor (161) is high while the controller (110) is executing the second control mode, the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) is too high, and thus the carbon dioxide concentration of the inside air may be too low. Accordingly, the controller (110) of the fourth aspect reduces the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) when the rising speed of the detection value of the oxygen sensor (161) is higher than the third predetermined value during execution of the second control mode. As a result, the reduction amount of the carbon dioxide concentration of the inside air can be kept low.

[0014]

A fifth aspect of the present disclosure is an embodiment of the third or fourth aspect. In the fifth aspect, when the detection value of the oxygen sensor (161) is higher than a fourth predetermined value or when the detection value of the carbon dioxide sensor (162) is higher than a fifth predetermined value during execution of the second control mode, the controller
5 (110) ends the second control mode and executes the first control mode, and the fourth predetermined value is higher than the first predetermined value, and the fifth predetermined value is higher than the second predetermined value.

[0015]

In the fifth aspect, when the detection value of the oxygen sensor (161) is higher than
10 the fourth predetermined value, or when the detection value of the carbon dioxide sensor (162) is higher than the fifth predetermined value, the controller (110) switches the control mode to be executed from the second control mode to the first control mode.

[0016]

A sixth aspect of the present disclosure is an embodiment of any one of the second to
15 fifth aspects. In the sixth aspect, the composition adjustment unit (100) is capable of executing a gas supply operation of supplying the treated gas to the storage (2) and an air introduction operation of supplying the outside air to the storage (2), and in the first control mode, the controller (110) switches a state in which the composition adjustment unit (100) performs the gas supply operation, a state in which the composition adjustment unit (100)
20 performs the air introduction operation, and a state in which the composition adjustment unit (100) pauses without performing the gas supply operation and the air introduction operation based on a value detected by the detector (160).

[0017]

The controller (110) of the sixth aspect switches the composition adjustment unit (100)
25 to the state of performing the gas supply operation, the state of performing the air introduction operation, and the state of pausing without performing the gas supply operation and the air introduction operation based on the value detected by the detector (160).

[0018]

A seventh aspect of the present disclosure is an embodiment of any one of the first to
30 sixth aspects. In the seventh aspect, the air supply unit (40) includes an air introduction port (41a) having a variable opening degree through which outside of the storage (2) communicates with inside of the storage (2), and the controller (110) increases the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) by increasing an opening degree of the air introduction port (41a), and reduces the flow rate of the outside air supplied to the storage

(2) by the air supply unit (40) by reducing the opening degree of the air introduction port (41a).
[0019]

The controller (110) of the seventh aspect changes the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) by changing the opening degree of the air introduction port (41a).
[0020]

An eighth aspect of the present disclosure is an embodiment of any one of the first to sixth aspects. In the eighth aspect, the air supply unit (40) includes an internal fan (35) that circulates the inside air inside the storage (2), and an air introduction port (41a) that allows communication between outside of the storage (2) and a suction-side region of the internal fan (35) inside the storage (2), and the controller (110) increases the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) by increasing a rotational speed of the internal fan (35), and reduces the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) by reducing the rotational speed of the internal fan (35).

[0021]

When the rotational speed of the internal fan (35) changes, the pressure in the suction-side region of the internal fan (35) inside the storage (2) changes, and the flow rate of the outside air flowing into the storage (2) from the outside through the air introduction port (41a) changes. Therefore, the controller (110) of the eighth aspect changes the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) by changing the rotational speed of the internal fan (35).

[0022]

A ninth aspect of the present disclosure is an embodiment of any one of the first to fifth aspects. In the ninth aspect, the composition adjustment unit (100) is capable of performing a gas supply operation of supplying the treated gas to the storage (2) and an air introduction operation of supplying the outside air to the storage (2), the composition adjustment unit (100) is capable of adjusting the flow rate of the outside air supplied to the storage (2) during execution of the air introduction operation, the composition adjustment unit (100) that performs the air introduction operation also serves as the air supply unit (40), and the controller (110) adjusts the flow rate of the outside air supplied to the storage (2) by the composition adjustment unit (100) that performs the air introduction operation based on a value detected by the detector (160).

[0023]

In the ninth aspect, the composition adjustment unit (100) that performs the air

introduction operation also serves as the air supply unit (40). The controller (110) adjusts the flow rate of the outside air supplied to the storage (2) by the composition adjustment unit (100) that performs the air introduction operation based on the value detected by the detector (160).
[0024]

5 A tenth aspect of the present disclosure is an embodiment of the first or second aspect. In the tenth aspect, the detector (160) includes a carbon dioxide sensor (162) that detects a carbon dioxide concentration of the inside air, the composition adjustment unit (100) is capable of executing a gas supply operation of supplying the treated gas to the storage (2) and an air introduction operation of supplying outside air to the storage (2), and the controller (110)
10 adjusts the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) so that a decrease rate of a detection value of the carbon dioxide sensor (162) becomes lower than the decrease rate during execution of the air introduction operation by the composition adjustment unit (100), in a state in which the composition adjustment unit (100) stops the gas supply operation and the air introduction operation.

15 [0025]

 The carbon dioxide concentration of the outside air is very low. Thus, the carbon dioxide concentration of the inside air gradually decreases in each of the state in which the composition adjustment unit (100) executes the air introduction operation and the state in which the air supply unit (40) supplies the outside air to the storage. The controller (110) of the tenth
20 aspect adjusts the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) so that the decrease rate of the detection value of the carbon dioxide sensor (162) becomes lower than the decrease rate during execution of the air introduction operation by the composition adjustment unit (100) in a state in which the composition adjustment unit (100) stops the gas supply operation and the air introduction operation. Therefore, in the state in
25 which the air supply unit (40) supplies the outside air to the storage, a decrease in the carbon dioxide concentration of the inside air is suppressed as compared with the state in which the composition adjustment unit (100) executes the air introduction operation.

[0026]

 An eleventh aspect of the present disclosure is an embodiment of the first or second
30 aspect. In the eleventh aspect, the detector (160) includes an oxygen sensor (161) that detects an oxygen concentration of the inside air and a carbon dioxide sensor (162) that detects a carbon dioxide concentration of the inside air, and the controller (110) is capable of executing an oxygen concentration reduction mode in which the controller (110) controls an operation of the composition adjustment unit (100) so that a detection value of the oxygen sensor (161)

decreases from the oxygen concentration of atmosphere to a sixth predetermined value in a state where the supply of the outside air to the storage (2) by the air supply unit (40) is stopped, and a composition maintenance mode in which the controller (110) controls operations of the composition adjustment unit (100) and the air supply unit (40) in order to maintain the composition of the inside air after an end of the oxygen concentration reduction mode, and the controller (110) adjusts the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) based on detection values of the oxygen sensor (161) and the carbon dioxide sensor (162) during execution of the composition maintenance mode.

[0027]

In the eleventh aspect, the controller (110) sequentially executes the oxygen concentration reduction mode and the composition maintenance mode. During execution of the composition maintenance mode, the controller (110) adjusts the flow rate of the outside air supplied to storage (2) by air supply unit (40) based on the detection values of the oxygen sensor (161) and the carbon dioxide sensor (162).

[0028]

A twelfth aspect of the present disclosure is an embodiment of any one of the first to eleventh aspects. In the twelfth aspect, the treated gas includes a first gas having a higher nitrogen concentration and a lower oxygen concentration than the outside air and a second gas having a lower nitrogen concentration and a higher oxygen concentration than the outside air, and the composition adjustment unit (100) includes an air treatment unit (95) that separates the outside air into the first gas and the second gas.

[0029]

In the twelfth aspect, the air treatment unit (95) of the composition adjustment unit (100) separates the outside air into the first gas and the second gas.

[0030]

A thirteenth aspect of the present disclosure is an embodiment of the twelfth aspect. In the thirteenth aspect, the air treatment unit (95) of the composition adjustment unit (100) includes an adsorbent that adsorbs nitrogen, and the composition adjustment unit (100) performs an operation of generating the second gas by adsorbing nitrogen contained in the outside air to the adsorbent of the air treatment unit (95) and an operation of generating the first gas by desorbing nitrogen from the adsorbent of the air treatment unit (95).

[0031]

In the thirteenth aspect, the air treatment unit (95) of the composition adjustment unit (100) separates the outside air into the first gas and the second gas using an adsorbent that

adsorbs nitrogen.

[0032]

A fourteenth aspect of the present disclosure is directed to a refrigeration apparatus (10) including the air composition adjustment apparatus (90) of any one of the first to thirteenth aspects, and a refrigerant circuit (11) that performs a refrigeration cycle to adjust a temperature of the inside air.

[0033]

The refrigeration apparatus (10) of the fourteenth aspect adjusts the composition of the inside air by the operation of the air composition adjustment apparatus (90), and adjusts the temperature of the inside air by the operation of the refrigerant circuit (11).

[0034]

A fifteenth aspect of the present disclosure is directed to a storage including the refrigeration apparatus (10) of the fourteenth aspect.

[0035]

The storage (2) of the fifteenth aspect includes a refrigeration apparatus (10) including the air composition adjustment apparatus (90) and the refrigerant circuit (11).

BRIEF DESCRIPTION OF THE DRAWINGS

[0036]

FIG. 1 is a schematic perspective view of a transportation refrigeration apparatus of an embodiment.

FIG. 2 is a cross-sectional view of a transportation container including the transportation refrigeration apparatus of the embodiment.

FIG. 3 is a piping system diagram illustrating a refrigerant circuit of a transportation refrigeration apparatus of the embodiment.

FIG. 4 is a schematic front view of a ventilation apparatus. FIG. 4(A) illustrates a state in which an opening and closing lid is at a closed position, FIG. 4(B) illustrates a state in which the opening and closing lid is at an intermediate position, and FIG. 4(C) illustrates a state in which the opening and closing lid is at a fully open position.

FIG. 5 is a piping system diagram illustrating a configuration of an inside air control apparatus of the embodiment.

FIG. 6 corresponds to FIG. 5 and is a diagram of the inside air control apparatus performing a first operation of a gas supply operation.

FIG. 7 corresponds to FIG. 5 and is a diagram of the inside air control apparatus

performing a second operation of the gas supply operation.

FIG. 8 corresponds to FIG. 5 and is a diagram of the inside air control apparatus performing an air introduction operation.

FIG. 9 is a block diagram illustrating a configuration of a controller of an air
5 composition adjustment apparatus of the embodiment.

FIG. 10 is a flowchart illustrating an operation performed by the controller of the embodiment.

DESCRIPTION OF EMBODIMENTS

10 [0037]

An embodiment of the present disclosure will be described below with reference to the drawings. In the following description, phrases related to the terms “front”, “rear”, “up”, “down”, “right”, and “left” are based on the directions indicated by the arrows in FIG. 1.

[0038]

15 The present disclosure relates to a transportation container (1). The transportation container (1) is a reefer container capable of controlling an internal temperature. The transportation container (1) is used to transport fresh products (e.g., fruits, vegetables, flowers, and ornamental plants) which breathe by absorbing oxygen (O₂) in the air and releasing carbon dioxide (CO₂) into the air.

20 [0039]

As illustrated in FIGS. 1 and 2, the transportation container (1) includes a container body (2) and a transportation refrigeration apparatus (10). The transportation refrigeration apparatus (10) is attached to the container body (2). The transportation container (1) is used for marine transportation. The transportation container (1) is conveyed by a marine
25 transporter such as a ship.

[0040]

–Container Body–

The container body (2) is a storage for storing the above fresh products.

[0041]

30 The container body (2) has a hollow box shape. The container body (2) is horizontally long. The container body (2) has an opening formed at one end in the longitudinal direction. The opening of the container body (2) is blocked by the transportation refrigeration apparatus (10). The container body (2) contains a storage space (5) for storing cargos, which are fresh products.

[0042]

The storage space (5) has a bottom portion where a floorboard (3) on which cargos are to be placed is disposed. An underfloor path (4) through which air blown from the transportation refrigeration apparatus (10) passes is formed between the floorboard (3) and a bottom plate of the container body (2). The underfloor path (4) extends along the bottom plate of the container body (2) in the longitudinal direction of the container body (2). The underfloor path (4) has ends, one of which is connected to a blowout port (27) of the transportation refrigeration apparatus (10) and the other one of which communicates with a space above the floorboard (3) (i.e., the space where the cargos are stored).

10 [0043]

–Transportation Refrigeration Apparatus–

The transportation refrigeration apparatus (10) includes a casing (20), a refrigerant circuit (11) that performs a refrigeration cycle, an external fan (34), and an internal fan (35).

[0044]

15 <Casing>

The casing (20) includes an external wall (21), an internal wall (22), a backboard (24), and a partition board (25). As will be described later, the casing (20) is provided with the refrigerant circuit (11), the external fan (34), and the internal fan (35).

[0045]

20 The external wall (21) is a plate-shaped member disposed to cover the open end of the container body (2). The external wall (21) has a lower portion protruding toward the inside of the container body (2). The internal wall (22) is a plate-shaped member formed along the external wall (21). The internal wall (22) is disposed to cover a surface of the external wall (21) facing the inside of the container body (2). The space between the external wall (21) and
25 the internal wall (22) is filled with a thermal insulator (23).

[0046]

The casing (20) has a lower portion recessed toward the inside of the container body (2). The lower portion of the casing (20) forms an external equipment room (28) communicating with a space outside the transportation container (1). The external fan (34) is
30 disposed in the external equipment room (28).

[0047]

The backboard (24) is a member having a substantially rectangular flat plate shape. The backboard (24) is disposed closer to the inside of the container body (2) than the internal wall (22) is. An inside air flow path (29) is formed between the backboard (24) and the

internal wall (22). The inside air flow path (29) has an upper end forming an intake port (26) of the casing (20) and has a lower end forming the blowout port (27) of the casing (20).

[0048]

5 The partition board (25) is a plate-shaped member disposed to partition the inside air flow path (29) into upper and lower sections. The partition board (25) is disposed in an upper portion of the inside air flow path (29). The partition board (25) partitions the inside air flow path (29) into a primary flow path (29a) above the partition board (25) and a secondary flow path (29b) below the partition board (25). The primary flow path (29a) communicates with the storage space (5) via the intake port (26). The secondary flow path (29b) communicates with the underfloor path (4) via the blowout port (27). The internal fan (35) is attached to the partition board (25). The internal fan (35) is disposed to blow air sucked from the primary flow path (29a) to the secondary flow path (29b).

[0049]

<Refrigerant Circuit>

15 As illustrated in FIG. 3, the refrigerant circuit (11) is a closed circuit in which a compressor (12), an external heat exchanger (13), an expansion valve (14), and an internal heat exchanger (15) are connected through piping. When the compressor (12) is actuated, a refrigerant circulates through the refrigerant circuit (11) to perform a vapor compression refrigeration cycle. As illustrated in FIG. 2, the external heat exchanger (13) is disposed in the external equipment room (28), and the internal heat exchanger (15) is disposed in the secondary flow path (29b) of the inside air flow path (29). The compressor (12) is disposed in the external equipment room (28).

[0050]

–Operation of Transportation Refrigeration Apparatus–

25 The transportation refrigeration apparatus (10) performs a cooling operation for cooling inside air in the transportation container (1).

[0051]

In the cooling operation, the compressor (12) of the refrigerant circuit (11) operates to circulate the refrigerant through the refrigerant circuit (11), thereby performing a vapor compression refrigeration cycle. In the refrigerant circuit (11), the refrigerant discharged from the compressor (12) passes through the external heat exchanger (13), the expansion valve (14), and the internal heat exchanger (15) in sequence, and then is sucked into and compressed in the compressor (12).

[0052]

In the cooling operation, the external fan (34) and the internal fan (35) operate. When the external fan (34) operates, the outside air outside of the transportation container (1) is sucked into the external equipment room (28) and pass through the external heat exchanger (13). In the external heat exchanger (13), the refrigerant dissipates heat to the outside air and then condenses. When the internal fan (35) operates, the inside air in the storage space (5) of the transportation container (1) is sucked into the inside air flow path (29) and passes through the internal heat exchanger (15). In the internal heat exchanger (15), the refrigerant absorbs heat from the inside air and then evaporates.

[0053]

The flow of the inside air will be described below. The inside air present in the storage space (5) flows into the primary flow path (29a) of the inside air flow path (29) through the intake port (26), and then is blown to the secondary flow path (29b) by the internal fan (35). The inside air having flowed into the secondary flow path (29b) is cooled when passing through the internal heat exchanger (15). Thereafter, the cooled air is blown to the underfloor path (4) through the blowout port (27), and then flows into the storage space (5) through the underfloor path (4).

[0054]

In the inside air flow path (29), the primary flow path (29a) is located on the suction side of the internal fan (35), and the secondary flow path (29b) is located on the discharge side of the internal fan (35). Thus, during operation of the internal fan (35), the air pressure in the secondary flow path (29b) is slightly higher than the air pressure in the primary flow path (29a).

[0055]

-Air Composition Adjustment Apparatus-

The transportation refrigeration apparatus (10) includes an air composition adjustment apparatus (90). The air composition adjustment apparatus (90) includes a ventilation apparatus (40), an inside air control apparatus (100), and a controller (110).

[0056]

The ventilation apparatus (40) is an air supply unit that supplies atmosphere, which is outside air, to the storage space (5) of the storage (2). The ventilation apparatus (40) can change a flow rate of outside air supplied to the storage space (5).

[0057]

The inside air control apparatus (100) processes atmospheric air, which is outside air, to generate a treated gas having a composition different from that of the outside air. The inside air control apparatus (100) is a composition adjustment unit that supplies the generated treated

gas to the storage space (5) of the storage (2).

[0058]

-Ventilation Apparatus-

The ventilation apparatus (40) will be described. The ventilation apparatus (40)
5 ventilates the storage space (5) of the container body (2). The ventilation apparatus (40) has
a function of supplying the outside air to the storage space (5) and a function of discharging
the inside air to an external space (6).

[0059]

<Configuration of Ventilation Apparatus>

As illustrated in FIG. 1, the ventilation apparatus (40) is disposed in an upper left
10 portion of a casing (20) of the transportation refrigeration apparatus (10). As illustrated in
FIG. 2, the ventilation apparatus (40) is provided in a ventilation apparatus attachment port
(38) formed in the casing (20). The ventilation apparatus attachment port (38) penetrates the
casing (20) in the front-rear direction.

[0060]

As illustrated in FIG. 2, an air supply passage (41) and an air discharge passage (42)
are formed inside the ventilation apparatus (40). The air supply passage (41) and the air
discharge passage (42) make the storage space (5) and the external space (6) communicate with
each other.

[0061]

Specifically, the air supply passage (41) allows the primary flow path (29a) of the
inside air flow path (29) to communicate with the external space (6). An end of the air supply
passage (41) on the side of the external space (6) is an air supply communication port (41a).
The air supply communication port (41a) is an air introduction port that allows the external
25 space (6) to communicate with the inside of the container body (2). The air discharge passage
(42) allows the secondary flow path (29b) of the inside air flow path (29) to communicate with
the external space (6). An end of the air discharge passage (42) on the side of the external
space (6) is an air discharge communication port (42a). The air supply communication port
(41a) and the air discharge communication port (42a) are slightly elongated openings extending
30 in the circumferential direction.

[0062]

The ventilation apparatus (40) includes an opening and closing lid (45). The opening
and closing lid (45) is a disk-shaped member. The opening and closing lid (45) is provided
so as to cover the air supply communication port (41a) and the air discharge communication

port (42a). The opening and closing lid (45) is driven by a motor (not illustrated) and is rotatable around a center axis thereof.

[0063]

As illustrated in FIG. 4, in the opening and closing lid (45), an air supply opening (46) and an air discharge opening (47) are formed. Each of the air supply opening (46) and the air discharge opening (47) penetrates the opening and closing lid (45) in the thickness direction. The shape of the air supply opening (46) is the same as the shape of the air supply communication port (41a). The shape of the air discharge opening (47) is the same as the shape of the air discharge communication port (42a). In the opening and closing lid (45), the air supply opening (46) and the air discharge opening (47) are formed at positions such that the entire air discharge opening (47) overlaps the air discharge communication port (42a) when the entire air supply opening (46) overlaps the air supply communication port (41a).

[0064]

<Operation of Ventilation Apparatus>

The ventilation apparatus (40) is configured to be able to adjust a flow rate (supply air flow rate) of the outside air supplied to the storage space (5) and a flow rate (exhaust air flow rate) of the inside air discharged from the storage space (5) by rotationally moving the opening and closing lid (45).

[0065]

Specifically, when the opening and closing lid (45) is rotationally moved, an area of a portion of the air supply communication port (41a) overlapping the air supply opening (46) and an area of a portion of the air discharge communication port (42a) overlapping the air discharge opening (47) change. The outside air flows into the air supply passage (41) through a portion of the air supply communication port (41a) overlapping with the air supply opening (46), and then flows into the storage space (5). The inside air flowing through the air discharge passage (42) flows out to the external space (6) through the portion of the air discharge communication port (42a) overlapping with the air discharge opening (47).

[0066]

Therefore, when the area of the portion of the air supply communication port (41a) overlapping the air supply opening (46) is increased, the supply air flow rate increases, and when the area of the portion is reduced, the supply air flow rate decreases. When the area of the portion of the air discharge communication port (42a) overlapping the air discharge opening (47) is increased, the exhaust air flow rate is increased, and when the area of the portion is decreased, the exhaust air flow rate is decreased.

[0067]

When the opening and closing lid (45) is at the position illustrated in FIG. 4(A), the entire air supply communication port (41a) is covered with the opening and closing lid (45), and the entire air discharge communication port (42a) is covered with the opening and closing lid (45). Thus, each of the area of the portion of the air supply communication port (41a) overlapping the air supply opening (46) and the area of the portion of the air discharge communication port (42a) overlapping the air discharge opening (47) becomes zero. That is, the air supply passage (41) and the air discharge passage (42) are fully closed. Therefore, in this state, each of the supply air flow rate and the exhaust air flow rate becomes zero.

[0068]

When the opening and closing lid (45) is at the position illustrated in FIG. 4(C), the entire air supply communication port (41a) overlaps the air supply opening (46), and the entire air discharge communication port (42a) overlaps the air discharge opening (47). Therefore, the area of the portion of the air supply communication port (41a) overlapping the air supply opening (46) (a portion denoted by a dot in FIG. 4(C)) and the area of the portion of the air discharge communication port (42a) overlapping the air discharge opening (47) (a portion denoted by a dot in FIG. 4(C)) are maximum. Thus, the air supply passage (41) and the air discharge passage (42) are fully opened. Therefore, in this state, each of the supply air flow rate and the exhaust air flow rate becomes the maximum flow rate.

[0069]

When the opening and closing lid (45) is at the position illustrated in FIG. 4(B), a part of the air supply communication port (41a) overlaps the air supply opening (46), and a part of the air discharge communication port (42a) overlaps the air discharge opening (47). Therefore, the area of the portion of the air supply communication port (41a) overlapping the air supply opening (46) (a portion denoted by a dot in FIG. 4(B)) and the area of the portion of the air discharge communication port (42a) overlapping the air discharge opening (47) (a portion denoted by a dot in FIG. 4(B)) are intermediate areas smaller than the maximum. Therefore, in this state, each of the supply air flow rate and the exhaust air flow rate becomes an intermediate flow rate larger than zero and smaller than the maximum flow rate.

[0070]

–Inside Air Control Apparatus–

The inside air control apparatus (100) is provided in the transportation refrigeration apparatus (10) to provide so-called controlled atmosphere (CA) transportation. The inside air control apparatus (100) adjusts a composition of air in the storage space (5) of the transportation

container (1).

[0071]

As illustrated in FIG. 5, the inside air control apparatus (100) includes a filter unit (220), a main unit (200), a gas supply pipe (275), a gas discharge pipe (276), a sensor unit (160), and a ventilation exhaust pipe (150). The inside air control apparatus (100) is a gas separation apparatus of a so-called pressure swing adsorption (PSA) type.

[0072]

The inside air control apparatus (100) generates a treated gas by treating atmospheric air that is outside air. Specifically, the inside air control apparatus (100) separates outside air into nitrogen-enriched gas having a higher nitrogen concentration and a lower oxygen concentration than the outside air and oxygen-enriched gas having a lower nitrogen concentration and a higher oxygen concentration than the outside air. The nitrogen-enriched gas is a first gas and the oxygen-enriched gas is a second gas.

[0073]

<Filter Unit and Outside Air Pipe>

The filter unit (220) is a member having a box shape. The filter unit (220) is installed in the external equipment room (28) of the transportation refrigeration apparatus (10). The filter unit (220) includes an air filter (221). The air filter (221) is a filter for capturing dust, salt, and the like contained in the outside air. The air filter (221) of the present embodiment is an air-permeable, waterproof membrane filter.

[0074]

The filter unit (220) is connected to the main unit (200) via an outside air pipe (241). One end of the outside air pipe (241) is connected to the filter unit (220). The other end of the outside air pipe (241) is connected to an air pump (231) to be described later. The outside air pipe (241) guides the outside air (atmospheric air) having passed through the air filter (221) to the air pump (231).

[0075]

<Main Unit>

The main unit (200) is installed in the external equipment room (28) of the transportation refrigeration apparatus (10). The main unit (200) includes the air pump (231), a first adsorption vessel (234), a second adsorption vessel (235), a first switching valve (232), a second switching valve (233), and a unit case (201) housing those components. The unit case (201) houses an introduction pipe (242), a suction pipe (243), a first gas pipe (244), and a second gas pipe (245).

[0076]

<Air Pump>

The air pump (231) includes a compression-side pump (231a), a decompression-side pump (231b), and a drive motor (231c). Each of the compression-side pump (231a) and the decompression-side pump (231b) sucks and discharges air. The compression-side pump (231a) and the decompression-side pump (231b) are connected to a drive shaft of the single drive motor (231c). In the air pump (231), both the compression-side pump (231a) and the decompression-side pump (231b) are driven by the single drive motor (231c).

[0077]

The compression-side pump (231a) includes a suction port connected to the other end of the outside air pipe (241). The compression-side pump (231a) includes a discharge port connected to one end of the introduction pipe (242). The compression-side pump (231a) supplies treated gas, which has been sucked from the outside air pipe (241), to the first adsorption vessel (234) and the second adsorption vessel (235) through the introduction pipe (242).

[0078]

The decompression-side pump (231b) includes a suction port connected to the suction pipe (243). The decompression-side pump (231b) includes a discharge port connected to the first gas pipe (244). The decompression-side pump (231b) discharges the gas to the first gas pipe (244), where the gas has been sucked from the first adsorption vessel (234) and the second adsorption vessel (235) through the suction pipe (243).

[0079]

<Introduction Pipe>

The introduction pipe (242) is a pipe for guiding treated gas, which has been discharged from the compression-side pump (231a), to the first adsorption vessel (234) and the second adsorption vessel (235). One end of the introduction pipe (242) is connected to the discharge port of the compression-side pump (231a). The other end of the introduction pipe (242) branches into two branch pipes, one of which is connected to the first switching valve (232) and the other one of which is connected to the second switching valve (233).

[0080]

<Suction Pipe>

The suction pipe (243) is a pipe for guiding gas, which has flown out from the first adsorption vessel (234) and the second adsorption vessel (235), to the decompression-side pump (231b). One end of the suction pipe (243) is connected to the suction port of the

decompression-side pump (231b). The other end of the suction pipe (243) branches into two branch pipes, one of which is connected to the first switching valve (232) and the other one of which is connected to the second switching valve (233).

[0081]

5 <First Gas Pipe>

The first gas pipe (244) is a pipe through which nitrogen-enriched gas discharged from the decompression-side pump (231b) flows. The first gas pipe (244) serves as a first gas passage through which nitrogen-enriched gas flows. One end of the first gas pipe (244) is connected to a discharge port of the decompression-side pump (231b). The other end of the first gas pipe (244) is connected to the gas supply pipe (275).

[0082]

The first gas pipe (244) is provided with a check valve (264). The check valve (264) allows gas to flow only from one end to the other end of the first gas pipe (244) and blocks gas from flowing in the reverse direction.

15 [0083]

 <Switching Valve>

The first switching valve (232) and the second switching valve (233) are switching valves each having three ports. The first switching valve (232) and the second switching valve (233) are each configured to switch between a first state (indicated by the solid line in FIG. 3) where a first port communicates with a second port so as to be blocked from a third port, and a second state (indicated by the broken line in FIG. 3) where the first port communicates with the third port so as to be blocked from the second port.

[0084]

The first switching valve (232) has the first port connected to one end of the first adsorption vessel (234). The first switching valve (232) has the second port connected to one of the branch pipes of the introduction pipe (242), and the third port connected to one of the branch pipes of the suction pipe (243). The first switching valve (232) switches between a state where the first adsorption vessel (234) is connected to the compression-side pump (231a) and a state where the first adsorption vessel (234) is connected to the decompression-side pump (231b).

[0085]

The second switching valve (233) has the first port connected to one end of the second adsorption vessel (235). The second switching valve (233) has the second port connected to one of the branch pipes of the introduction pipe (242), and the third port connected to one of

the branch pipes of the suction pipe (243). The second switching valve (233) switches between a state where the second adsorption vessel (235) is connected to the compression-side pump (231a) and a state where the second adsorption vessel (235) is connected to the decompression-side pump (231b).

5 [0086]

<Adsorption Vessel>

The first adsorption vessel (234) and the second adsorption vessel (235) are members each including a cylindrical container and an adsorbent, where both ends of the cylindrical container are closed and the adsorbent fills the container. The adsorption vessel (234, 235)
10 uses the adsorbent in order to separate air to be treated (outside air in the present embodiment) into an oxygen-enriched gas and a nitrogen-enriched gas.

[0087]

The adsorbent that fills each adsorption vessel (234, 235) has characteristics of adsorbing nitrogen and water (water vapor) in treated gas in a pressurized state with a pressure
15 higher than the atmospheric pressure, and desorbing nitrogen and water in a depressurized state with a pressure lower than the atmospheric pressure. One example of an adsorbent having such characteristics is porous zeolite with pores having a diameter smaller than the diameter of nitrogen molecules (3.0 angstrom) and larger than the diameter of oxygen molecules (2.8 angstrom).

20 [0088]

The first adsorption vessel (234) and the second adsorption vessel (235) constitute an air treatment unit (95) together with the first switching valve (232) and the second switching valve (233).

[0089]

25 <Second Gas Pipe>

The second gas pipe (245) includes a trunk pipe (246), a first branch pipe (247a), and a second branch pipe (247b). The second gas pipe (245) serves as a second gas passage through which oxygen-enriched gas flows.

[0090]

30 The first branch pipe (247a) is a pipe for connecting the other end of the first adsorption vessel (234) to one end of the trunk pipe (246). The second branch pipe (247b) is a pipe for connecting the other end of the second adsorption vessel (235) to one end of the trunk pipe (246). The first branch pipe (247a) and the second branch pipe (247b) are each provided with a check valve (261). Each check valve (261) allows air to flow in a direction

in which the air flows out from the associated adsorption vessel (234, 235) and blocks air from flowing in the reverse direction.

[0091]

As described above, one end of the trunk pipe (246) is connected with the first branch
5 pipe (247a) and the second branch pipe (247b). The other end of the trunk pipe (246) is
connected to the gas discharge pipe (276) described later. The trunk pipe (246) is provided
with an orifice (263) and a check valve (262) in sequence from one end to the other end thereof.
The check valve (262) allows air to flow from one end to the other end of the trunk pipe (246)
and blocks air from flowing in the reverse direction.

10 [0092]

<Purge Pipe>

The first branch pipe (247a) and the second branch pipe (247b) of the second gas pipe
(245) are each connected with a purge pipe (250). The purge pipe (250) has ends, one of
which is connected to the first branch pipe (247a) and the other one of which is connected to
15 the second branch pipe (247b). The one end of the purge pipe (250) is connected to the first
branch pipe (247a) between the first adsorption vessel (234) and the check valve (261). The
other end of the purge pipe (250) is connected to the second branch pipe (247b) between the
second adsorption vessel (235) and the check valve (261).

[0093]

20 The purge pipe (250) is provided with a purge valve (251). The purge valve (251) is
an on-off valve comprised of an electromagnetic valve. The purge valve (251) is opened to
equalize the pressures of the first adsorption vessel (234) and the second adsorption vessel
(235). An orifice (252) is provided on each side of the purge valve (251) of the purge pipe
(250).

25 [0094]

<Exhaust Connection Pipe>

The first gas pipe (244) is connected with an exhaust connection pipe (271). The
exhaust connection pipe (271) has ends, one of which is connected to the first gas pipe (244)
and the other one of which is connected to the second gas pipe (245). The one end of the
30 exhaust connection pipe (271) is connected to the first gas pipe (244) between the
decompression-side pump (231b) and the check valve (264). The other end of the exhaust
connection pipe (271) is connected to one end of the gas discharge pipe (276).

[0095]

The exhaust connection pipe (271) is provided with a gas discharge valve (272). The

gas discharge valve (272) is an on-off valve comprised of an electromagnetic valve. When the gas discharge valve (272) is opened, the nitrogen-enriched gas flowing in the first gas pipe (244) is discharged to the outside of the container body (2).

[0096]

5 <Gas Supply Pipe>

As described above, the first gas pipe (244) is connected to one end of the gas supply pipe (275). The gas supply pipe (275) extends to the outside of the unit case (201). The other end of the gas supply pipe (275) opens to a downstream side of the internal fan (35) in the inside air flow path (29) of the transportation refrigeration apparatus (10). The gas supply
10 pipe (275) is a pipe for introducing gas flowing therein from one end thereof to the inside of the container body (2).

[0097]

The gas supply pipe (275) is provided with a gas supply valve (273). The gas supply valve (273) is an on-off valve comprised of an electromagnetic valve.

15 [0098]

<Gas Discharge Pipe>

As described above, one end of the gas discharge pipe (276) is connected with the trunk pipe (246) of the second gas pipe (245) and the exhaust connection pipe (271). The gas discharge pipe (276) extends to the outside of the unit case (201). The other end of the gas
20 discharge pipe (276) opens to the external equipment room (28) of the transportation container (1). The gas discharge pipe (276) is a pipe for discharging gas flowing therein from one end thereof to the outside of the container body (2).

[0099]

<Measurement Pipe>

25 The first gas pipe (244) is connected with a measurement pipe (281). The measurement pipe (281) is a pipe for connecting the first gas pipe (244) to the sensor unit (160). One end of the measurement pipe (281) is connected to the first gas pipe (244) at a downstream side of the check valve (264). The other end of the measurement pipe (281) is connected to the sensor unit (160).

30 [0100]

The measurement pipe (281) is provided with a measurement on-off valve (282). The measurement on-off valve (282) is an on-off valve comprised of an electromagnetic valve. The measurement on-off valve (282) is opened when sending air flowing in the first gas pipe (244) to the sensor unit (160).

[0101]

<Bypass Pipe>

The introduction pipe (242) is connected with a bypass connection pipe (255). The bypass connection pipe (255) is a pipe for enabling outside air to bypass the first adsorption vessel (234) and the second adsorption vessel (235) and to be supplied to the storage space (5) of the transportation container (1). One end of the bypass connection pipe (255) is connected between the branch point of the introduction pipe (242) and the compression-side pump (231a). The other end of the bypass connection pipe (255) is connected to one end of the gas supply pipe (275).

10 [0102]

The bypass connection pipe (255) is provided with a bypass valve (256). The bypass valve (256) is an on-off valve comprised of an electromagnetic valve. The bypass valve (256) is opened when the outside air discharged by the compression-side pump (231a) is supplied to the storage space (5) without changing the composition of the outside air.

15 [0103]

<Sensor Unit>

The sensor unit (160) includes an oxygen sensor (161), a carbon dioxide sensor (162), and a sensor case (163). The sensor unit (160) is a detector that detects a concentration of a component of the inside air. The sensor unit (160) is provided in the secondary flow path (29b) of the inside air flow path (29).

20

[0104]

The oxygen sensor (161) is, e.g., a sensor of a zirconia current type that measures an oxygen concentration of mixed gas such as air. The carbon dioxide sensor (162) is, e.g., a non-dispersive infrared (NDIR) sensor that measures a carbon dioxide concentration of mixed gas such as air. The oxygen sensor (161) and the carbon dioxide sensor (162) are housed in the sensor case (163).

25

[0105]

The sensor case (163) is a box-shaped member. The sensor case (163) includes an air filter (164). The air filter (164) is a membrane filter for capturing dust and the like contained in the inside air. The air filter (164) filters the inside air flowing into the sensor case (163).

30

[0106]

The sensor case (163) is connected with the measurement pipe (281). The sensor case (163) is connected with an outlet pipe (165). The outlet pipe (165) has an inlet end

connected to the sensor case (163), and an outlet end opening to an upstream of the internal fan (35) in the inside air flow path (29). That is, the outlet end of the outlet pipe (165) opens to the primary flow path (29a) of the inside air flow path (29).

[0107]

5 When the measurement on-off valve (282) is closed, the inside air flows inside the sensor case (163). Specifically, the inside air flowing through the secondary flow path (29b) of the inside air flow path (29) flows into the sensor case (163) through the air filter (164). After having passed through the sensor case (163), the inside air flows through the outlet pipe (165), and then flows into the primary flow path (29a) of the inside air flow path (29). Thus, 10 when the measurement on-off valve (282) is closed, the oxygen sensor (161) measures an oxygen concentration of the inside air, and the carbon dioxide sensor (162) measures a carbon dioxide concentration of the inside air.

[0108]

 On the other hand, when the measurement on-off valve (282) is opened, the gas 15 flowing in the measurement pipe (281) flows inside the sensor case (163). Specifically, the gas flowing in the first gas pipe (244) or the bypass connection pipe (255) flows into the sensor case (163) through the measurement pipe (281). After having passed through the sensor case (163), the gas flows through the outlet pipe (165), and then flows into the primary flow path (29a) of the inside air flow path (29). Thus, when the measurement on-off valve (282) is 20 opened, the oxygen sensor (161) measures an oxygen concentration of the gas flowing from the measurement pipe (281) into the sensor case (163), and the carbon dioxide sensor (162) measures a carbon dioxide concentration of the gas flowing from the measurement pipe (281) into the sensor case (163).

[0109]

25 <Ventilation Exhaust Pipe>

 The ventilation exhaust pipe (150) is a pipe for discharging inside air in the transportation container (1) to the external space. The ventilation exhaust pipe (150) penetrates the external wall (21) and the internal wall (22) of the transportation refrigeration apparatus (10). The ventilation exhaust pipe (150) is provided with a ventilation exhaust 30 valve (151). The ventilation exhaust valve (151) is an on-off valve comprised of an electromagnetic valve.

[0110]

-Gas Supply Operation of Inside Air Control Apparatus-

 The inside air control apparatus (100) performs a gas supply operation. The gas

supply operation is an operation of generating the first gas by treating the outside air and supplying the first gas to the storage space (5) of the storage (2). In the gas supply operation, the ventilation exhaust valve (151) is opened.

[0111]

5 In the gas supply operation, the inside air control apparatus (100) alternately repeats the first operation and the second operation. The inside air control apparatus (100) repeats the first operation and the second operation alternately each for predetermined switching period (e.g., 14 seconds). As a result, the outside air is separated into the nitrogen-enriched gas (first gas) and the oxygen-enriched gas (second gas) in the air treatment unit (95) of the inside air
10 control apparatus (100).

[0112]

<First Operation>

As illustrated in FIG. 6, in the first operation, the first switching valve (232) is set to the first state, and the second switching valve (233) is set to the second state. In the first
15 operation, the purge valve (251), the bypass valve (256), and the measurement on-off valve (282) are held closed. In the first operation, the air pump (231) operates to perform an adsorption operation for the first adsorption vessel (234) and a desorption operation for the second adsorption vessel (235).

[0113]

20 The compression-side pump (231a) sucks and compresses the outside air (atmospheric air) from the outside air pipe (241), and supplies the compressed outside air to the first adsorption vessel (234). In the first adsorption vessel (234), nitrogen and water (water vapor) in the supplied outside air are adsorbed by the adsorbent. As a result, in the first adsorption
25 vessel (234), oxygen-enriched gas having a lower nitrogen concentration and a higher oxygen concentration than the outside air is produced. The oxygen-enriched gas flows out from the first adsorption vessel (234) to the first branch pipe (247a) of the second gas pipe (245), and then is discharged to the external space (6) through the gas discharge pipe (276).

[0114]

30 Meanwhile, the decompression-side pump (231b) sucks gas from the second adsorption vessel (235). In the second adsorption vessel (235), the pressure therein decreases, and nitrogen and water are desorbed from the adsorbent. As a result, in the second adsorption vessel (235), nitrogen-enriched gas having a higher nitrogen concentration and a lower oxygen concentration than the outside air is produced. The nitrogen-enriched gas flows from the second adsorption vessel (235) into the suction pipe (243), and is sucked into the

decompression-side pump (231b). The decompression-side pump (231b) compresses and discharges the sucked nitrogen-enriched gas to the first gas pipe (244). The nitrogen-enriched gas flowing through the first gas pipe (244) is supplied to the storage space (5) of the storage (2) through the gas supply pipe (275).

5 [0115]

<Second Operation>

As illustrated in FIG. 7, in the second operation, the first switching valve (232) is set to the second state, and the second switching valve (233) is set to the first state. In the second operation, the purge valve (251), the bypass valve (256), and the measurement on-off valve (282) are held closed. In the second operation, the air pump (231) operates to perform a desorption operation for the first adsorption vessel (234) and an adsorption operation for the second adsorption vessel (235).

[0116]

The compression-side pump (231a) sucks and compresses the outside air (atmospheric air) from the outside air pipe (241), and supplies the compressed outside air to the second adsorption vessel (235). In the second adsorption vessel (235), nitrogen and water (water vapor) in the supplied outside air are adsorbed the adsorbent. As a result, in the second adsorption vessel (235), oxygen-enriched gas having a lower nitrogen concentration and a higher oxygen concentration than the outside air is produced. The oxygen-enriched gas flows out from the second adsorption vessel (235) to the second branch pipe (247b) of the second gas pipe (245), and then is discharged to the external space (6) through the gas discharge pipe (276).

[0117]

Meanwhile, the decompression-side pump (231b) sucks gas from the first adsorption vessel (234). In the first adsorption vessel (234), the pressure therein decreases, and nitrogen and water are desorbed from the adsorbent. As a result, in the first adsorption vessel (234), nitrogen-enriched gas having a higher nitrogen concentration and a lower oxygen concentration than the outside air is produced. The nitrogen-enriched gas flows from the first adsorption vessel (234) into the suction pipe (243), and is sucked into the decompression-side pump (231b). The decompression-side pump (231b) compresses and discharges the sucked nitrogen-enriched gas to the first gas pipe (244). The nitrogen-enriched gas flowing through the first gas pipe (244) is supplied to the storage space (5) of the storage (2) through the gas supply pipe (275).

[0118]

-Air Introduction Operation of Inside Air Control Apparatus-

The inside air control apparatus (100) performs an air introduction operation. The air introduction operation is an operation of supplying the outside air, which is the atmosphere, to the storage space (5) of the storage (2) as it is without changing the composition of the outside air.

5 [0119]

As illustrated in FIG. 8, in the air introduction operation, both the first switching valve (232) and the second switching valve (233) are set to the second state. In the air introduction operation, the gas supply valve (273) and the bypass valve (256) are held opened, and the other on-off valves (251, 272, 282) are held closed. In the air introduction operation, the air pump (231) is operated, and the ventilation exhaust valve (151) is opened.

10 [0120]

The compression-side pump (231a) sucks and compresses the outside air (atmospheric air) from the outside air pipe (241), and discharges the compressed outside air to the introduction pipe (242). The outside air discharged from the compression-side pump (231a) flows through the introduction pipe (242), the bypass connection pipe (255), and the gas supply pipe (275) in sequence, and is supplied to the inside air flow path (29). In this manner, in the air introduction operation, the air having the same composition as that of the atmospheric air is supplied to the storage space (5) of the transportation container (1).

15 [0121]

The decompression-side pump (231b) sucks gas from both the first adsorption vessel (234) and the second adsorption vessel (235) and discharges the sucked gas to the first gas pipe (244). The gas discharged from the decompression-side pump (231b) to the first gas pipe (244) flows into the gas supply pipe (275), and is supplied to the inside air flow path (29) together with the outside air having flowed from the bypass connection pipe (255) into the gas supply pipe (275).

20 [0122]

When the decompression-side pump (231b) sucks gas from the first adsorption vessel (234) and the second adsorption vessel (235), the pressures of the first adsorption vessel (234) and the second adsorption vessel (235) gradually decrease. Then, when the duration of the air introduction operation exceeds a certain time (for example, 45 seconds), the flow rate of gas sucked by the decompression-side pump (231b) reaches substantially zero.

25 [0123]

-Controller-

As illustrated in FIG. 9, the controller (110) includes a microcomputer (111) mounted

on a control board, and a memory device (112) storing software for operating the microcomputer (111). The memory device (112) is a semiconductor memory.

[0124]

The controller (110) controls the components of the inside air control apparatus (100).

5 The controller (110) receives values measured by the oxygen sensor (161) and the carbon dioxide sensor (162). The controller (110) controls the air pump (231), a first switching valve (136), and a second switching valve (137). The controller (110) controls the ventilation exhaust valve (151), the purge valve (251), the bypass valve (256), the gas discharge valve (272), the gas supply valve (273), and the measurement on-off valve (282).

10 [0125]

The controller (110) controls the ventilation apparatus (40). Specifically, the controller (110) rotates the opening and closing lid (45) of the ventilation apparatus (40) to adjust opening degrees of the air supply communication port (41a) and the air discharge communication port (42a). When the opening degree of the air supply communication port
15 (41a) is changed, the flow rate of the outside air supplied to the storage space (5) through the air supply passage (41) changes. When the opening degree of the air discharge communication port (42a) is changed, the flow rate of the inside air discharged to the external space (6) through the air discharge passage (42) changes.

[0126]

20 -Control Operation of Controller (Overview)-

The outline of the control operation performed by the controller (110) will be described.

[0127]

<Oxygen Concentration Reduction Mode>

25 The controller (110) executes an oxygen concentration reduction mode when the air composition adjustment apparatus (90) starts operating. The oxygen concentration reduction mode is a control mode in which the air composition adjustment apparatus (90) is controlled so that the oxygen concentration of the inside air decreases from the oxygen concentration (21%) of the atmosphere to the set value SP_O2 of the oxygen concentration. The set value
30 SP_O2 of the oxygen concentration is a sixth predetermined value. The oxygen concentration reduction mode is processing from step ST1 to step ST2 in the flowchart of FIG. 10.

[0128]

<Composition Maintenance Mode>

When the oxygen concentration reduction mode ends, the controller (110) then

executes a composition maintenance mode. The composition maintenance mode is a control mode in which the air composition adjustment apparatus (90) is controlled so that the oxygen concentration and the carbon dioxide concentration of the inside air are maintained within respective allowable ranges. The composition maintenance mode is processing from step ST3 to step ST9 in the flowchart of FIG. 10.

[0129]

In the present embodiment, the allowable range of the oxygen concentration is a range of $SP_O2-\alpha$ or more and $SP_O2+\alpha$ or less ($SP_O2-\alpha \leq M_O2 \leq SP_O2+\alpha$). The constant α is, for example, 1%. The measurement value M_O2 of the oxygen concentration is a detection value of the oxygen sensor (161). The set value SP_O2 of the oxygen concentration is input to the controller (110) by an administrator or the like of the transportation refrigeration apparatus (10). The set value SP_O2 of the oxygen concentration is, for example, 3%. The set value SP_O2 of the oxygen concentration is set to a value corresponding to the kinds of fruits and vegetables stored in the storage space (5).

[0130]

The allowable range of the carbon dioxide concentration is a range of $SP_CO2-\beta$ or more and $SP_CO2+\beta$ or less ($SP_CO2-\beta \leq M_CO2 \leq SP_CO2+\beta$). The constant β is, for example, 1%. The measurement value M_CO2 of the carbon dioxide concentration is a detection value of the carbon dioxide sensor (162). The set value SP_CO2 of the carbon dioxide concentration is input to the controller (110) by an administrator or the like of the transportation refrigeration apparatus (10). The set value SP_CO2 of the carbon dioxide concentration is, for example, 5%. The set value SP_CO2 of the carbon dioxide concentration is set to a value corresponding to the kinds of fruits and vegetables stored in the storage space (5).

[0131]

The controller (110) selectively performs the first control mode and the second control mode in the composition maintenance mode.

[0132]

<First Control Mode>

The first control mode is a control mode in which the inside air control apparatus (100) is operated in a state where supply of air and discharge of air by the ventilation apparatus (40) are stopped. The first control mode is processing from step ST3 to step ST5 in the flowchart of FIG. 10. In the first control mode, the controller (110) controls operation of the inside air control apparatus (100) so that the oxygen concentration and the carbon dioxide concentration

of the inside air are maintained in respective allowable ranges.

[0133]

<Second Control Mode>

The second control mode is a control mode in which the ventilation apparatus (40) is
5 caused to supply air and discharge air in a state where the inside air control apparatus (100) is
stopped. The second control mode is processing from step ST6 to step ST9 in the flowchart
of FIG. 10. The second control mode is executed when it is necessary to minimize the
reduction amount in the carbon dioxide concentration of the inside air while increasing the
oxygen concentration of the inside air during execution of the composition maintenance mode.
10 In the second control mode, the controller (110) adjusts a supply air flow rate by the ventilation
apparatus (40) so that the carbon dioxide concentration of the inside air does not excessively
decrease.

[0134]

-Control Operation of Controller (Details)-

15 The control operation performed by the controller (110) will be described in detail
with reference to the flowchart of FIG. 10.

[0135]

<Step ST1>

As described above, the controller (110) executes the oxygen concentration reduction
20 mode when the air composition adjustment apparatus (90) starts operating.

[0136]

In the processing of step ST1, the controller (110) sets the opening and closing lid (45)
of the ventilation apparatus (40) to a position covering the entire air supply communication
port (41a) and the entire air discharge communication port (42a). In this state, both the air
25 supply communication port (41a) and the air discharge communication port (42a) are fully
closed, and the ventilation apparatus (40) performs neither air supply nor air exhaust.

[0137]

In the processing of step ST1, the controller (110) causes the inside air control
apparatus (100) to perform a gas supply operation. In the gas supply operation, the inside air
30 control apparatus (100) alternately repeats the first operation and the second operation to supply
the nitrogen-enriched gas (first gas) to the storage space (5) of the container body (2). In the
gas supply operation, the ventilation exhaust valve (151) is in the open state, and the air in the
storage space (5) is discharged to the external space (6) through the ventilation exhaust pipe
(150). Therefore, the air in the storage space (5) is gradually replaced by the nitrogen-

enriched gas, and the oxygen concentration of the inside air of the storage space (5) gradually decreases.

[0138]

<Step ST2>

5 While the inside air control apparatus (100) is performing the gas supply operation, the controller (110) performs the processing of step ST2.

[0139]

In the processing of step ST2, the controller (110) obtains the detection value measured by the oxygen sensor (161). The detection value of the oxygen sensor (161) is a measurement value M_O2 of the oxygen concentration of the inside air. The controller (110) compares the measurement value M_O2 of the oxygen concentration with the set value SP_O2 of the oxygen concentration.

[0140]

When the measurement value M_O2 of the oxygen concentration is higher than the set value SP_O2 of the oxygen concentration ($M_O2 > SP_O2$), the controller (110) causes the inside air control apparatus (100) to continue the gas supply operation and performs the processing of step ST2 again. On the other hand, when the measurement value M_O2 of the oxygen concentration is equal to or less than the set value SP_O2 of the oxygen concentration ($M_O2 \leq SP_O2$), the controller (110) ends the oxygen concentration reduction mode and starts the first control mode of the composition maintenance mode.

[0141]

<Step ST3>

The controller (110) that has started the first control mode of the composition maintenance mode performs the processing of step ST3.

25 [0142]

In the processing of step ST3, the controller (110) sets the opening and closing lid (45) of the ventilation apparatus (40) to a position covering the entire air supply communication port (41a) and the entire air discharge communication port (42a). In this state, both the air supply communication port (41a) and the air discharge communication port (42a) are fully closed, and the ventilation apparatus (40) performs neither air supply nor air exhaust. When the air supply communication port (41a) and the air discharge communication port (42a) are already in the fully closed state at the start of the processing of step ST3, the controller (110) keeps the position of the opening and closing lid (45) of the ventilation apparatus (40) unchanged.

[0143]

In the processing of step ST3, the controller (110) controls the operation of the inside air control apparatus (100) so that the oxygen concentration and the carbon dioxide concentration of the inside air are maintained in the respective allowable ranges.

5 [0144]

In the processing of step ST3, the controller (110) acquires the detection value of the oxygen sensor (161) and the detection value of the carbon dioxide sensor. The detection value of the oxygen sensor (161) is a measurement value M_O2 of the oxygen concentration of the inside air. The detection value of the carbon dioxide sensor (162) is a measurement value
10 M_CO2 of the carbon dioxide concentration of the inside air.

[0145]

In the processing of step ST3, the controller (110) switches the inside air control apparatus (100) to a state in which the gas supply operation is performed, a state in which the air introduction operation is performed, and a pause state in which the gas supply operation
15 and the air introduction operation are not performed based on the measurement value M_O2 of the oxygen concentration and the measurement value M_CO2 of the carbon dioxide concentration.

[0146]

The controller (110) causes the inside air control apparatus (100) to perform the gas
20 supply operation when the oxygen concentration of the inside air needs to be lowered. When the inside air control apparatus (100) performs the gas supply operation, the nitrogen-enriched gas is supplied to the storage space (5), and the oxygen concentration of the inside air decreases.

[0147]

The controller (110) causes the inside air control apparatus (100) to perform the air
25 introduction operation when the oxygen concentration of the inside air needs to be increased and when the carbon dioxide concentration of the inside air needs to be decreased. When the inside air control apparatus (100) performs the air introduction operation, the outside air (atmosphere) is supplied to the storage space (5) as it is. The outside air, which is the atmosphere, has an oxygen concentration of 21% and a carbon dioxide concentration of 0.03%.
30 Therefore, when the outside air is supplied to the storage space (5), the oxygen concentration of the inside air increases, and the carbon dioxide concentration of the inside air decreases.

[0148]

The controller (110) brings the inside air control apparatus (100) into a pause state when it is not necessary to adjust both the oxygen concentration and the carbon dioxide

concentration of the inside air. The inside air control apparatus (100) in the pause state performs neither the gas supply operation nor the air introduction operation. On the other hand, in the storage space (5), the stored fruits and vegetables breathe. Therefore, while the inside air control apparatus (100) is in the pause state, the oxygen concentration of the inside
5 air gradually decreases, and the carbon dioxide concentration of the inside air gradually increases.

[0149]

<Step ST4>

The controller (110) performs the processing of step ST4 while controlling the inside
10 air control apparatus (100). In the processing of step ST4, the controller (110) determines whether or not an end instruction of the composition maintenance mode has been input. The end instruction of the composition maintenance mode is input, for example, when the transportation of fruits and vegetables is ended.

[0150]

15 When an end instruction of the composition maintenance mode is input, the controller (110) ends the composition maintenance mode. On the other hand, when the end instruction of the composition maintenance mode is not input, the controller (110) continues the composition maintenance mode and performs the processing of step ST5.

[0151]

20 <Step ST5>

In the processing of step ST5, the controller (110) acquires the measurement value M_O2 of the oxygen concentration of the inside air and the measurement value M_CO2 of the carbon dioxide concentration of the inside air. The controller (110) then determines whether or not the first condition and the second condition are satisfied.

25 [0152]

The first condition is that “the measurement value M_O2 of oxygen concentration is equal to or less than the lower limit value $SP_O2-\alpha$ of the allowable range of oxygen concentration ($M_O2 \leq SP_O2-\alpha$)”. The lower limit value $SP_O2-\alpha$ of the allowable range of oxygen concentration is a first predetermined value. The first condition may be a condition
30 that “the measurement value M_O2 of oxygen concentration is lower than the first predetermined value ($M_O2 < SP_O2-\alpha$)”.

[0153]

The second condition is that “the measurement value M_CO2 of carbon dioxide concentration is lower than the set value SP_CO2 of carbon dioxide concentration

($M_CO2 < SP_CO2$)". The set value SP_CO2 of the carbon dioxide concentration is a second predetermined value.

[0154]

When both the first condition and the second condition are not satisfied and when only one of the first condition and the second condition is satisfied, the controller (110) continues the first control mode. Specifically, the controller (110) performs the processing of step ST3 again.

[0155]

On the other hand, when both the first condition and the second condition are satisfied, it is necessary to reduce the reduction amount of the carbon dioxide concentration of the inside air as much as possible while increasing the oxygen concentration of the inside air. Therefore, the controller (110) ends the first control mode and starts the second control mode.

[0156]

<Step ST6>

The controller (110) that has started the second control mode performs the processing of step ST6.

[0157]

In the processing of step ST6, the controller (110) brings the inside air control apparatus (100) into a pause state. The inside air control apparatus (100) in a pause state does not perform both the gas supply operation of supplying the nitrogen-enriched gas to the storage space (5) and the air introduction operation of supplying outside air to the storage space (5).

[0158]

In the processing of step ST6, the controller (110) causes the ventilation apparatus (40) to supply air and exhaust air. Specifically, the controller (110) rotates the opening and closing lid (45) of the ventilation apparatus (40) to open a part of each of the air supply communication port (41a) and the air discharge communication port (42a). At that time, the controller (110) moves the opening and closing lid (45) to a position where the areas of the opening portions of the air supply communication port (41a) and the air discharge communication port (42a) become a relatively small predetermined initial value.

[0159]

When a part of the air supply communication port (41a) is opened, the outside air is supplied to the storage space (5) through the air supply passage (41). When a part of the air discharge communication port (42a) is opened, the inside air having passed through the air discharge passage (42) is discharged to the external space (6).

[0160]

An opening portion of the air supply communication port (41a) is a portion of the air supply communication port (41a) overlapping the air supply opening (46) of the opening and closing lid (45) (a portion denoted by a dot in FIG. 4). The initial value of the opening portion of the air supply communication port (41a) is, for example, about 1/6 of the entire area of the air supply communication port (41a). An opening portion of the air discharge communication port (42a) is a portion (a portion denoted by a dot in FIG. 4) overlapping with the air discharge opening (47) of the opening and closing lid (45) in the air discharge communication port (42a). The initial value of the opening portion of the air discharge communication port (42a) is, for example, about 1/6 of the entire area of the air discharge communication port (42a).

[0161]

<Step ST7>

The controller (110) performs the processing of step ST7 next to the processing of step ST6.

[0162]

In the processing of step ST7, the controller (110) calculates a rising speed of the measurement value M_O2 of the oxygen concentration. Specifically, the controller (110) acquires the measurement value M_O2 of the oxygen concentration at the time when the processing of step ST7 is started and the measurement value M_O2 of the oxygen concentration at the time when a predetermined time (for example, 60 minutes) has elapsed from the start of the processing of step ST7, and calculates the amount of change (that is, the rising speed of the measurement value M_O2 of the oxygen concentration) in the measurement value M_O2 of the oxygen concentration per unit time using these values.

[0163]

In the processing of step ST7, the controller (110) determines whether or not the third condition is satisfied. The third condition is that “the rising speed of the measurement value M_O2 of the oxygen concentration is higher than a reference rising speed”. The reference rising speed is a third predetermined value. The reference rising speed of the present embodiment is a rising speed of the measurement value M_O2 of the oxygen concentration when the inside air control apparatus (100) executes the air introduction operation in the first control mode of the controller (110).

[0164]

If the third condition is satisfied, the controller (110) performs the processing of step ST8. On the other hand, in a case where the third condition is not satisfied, the controller

(110) performs the processing of step ST9.

[0165]

<Step ST8>

When the rising speed of the measurement value M_O2 of the oxygen concentration
5 is higher than the reference rising speed, the flow rate of the outside air supplied to the storage
space (5) by the ventilation apparatus (40) is too large. When the ventilation apparatus (40)
supplies the outside air to the storage space (5), the inside air containing carbon dioxide is
discharged to the external space (6) accordingly. Thus, if the flow rate of the outside air
supplied to the storage space (5) by the ventilation apparatus (40) is too high, the carbon dioxide
10 concentration of the inside air may be too low. Therefore, in this case, the controller (110)
performs the processing of step ST8.

[0166]

In the processing of step ST8, the controller (110) rotationally moves the opening and
closing lid (45) of the ventilation apparatus (40) to reduce the area of the opening portion of
15 the air supply communication port (41a) and the area of the opening portion of the air discharge
communication port (42a). When the area of the opening portion of the air supply
communication port (41a) decreases, the flow rate of the outside air supplied to the storage
space (5) through the air supply passage (41) decreases. When the area of the opening portion
of the air discharge communication port (42a) decreases, the flow rate of the inside air that
20 passes through the air discharge passage (42) and is discharged to the external space (6)
decreases.

[0167]

When the processing of step ST8 ends, the controller (110) performs the processing
of step ST7 again.

25 [0168]

<Step ST9>

When the rising speed of the measurement value M_O2 of the oxygen concentration
is equal to or lower than the reference rising speed, the flow rate of the outside air supplied to
the storage space (5) by the ventilation apparatus (40) and the flow rate of the inside air
30 discharged from the storage space (5) by the ventilation apparatus (40) are appropriate.
Therefore, in this case, the controller (110) performs the processing of step ST9.

[0169]

In the processing of step ST9, the controller (110) determines whether or not the fourth
condition is satisfied and whether or not the fifth condition is satisfied.

[0170]

The fourth condition is that “the measurement value M_{O2} of the oxygen concentration is equal to or more than the upper limit value $SP_{O2+\alpha}$ of the allowable range of the oxygen concentration”. The upper limit value $SP_{O2+\alpha}$ of the allowable range of the oxygen concentration is a fourth predetermined value. The fourth predetermined value, “the upper limit value $SP_{O2+\alpha}$ of the allowable range of the oxygen concentration” is higher than the first predetermined value, “the lower limit value $SP_{O2-\alpha}$ of the allowable range of the oxygen concentration”. The fourth condition may be a condition that “the measurement value M_{O2} of the oxygen concentration is higher than the fourth predetermined value”.

10 [0171]

The fifth condition is that “the measurement value M_{CO2} of the carbon dioxide concentration is equal to or more than the upper limit value $SP_{CO2+\beta}$ of the allowable range of the carbon dioxide concentration”. The upper limit value $SP_{CO2+\beta}$ of the allowable range of the carbon dioxide concentration is a fifth predetermined value. The fifth predetermined value, “the upper limit value $SP_{CO2+\beta}$ of the allowable range of the carbon dioxide concentration” is higher than the second predetermined value, “the carbon dioxide concentration setting value SP_{CO2} ”. The fifth condition may be a condition that “the measurement value M_{CO2} of the carbon dioxide concentration is higher than the fifth predetermined value”.

20 [0172]

When the fourth condition does not hold, it is necessary to further increase the oxygen concentration of the inside air. When the fifth condition is not satisfied, it is necessary to keep the reduction amount of the carbon dioxide concentration of the inside air small. Therefore, when both the fourth condition and the fifth condition are not satisfied, the controller (110) continues the second control mode. Specifically, the controller (110) performs the processing of step ST7 again.

[0173]

When the fourth condition is established, it is not necessary to increase the oxygen concentration of the inside air. When the fifth condition is satisfied, there is no need to reduce the reduction amount of the carbon dioxide concentration of the inside air. Therefore, when one or both of the fourth condition and the fifth condition are satisfied, the controller (110) ends the second control mode and starts the first control mode. Specifically, the controller (110) performs the processing of step ST3 again.

[0174]

–Feature of Embodiment–

The controller (110) of the air composition adjustment apparatus (90) of the present embodiment performs the first control mode and the second control mode in the composition maintenance mode. Therefore, even when fruits and vegetables (for example, berries such as blueberries) having a relatively small respiration amount are stored in the storage space (5), the carbon dioxide concentration of the inside air can be maintained in the allowable range (range of $SP_CO_2 \pm \beta$) as long as possible. The reason will be described below.

[0175]

In the first control mode, the controller (110) causes the inside air control apparatus (100) to perform the air introduction operation when the oxygen concentration of the inside air needs to be increased (see step ST3 in FIG. 10). When the inside air control apparatus (100) performs the air introduction operation, the outside air (atmosphere) is supplied to the storage space (5) as it is. The outside air, which is the atmosphere, has an oxygen concentration of 21% and a carbon dioxide concentration of 0.03%. Therefore, when the outside air is supplied to the storage space (5), the oxygen concentration of the inside air increases, and at the same time, the carbon dioxide concentration of the inside air decreases.

[0176]

Here, the factor of increasing the amount of carbon dioxide contained in the inside air is only breathing of fruits and vegetables stored in the storage space (5). Therefore, when respiration amounts of fruits and vegetables stored in the storage space (5) are relatively small, if the inside air control apparatus (100) executes the air introduction operation to increase the oxygen concentration of the inside air, the carbon dioxide concentration of the inside air may be excessively decreased.

[0177]

In particular, in the inside air control apparatus (100) of the present embodiment, the rotational speed of the drive motor (231c) of the air pump (231) cannot be changed. Therefore, since the flow rate of the outside air discharged from the compression-side pump (231a) cannot be adjusted, the flow rate of the outside air supplied to the storage space (5) cannot be adjusted in the air introduction operation. Thus, depending on the air introduction operation performed by the inside air control apparatus (100) of the present embodiment, there has been a possibility that the carbon dioxide concentration of the inside air cannot be maintained within the allowable range when the respiration amounts of fruits and vegetables stored in the storage space (5) are relatively small.

[0178]

Therefore, when the first condition and the second condition illustrated in step ST5 of FIG. 10 are satisfied during execution of the first control mode, the controller (110) of the present embodiment ends the first control mode and starts the second control mode. In the second control mode, the controller (110) brings the inside air control apparatus (100) into a pause state, and adjusts a flow rate of the outside air supplied to the storage space (5) by the ventilation apparatus (40).

[0179]

In the ventilation apparatus (40) of the present embodiment, the flow rate of the outside air supplied to the storage space (5) can be set to a value lower than the flow rate of the outside air supplied to the storage space (5) by the inside air control apparatus (100) in the air introduction operation. Therefore, when the controller (110) executes the second control mode, the flow rate of the outside air supplied to the storage space (5) can be reduced as compared with the state where the inside air control apparatus (100) executes the air introduction operation.

[0180]

Therefore, even when the respiration amounts of fruits and vegetables stored in the storage space (5) are relatively small, the reduction amount in the carbon dioxide concentration of the inside air can be reduced as much as possible while the oxygen concentration of the inside air is increased by suppressing the flow rate of the outside air supplied to the storage space (5) to a low level. As a result, it is possible to extend the time during which the carbon dioxide concentration of the inside air is kept within the allowable range, and it is possible to keep freshness of fruits and vegetables stored in the storage space (5) for a long period of time.

[0181]

—Variations of Embodiment—

The following variation may be applied to the air composition adjustment apparatus (90) of the embodiment. The following variations may be combined or replaced as necessary as long as the functions of the air composition adjustment apparatus (90) are not impaired.

[0182]

<First Variation>

The ventilation apparatus (40) of the embodiment may be configured to adjust a flow rate (supply air flow rate) of the outside air supplied to the storage space (5) and a flow rate (exhaust air flow rate) of the inside air discharged to the external space (6) by adjusting a rotational speed of the internal fan (35). In the present variation, the controller (110) increases the supply air flow rate and the exhaust air flow rate of the ventilation apparatus (40) by

increasing the rotational speed of the internal fan (35). The controller (110) reduces the rotational speed of the internal fan (35) to reduce the supply air flow rate and the exhaust air flow rate of the ventilation apparatus (40).

[0183]

5 <Second Variation>

In the air composition adjustment apparatus (90) of the embodiment, the inside air control apparatus (100) may be configured to function as a composition adjustment unit and also function as an air supply unit. In the present variation, the ventilation apparatus (40) may be provided in the transportation refrigeration apparatus (10) or may be omitted.

10 [0184]

The inside air control apparatus (100) of the present variation is configured to be able to adjust a flow rate of the outside air supplied to the storage space (5) in an air introduction operation.

[0185]

15 Specifically, in the inside air control apparatus (100) of the present variation, the bypass valve (256) is constituted by an electric valve having a variable opening degree. In this case, the controller (110) increases the supply air flow rate and the exhaust air flow rate of the inside air control apparatus (100) that performs the air introduction operation by increasing the opening degree of the bypass valve (256). The controller (110) reduces the opening
20 degree of the bypass valve (256) to reduce the supply air flow rate and the exhaust air flow rate of the inside air control apparatus (100) that performs the air introduction operation.

[0186]

The inside air control apparatus (100) of the present variation may be configured to be able to adjust the outside air discharged from the compression-side pump (231a) by making
25 a rotational speed of the drive motor (231c) of the air pump (231) variable. In this case, the controller (110) increases the supply air flow rate and the exhaust air flow rate of the inside air control apparatus (100) that performs the air introduction operation by increasing the rotational speed of the drive motor (231c) of the air pump (231). The controller (110) reduces the rotational speed of the drive motor (231c) of the air pump (231) to reduce the supply air flow
30 rate and the exhaust air flow rate of the inside air control apparatus (100) that performs the air introduction operation.

[0187]

 <Third Variation>

In the air composition adjustment apparatus (90) of the embodiment, the controller

(110) may be configured to adjust the supply air flow rate and the exhaust air flow rate of the ventilation apparatus (40) by opening and closing the air supply communication port (41a) and the air discharge communication port (42a) of the ventilation apparatus (40).

[0188]

5 The controller (110) of the present variation switches the air supply communication port (41a) and the air discharge communication port (42a) between a state in which a part of each is opened and a state in which the whole of each is covered with the opening and closing lid (45) by periodically moving the opening and closing lid (45) of the ventilation apparatus (40). The controller (110) of the present variation adjusts the supply air flow rate and the
10 exhaust air flow rate of the ventilation apparatus (40) by changing the ratio between the time during which the air supply communication port (41a) and the air discharge communication port (42a) are partially opened and the time during which the air supply communication port (41a) and the air discharge communication port (42a) are entirely covered with the opening and closing lid.

15 [0189]

<Fourth Variation>

 The air treatment unit (95) of the inside air control apparatus (100) of the embodiment may be configured to separate the outside air (atmosphere) into a nitrogen-enriched gas (first gas) and an oxygen-enriched gas (second gas) using a gas separation membrane. The gas
20 separation membrane has a property that the permeation rate of nitrogen is lower than both the permeation rate of oxygen and the permeation rate of carbon dioxide. Therefore, in the air treatment unit (95) of the present variation, the outside air is separated into the oxygen-enriched gas that has permeated through the gas separation membrane and the nitrogen-enriched gas that has not permeated through the gas separation membrane.

25 [0190]

<Fifth Variation>

 The air composition adjustment apparatus (90) of the embodiment may be installed in a stationary refrigerator or freezer. The air composition adjustment apparatus (90) of the
30 embodiment may be installed in a container for overland transportation by truck, rail, and the like. The air composition adjustment apparatus (90) of the embodiment may be installed in a refrigerating/freezing truck including a vehicle body integrated with a box defining a cargo space. As described above, the storage including the air composition adjustment apparatus (90) of the embodiment is not limited to the transportation container for marine transportation, and may be a transportation container for overland transportation, a box provided in a truck

and defining a cargo space, or a stationary refrigerator or freezer.

[0191]

While the embodiment and variations thereof have been described above, it will be understood that various changes in form and details may be made without departing from the spirit and scope of the claims. The foregoing embodiment and variations thereof may be combined or replaced with each other without deteriorating the intended functions of the present disclosure. The ordinal numbers such as “first,” “second,” ... in the description and claims are used to distinguish the terms to which these expressions are given, and do not limit the number and order of the terms.

INDUSTRIAL APPLICABILITY

[0192]

As described above, the present disclosure is useful for an air composition adjustment apparatus, a refrigeration apparatus, and a storage.

DESCRIPTION OF REFERENCE CHARACTERS

[0193]

2: storage

10: refrigeration apparatus

11: refrigerant circuit

35: internal fan

40: ventilation apparatus (air supply unit)

41a: air supply communication port (air introduction port)

90: air composition adjustment apparatus

95: air treatment unit

100: inside air control apparatus (composition adjustment unit)

110: controller

160: sensor unit (detector)

161: oxygen sensor

162: carbon dioxide sensor

CLAIMS

[Claim 1] An air composition adjustment apparatus (90) that adjusts a composition of inside air inside a storage (2), the air composition adjustment apparatus comprising:

a composition adjustment unit (100) that generates a treated gas having a composition
5 different from a composition of outside air by treating the outside air, and supplies the treated gas to the storage (2);

an air supply unit (40) that supplies the outside air to the storage (2) and is capable of changing a flow rate of the outside air supplied to the storage (2);

a detector (160) that detects a concentration of one or more components of the inside
10 air; and

a controller (110) that adjusts the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) based on a value detected by the detector (160).

[Claim 2] The air composition adjustment apparatus according to claim 1, wherein

the controller (110) executes:

15 a first control mode in which the controller (110) controls an operation of the composition adjustment unit (100) based on the value detected by the detector (160) in a state in which supply of the outside air to the storage (2) by the air supply unit (40) is stopped; and

a second control mode in which the controller (110) adjusts the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) based on the value detected
20 by the detector (160) in a state where the composition adjustment unit (100) is stopped.

[Claim 3]

The air composition adjustment apparatus according to claim 2, wherein

the detector (160) includes an oxygen sensor (161) that detects an oxygen concentration of the inside air and a carbon dioxide sensor (162) that detects a carbon dioxide
25 concentration of the inside air, and

the controller (110) ends the first control mode and executes the second control mode when a detection value of the oxygen sensor (161) is lower than a first predetermined value and a detection value of the carbon dioxide sensor (162) is lower than a second predetermined value during execution of the first control mode.

30 [Claim 4] The air composition adjustment apparatus according to claim 3, wherein

the controller (110) reduces the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) when a rising speed of the detection value of the oxygen sensor (161) is higher than a third predetermined value during execution of the second control mode.

[Claim 5] The air composition adjustment apparatus according to claim 3 or 4, wherein

when the detection value of the oxygen sensor (161) is higher than a fourth predetermined value or when the detection value of the carbon dioxide sensor (162) is higher than a fifth predetermined value during execution of the second control mode, the controller (110) ends the second control mode and executes the first control mode, and

5 the fourth predetermined value is higher than the first predetermined value, and the fifth predetermined value is higher than the second predetermined value.

[Claim 6] The air composition adjustment apparatus according to any one of claims 2 to 5, wherein

10 the composition adjustment unit (100) is capable of executing a gas supply operation of supplying the treated gas to the storage (2) and an air introduction operation of supplying the outside air to the storage (2), and

 in the first control mode, the controller (110) switches a state in which the composition adjustment unit (100) performs the gas supply operation, a state in which the composition adjustment unit (100) performs the air introduction operation, and a state in which the
15 composition adjustment unit (100) pauses without performing the gas supply operation and the air introduction operation based on a value detected by the detector (160).

[Claim 7] The air composition adjustment apparatus according to any one of claims 1 to 6, wherein

20 the air supply unit (40) includes an air introduction port (41a) having a variable opening degree through which outside of the storage (2) communicates with inside of the storage (2), and

 the controller (110)

 increases the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) by increasing an opening degree of the air introduction port (41a), and

25 reduces the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) by reducing the opening degree of the air introduction port (41a).

[Claim 8] The air composition adjustment apparatus according to any one of claims 1 to 6, wherein

 the air supply unit (40) includes

30 an internal fan (35) that circulates the inside air inside the storage (2), and an air introduction port (41a) that allows communication between outside of the storage (2) and a suction-side region of the internal fan (35) inside the storage (2), and

 the controller (110)

 increases the flow rate of the outside air supplied to the storage (2) by the air

supply unit (40) by increasing a rotational speed of the internal fan (35), and

reduces the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) by reducing the rotational speed of the internal fan (35).

[Claim 9] The air composition adjustment apparatus according to any one of claims 1 to 5,

5 wherein

the composition adjustment unit (100) is capable of performing a gas supply operation of supplying the treated gas to the storage (2) and an air introduction operation of supplying the outside air to the storage (2),

10 the composition adjustment unit (100) is capable of adjusting the flow rate of the outside air supplied to the storage (2) during execution of the air introduction operation,

the composition adjustment unit (100) that performs the air introduction operation also serves as the air supply unit (40), and

15 the controller (110) adjusts the flow rate of the outside air supplied to the storage (2) by the composition adjustment unit (100) that performs the air introduction operation based on a value detected by the detector (160).

[Claim 10] The air composition adjustment apparatus according to claim 1 or 2, wherein

the detector (160) includes a carbon dioxide sensor (162) that detects a carbon dioxide concentration of the inside air,

20 the composition adjustment unit (100) is capable of executing a gas supply operation of supplying the treated gas to the storage (2) and an air introduction operation of supplying outside air to the storage (2), and

the controller (110) adjusts the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) so that a decrease rate of a detection value of the carbon dioxide sensor (162) becomes lower than the decrease rate during execution of the air introduction operation by the composition adjustment unit (100), in a state in which the composition adjustment unit (100) stops the gas supply operation and the air introduction operation.

[Claim 11] The air composition adjustment apparatus according to claim 1 or 2, wherein

30 the detector (160) includes an oxygen sensor (161) that detects an oxygen concentration of the inside air and a carbon dioxide sensor (162) that detects a carbon dioxide concentration of the inside air, and

the controller (110) is capable of executing:

an oxygen concentration reduction mode in which the controller (110) controls an operation of the composition adjustment unit (100) so that a detection value of the oxygen sensor (161) decreases from the oxygen concentration of atmosphere to a sixth

predetermined value in a state where the supply of the outside air to the storage (2) by the air supply unit (40) is stopped; and

a composition maintenance mode in which the controller (110) controls operations of the composition adjustment unit (100) and the air supply unit (40) in order to maintain the composition of the inside air after an end of the oxygen concentration reduction mode, and

the controller (110) adjusts the flow rate of the outside air supplied to the storage (2) by the air supply unit (40) based on detection values of the oxygen sensor (161) and the carbon dioxide sensor (162) during execution of the composition maintenance mode.

[Claim 12] The air composition adjustment apparatus according to any one of claims 1 to 11, wherein

the treated gas includes a first gas having a higher nitrogen concentration and a lower oxygen concentration than the outside air and a second gas having a lower nitrogen concentration and a higher oxygen concentration than the outside air, and

the composition adjustment unit (100) includes an air treatment unit (95) that separates the outside air into the first gas and the second gas.

[Claim 13] The air composition adjustment apparatus according to claim 12, wherein

the air treatment unit (95) of the composition adjustment unit (100) includes an adsorbent that adsorbs nitrogen, and

the composition adjustment unit (100) performs an operation of generating the second gas by adsorbing nitrogen contained in the outside air to the adsorbent of the air treatment unit (95) and an operation of generating the first gas by desorbing nitrogen from the adsorbent of the air treatment unit (95).

[Claim 14] A refrigeration apparatus comprising:

the air composition adjustment apparatus (90) according to any one of claims 1 to 13; and

a refrigerant circuit (11) that performs a refrigeration cycle to adjust a temperature of the inside air.

[Claim 15] A storage comprising the refrigeration apparatus (10) according to claim 14.