

DESCRIPTION

TITLE

CONTAINER REFRIGERATION APPARATUS

5

TECHNICAL FIELD

[0001]

The present disclosure relates to a container refrigeration apparatus.

10 BACKGROUND ART

[0002]

A container refrigeration apparatus, which is an apparatus configured to cool the inside of a container, has been conventionally known. The container stores an object such as food. The container refrigeration apparatus cools the inside air of the container by an evaporator.

15 As a result, the temperature around the object is maintained at a predetermined temperature or lower.

CITATION LIST

PATENT LITERATURE

20 [0003]

Patent Literature 1: Japanese Patent No. 5625582

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

25 [0004]

When a container refrigeration apparatus rapidly cools the inside air of a container, the pressure in the container decreases. As a result, the pressure of the inside of the container becomes a negative pressure, which is lower than the atmospheric pressure, and thus damage to the container may be caused.

30 [0005]

An object of the present disclosure is to restrain damage to a container caused by a decrease in pressure in the container.

SOLUTIONS TO THE PROBLEM

[0006]

A first aspect is intended for a container refrigeration apparatus, the container refrigeration apparatus includes a pressure detection unit (P) configured to detect a pressure of an inside of a container (1), a pressure equalizing mechanism (40, 80) configured to equalize
5 the pressure of the inside of the container (1) and a pressure of an outside of the container (1), and a control unit (100) configured to control the pressure equalizing mechanism (40, 80) so that the pressure equalizing mechanism (40, 80) performs a pressure equalizing action to equalize the pressure of the inside of the container (1) and the pressure of the outside of the container (1) when the pressure detection unit (P) detects a pressure lower than a predetermined
10 first pressure that is lower than an atmospheric pressure during a cooling operation in which the inside of the container (1) is cooled. Here, examples of the “pressure detection unit” include not only a means for direct detection of a pressure by a sensor but also a means for indirect detection of a pressure using an index for estimation of the pressure.

[0007]

15 In the first aspect, in the cooling operation in which the inside of the container (1) is cooled, when the pressure in the container (1) is lower than the predetermined first pressure, the control unit (100) makes the pressure equalizing mechanism (40, 80) perform the pressure equalizing action. In the pressure equalizing action, the pressure equalizing mechanism (40, 80) equalizes the pressure of the inside of the container (1) and the pressure of the outside of
20 the container (1), and thus the internal pressure of the container (1) can be restrained from becoming a negative pressure. As a result, damage to the container (1) can be restrained.

[0008]

According to a second aspect, in the first aspect, the pressure equalizing mechanism (40, 80) is a ventilator (40) configured to ventilate the container (1), and the ventilator (40)
25 introduces outside air of the container (1) into the inside of the container (1) in the pressure equalizing action.

[0009]

In the pressure equalizing action of the second aspect, the ventilator (40) serving as a pressure equalizing mechanism introduces the outside air of the container (1) into the inside of
30 the container (1). As a result, the internal pressure of the container (1) can be restrained from becoming a negative pressure, and damage to the container (1) can be restrained.

[0010]

According to a third aspect, in the first aspect, the pressure equalizing mechanism (40, 80) is an adjuster (80) configured to adjust a composition of inside air of the container (1), and

the adjuster (80) introduces outside air of the container (1) into the inside of the container (1) in the pressure equalizing action.

[0011]

In the pressure equalizing action of the third aspect, the adjuster (80) serving as a pressure equalizing mechanism introduces the outside air of the container (1) into the inside of the container (1). As a result, the internal pressure of the container (1) can be restrained from becoming a negative pressure, and damage to the container (1) can be restrained.

[0012]

According to a fourth aspect, in any one of the first to the third aspects, the control unit (100) terminates the pressure equalizing action when the pressure detection unit (P) detects a pressure higher than a predetermined second pressure that is lower than an atmospheric pressure during the pressure equalizing action.

[0013]

In the fourth aspect, in the pressure equalizing action, when the pressure in the container (1) is higher than the predetermined first pressure, the control unit (100) terminates the pressure equalizing action. Thus, in the container (1), an increase in the air temperature due to the pressure equalizing action can be quickly restrained.

[0014]

According to a fifth aspect, in the fourth aspect, the control unit (100) terminates the pressure equalizing action when the pressure in the container (1) is higher than the predetermined first pressure and the air temperature in the container (1) is lower than a predetermined temperature.

[0015]

In the fifth aspect, the pressure equalizing action is terminated when the pressure in the container (1) is higher than the predetermined first pressure and the air temperature in the container (1) is lower than the predetermined temperature. If the pressure equalizing action is terminated under a condition in which the air temperature in the container (1) is relatively high, a further decrease in the air temperature due to the cooling operation may increase the negative pressure in the container (1) again. Meanwhile, in the present invention, the pressure equalizing action is terminated after the air temperature in the container (1) becomes relatively low, and thus in the subsequent cooling operation, the negative pressure in the container (1) can be restrained from increasing again. As a result, damage to the container (1) can be restrained.

[0016]

According to a sixth aspect, in any one of the first to the fifth aspects, the control unit (100) controls the pressure equalizing mechanism (40, 80) so that the pressure equalizing mechanism (40, 80) performs a first pressure equalizing action as the pressure equalizing action when the pressure detection unit (P) detects a pressure lower than the predetermined first pressure that is lower than an atmospheric pressure during a cooling operation performed first after the container refrigeration apparatus is started.

[0017]

In the sixth aspect, the first pressure equalizing action is performed when the pressure detection unit (P) detects a pressure lower than the predetermined first pressure that is lower than the atmospheric pressure during the cooling operation performed first after the container refrigeration apparatus is started. Therefore, even if the cooling operation performed first rapidly decreases the air temperature in the container (1), damage to the container (1) can be restrained.

[0018]

In a seventh aspect, in any one of the first to the fifth aspects, the control unit (100) performs a second pressure equalizing action as the pressure equalizing action when the pressure detection unit (P) detects a pressure lower than the predetermined first pressure that is lower than an atmospheric pressure after a door (D) of the container (1) is opened and closed during the cooling operation.

[0019]

In the seventh aspect, the second pressure equalizing action is performed when the pressure detection unit (P) detects a pressure lower than the predetermined first pressure that is lower than the atmospheric pressure after the door (D) is temporarily opened during the cooling operation. Therefore, even if air having a relatively high temperature enters the container (1) when the door (D) is opened and the air is rapidly cooled, damage to the container (1) can be restrained.

[0020]

According to an eighth aspect, in the seventh aspect, the control unit (100) controls the pressure equalizing mechanism (40, 80) so that the pressure equalizing mechanism (40, 80) performs a first pressure equalizing action as the pressure equalizing action when the pressure detection unit (P) detects a pressure lower than the predetermined first pressure that is lower than an atmospheric pressure during a cooling operation performed first after the container refrigeration apparatus is started, and the pressure equalizing mechanism (40, 80) introduces outside air of the container (1) into the inside of the container (1) at a higher flow rate in the

second pressure equalizing action than in the first pressure equalizing action.

[0021]

In the eighth aspect, in the second pressure equalizing action, the pressure equalizing mechanism (40, 80) introduces the outside air of the container (1) into the inside of the container (1) at a higher flow rate than in the first pressure equalizing action. This is because when air having a relatively high temperature is cooled inside the container (1) after the door (D) is temporarily opened, there is a high possibility that the internal pressure of the container (1) decreases more quickly than during the cooling operation performed first after the container refrigeration apparatus is started.

[0022]

According to a ninth aspect, in any one of the first to the eighth aspects, the control unit (100) controls the pressure equalizing mechanism (40, 80) so that the pressure equalizing mechanism (40, 80) introduces outside air of the container (1) into the inside of the container (1) at a lower flow rate as inside air of the container (1) has a lower temperature in the cooling operation.

[0023]

In the ninth aspect, when the air temperature in the container (1) is high and the negative pressure in the container (1) tends to increase, a large amount of the outside air is introduced. When the air temperature in the container (1) is low and introduction of the outside air tends to increase the cooling load, a small amount of the outside air is introduced.

[0024]

According to a tenth aspect, in any one of the first to the ninth aspects, the pressure detection unit (P) is a pressure sensor (53).

[0025]

In the tenth aspect, the internal pressure of the container (1) is detected by the pressure sensor (53).

[0026]

According to an eleventh aspect, in any one of the first to the ninth aspects, the container refrigeration apparatus includes a drain pipe (60) configured to discharge condensed water generated inside the container (1) to the outside of the container (1), the drain pipe (60) includes a trap (61) configured to collect the condensed water, and the pressure detection unit (P) detects a pressure of the inside of the container (1), based on a water level in the trap (61).

[0027]

In the eleventh aspect, the pressure of the inside of the container (1) is detected on the

basis of the water level in the trap (61) of the drain pipe (60). This is because a change in the pressure of the inside of the container (1) causes a change in the water level in the trap (61).

[0028]

According to a twelfth aspect, in any one of the first to the ninth aspects, the pressure detection unit (P) detects a pressure of the inside of the container (1), based on a temperature of air in the container (1) before or at a start of the cooling operation and a temperature of the air in the container (1) during the cooling operation.

[0029]

In the twelfth aspect, the pressure of the inside of the container (1) is detected on the basis of the temperature of the air in the container (1) before and after the start of the cooling operation. This is because a decrease in the temperature of the air in the container (1) caused by the cooling operation results in a change in the pressure of the inside of the container (1).

[0030]

According to a thirteenth aspect, in any one of the first to the ninth aspects, the container refrigeration apparatus includes a gas sensor (71, 72) configured to detect a concentration of a gas component in inside air of the container (1), and the pressure detection unit (P) detects a pressure of the inside of the container (1), based on a concentration detected by the gas sensor (71, 72) before or at a start of the cooling operation and a concentration detected by the gas sensor (71, 72) during the cooling operation.

[0031]

In the thirteenth aspect, the pressure of the inside of the container (1) is detected on the basis of the concentration detected by the gas sensor (71, 72) before and after the start of the cooling operation. This is because there is a correlation between the concentration detected by the gas sensor (71, 72) and the pressure of the inside of the container (1).

BRIEF DESCRIPTION OF THE DRAWINGS

[0032]

FIG. 1 is a perspective view of a container refrigeration apparatus according to an embodiment as viewed from a front side.

FIG. 2 is a longitudinal sectional view of a container refrigeration apparatus.

FIG. 3 is a block diagram of main devices of a container refrigeration apparatus.

FIG. 4 is a pipe system diagram of a container refrigeration apparatus.

FIG. 5 is a schematic front view of a ventilator. FIG. 5(A) illustrates a state in which a lid is at a closed position, FIG. 5(B) illustrates a state in which the lid is at an intermediate

position, and FIG. 5(C) illustrates a state in which the lid is at a fully open position.

FIG. 6 is a perspective view of a container as viewed from a rear side (door side).

FIG. 7 is a flowchart for illustration of a control action of a pressure equalizing mechanism.

5 FIG. 8 is a flowchart for illustration of control of a pressure equalizing mechanism in a first mode.

FIG. 9 is a flowchart for illustration of control of a pressure equalizing mechanism in a second mode.

10 FIG. 10 is a schematic configuration view illustrating a drain pipe and a pressure detection unit in Modification 1A, and illustrates a state in which the pressure of the inside of a container is equal to the pressure of the outside of the container.

FIG. 11 is a schematic configuration view illustrating a drain pipe and a pressure detection unit in Modification 1A, and illustrates a state in which the pressure of the inside of a container is lower than the pressure of the outside of the container.

15 FIG. 12 is a diagram corresponding to FIG. 3 of Modification 1C.

FIG. 13 is a diagram corresponding to FIG. 3 of Modification 1D.

FIG. 14 is a view corresponding to FIG. 2 of Modification 2A.

FIG. 15 is a diagram corresponding to FIG. 3 of Modification 2B.

20 **DESCRIPTION OF EMBODIMENTS**

[0033]

Hereinafter, embodiments of the present disclosure will be described in detail with reference to the drawings. The present disclosure is not limited to the embodiments described below, and various modifications can be made without departing from the technical concept of
25 the present disclosure. Each drawing is for conceptually describing the present disclosure, and therefore a dimension, a ratio, or a number may be exaggerated or simplified as necessary for easy understanding.

[0034]

(1) Overall configuration of container refrigeration apparatus

30 A container refrigeration apparatus (10) will be described. 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.

[0035]

As illustrated in FIGS. 1 and 2, the container refrigeration apparatus (10) is provided

in a container (1). The container (1) is used for marine transportation. The container (1) is a refrigeration container configured to cool its inside air. The container (1) includes a container main body (2) and the container refrigeration apparatus (10). The container main body (2) stores an object such as food or a plant. The container refrigeration apparatus (10) cools the air in an interior space (3) of the container main body (2). As illustrated in FIG. 2, the container main body (2) has a front surface in which a front surface opening (4) is formed. The container refrigeration apparatus (10) is attached to the container main body (2) so as to close the front surface opening (4) of the container main body (2).

[0036]

As illustrated in FIG. 3, the container refrigeration apparatus (10) includes a cooling unit (10A) for cooling of the interior space (3), and a ventilator (40) for ventilation of the interior space (3).

[0037]

(2) Cooling unit

As illustrated in FIGS. 1 and 2, the cooling unit (10A) includes a casing (11). The casing (11) constitutes a lid of the front surface opening (4) of the container main body (2). The casing (11) includes a casing main body (12) and a partition plate (13). The casing main body (12) separates the interior space (3) from the exterior space (5), which is an outer space of the container main body (2). The partition plate (13) is positioned in the back side (rear side) with respect to the casing (11).

[0038]

The cooling unit (10A) includes a compressor (25), an exterior heat exchanger (26), and an exterior fan (27), which are devices disposed on the exterior of the container main body (2). The cooling unit (10A) includes an interior heat exchanger (29) and an interior fan (30), which are devices disposed in the container main body (2).

[0039]

(2-1) Casing main body

As illustrated in FIG. 2, the casing main body (12) includes a flat plate portion (12a) and a recessed portion (12b). The flat plate portion (12a) is formed in an upper portion of the casing main body (12) so as to be substantially flush with the front surface opening (4) of the casing (11). As illustrated in FIG. 1, the flat plate portion (12a) is provided with an inspection window (22). The inspection window (22) is disposed in a right-side portion of the flat plate portion (12a). The inspection window (22) is a transparent window to check the inside of the casing main body (12).

[0040]

The recessed portion (12b) is formed in a lower portion of the casing (11). The recessed portion (12b) is formed by recessing the flat plate portion (12a) rearward from the lower end of the flat plate portion (12a). An exterior accommodating space (14) is formed in front of the recessed portion (12b). An interior accommodating space (15) is formed above the recessed portion (12b) between the flat plate portion (12a) and the partition plate (13). The lower end of the recessed portion (12b) constitutes a bottom plate (12c). The bottom plate (12c) extends from the left end to the right end of the casing main body (12).

[0041]

The casing main body (12) includes an exterior casing (16), a heat insulating layer (17), and an interior casing (18) that are stacked in the thickness direction (front-rear direction). The exterior casing (16) faces the exterior space (5). The interior casing (18) faces the inside of the casing main body (12). The heat insulating layer (17) is provided between the exterior casing (16) and the interior casing (18). The exterior casing (16) includes an aluminum material. The interior casing (18) includes a fiber-reinforced plastic (FRP). The heat insulating layer (17) includes a foamed resin.

[0042]

(2-2) Partition plate and air passage

As illustrated in FIG. 2, the partition plate (13) is a plate-shaped member positioned behind the recessed portion (12b). The partition plate (13) extends in the up-down direction so as to be separated from the rear surface of the recessed portion (12b) by a predetermined gap. An internal passage (19) through which interior air flows is formed between the casing main body (12) and the partition plate (13). An inlet port (20) is formed between the upper end of the partition plate (13) and the upper wall (2a) of the container main body (2). The interior space (3) and the inlet end of the internal passage (19) communicate with each other by the inlet port (20). An outlet port (21) is formed between the lower end of the partition plate (13) and the lower wall (2b) of the container main body (2). The interior space (3) and the outlet end of the internal passage (19) communicate with each other by the outlet port (21).

[0043]

(2-3) Devices in exterior space

The compressor (25), the exterior heat exchanger (26), and the exterior fan (27) are provided in the exterior accommodating space (14). The compressor (25) is installed on the bottom plate (12c) of the casing (11). The compressor (25) is disposed in a lower portion in the exterior accommodating space (14). The compressor (25) is disposed in a right-side

portion in the exterior accommodating space (14).

[0044]

The exterior fan (27) is positioned in an upper portion in the exterior accommodating space (14). The exterior fan (27) includes a propeller fan. As illustrated in FIG. 2, an external passage (28) through which exterior air flows is formed on the back side of the exterior fan (27).

[0045]

The exterior heat exchanger (26) is provided at a height position between the exterior fan (27) and the compressor (25) in the exterior accommodating space (14). The exterior heat exchanger (26) is positioned in the external passage (28). The exterior heat exchanger (26) is a fin and tube heat exchanger.

[0046]

(2-4) Devices in interior space

The interior heat exchanger (29) and the interior fan (30) are provided in the interior accommodating space (15). The interior heat exchanger (29) is supported by the casing (11) across the casing main body (12) and the partition plate (13). The interior heat exchanger (29) is a fin and tube heat exchanger.

[0047]

(2-5) Refrigerant circuit

As illustrated in FIG. 4, the cooling unit (10A) includes a refrigerant circuit (R). The refrigerant circuit (R) is filled with a refrigerant. In the refrigerant circuit (R), the refrigerant circulates to perform a vapor compression refrigeration cycle. As the refrigerant in the refrigerant circuit (R), for example, a natural refrigerant such as propane or carbon dioxide is used.

[0048]

The refrigerant circuit (R) mainly includes the compressor (25), the exterior heat exchanger (26), an expansion valve (31), and the interior heat exchanger (29).

[0049]

The compressor (25) sucks and compresses the refrigerant. The compressor (25) discharges the compressed refrigerant. The compressor (25) has a discharge portion to which a discharge pipe (32) is connected. The compressor (25) has a suction portion to which a suction pipe (33) is connected. The suction pipe (33) is provided with an accumulator (34). The accumulator (34) is a container that stores a liquid refrigerant.

[0050]

The exterior heat exchanger (26) exchanges heat between the refrigerant flowing inside the exterior heat exchanger (26) and the exterior air. A gas end in the exterior heat exchanger (26) communicates with the discharge pipe (32). A liquid end in the exterior heat exchanger (26) is connected to a liquid end of the interior heat exchanger (29) via a liquid pipe (35). The exterior heat exchanger (26) functions as a radiator (condenser) in which the refrigerant radiates heat to air.

[0051]

The expansion valve (31) is provided in the liquid pipe (35). The expansion valve (31) is an expansion mechanism that decompresses the high-pressure refrigerant to the low-pressure refrigerant. The expansion valve (31) is an electronic expansion valve having an adjustable opening degree. For example, the expansion mechanism may be a capillary tube or an expander. In the liquid pipe (35), a receiver (36) is provided between the exterior heat exchanger (26) and the expansion valve (31). The receiver (36) is a container that stores the refrigerant surplus in the refrigerant circuit (R).

[0052]

The interior heat exchanger (29) exchanges heat between the refrigerant flowing inside the interior heat exchanger (29) and the interior air. A gas end in the interior heat exchanger (29) communicates with the suction pipe (33). The interior heat exchanger (29) functions as an evaporator in which the refrigerant absorbs heat from air.

[0053]

The refrigerant circuit (R) includes a bypass pipe (37). The bypass pipe (37) has an inlet end communicating with the discharge pipe (32), and has an outlet end communicating with the liquid pipe (35). The bypass pipe (37) sends the refrigerant discharged from the compressor (25) to the interior heat exchanger (29) while the exterior heat exchanger (26) is bypassed.

[0054]

The refrigerant circuit (R) is provided with a first valve (38) and a second valve (39). The first valve (38) is provided between the discharge side of the compressor (25) and the gas end in the exterior heat exchanger (26) in the downstream side with respect to the connection portion of the bypass pipe (37). The second valve (39) is provided in the bypass pipe (37). The first valve (38) and the second valve (39) each include an electromagnetic on-off valve. For example, the first valve (38) and the second valve (39) may be a flow-rate adjusting valve having an adjustable opening degree.

[0055]

(3) Ventilator

A configuration of the ventilator (40) will be described with reference to FIGS. 1, 2, and 5. The ventilator (40) ventilates the interior space (3) of the container main body (2). The ventilator (40) of the present embodiment has an air supply function of supplying the exterior air, which is outdoor air, to the interior space (3) and an air discharge function of discharging the interior air to the exterior space (5). In the present embodiment, the ventilator (40) also serves as a pressure equalizing mechanism.

[0056]

As illustrated in FIG. 1, the ventilator (40) is disposed in a left-side portion of the flat plate portion (12a) of the casing main body (12). As illustrated in FIG. 2, the ventilator (40) is provided in a ventilator attachment port (6) formed in the front surface of the casing main body (12). The ventilator attachment port (6) penetrates the casing main body (12) in the front-rear direction. The ventilator attachment port (6) is formed across the exterior casing (16), the heat insulating layer (17), and the interior casing (18).

[0057]

An air supply passage (41) and an air discharge passage (42) are formed inside the ventilator (40). The air supply passage (41) and the air discharge passage (42) make the interior space (3) and the exterior space (5) communicate with each other. Specifically, the inlet end of the air supply passage (41) communicates with the exterior space (5). The outlet end of the air supply passage (41) communicates with a primary side (upstream side) of the interior fan (30) in the internal passage (19). The inlet end of the air discharge passage (42) communicates with a secondary side (downstream side) of the interior fan (30) in the internal passage (19). The outlet end of the air discharge passage (42) communicates with the exterior space (5).

[0058]

The ventilator (40) includes a ventilation fan. The ventilation fan includes the above-described interior fan (30). The interior fan (30) of the present embodiment is shared by the ventilator (40) and the cooling unit (10A). When the interior fan (30) is driven, the exterior air of the exterior space (5) is supplied to the interior space (3) through the air supply passage (41). At the same time, the interior air of the interior space (3) is discharged to the exterior space (5) through the air discharge passage (42).

[0059]

As illustrated in FIGS. 2 and 5, an air supply communication port (41a) is formed at an end portion of the air supply passage (41) on the side of the exterior space (5). An air

discharge communication port (42a) is formed at an end portion of the air discharge passage (42) on the side of the exterior space (5).

[0060]

As illustrated in FIG. 2, the ventilator (40) includes a motor (43), a drive shaft (44) that is rotatably driven by the motor (43), and an opening and closing lid (45) connected to the drive shaft (44). The motor (43) and the drive shaft (44) are housed in a casing of the ventilator (40). The motor (43) includes a stepping motor. The drive shaft (44) is directly connected to the motor (43). For example, the drive shaft (44) may be indirectly connected to the motor (43) via a pinion or a gear.

[0061]

The opening and closing lid (45) is provided in front of the drive shaft (44). The opening and closing lid (45) is rotatable about the shaft center of the drive shaft (44). The opening and closing lid (45) varies its rotational angle to open and close the air supply passage (41) and the air discharge passage (42). The opening and closing lid (45) constitutes an opening degree adjusting mechanism that adjusts the opening degrees of the air supply passage (41) and the air discharge passage (42).

[0062]

As illustrated in FIG. 5, in the opening and closing lid (45), an air supply opening (46) and an air discharge opening (47) are formed. The air supply opening (46) can communicate with the air supply communication port (41a). The air discharge opening (47) can communicate with the air discharge communication port (42a).

[0063]

Specifically, when the opening and closing lid (45) has a first rotational angle (at a closed position) illustrated in FIG. 5(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, the air supply passage (41) and the air discharge passage (42) are fully closed.

[0064]

When the opening and closing lid (45) has a second rotational angle (at a fully open position) illustrated in FIG. 5(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). Thus, the air supply passage (41) and the air discharge passage (42) are fully opened.

[0065]

When the opening and closing lid (45) has a third rotational angle (at an intermediate position) illustrated in FIG. 5(B), a part of the air supply communication port (41a) axially overlaps the air supply opening (46), and a part of the air discharge communication port (42a) axially overlaps the air discharge opening (47). The intermediate position is a position
5 between the closed position and the fully open position. Thus, the opening degrees of the air supply passage (41) and the air discharge passage (42) are smaller than in the fully open state.
[0066]

Adjusting the rotational angle of the opening and closing lid (45) between the closed position and the fully open position adjusts the opening degrees of the air supply passage (41)
10 and the air discharge passage (42), and further adjusts the amount of the air ventilated by the ventilator (40).
[0067]

(4) Sensor

The container refrigeration apparatus (10) includes a plurality of sensors. As
15 illustrated in FIGS. 2 and 3, the plurality of sensors include an interior temperature sensor (51), an exterior temperature sensor (52), and the pressure sensor (53).
[0068]

The interior temperature sensor (51) detects the temperature of the interior air in the container (1). The interior temperature sensor (51) is disposed in the upstream side of the air
20 flow with respect to the interior fan (30) in the internal passage (19). The interior temperature sensor (51) is disposed near the inlet port (20) of the internal passage (19).
[0069]

The exterior temperature sensor (52) detects the temperature of the exterior air outside the container (1). The exterior temperature sensor (52) is disposed in the upstream side of the
25 air flow with respect to the exterior heat exchanger (26) in the external passage (28). The exterior temperature sensor (52) is disposed near the inlet port of the external passage (28).
[0070]

The pressure sensor (53) is an example of the pressure detection unit (P). The pressure sensor (53) detects the pressure of the inside of the container (1). The pressure sensor
30 (53) is disposed in the internal passage (19). The pressure sensor (53) is disposed, for example, in the upstream side of the air flow with respect to the interior fan (30) in the internal passage (19), but, for example, may be disposed in the downstream side of the air flow with respect to the interior fan (30) in the internal passage (19).
[0071]

(5) Control unit and operation unit

As illustrated in FIG. 3, the container refrigeration apparatus (10) includes the control unit (100). The control unit (100) controls the cooling unit (10A) and the ventilator (40). The control unit (100) includes a micro processor, an electric circuit, and an electronic circuit.

5 The microprocessor includes a central processing unit (CPU), a memory, a communication interface, analog input/output, and a contact input/output interface. The memory stores various programs to be performed by the CPU and data used by the programs.

[0072]

The control unit (100) controls each device of the cooling unit (10A). Specifically,

10 the control unit (100) controls the number of rotations of the compressor (25), the number of rotations of the interior fan (30), the number of rotations of the exterior fan (27), the opening degree of the expansion valve (31), and the like. The control unit (100) controls the motor (43) of the ventilator (40). The control unit (100) adjusts the opening degrees of the air supply passage (41) and the air discharge passage (42) of the ventilator (40), and further adjusts the

15 amount of the air ventilated by the ventilator (40).

[0073]

As illustrated in FIG. 3, the container refrigeration apparatus (10) includes an operation unit (110). The operation unit (110) includes, for example, a touch panel provided in the container refrigeration apparatus (10), a remote controller, a switch, and the like. For

20 example, the operation unit (110) may be a communication terminal connected to the container refrigeration apparatus (10) via a network. An operation of the operation unit (110) by a user can switch an operating mode of the container refrigeration apparatus (10) or change set values in each operating mode. The set values include the target temperature of the interior space (3).

25 [0074]

(6) Outline of cooling operation

The container refrigeration apparatus (10) performs a cooling operation. The cooling operation is an operating mode performed by an operation of the operation unit (110) by a user or the like.

30 [0075]

During the cooling operation, a refrigeration cycle is performed in which the refrigerant compressed by the compressor (25) is condensed in the exterior heat exchanger (26), decompressed by the expansion valve (31), and evaporated in the interior heat exchanger (29). The air flowing out of the interior space (3) into the internal passage (19) is cooled in

the interior heat exchanger (29) functioning as an evaporator. The cooled air is sent to the interior space (3). In the cooling operation, the control unit (100) controls the number of rotations of the compressor (25) on the basis of a difference between the temperature of the interior air in the interior space (3) and the target temperature.

5 [0076]

In the cooling operation, the control unit (100) controls the compressor (25) so that the temperature of the interior air reaches the target temperature. When the temperature of the interior air reaches the target temperature (thermo-off temperature, for example, -18°C), the control unit (100) stops the compressor (25). As a result, the interior heat exchanger (29) is substantially stopped (in a thermo-off state). Then, when the temperature of the interior air reaches a predetermined temperature (thermo-on temperature, for example, -16°C) higher than the target temperature, the control unit (100) operates the compressor (25) to make the interior heat exchanger (29) function as an evaporator. The control unit (100) controls the number of rotations of the compressor (25) so as to adjust the evaporation temperature in the interior heat exchanger (29). As a result, the temperature of the interior air is maintained within a predetermined target range. The thermo-off temperature corresponds to a set temperature input by the operation unit (110). The value of the thermo-on temperature is obtained by adding a predetermined temperature (for example, 2°C) to the set temperature.

[0077]

20 (7) Countermeasure against destruction of container in cooling operation

(7-1) Problem

In the above-described cooling operation, cooling the interior air results in a decrease in the temperature of the interior air. A decrease in the temperature of the interior air during the cooling operation leads to a decrease in the pressure of the inside of the container (1) due to a decrease in the volume of the interior air, and the pressure of the inside of the container (1) may become a negative pressure, which is lower than the atmospheric pressure. As a result, the negative pressure inside the container (1) exceeds the pressure resistance of the container (1) to cause a problem of damage to the container (1). The damage to the container (1) is, for example, deformation of the container main body (2) due to the negative pressure inside the container (1).

30 [0078]

In the cooling operation, the pressure of the container (1) rapidly decreases particularly in the following two periods.

[0079]

The first period is a pull-down operation period. The pull-down operation is a cooling operation performed first after the container refrigeration apparatus (10) is started. In other words, the pull-down operation is the cooling operation performed first after the power source of the container refrigeration apparatus (10) is turned on. At the start of the pull-down operation, the temperature of the interior air is close to the outside air temperature and relatively high. In the pull-down operation, the interior air having a relatively high temperature is cooled to a temperature for refrigeration and freezing of an object. For example, in a case where the temperature of the interior air at the start of the pull-down operation is 30°C, the air may be cooled to a target temperature of -12°C. When the interior air having a relatively high temperature is cooled to result in a large temperature difference as described above, the pressure of the inside of the container (1) decreases, and the negative pressure increases.

[0080]

The second period is a period after the door (D) of the container (1) is temporarily opened during the cooling operation. As illustrated in FIG. 6, the container (1) includes the door (D) for taking in and out of an object. The door (D) is provided, for example, on a rear surface (7) on the rear side of the container (1). The door (D) is formed on the rear surface, and opens and closes an opening communicating with the interior space (3). In the cooling operation, the temperature of the interior air is kept within the target range, that is, the range between the thermo-off temperature (-18°C) and the thermo-on temperature (-16°C) described above. A case is assumed in which an operator temporarily opens the door (D) of the container (1) for some purpose and then closes the door (D) when the interior heat exchanger (29) is in a thermo-off state. When the door (D) is opened, the outside air of the container (1) enters the inside of the container (1). The air entering the inside of the container (1) from the outside has a temperature (for example, 30°C) higher than the interior air temperature (for example, -18°C). As a result, the entering air is rapidly cooled by the surrounding interior air. When the entry of the outside air increases the temperature of the interior air to a temperature higher than the thermo-on temperature, the compressor (25) is operated to set the interior heat exchanger (29) to a thermo-on state. As a result, the entering air is rapidly cooled by the interior heat exchanger (29). As described above, when the door (D) is opened and closed during the cooling operation, the pressure of the inside of the container (1) rapidly decreases, and the negative pressure increases. This problem is particularly noticeable when the door (D) is opened and closed while the interior heat exchanger (29) is in a thermo-off state.

[0081]

Such a problem of damage to the container (1) is due to the following points. The

container (1) is required to improve in airtightness from the viewpoint of quality control of an object. The higher the airtightness of the container (1) is, the smaller the amount of the air leaked from a gap of the container (1) is. As a result, the energy conservation of the container refrigeration apparatus (10) is improved. Meanwhile, If the container (1) has a high
5 airtightness, when the inside of the container (1) has a negative pressure in the cooling operation, the outside air of the container (1) is less likely to enter the inside of the container (1) through a gap. Thus, the cooling operation is accompanied by a further increase in the negative pressure inside the container (1), and the negative pressure exceeds the pressure resistance of the container (1).

10 [0082]

(7-2) Control of pressure equalizing mechanism

The container refrigeration apparatus (10) performs a pressure equalizing action in order to solve the above problem. The pressure equalizing action is an action of equalizing the pressure between the outside and the inside of the container (1) when the negative pressure
15 inside the container (1) increases during the cooling operation. In other words, the pressure equalizing action is an action of introducing the outside air of the container (1) into the inside of the container (1) when the negative pressure inside the container (1) increases during the cooling operation. The pressure equalizing action of the present embodiment is performed by the ventilator (40) that is a pressure equalizing mechanism. The pressure equalizing action
20 includes a first pressure equalizing action and a second pressure equalizing action. The first pressure equalizing action is an action of equalizing the pressure between the outside and the inside of the container (1) in the above-described pull-down operation. The second pressure equalizing action is an action of equalizing the pressure between the outside and the inside of the container (1) after the door (D) is opened and closed during the cooling operation. The
25 first pressure equalizing action is performed in a first mode. The first mode is a control mode for control of the pressure equalizing mechanism during the pull-down operation. The second pressure equalizing action is performed in a second mode. The second mode is a control mode for control of the pressure equalizing mechanism after the door (D) is opened and closed.

[0083]

30 The control of the pressure equalizing mechanism will be described in detail with reference to the flowcharts of FIGS. 7 to 9.

[0084]

(7-2-1) Basic control

As illustrated in FIG. 7, when a start of the cooling operation is commanded in a step

S11, the control unit (100) issues a command to start the cooling operation in a step S12. The command for the start of the cooling operation is input to the control unit (100) by an operation of the operation unit (110) by a user. At the start of the cooling operation, the ventilator (40) does not equalize the pressure between the inside and the outside of the container (1).
5 Specifically, the opening and closing lid (45) of the ventilator (40) is at the fully closed position.
[0085]

The control unit (100) determines whether to perform a pressure equalizing action based on a pressure detected by the pressure sensor (53). The pressure detected by the pressure sensor (53) corresponds to the pressure of the inside of the container (1). The control
10 unit (100) determines whether to proceed to the first mode or the second mode according to the change rate of the detected pressure until the detected pressure becomes a first pressure or lower. If the change rate is low, the process proceeds to the first mode, and if the change rate is high, the process proceeds to the second mode.
[0086]

Specifically, in a step S13, if a first condition that the pressure detected by the pressure sensor (53) is the first pressure or lower is satisfied and a time Δt until the detected pressure reaches the first pressure is a predetermined time t_1 or longer, the control unit (100) performs the processing of the first mode in a step S17. The first pressure is a predetermined pressure lower than the atmospheric pressure. The condition that the detected pressure is the first
20 pressure or lower means that the negative pressure is a predetermined value or larger. The first pressure is, for example, a pressure corresponding to a negative pressure of 2 [KPa]. The negative pressure corresponding to the first pressure is set to a predetermined value lower than the pressure resistance of the container (1). The time Δt until the detected pressure reaches the first pressure is the time from a time point t_a when the detected pressure starts to decrease
25 to a time point t_b when the detected pressure reaches the first pressure. For example, the control unit (100) sets the time point t_a when the detected pressure starts to decrease at a predetermined change rate (gradient).
[0087]

As described above, if the time Δt until the detected pressure reaches the first pressure
30 is relatively long in the step S13, it can be determined that the pressure of the inside of the container (1) is decreased due to the pull-down operation. Thus, the process proceeds to the first mode in the step S17 to perform the control of the ventilator (40) corresponding to the pull-down operation illustrated in FIG. 8.
[0088]

If the condition of the step S13 is not satisfied, the process proceeds to a step S14. In the step S14, if the first condition that the detected pressure is the first pressure or lower is satisfied and the time Δt until the detected pressure reaches the first pressure is the predetermined time $t1$ or shorter, the control unit (100) performs the processing of the second mode in a step S18. If cooling of the air inside the container (1) accompanies opening and closing of the door (D) during the cooling operation, the decrease rate of the pressure of the inside of the container (1) is higher than in the pull-down operation. Therefore, if the time Δt until the detected pressure reaches the first pressure is relatively short, it can be determined that the pressure of the inside of the container (1) is decreased due to the opening and closing of the door (D). Thus, the process proceeds to the second mode in the step S18 to perform the control of the ventilator (40) after the opening and closing of the door (D) illustrated in FIG. 9. [0089]

If the conditions of the step S13 and the step S14 are not satisfied, the process proceeds to a step S15. In the step S15, if the end of the cooling operation is commanded, the control unit (100) terminates the cooling operation in a step S16. The command for the end of the cooling operation is input to the control unit (100) by an operation of the operation unit (110) by a user. [0090]

(7-2-2) First mode

The first mode is a control mode of the ventilator (40) during the pull-down operation. As illustrated in FIG. 8, if the process proceeds to the first mode, the control unit (100) controls the ventilator (40) in a step S21 so that the ventilator (40) performs a pressure equalizing action to equalize the pressure between the inside and the outside of the container (1). In other words, the control unit (100) controls the ventilator (40) so that if the first condition in the step S13 is satisfied during the cooling operation (pull-down operation) performed first after the container refrigeration apparatus (10) is started, the ventilator (40) performs the first pressure equalizing action as the pressure equalizing action. [0091]

In the step S21, the control unit (100) controls the ventilator (40) so that the outside air is introduced at a first flow rate into the inside of the container (1). Specifically, the control unit (100) adjusts the rotational angle of the opening and closing lid (45) of the ventilator (40), that is, the opening degrees of the air supply passage (41) and the air discharge passage (42) so that the flow rate of the air introduced into the container (1) is the first flow rate. The introduction of the outside air into the inside of the container (1) equalizes the pressure between

the outside and the inside of the container (1). As a result, the pressure of the inside of the container (1) quickly increases. In other words, the negative pressure in the container (1) decreases.

[0092]

5 Next, in a step S22, if the detected pressure is higher than the second pressure and the interior temperature is a first temperature or lower, the process proceeds to a step S23. In the step S23, the control unit (100) controls the ventilator (40) so that the outside air is introduced at a second flow rate into the inside of the container (1). The second pressure has the same value as the first pressure, and is a pressure corresponding to a negative pressure of 2 [Kpa].
10 The second pressure may be higher than the first pressure or lower than the first pressure. The second flow rate is a predetermined flow rate lower than the first flow rate. The first flow rate is, for example, 5 [m³/h], and the second flow rate is, for example, 3 [m³/h]. The first temperature is, for example, 10°C. The interior temperature is the value detected by the interior temperature sensor (51).

15 [0093]

 As described above, in the present embodiment, if the temperature of the interior air becomes lower than a predetermined temperature in the pressure equalizing action, the control unit (100) decreases the amount of air introduced into the container (1). This is because when the temperature of the interior air is low, the pressure of the inside of the container (1) does not
20 significantly decrease, resulting in a low possibility of damage to the container (1). Decreasing the amount of outside air introduced enables quick cooling of the interior air in the pull-down operation. Decreasing the amount of outside air introduced enables reduction of the cooling load in the container (1) and quick completion of the pull-down operation.

[0094]

25 Next, in a step S24, if a second condition that the detected pressure is higher than the second pressure is satisfied and a third condition that the interior temperature is a second temperature or lower is satisfied, the process proceeds to a step S25. In the step S25, the control unit (100) ends the pressure equalizing control of the ventilator (40). Specifically, the control unit (100) sets the opening and closing lid (45) of the ventilator (40) to the fully closed
30 position. The second temperature is a predetermined temperature lower than the first temperature. The second temperature is, for example, 0°C.

[0095]

 If the temperature of the interior air reaches the second temperature (for example, 0°C), the internal pressure of the container (1) does not significantly decrease, resulting in a

low possibility that the inside of the container (1) has a negative pressure, even if the pull-down operation further decreases the temperature of the interior air. Thus, if the second condition and the third condition are satisfied in the step S24, the control unit (100) terminates the pressure equalizing action of the ventilator (40).

5 [0096]

The above control can restrain the negative pressure inside the container (1) from exceeding the pressure resistance of the container (1), even if the pressure of the inside of the container (1) decreases during the pull-down operation. As a result, damage to the container (1) due to the pull-down operation can be restrained.

10 [0097]

(7-2-3) Second mode

The second mode is a control mode of the ventilator (40) after the door (D) is temporarily opened and closed during the cooling operation. As described above, the proceeding condition (step S14) to the second mode is easily satisfied if the door (D) is temporarily opened and closed when the interior heat exchanger (29) is in a thermo-off state, in other words, when the interior temperature is within the target range.

[0098]

As illustrated in FIG. 9, if the process proceeds to the second mode, the control unit (100) controls the ventilator (40) in a step S31 so that the ventilator (40) performs a pressure equalizing action to equalize the pressure between the inside and the outside of the container (1). In other words, the control unit (100) controls the ventilator (40) so that if the first condition in the step S14 is satisfied after the door (D) is opened and closed during the cooling operation, the ventilator (40) performs the second pressure equalizing action as the pressure equalizing action.

25 [0099]

In the step S31, the control unit (100) controls the ventilator (40) so that the outside air is introduced at a third flow rate into the inside of the container (1). Specifically, the control unit (100) adjusts the rotational angle of the opening and closing lid (45) of the ventilator (40), that is, the opening degrees of the air supply passage (41) and the air discharge passage (42) so that the flow rate of the air introduced into the container (1) is the third flow rate. The introduction of the outside air into the inside of the container (1) equalizes the pressure between the outside and the inside of the container (1). As a result, the pressure of the inside of the container (1) quickly increases. In other words, the negative pressure in the container (1) decreases.

[0100]

Here, the third flow rate is higher than the first flow rate and the second flow rate in the first mode. The third flow rate is, for example, 10 [m³/h]. That is, the ventilator (40) introduces the outside air of the container (1) into the inside of the container (1) in the second pressure equalizing action at a higher flow rate than in the first pressure equalizing action. As described above, after the door (D) is opened and closed, the pressure of the inside of the container (1) decreases more quickly than in the pull-down operation. To cope with this, the ventilator (40) introduces the outside air at a relatively high flow rate, and thus can restrain the negative pressure in the container (1) from reaching the pressure resistance of the container (1).

[0101]

Next, in a step S32, if the second condition that the detected pressure is higher than the second pressure is satisfied, the process proceeds to a step S33. In the step S33, the control unit (100) ends the pressure equalizing control of the ventilator (40). Specifically, the control unit (100) sets the opening and closing lid (45) of the ventilator (40) to the fully closed position.

[0102]

The above control can restrain the negative pressure in the container (1) from exceeding the pressure resistance of the container (1), even if opening and closing of the door (D) is accompanied by a decrease in the pressure of the inside of the container (1). As a result, damage to the container (1) due to opening and closing of the door (D) can be restrained.

[0103]

(8) Effect of embodiment

(8-1)

The control unit (100) of the present embodiment controls the ventilator (40) so that if the first condition that the pressure detected by the pressure detection unit (P) is lower than the predetermined first pressure being lower than the atmospheric pressure is satisfied during the cooling operation for cooling of the inside of the container (1), the ventilator (40) performs the pressure equalizing action to equalize the pressure between the inside and the outside of the container (1).

[0104]

Thus, even if the pressure of the inside of the container (1) decreases due to cooling of the air in the container (1), the pressure equalizing action can quickly increase the pressure of the inside of the container (1). As a result, the negative pressure in the container (1) can be restrained from increasing, and damage to the container (1) can be restrained.

[0105]

Furthermore, such control can restrain damage to the container (1) even if the container (1) having high airtightness is used. As a result, it is possible to restrain deterioration of the energy conservation of the container refrigeration apparatus (10) caused by entry of the outside air from a gap of the container (1).

5 [0106]

(8-2)

In the embodiment, the pressure equalizing mechanism is the ventilator (40) configured to ventilate the container (1). Thus, the ventilator (40) can be used as the pressure equalizing mechanism, so that the number of parts can be reduced. The ventilator (40) can
10 introduce the outside air at a relatively high flow rate into the container (1). Thus, even if the pressure in the container (1) suddenly decreases, the outside air enough to cope with the decrease can be quickly introduced into the container (1).

[0107]

Furthermore, the ventilator (40) can adjust the ventilation amount, that is, the amount
15 of outside air introduced. Thus, the outside air corresponding to a pressure decrease in the container (1) can be introduced into the container (1). As a result, it is possible to restrain deterioration of the energy conservation of the container refrigeration apparatus (10) caused by introduction of an excessive amount of outside air.

[0108]

20 (8-3)

The control unit (100) terminates the pressure equalizing action if the pressure detection unit (P) detects a pressure higher than the predetermined second pressure that is lower than the atmospheric pressure during the pressure equalizing action.

[0109]

25 This control can prevent a situation in which the pressure equalizing action is continued while the pressure of the inside of the container (1) is high. As a result, it is possible to restrain deterioration of the energy conservation of the container refrigeration apparatus (10) caused by introduction of an excessive amount of outside air.

[0110]

30 (8-4)

The control unit (100) terminates the pressure equalizing action if the pressure detection unit (P) detects a pressure higher than the predetermined second pressure that is lower than the atmospheric pressure and air in the container (1) has a temperature lower than a predetermined temperature. In other words, the control unit (100) does not terminate the

pressure equalizing action when the air in the container (1) has a temperature of the predetermined temperature or higher, even if the pressure detection unit (P) detects a pressure higher than the predetermined second pressure that is lower than the atmospheric pressure.

[0111]

5 If the air in the container (1) has a low temperature (for example, 0°C), there is a low possibility that further cooling of the air increases the negative pressure in the container (1). Thus, the negative pressure in the container (1) can be restrained from increasing again to cause damage to the container (1) after the end of the pressure equalizing action.

[0112]

10 (8-5)

 The control unit (100) controls the ventilator (40) so that if the pressure detection unit (P) detects a pressure lower than the predetermined first pressure that is lower than the atmospheric pressure during the cooling operation (pull-down operation) performed first after the container refrigeration apparatus (10) is started, the ventilator (40) performs the first
15 pressure equalizing action as the pressure equalizing action.

[0113]

 In the pull-down operation, the negative pressure in the container (1) tends to increase, resulting in a high possibility of damage to the container (1). The first pressure equalizing action at this timing can prevent damage to the container (1).

20 [0114]

 (8-6)

 The control unit (100) controls the ventilator (40) so that if the pressure detection unit (P) detects a pressure lower than the predetermined first pressure that is lower than the atmospheric pressure after the door (D) of the container (1) is opened and closed during the
25 cooling operation, the ventilator (40) performs the second pressure equalizing action as the pressure equalizing action.

[0115]

 If the door of the container (1) is temporarily opened and closed, the negative pressure in the container (1) tends to increase, resulting in a high possibility of damage to the container
30 (1). The second pressure equalizing action at this timing can prevent damage to the container (1).

[0116]

 (8-7)

 The control unit (100) controls the pressure equalizing mechanism (40, 80) so that the

pressure equalizing mechanism (40, 80) introduces the outside air of the container (1) into the inside of the container (1) at a lower flow rate as the interior air has a lower temperature in the cooling operation (strictly, pull-down operation).

[0117]

5 If the interior air has a high temperature, cooling of the interior air tends to cause an increase in the negative pressure in the container (1). At this time, the amount of outside air introduced is increased, and thus damage to the container (1) can be reliably restrained.

[0118]

10 If the interior air has a low temperature, cooling of the interior air is less likely to cause an increase in the negative pressure in the container (1). At this time, a small amount of outside air is introduced, so that the amount of outside air introduced does not become excessively large. As a result, it is possible to restrain deterioration of the reliability of the container refrigeration apparatus (10) caused by introduction of the outside air. In particular if the interior air has a low temperature, the temperature difference between the outside air and
15 the interior air is large, and introduction of the outside air tends to cause an increase in the cooling load of the container (1). At this time, decreasing the amount of outside air introduced can prevent deterioration of the energy conservation of the container refrigeration apparatus (10).

[0119]

20 (8-8)

 The pressure detection unit (P) is a pressure sensor (53). Thus, the pressure in the container (1) can be accurately detected.

[0120]

(9) Modifications

25 For example, the above-described embodiment may have a configuration as in Modifications described below. Hereinafter, points different from the above embodiment will be particularly described.

[0121]

(9-1) Modification 1: Modification of pressure detection unit

30 For example, the pressure detection unit (P) of the above embodiment may have a configuration as in Modifications described below.

[0122]

(9-1-1) Modification 1A

As schematically illustrated in FIG. 10, a container refrigeration apparatus (10) of

Modification 1A includes a drain pipe (60). The drain pipe (60) has an inlet end (60a) communicating with an interior space (3) inside a container (1). The drain pipe (60) has an outlet end (60b) communicating with an exterior space (5) outside the container (1). The inlet end (60a) of the drain pipe (60) forms a flow path for discharge of the water received by a drain pan inside the container (1) to the outside of the container (1). The drain pan is disposed below an interior heat exchanger (29) and receives condensed water generated from air cooled by the interior heat exchanger (29). For example, the drain pipe (60) may be a flexible resin hose, or may be a hard metal pipe.

[0123]

The drain pipe (60) has a trap (61) curved downward. The trap (61) includes a first straight portion (62) close to the inside of the container (1), a second straight portion (63) close to the outside of the container (1), and a U-shaped portion (64) continuous with the lower end of the first straight portion (62) and the lower end of the second straight portion (63). The first straight portion (62) and the second straight portion (63) extend in the up-down direction. The first straight portion (62) and the second straight portion (63) have the same flow path cross-sectional area. The trap (61) collects water, and thus the water separates the inside of the container (1) and the outside of the container (1).

[0124]

The pressure detection unit (P) of Modification 1A includes a water level gauge that measures the water level in the trap (61), and a control unit (100). The water level gauge includes a first water level sensor (65) and a second water level sensor (66). The first water level sensor (65) and the second water level sensor (66) are an ultrasonic sensor, a radio wave sensor, an electrode sensor, a float sensor, or the like. The first water level sensor (65) is disposed inside the first straight portion (62). The first water level sensor (65) measures the water level in the first straight portion (62). The second water level sensor (66) is disposed inside the second straight portion (63). The second water level sensor (66) measures the water level in the second straight portion (63).

[0125]

The pressure detection unit (P) detects the pressure based on the water level difference between the first straight portion (62) and the second straight portion (63). If the pressure P_b of the inside of the container (1) is equal to the pressure P_0 (atmospheric pressure) of the outside of the container (1), the water level h_1 of the first straight portion (62) is equal to the water level h_2 of the second straight portion (63), as illustrated in FIG. 10. If the pressure P_b of the inside of the container (1) decreases during the cooling operation, the pressure P_b

becomes lower than the pressure P0 of the outside of the container (1). As a result, the water level h1 of the first straight portion (62) becomes higher than the water level h2 of the second straight portion (63), as illustrated in FIG. 11. In the state of FIG. 11, the following relational expression (1) is satisfied.

5 [0126]

$$P_b \times A_1 + \rho \times g \times H \times A_1 = P_0 \times A_2 \cdots (1)$$

Here, A1 represents the flow path cross-sectional area of the first straight portion (62), and A2 represents the flow path cross-sectional area of the second straight portion (63). In this example, A1 and A2 are equal. ρ represents the density of water, g represents the gravitational acceleration, and H represents the difference between the water level h1 and the water level h2 ($H = h_1 - h_2$).

[0127]

The control unit (100) calculates P_b of the inside of the container (1) using the water levels measured by the first water level sensor (65) and the second water level sensor (66) and the relational expression (1). As described above, in Modification 1, the pressure of the inside of the container (1) can be detected.

[0128]

(9-1-2) Modification 1B

A pressure detection unit (P) of Modification 1B detects the pressure of the inside of a container (1) based on the temperature of the air in the container (1) and the temperature of the air in the container (1) during the cooling operation. The pressure detection unit (P) includes an interior temperature sensor (51) and a control unit (100).

[0129]

The interior temperature sensor (51) measures the temperature T0 of the air in the container (1) before or at a start of the cooling operation. Then, the interior temperature sensor (51) measures the temperature Tb of the air in the container (1) during the cooling operation. The control unit (100) calculates the pressure P_b in the container (1) on the basis of the following relational expression (2) based on the Boyle-Charles' law.

[0130]

30 $P_0 \times V/T_0 = P_b \times V/T_b \cdots (2)$

Here, P0 represents the pressure in the container (1) before or at the start of the cooling operation, and corresponds to the atmospheric pressure. V represents the volume of an interior space (3) inside the container (1). As described above, in Modification 2, the pressure of the inside of the container (1) can be detected.

[0131]

For example, the pressure detection unit (P) may include an exterior temperature sensor (52). For example, the temperature detected by the exterior temperature sensor (52) may be regarded as the temperature T0 of the air in the container (1) before or at the start of the cooling operation.

[0132]

(9-1-3) Modification 1C

As illustrated in FIG. 12, a pressure detection unit (P) of Modification 1C includes a humidity sensor (71) that is a gas sensor, and a control unit (100). The humidity sensor (71) measures the concentration of water vapor in the air in a container (1), that is, the humidity of the air. The humidity sensor (71) is disposed inside the container (1). The humidity sensor (71) is disposed in the upstream side of the air flow with respect to an interior fan (30) in an internal passage (19). The humidity sensor (71) is a capacitive sensor or a resistive sensor. The humidity sensor (71) is characterized in that the detected value depends on the pressure around the humidity sensor (71).

[0133]

The humidity sensor (71) measures the humidity R0 of the air in the container (1) before or at a start of the cooling operation. Then, the humidity sensor (71) measures the humidity Rb of the air in the container (1) during the cooling operation. The humidity detected by the humidity sensor (71) depends on the pressure in the container (1). In other words, there is a correlation between the humidity detected by the humidity sensor (71) and the pressure in the container (1). The control unit (100) stores data correlated with the humidity detected by the humidity sensor (71) and the pressure in the container (1). These data include a relational expression and a table. The control unit (100) calculates the pressure in the container (1) using these data, the humidity R0, and the humidity Rb. As described above, in Modification 1C, the pressure of the inside of the container (1) can be detected using the humidity sensor (71).

[0134]

The humidity sensor (71) is also used for adjusting the humidity of the air in the container (1). The control unit (100) controls a refrigerant circuit (R) on the basis of the value detected by the humidity sensor (71).

[0135]

(9-1-4) Modification 1D

As illustrated in FIG. 13, a pressure detection unit (P) of Modification 1D includes a

carbon dioxide sensor (72) that is a gas sensor, and a control unit (100). The carbon dioxide sensor (72) measures the concentration of carbon dioxide in the air in a container (1). The carbon dioxide sensor (72) is disposed inside the container (1). The carbon dioxide sensor (72) is disposed in the upstream side of the air flow with respect to an interior fan (30) in an internal passage (19). The carbon dioxide sensor (72) is a semiconductor sensor, an infrared (NDIR) sensor, or a thermal conductivity sensor. The carbon dioxide sensor (72) is characterized in that the detected value depends on the pressure around the carbon dioxide sensor (72).

[0136]

The carbon dioxide sensor (72) measures the carbon dioxide concentration C_0 in the air in the container (1) before or at a start of the cooling operation. Then, the carbon dioxide sensor (72) measures the carbon dioxide concentration C_b in the air in the container (1) during the cooling operation. The carbon dioxide concentration detected by the carbon dioxide sensor (72) depends on the pressure in the container (1). In other words, there is a correlation between the concentration detected by the carbon dioxide sensor (72) and the pressure in the container (1). The control unit (100) stores data correlated with the concentration detected by the carbon dioxide sensor (72) and the pressure in the container (1). These data include a relational expression and a table. The control unit (100) calculates the pressure in the container (1) using these data, the concentration C_0 , and the concentration C_b . As described above, in Modification 1D, the pressure of the inside of the container (1) can be detected using the carbon dioxide sensor (72). For example, the gas sensor may be not the carbon dioxide sensor (72), but an oxygen sensor that measures the oxygen concentration in the air in the container (1).

[0137]

The carbon dioxide sensor (72) and the oxygen sensor are used for adjusting the composition of the air in the container (1). The control unit (100) controls an adjuster (80) on the basis of the concentration detected by the carbon dioxide sensor (72) or the oxygen sensor. The adjuster (80) adjusts the composition of the air in an interior space (3) using, for example, a pressure swing adsorption (PSA) apparatus or a gas separation membrane. Details of the adjuster (80) will be described below.

[0138]

For example, the control unit (100) may adjust the ventilation amount of the ventilator (40) on the basis of the concentration detected by the carbon dioxide sensor (72) or the oxygen sensor.

[0139]

(9-2) Modification 2: Modification of pressure equalizing mechanism

For example, the pressure equalizing mechanism (40, 80) of the above embodiment may have a configuration as in Modifications described below.

5 [0140]

(9-2-1) Modification 2A

As schematically illustrated in FIG. 14, a pressure equalizing mechanism of Modification 2A is an adjuster (80) that adjusts the composition of the inside air of a container (1). The adjuster (80) is disposed in an exterior accommodating space (14) of a casing (11).
10 The adjuster (80) includes a supply path (81), an air discharge path (82), an air pump (83), and a PSA apparatus (84).

[0141]

The supply path (81) is a flow path for introduction of outside air into an interior space (3). The supply path (81) has an inlet end opening to an exterior space (5). The supply path
15 (81) has an outlet end communicating with the interior space (3). The air discharge path (82) is a flow path for discharge of the air from the PSA apparatus (84) to the exterior space (5).

[0142]

The supply path (81) is provided with the air pump (83) and the PSA apparatus (84). The air pump (83) is a conveyance unit that conveys air. The air pump (83) is a pressurizing
20 unit that pressurizes the air and a decompressing unit that decompresses the air. The PSA apparatus (84) includes two adsorption units. Each adsorption unit is an adsorption tower filled with an adsorbent that adsorbs nitrogen in the air. The adsorbent is, for example, zeolite.

[0143]

The air pump (83) pressurizes one of the two adsorption units and decompresses the
25 other. In the pressurized adsorption unit, nitrogen in the air is adsorbed by the adsorbent, and thus oxygen-enriched air is generated that has a lower nitrogen concentration and a higher oxygen concentration than the outside air. In the decompressed adsorption unit, nitrogen desorbs from the adsorbent, and thus nitrogen-enriched air is generated that has a higher nitrogen concentration and a lower oxygen concentration than the outside air. The oxygen-
30 enriched air is discharged to the exterior space (5) through the air discharge path (82). The nitrogen-enriched air is supplied to the interior space (3) through the supply path (81). Thus, the oxygen concentration in the interior space (3) is adjusted.

[0144]

In Modification 2A, if the pressure of the inside of the container (1) becomes lower

than the first pressure during the cooling operation, a control unit (100) controls the adjuster (80) so that the pressure is equalized between the inside and the outside of the container (1). Specifically, the control unit (100) operates the air pump (83) so that the air pump (83) performs a pressure equalizing action of introducing the outside air of the container (1) into the inside of the container (1) through the supply path (81). Thus, damage to the container (1) due to the negative pressure can be restrained.

[0145]

The adjuster (80) preferably includes a bypass flow path through which the air in the supply path (81) bypasses the PSA apparatus (84) and is supplied to the interior space (3) in the pressure equalizing action. Thus, the outside air can be introduced into the inside of the container (1) without changing the composition of the outside air. Furthermore, the flow path resistance against the air flowing through the supply path (81) can be reduced, and the power of the air pump (83) can be saved.

[0146]

In the pressure equalizing action, for example, the adjuster (80) may introduce the air pressurized to a pressure higher than the atmospheric pressure by the air pump (83). Thus, the pressure of the inside of the container (1) can be quickly increased.

[0147]

If the pressure of the inside of the container (1) becomes higher than the second pressure due to the pressure equalizing action, the control unit (100) terminates the pressure equalizing action of the adjuster (80). Specifically, the control unit (100) stops the air pump (83).

[0148]

In Modification 2B, the adjuster (80) functions not only as an adjuster of the composition of the air but also as a pressure equalizing mechanism, so that the number of parts can be reduced.

[0149]

(9-2-2) Modification 2B

An object of Modification 2B is a refrigeration container (C) including a container refrigeration apparatus (10) and a container (1). The pressure equalizing mechanism of Modification 2B is a door (D) of the container (1). As illustrated in FIG. 15, a refrigeration container (1) includes a drive mechanism (90) that automatically opens and closes the door (D). The drive mechanism (90) opens and closes the door (D) in response to a command from a control unit (100).

[0150]

If the pressure of the inside of the container (1) becomes lower than the first pressure during the cooling operation, the control unit (100) controls the drive mechanism (90) so that the pressure is equalized between the inside and the outside of the container (1) by opening the door (D). Thus, the pressure of the inside of the container (1) can be quickly increased, and damage to the container (1) due to the negative pressure can be restrained.

[0151]

If the pressure of the inside of the container (1) becomes higher than the second pressure due to the pressure equalizing action, the control unit (100) terminates the pressure equalizing action of the adjuster (80). Specifically, the control unit (100) controls the drive mechanism (90) to close the door (D).

[0152]

(9-3) Modification 3

For example, the control unit (100) may perform the control in the first mode illustrated in FIG. 8 when the cooling operation is the pull-down operation and the first condition that the detected pressure is the first pressure or lower is satisfied. If a start of the cooling operation performed first after turning-on of the power source of the container refrigeration apparatus (10) is commanded, the control unit (100) determines that the cooling operation is the pull-down operation.

[0153]

(9-4) Modification 4

For example, the container refrigeration apparatus (10) may include a detection unit that detects opening and closing of the door (D). For example, the control unit (100) may perform the control in the second mode illustrated in FIG. 9 when a fourth condition that opening and closing of the door (D) is detected by the detection unit during the cooling operation is satisfied and then the first condition that the detected pressure is the first pressure or lower is satisfied.

[0154]

For example, the control unit (100) may perform the control in the second mode when a fifth condition that the temperature of the interior air becomes higher than the target range is satisfied and then the first condition is satisfied. For example, the control unit (100) may perform the control in the second mode when the fourth condition, the fifth condition, and the first condition are satisfied in this order.

[0155]

(9-5) Modification 5

For example, the first pressure (see the step S14) that is an execution threshold for the second pressure equalizing action in the second mode may be higher than the first pressure (see the step S13) that is an execution threshold for the first pressure equalizing action in the first mode. In this case, when the door (D) is opened and closed during the cooling operation and the pressure in the container (1) decreases, the second pressure equalizing action in the second mode can be quickly performed. As described above, the pressure in the container (1) rapidly decreases after the door (D) is opened and closed, but damage to the container (1) can be restrained by quickly coping with the pressure change.

[0156]

(9-6) Modification 6

For example, the control unit (100) may control the pressure equalizing mechanism (40, 80) so that the pressure equalizing mechanism (40, 80) introduces the outside air of the container (1) into the inside of the container (1) at a lower flow rate as the time of the cooling operation becomes longer in the cooling operation. The control unit (100) preferably controls the pressure equalizing mechanism (40, 80) so that the pressure equalizing mechanism (40, 80) introduces the outside air of the container (1) into the inside of the container (1) at a lower flow rate as the time of the cooling operation becomes longer particularly in the pull-down operation.

[0157]

As the cooling operation time elapses, the temperature of the interior air decreases. If the interior air has a low temperature, cooling of the interior air is less likely to cause an increase in the negative pressure in the container (1). At this time, a small amount of outside air is introduced, so that the amount of outside air introduced does not become excessively large. As a result, it is possible to restrain deterioration of the reliability of the container refrigeration apparatus (10) caused by introduction of the outside air. When the interior air has a low temperature, introduction of the outside air tends to cause an increase in the cooling load of the container (1). At this time, decreasing the amount of outside air introduced can prevent deterioration of the energy conservation of the container refrigeration apparatus (10).

[0158]

(9-7) Modification 7

A control unit (100) of Modification 7 controls a refrigerant circuit (R) so that the refrigerant circuit (R) performs a dehumidifying operation to dehumidify the interior air before the cooling operation. In the dehumidifying operation, a compressor (25) is operated, and an interior heat exchanger (29) functions as an evaporator. The control unit (100) adjusts the

number of rotations of the compressor (25) and the evaporation temperature in the interior heat exchanger (29) so that the interior heat exchanger (29) cools the air to the dew point temperature or less. The evaporation temperature Te_1 in the dehumidifying operation is higher than the evaporation temperature Te_2 in the cooling operation. Therefore, in the dehumidifying operation, the inside air of the container (1) can be dehumidified without significantly decreasing the temperature of the air.

[0159]

When the cooling operation is performed after the dehumidifying operation, the temperature of the air in the container (1) decreases as described above. Here, the interior air has a humidity reduced by the dehumidifying operation. Therefore, even if the air in the container (1) is cooled, the pressure in the container (1) can be restrained from significantly decreasing. As a result, damage to the container (1) due to the negative pressure can be restrained.

[0160]

(10) Other Embodiments

In the above embodiment and Modifications, for example, the following configurations may be adopted.

[0161]

For example, the container (1) may be not for marine transportation, and may be for land transportation by a vehicle such as a trailer or a railway.

[0162]

For example, the ventilator (40) may have only an air supply function of supplying the exterior air of the exterior space (5) to the interior space (3), and may have no air discharge function. In other words, for example, the ventilator (40) may include only the air supply passage (41), and may discharge the air naturally from an air discharge port provided in the container main body (2).

[0163]

For example, the ventilation fan of the ventilator (40) may be a fan, other than the interior fan, dedicated to ventilation.

[0164]

For example, the opening degree adjusting mechanism that adjusts the opening degrees of the air supply passage (41) and the air discharge passage (42) may not necessarily be the opening and closing lid (45). For example, the opening degree adjusting mechanism may be a damper or a valve mechanism provided in the air supply passage (41) or the air

discharge passage (42).

[0165]

The embodiment and Modifications are described above, but it will be understood that various changes can be made to modes and details without departing from the gist and the scope of the claims. The above-described embodiment, Modifications, and other embodiments may be combined or replaced appropriately as long as a function of the present disclosure is not impaired.

[0166]

The above-described terms “first”, “second”, “third”, ... are just used to distinguish words qualified with these terms, and do not limit the number or order of the words.

INDUSTRIAL APPLICABILITY

[0167]

As described above, the present disclosure is useful for a container refrigeration apparatus.

REFERENCE SIGNS LIST

[0168]

1: container

10: container refrigeration apparatus

40: ventilator (pressure equalizing mechanism)

53: pressure sensor

60: drain pipe

61: trap

71, 72: gas sensor

80: adjuster (pressure equalizing mechanism)

100: control unit

D: door

P: pressure detection unit

CLAIMS

[Claim 1] A container refrigeration apparatus comprising:

a pressure detection unit (P) configured to detect a pressure of an inside of a container (1);

5 a pressure equalizing mechanism (40, 80) configured to equalize the pressure of the inside of the container (1) and a pressure of an outside of the container (1); and

a control unit (100) configured to control the pressure equalizing mechanism (40, 80) so that the pressure equalizing mechanism (40, 80) performs a pressure equalizing action to equalize the pressure of the inside of the container (1) and the pressure of the outside of the container (1) when the pressure detection unit (P) detects a pressure lower than a predetermined first pressure that is lower than an atmospheric pressure during a cooling operation in which the inside of the container (1) is cooled.

[Claim 2] The container refrigeration apparatus according to claim 1, wherein

the pressure equalizing mechanism (40, 80) is a ventilator (40) configured to ventilate the container (1), and

the ventilator (40) introduces outside air of the container (1) into the inside of the container (1) in the pressure equalizing action.

[Claim 3] The container refrigeration apparatus according to claim 1, wherein

the pressure equalizing mechanism (40, 80) is an adjuster (80) configured to adjust a composition of inside air of the container (1), and

the adjuster (80) introduces outside air of the container (1) into the inside of the container (1) in the pressure equalizing action.

[Claim 4] The container refrigeration apparatus according to any one of claims 1 to 3, wherein

the control unit (100) terminates the pressure equalizing action when the pressure detection unit (P) detects a pressure higher than a predetermined second pressure that is lower than an atmospheric pressure during the pressure equalizing action.

[Claim 5] The container refrigeration apparatus according to claim 4, wherein

the control unit (100) terminates the pressure equalizing action when the pressure detection unit (P) detects a pressure higher than the predetermined second pressure that is lower than an atmospheric pressure and air in the container (1) has a temperature lower than a predetermined temperature.

[Claim 6] The container refrigeration apparatus according to any one of claims 1 to 5, wherein

the control unit (100) controls the pressure equalizing mechanism (40, 80) so that the pressure equalizing mechanism (40, 80) performs a first pressure equalizing action as the pressure equalizing action when the pressure detection unit (P) detects a pressure lower than the predetermined first pressure that is lower than an atmospheric pressure during a cooling operation performed first after the container refrigeration apparatus is started.

[Claim 7] The container refrigeration apparatus according to any one of claims 1 to 5, wherein

the control unit (100) controls the pressure equalizing mechanism (40, 80) so that the pressure equalizing mechanism (40, 80) performs a second pressure equalizing action as the pressure equalizing action when the pressure detection unit (P) detects a pressure lower than the predetermined first pressure that is lower than an atmospheric pressure after a door of the container (1) is opened and closed during the cooling operation.

[Claim 8] The container refrigeration apparatus according to claim 7, wherein

the control unit (100) controls the pressure equalizing mechanism (40, 80) so that the pressure equalizing mechanism (40, 80) performs a first pressure equalizing action as the pressure equalizing action when the pressure detection unit (P) detects a pressure lower than the predetermined first pressure that is lower than an atmospheric pressure during a cooling operation performed first after the container refrigeration apparatus is started, and

the pressure equalizing mechanism (40, 80) introduces outside air of the container (1) into the inside of the container (1) at a higher flow rate in the second pressure equalizing action than in the first pressure equalizing action.

[Claim 9] The container refrigeration apparatus according to any one of claims 1 to 8, wherein

the control unit (100) controls the pressure equalizing mechanism (40, 80) so that the pressure equalizing mechanism (40, 80) introduces outside air of the container (1) into the inside of the container (1) at a lower flow rate as inside air of the container (1) has a lower temperature in the cooling operation.

[Claim 10] The container refrigeration apparatus according to any one of claims 1 to 9, wherein

the pressure detection unit (P) is a pressure sensor (53).

[Claim 11] The container refrigeration apparatus according to any one of claims 1 to 9, comprising a drain pipe (60) configured to discharge condensed water generated inside the container (1) to the outside of the container (1), the drain pipe (60) including a trap (61) configured to collect the condensed water,

wherein the pressure detection unit (P) detects a pressure of the inside of the container (1), based on a water level in the trap (61).

[Claim 12] The container refrigeration apparatus according to any one of claims 1 to 9, wherein

5 the pressure detection unit (P) detects a pressure of the inside of the container (1), based on a temperature of air in the container (1) before or at a start of the cooling operation and a temperature of the air in the container (1) during the cooling operation.

[Claim 13] The container refrigeration apparatus according to any one of claims 1 to 9, comprising a gas sensor (71, 72) configured to detect a concentration of a gas component in
10 inside air of the container (1),

 wherein the pressure detection unit (P) detects a pressure of the inside of the container (1), based on a concentration detected by the gas sensor (71, 72) before or at a start of the cooling operation and a concentration detected by the gas sensor (71, 72) during the cooling operation.

15