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(54) **ULTRA-LOW TEMPERATURE FREEZER**

(57) An ultra-low temperature freezer includes: an insulated case defining a storage compartment having an opening in an upper face; and an insulated door configured to be able to open and close the opening so that the storage compartment can be seen from the front face side of the insulated case, the front face of the insulated case having a thickness smaller than thicknesses of both side faces and a back face of the insulated case.

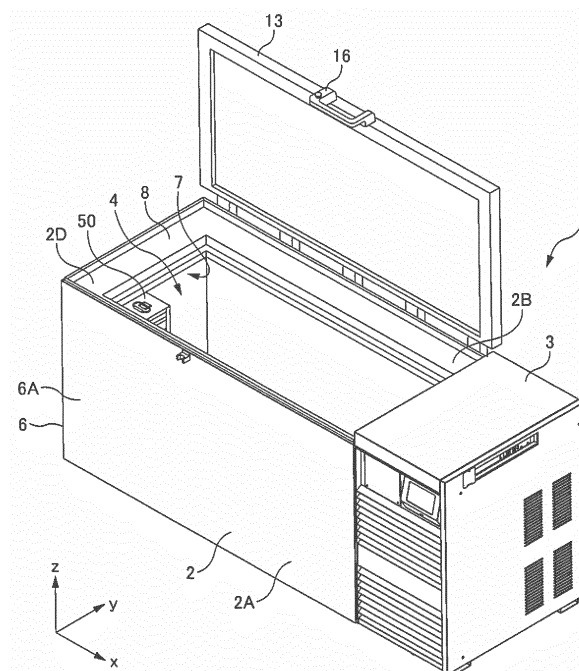


FIG. 2

Description

[Technical Field]

5 **[0001]** The present disclosure relates to an ultra-low temperature freezer.

[Background Art]

10 **[0002]** Ultra-low temperature freezers have been developed, which are each configured to cool the interior of the freezer to an ultra-low temperature, for example, -80°C or lower to preserve body tissues or store frozen food for a long period of time.

15 **[0003]** Such an ultra-low temperature freezer is required to have high insulation performance to maintain the interior of the freezer at an ultra-low temperature, and accordingly, various techniques have been developed (for example, see Patent Literature 1).

[Citation List]

[Patent Literature]

20 **[0004]** [PTL 1] Japanese Patent No. 5026736

[Summary]

[Technical Problem]

25 **[0005]** Meanwhile, the ultra-low temperature freezer particularly has a low temperature in the freezer. Thus, in order to minimize an increase in temperature within the freezer, it is preferable to open and close a door in as short a period of time as possible, when moving in and out a storage item. It is also required to move a storage item in and out as easily as possible in order to ensure work safety when a storage item is moved in and out.

30 **[0006]** In addition, the ultra-low temperature freezer is required to have high reliability. Thus, even though moving in and out of a storage item is facilitated, it is still important to minimize deterioration of strength of the ultra-low temperature freezer.

35 **[0007]** The present disclosure has been made in view of the above, and an aspect thereof is to provide an ultra-low temperature freezer capable of moving a storage item in and out more easily, while minimizing deterioration of strength thereof.

[Solution to Problem]

40 **[0008]** An ultra-low temperature freezer according to an aspect of the present disclosure includes: an insulated case defining a storage compartment having an opening in an upper face; and an insulated door configured to be able to open and close the opening so that the storage compartment can be seen from the front face side of the insulated case, the front face of the insulated case having a thickness smaller than thicknesses of both side faces and a back face of the insulated case.

45 [Advantageous Effects]

50 **[0009]** According to the present disclosure, it is possible to provide an ultra-low temperature freezer capable of moving a storage item in and out more easily while minimizing deterioration of strength thereof.

[Brief Description of Drawings]

[0010]

55 Fig. 1 is an external perspective view illustrating an ultra-low temperature freezer according to an embodiment of the present disclosure.

Fig. 2 is an external perspective view illustrating a state where an insulated door of an ultra-low temperature freezer according to an embodiment of the present disclosure is opened.

Fig. 3 is a perspective front view illustrating a storage compartment of an ultra-low temperature freezer according

to an embodiment of the present disclosure.

Fig. 4 is a perspective plan view illustrating a storage compartment of an ultra-low temperature freezer according to an embodiment of the present disclosure.

Fig. 5 is a perspective side view illustrating a storage compartment of an ultra-low temperature freezer according to an embodiment of the present disclosure.

Fig. 6 is an external perspective view illustrating a vacuum insulated panel of an ultra-low temperature freezer according to an embodiment of the present disclosure.

Fig. 7 is an exploded perspective view illustrating an ultra-low temperature freezer according to an embodiment of the present disclosure when viewed from a back side thereof.

Fig. 8 is a diagram illustrating a state where an inner cover is mounted to an ultra-low temperature freezer according to an embodiment of the present disclosure.

Fig. 9 is an external perspective view illustrating a storage rack according to an embodiment of the present disclosure.

Fig. 10 is a diagram illustrating a refrigerant circuit of an ultra-low temperature freezer according to an embodiment of the present disclosure.

[Description of Embodiments]

[0011] At least the following matters will be made clear from the present description with reference to the accompanying drawings.

[0012] An ultra-low temperature freezer 1 according to an embodiment of the present disclosure is a refrigeration apparatus capable of cooling an interior of a storage compartment 4, which will be described later, to a predetermined temperature or lower (for example, -80°C or lower) of an ultra-low temperature. The ultra-low temperature freezer 1 is suitable for the preservation at the ultra-low temperature of a stored item, such as frozen food or body tissue and specimen to be preserved at a low temperature for a long period of time.

==Configuration of ultra-low temperature freezer==

[0013] Fig. 1 is an external perspective view illustrating the ultra-low temperature freezer 1 according to an embodiment of the present disclosure. Fig. 2 is an external perspective view illustrating a state where an insulated door 13 of the ultra-low temperature freezer 1 is opened. Fig. 3 is a perspective front view illustrating the storage compartment 4 of the ultra-low temperature freezer 1. Fig. 4 is a perspective plan view illustrating the storage compartment 4 of the ultra-low temperature freezer 1. Fig. 5 is a perspective side view illustrating the storage compartment 4 of the ultra-low temperature freezer 1.

[0014] Note that, in the following description, a direction from left to right when facing a front face of the ultra-low temperature freezer 1 is defined as a forward direction of an X-axis, a direction from the front to the rear is defined as a forward direction of a Y-axis, and a vertically upward direction is defined as a forward direction of a Z-axis.

[0015] The ultra-low temperature freezer 1 includes: a substantially rectangular parallelepiped insulated case 2 that defines the storage compartment 4 having an opening on an upper face; the insulated door 13 configured to be able to open and close the opening of the storage compartment 4 so that the storage compartment 4 can be seen from the front face side of the insulated case 2; and a machinery compartment 3 disposed on a side of the insulated case 2.

[0016] The insulated case 2 includes a front insulated wall (front face) 2A, a rear insulated wall (back face) 2B, a right insulated wall (side face) 2C, a left insulated wall (side face) 2D and an insulated bottom 2E, and forms the storage compartment 4 in the interior thereof. Fig. 2 illustrates a state where a storage rack 50 is stored in the storage compartment 4.

[0017] The storage rack 50 includes, as illustrated in Fig. 9, storage shelves 51 stacked in a multiple manner. The storage shelves 51 each capable of storing a container not shown that stores a sample of body tissue and/or the like. A worker lifts up the storage rack 50 holding a handle 52, and moves the storage rack 50 into and out of the storage compartment 4.

[0018] Thus, when the storage rack 50 is moved in and out of the storage compartment 4, the worker needs to lift up the storage rack 50 to the height at which the front insulated wall 2A of the insulated case 2 can be cleared.

[0019] In the ultra-low temperature freezer 1 according to an embodiment of the present disclosure, as illustrated in Fig. 4, the front insulated wall 2A is formed such that a thickness T1 thereof becomes smaller than a thickness T2 of the rear insulated wall 2B, a thickness T3 of the right insulated wall 2C, and a thickness T4 of the left insulated wall 2D, to facilitate moving of the storage rack 50 into and out of the storage compartment 4.

[0020] The insulated case 2 is configured into such a shape. Thus, when moving a storage item such as the storage rack 50 in and out of the storage compartment 4, a worker can lift up and down the storage rack 50 at a position closer to the worker's standing place. This can facilitate moving in and out of the storage rack 50. Accordingly, it becomes possible to move the storage rack 50 in and out of the storage compartment 4 in a short period of time, thereby being

able to reduce a period of time in which the insulated door 13 should be kept open. This can minimize an increase in temperature within the storage compartment 4.

[0021] Further, the storage rack 50 can be lifted up and down at a position closer to a worker's standing place. Thus, it becomes possible to move the storage rack 50 in and out in a posture with less strain, thereby being able to enhance safety of the work.

[0022] It is more preferable that the thickness T1 of the front insulated wall 2A is set to be equal to or smaller than $\frac{2}{3}$ of the thickness T2 of the rear insulated wall 2B. With such an embodiment, the aforementioned work of moving the storage rack 50 in and out of the storage compartment 4 can be further facilitated.

[0023] It is further preferable that the thickness T1 of the front insulated wall 2A is set to be equal to or smaller than $\frac{1}{3}$ of the thickness T2 of the rear insulated wall 2B. With such an embodiment, the work of moving the storage rack 50 in and out of the storage compartment 4 can be still further facilitated.

[0024] Note that the thickness T1 of the front insulated wall 2A that is set to be equal to or greater than $\frac{1}{4}$ of the thickness T2 of the rear insulated wall 2B can minimize degradation in cooling performance of the insulated case 2 as well as degradation in mechanical strength of the insulated case 2.

[0025] Further, Fig. 2 illustrates a state where the single storage rack 50 is stored in the storage compartment 4. However, needless to say, a plurality of the storage racks 50 can be stored within the storage compartment 4 in a range of the capacity of the storage compartment 4. Accordingly, reduction in the thickness T1 of the front insulated wall 2A to be smaller than the thickness T2 of the rear insulated wall 2B as described above increases the capacity of the storage compartment 4, and also enables storage of more storage racks 50.

[0026] The insulated door 13 is configured using a plurality of (5 pieces in an embodiment of the present disclosure) pivot members 14 that are disposed side by side along an upper end part of the rear insulated wall 2B, by pivoting on or being pivotally supported by these pivot members 14. The insulated door 13 is configured to open and close the opening of the insulated case 2 by pivoting on a central axis formed along the upper end part of the rear insulated wall 2B. A handle portion 16 is provided to the insulated door 13, and a worker operates the handle portion 16 to open and close the insulated door 13.

[0027] Further the insulated case 2 according to an embodiment of the present disclosure includes an inner case 7 whose upper face is configured to be opened, and an outer case 6 surrounding the inner case 7, a breaker 8, an insulating material 9, and a vacuum insulated panel 12.

[0028] The outer case 6 is configured with a board material made of a steel plate, and is open on the upper side and constitutes outer wall surfaces and outer bottom surface of the insulated case 2. The inner case 7 is configured with a board material made of metal having high thermal conductivity, such as aluminum, and similarly is open on the upper side and constitutes inner wall surfaces and inner bottom surface of the insulated case 2. The breaker 8 is a member made of a synthetic resin, and is mounted to connect between the outer case 6 and the inner case 7.

[0029] The insulating material 9 is a polyurethane resin filled in a space surrounded by the outer case 6, the inner case 7, and the breaker 8. The insulating material 9 is filled in each of the front insulated wall 2A, the rear insulated wall 2B, the right insulated wall 2C, the left insulated wall 2D and the insulated bottom 2E of the insulated case 2.

[0030] The vacuum insulated panel 12 is a member having insulating properties configured such that glass wool is stored in a casing constituted by a multi-layer film, such as aluminum and a synthetic resin, having no air permeability, the air in the casing is discharged by a predetermined vacuum discharge means, and an opening of the casing is joined by thermal welding, or the like.

[0031] The vacuum insulated panel 12 is mounted between the outer case 6 and the aforementioned insulating material 9 filled between the inner case 7 and the outer case 6.

[0032] The vacuum insulated panel 12 according to an embodiment of the present disclosure has insulating properties higher than that of the insulating material 9. Thus, the combined use of the insulating material 9 and the vacuum insulated panel 12 can achieve insulating properties higher than insulating properties in the case where only the insulating material 9 is used.

[0033] Accordingly, in the ultra-low temperature freezer 1 according to an embodiment of the present disclosure, the vacuum insulated panel 12 and the insulating material 9 are used in combination for the front insulated wall 2A. More specifically, in an embodiment of the present disclosure, the vacuum insulated panel 12 is mounted between the inner case 7 and the outer case 6 only in the front insulated wall 2A. Figs. 4 and 6 illustrate a state where the ultra-low temperature freezer 1 according to an embodiment of the present disclosure has the vacuum insulated panel 12 only in the front insulated wall 2A.

[0034] With such an embodiment, even in the case where the front insulated wall 2A is formed to have a thickness that is smaller than the thicknesses of the rear insulated wall 2B, the right insulated wall 2C, and the left insulated wall 2D, the front insulated wall 2A is able to ensure insulating properties equivalent to the insulating properties of the rear insulated wall 2B, the right insulated wall 2C and the left insulated wall 2D. Accordingly, it becomes possible to restrain power consumption that is necessary for cooling the interior of the storage compartment 4 to a predetermined temperature or lower (for example, -80°C or lower).

[0035] Further, a configuration is made such that only the thickness of the front insulated wall 2A is reduced while the thicknesses of the rear insulated wall 2B, the right insulated wall 2C, and the left insulated wall 2D are made greater than the thickness of the front insulated wall 2A. This can minimize degradation of strength of the insulated case 2. Accordingly, reliability, such as failure tolerance and durability, of the ultra-low temperature freezer 1 can also be maintained.

[0036] Further, in the ultra-low temperature freezer 1 according to an embodiment of the present disclosure, as illustrated in Fig 4, a configuration is made such that the vacuum insulated panel 12 is mounted between the insulating material 9 and the outer case 6 in the front insulated wall 2A.

[0037] Accordingly, the vacuum insulated panel 12 is mounted such that the insulating material 9 is interposed between the vacuum insulated panel 12 and the inner case 7. This can minimize reduction in temperature of the vacuum insulated panel 12 caused by the inner case 6 which is cooled to such a degree equivalent to the degree of cooling the interior of the storage compartment 4, thereby being able to minimize degradation of insulation performance caused by damage, such as crack, fracture, and rupture, occurring in the vacuum insulated panel 12. Consequently, reliability, such as failure tolerance and durability of the ultra-low temperature freezer 1 can be maintained.

[0038] Further, as illustrated in Figs. 3, 5, 8, and the like, in the ultra-low temperature freezer 1 according to an embodiment of the present disclosure, an inner cover 15 (inner cover A 15A, inner cover B 15B) can be mounted in a portion on the inner peripheral side of the breaker 8. The inner cover 15 is constituted by a board material having insulating properties, such as expanded polystyrene.

[0039] With such an embodiment, even while an insulated door 2 is open, the opening on the upper side of the storage compartment 4 can be closed by the inner cover 15. This can minimize intrusion of the outside air into the storage compartment 4, and minimize an increase in the temperature within the storage compartment 4.

[0040] Further, as illustrated in Fig. 8, the ultra-low temperature freezer 1 according to an embodiment of the present disclosure is configured such that the storage compartment 4 can be opened and closed using a plurality of the inner covers 15 (a single inner cover A 15A and two inner covers B 15B in an example illustrated in Fig. 8). With such an embodiment, the inner cover 15 at a location where the cover does not need to be opened to move the storage rack 50 in and out of the storage compartment 4, is not required to be opened. This can minimize intrusion of the outside air into the storage compartment 4, thereby being able to minimize an increase within the temperature in the storage compartment 4.

[0041] Further, it is only necessary to open only the inner cover 15 at a location where the cover needs to be opened to move the storage rack 50 into and out of the storage compartment 4. This can facilitate demounting of the inner cover 15, thereby being able to reduce workload.

[0042] Note that, when the insulated door 13 is closed, the inner cover 15 is pressed from above by the insulated door 13, so that the storage compartment 4 can be tightly sealed in an insulated state.

[0043] The interior of the storage compartment 4 is cooled by a first refrigerant circuit 100 and a second refrigerant circuit 200.

[0044] Although the details will be described later, the first refrigerant circuit 100 includes a first compressor 101, condensers 102, 104, a decompressor 108, and a first evaporator 111, and is configured to cool the interior (storage compartment 4) of the insulated case 2 to a predetermined temperature or lower by circulating a refrigerant in this order.

[0045] Similarly, the second refrigerant circuit 200 includes a second compressor 201, condensers 202, 204, a decompressor 208, and a second evaporator 211, and is configured to cool the interior (storage compartment 4) of the insulated case 2 to a predetermined temperature or lower by circulating a refrigerant in this order.

[0046] Then, the first evaporator 111 constituting the first refrigerant circuit 100 and the second evaporator 211 constituting the second refrigerant circuit 200 are mounted, to enable heat exchange, so as to surround the storage compartment 4 on a circumferential surface on the insulating material 9 side of the inner case 7 (outer circumferential surface of the inner case 7).

[0047] Further, in the ultra-low temperature freezer 1 according to an embodiment of the present disclosure, a heat exchanger 109 constituting the first refrigerant circuit 100 and a heat exchanger 209 constituting the second refrigerant circuit 200 are provided, as illustrated in Figs. 4 and 7, within the rear insulated wall 2B of the insulated case 2, while being covered with the insulating material 9. Then, a portion of a rear wall 6B where the heat exchangers 109, 209 are provided is covered with a plate-shaped rear surface cover 6D.

[0048] Note that the first compressor 101 constituting the first refrigerant circuit 100 and the second compressor 201 constituting the second refrigerant circuit 200 are housed in the machinery compartment 3 together with various devices such as a control circuit of the ultra-low temperature freezer 1.

[0049] The control circuit includes a Central Processing Unit (CPU) and memory, and is configured to execute a control program for controlling the ultra-low temperature freezer 1.

[0050] The machinery compartment 3 includes, as illustrated in Fig. 1, a front panel 3A, a rear panel 3D, and a side panel 3B constituting a side face opposite to the side on which the insulated case 2 is provided. Ventilation slits 3C are formed in the front panel 3A and the side panel 3B.

[0051] Further, in the front panel 3A of the machinery compartment 3, an operation panel 21 for operating the ultra-low temperature freezer 1 is provided.

[0052] Further, although not illustrated, a measurement hole passes through between the machinery compartment 3 and the insulated case 2. This measurement hole is formed to pass through the outer case 6 constituting the insulated case 2, the insulating material 9, and the inner case 7, so as to communicate between the storage compartment 4 and the machinery compartment 3. It is possible to insert a temperature sensor through the measurement hole from the machinery compartment 3 to the interior of the storage compartment 4.

[0053] A cable is drawn from the temperature sensor, which is inserted into the storage compartment 4, to the machinery compartment 3 through the measurement hole. This cable is coupled to a control circuit in the machinery compartment 3. Then, in this measurement hole, a gap formed with the cable is closed with a plug made of a spongelike deformable material having insulating properties. Note that, in a state where the temperature sensor is not mounted, the measurement hole is closed in an insulating manner with this plug.

==Refrigerant circuit of ultra-low temperature freezer==

[0054] Next, a refrigerant circuit 150 of the ultra-low temperature freezer 1 according to an embodiment of the present disclosure will be described with reference to Fig. 10. Fig. 10 is a circuit diagram illustrating an example of the refrigerant circuit 150 according to an embodiment of the present disclosure.

[0055] As indicated in an example in Fig. 10, the refrigerant circuit 150 includes two substantially identical refrigerant circuits, that is, the first refrigerant circuit 100 and the second refrigerant circuit 200.

<<<First refrigerant circuit>>>

[0056] The first refrigerant circuit 100 includes the first compressor 101, the upstream condenser 102 and the downstream condenser 104, a shunt 107 configured to separate gas and liquid, the decompressor 108 and the heat exchanger 109, and a decompressor 110 and the first evaporator 111. The first refrigerant circuit 100 is configured in an annular manner so that that a refrigerant discharged from the first compressor 101 is returned to the first compressor 101 again. In the first refrigerant circuit 100, for example, a zeotropic refrigerant mixture (hereinafter, simply referred to as the "refrigerant") containing four types of refrigerants, which will be described later, is sealed.

[0057] Further, in this first refrigerant circuit 100, an oil cooler 101a is provided at an oil reservoir within the first compressor 101, a pipe 103 is provided between the upstream condenser 102 and the oil cooler 101a, a dehydrator 106 is provided between the downstream condenser 104 and the shunt 107, a buffer 112 is provided between the first compressor 101 on the intake side and the heat exchanger 109.

[0058] Further, the first refrigerant circuit 100 includes a first fan 105 to cool the upstream condenser 102 and the downstream condenser 104. The first fan 105 is a propeller blower including a fan motor 105a.

[0059] The first compressor 101 is configured to compress and discharge the intake refrigerant to the upstream condenser 102.

[0060] The upstream condenser 102 is configured such that, for example, a copper or aluminum tube to radiate the heat of the refrigerant discharged from the first compressor 101 is formed into a meander shape.

[0061] The downstream condenser 104 is configured such that, for example, a copper or aluminum tube to further radiate the heat of the refrigerant outputted from the upstream condenser 102 is formed into a meander shape.

[0062] These upstream condenser 102 and downstream condenser 104 are integrally configured in a single tube sheet.

[0063] The shunt 107 is configured to separate the refrigerant outputted from the downstream condenser 104 into the refrigerant in the liquid phase and a refrigerant in a gas phase, and decompress the refrigerant in the liquid phase through the decompressor (capillary tube) 108, and thereafter evaporate the decompressed refrigerant in an outer tube 109a of the heat exchanger 109.

[0064] The heat exchanger 109 is, for example, a metal or aluminum double tube including the outer tube 109a and an inner tube 109b. The refrigerant in the gas phase from the shunt 107 flows through the inner tube 109b, and the refrigerant in the gas phase, which is obtained by evaporating the refrigerant in the liquid phase, flowing through the inner tube 109b is cooled at the outer tube 109a.

[0065] The decompressor 110 is, for example, a capillary tube, configured to decompress the refrigerant having entered the liquid phase by being cooled at the inner tube 109b of the heat exchanger 109, and output the decompressed refrigerant to the first evaporator 111.

[0066] The first evaporator 111 is, for example, a copper or aluminum tube to evaporate the refrigerant decompressed by the decompressor 110. As described above, the first evaporator 111 is, for example, attached to the outer faces except the upper opening of the inner case 7 so as to thermally contact the outer faces. Note that such attachment of the first evaporator 111 is not limited to this, as long as a configuration allowing thermal contact.

[0067] The refrigerant is configured to cool an interior of the inner case 7 by cooling action when being evaporated

(vaporized) in the first evaporator 111. This refrigerant having entered the gas phase by evaporation is taken into the compressor 101 in the heat exchanger 109 together with the previously evaporated refrigerant.

[0068] Note that the pipe 103 is provided inside the peripheral portion of the upper face opening of the outer case 6. This peripheral portion of the upper face opening is a portion where packing (not illustrated) mounted to the insulated door 13 closely contact in a state where the aforementioned insulated door 13 is closed, and the high-temperature refrigerant discharged from the compressor 101 flows in the pipe 103. Thus, heating by this refrigerant prevents condensation which is caused by cooling from the low-temperature inner case 7 side. This can enhance hermeticity within the outer case 6. Further, the dehydrator 106 is configured to remove moisture contained in the refrigerant. Further, the buffer 112 includes a capillary tube 112a and an expansion tank 112b, and the amount of the refrigerant that circulates in the first refrigerant circuit 100 is maintained appropriate by taking the refrigerant in the gas phase on the intake side of the first compressor 101 into the expansion tank 112b through the capillary tube 112a.

<<<Second refrigerant circuit>>>

[0069] The second refrigerant circuit 200 includes, similarly to the above, the second compressor 201, the upstream condenser 202 and the downstream condenser 204, a shunt 207 configured to separate gas and liquid, the decompressor 208 and the heat exchanger 209, and a decompressor 210 and the second evaporator 211. The second refrigerant circuit 200 is configured in an annular manner so that a refrigerant discharged from the second compressor 201 is returned to the second compressor 201 again. In the second refrigerant circuit 200, the refrigerant similar to the above is sealed. Further, this second refrigerant circuit 200 includes, similarly to the above, an oil cooler 201a, a pipe 203, a dehydrator 206, and a buffer 212. Here, the heat exchanger 209 includes an outer tube 209a and an inner tube 209b. Further, the buffer 212 includes a capillary tube 212a and an expansion tank 212b.

[0070] In the second refrigerant circuit 200, a second fan 205 is provided to cool the upstream condenser 202 and the downstream condenser 204. The second fan 205 is a propeller blower including a fan motor 205a.

[0071] Note that the aforementioned pipe 103 and pipe 203 are provided inside the peripheral portion of the upper face opening of the outer case 6, for example, so as to overlap each other. The aforementioned first evaporator 111 and second evaporator 211 are, for example, attached in such a manner as to thermally contact the outer faces except the upper face opening of the inner case 7, for example, so as not to overlap each other.

<<<Refrigerant>>>

[0072] The refrigerant according to an embodiment of the present disclosure is, for example, a zeotropic refrigerant mixture containing R245fa, R600, R23, and R14. Here, R245fa indicates Pentafluoropropane ($\text{CHF}_2\text{CH}_2\text{CF}_3$), and has a boiling point of +15.3°C. R600 indicates normal butane ($\text{n-C}_4\text{H}_{10}$), and has a boiling point of -0.5°C. R23 indicates Trifluoromethane (CHF_3), and has a boiling point of -82.1°C. R14 indicates Tetrafluoromethane (CF_4), and has a boiling point of -127.9°C.

[0073] Note that R600 has a high boiling point (evaporation temperature), and easily contains oil, water, etc. Further, R245fa is a refrigerant to be made noncombustible by being mixed with R600, which is combustible, at a predetermined ratio (e.g., R245fa and R600 are in the ratio of 7:3).

[0074] In the first refrigerant circuit 100, the refrigerant compressed in the first compressor 101 radiates heat in the upstream condenser 102 and the downstream condenser 104, and is condensed to enter the liquid phase. Then, the refrigerant in the liquid state is subjected to a moisture removal process in the dehydrator 106, and thereafter is separated, in the shunt 107, into the refrigerant in the liquid phase (mainly R245fa, R600 having a high boiling temperature) and the refrigerant in the gas state (R23, R14). Note that, in an embodiment of the present disclosure, the refrigerant having radiated heat in the upstream condenser 102 cools the oil within the first compressor 101 at the oil cooler 101a, and thereafter radiates heat again in the downstream condenser 104.

[0075] The refrigerant in the separated liquid state (mainly R245fa, R600) is decompressed in the decompressor 108, and thereafter is evaporated at the outer tube 109a in the heat exchanger 109.

[0076] The refrigerant in the separated gas state (R23, R14) is cooled and condensed by the heat of evaporation of the aforementioned refrigerant (R245fa, R600) evaporated in the outer tube 109a and the refrigerant in the gas phase (R23, R14) returned from the first evaporator 111, while passing through the inner tube 109b of the heat exchanger 109, resulting in the refrigerant in the liquid state. At this time, the refrigerant having not been evaporated in the first evaporator 111 is evaporated.

[0077] Note that the second refrigerant circuit 200 is similar to the above.

[0078] Further, as described above, R245fa has a boiling point of about 15°C, R600 has a boiling point of about 0°C, R23 has a boiling point of about -82°C, and R14 has a boiling point of about -128°C. Accordingly, in the first refrigerant circuit 100 and the second refrigerant circuit 200, R23 and R14 in the zeotropic refrigerant mixture are cooled through vaporization action of R600, and R23, R14 having entered in the liquid phase are guided to the first evaporator 111 and

the second evaporator 211, and evaporated. This can cause an item to be cooled, for example, to a temperature corresponding to a boiling point of R23 and R14 (e.g., about -82°C to -128°C). Note that the refrigerant having not been evaporated in the first evaporator 111 and the second evaporator 211 is evaporated in the heat exchangers 109, 209.

[0079] As described above, the ultra-low temperature freezer 1 according to an embodiment of the present disclosure is configured to cool the interior of the storage compartment 4 to an ultra-low temperature of a predetermined temperature or lower (for example, -80°C or lower).

[0080] Then, as described above, the ultra-low temperature freezer 1 according to an embodiment of the present disclosure is formed such that the thickness of the front insulated wall 2A in the insulated case 2 becomes smaller than the thicknesses of the rear insulated wall 2B, the right insulated wall 2C, and the left insulated wall 2D.

[0081] With such an embodiment, when moving the storage rack 50 in and out of the storage compartment 4, it becomes possible for a worker to lift up and down the storage rack 50 at a position closer to his/her standing place. This can facilitate moving the storage rack 50 in and out of the storage compartment 4.

[0082] In addition, it becomes possible to move the storage rack 50 in and out of the storage compartment 4 in a short period of time, thereby being able to reduce a period of time in which the insulated door 13 should be kept open. This can minimize an increase in the temperature within the storage compartment 4.

[0083] Further, it becomes possible to lift up and down the storage rack 50 at a position closer to a worker's standing place, thereby being able to move in and out the storage rack 50 in a less strain posture, and also enhance work safety.

[0084] Further, the ultra-low temperature freezer 1 according to an embodiment of the present disclosure is configured such that the insulating material 9 is filled between the inner case 7 and the outer case 6, as well as the vacuum insulated panel 12 is mounted between the inner case 7 and the outer case 6 only in the front insulated wall 2A which has a thickness smaller than thicknesses of the rear insulated wall 2B, the right insulated wall 2C, and the left insulated wall 2D.

[0085] With such an embodiment, even if the thickness of the front insulated wall 2A is made smaller than the thicknesses of the rear insulated wall 2B, the right insulated wall 2C, and the left insulated wall 2D, the front insulated wall 2A can ensure insulation performance equivalent to the rear insulated wall 2B, the right insulated wall 2C, and the left insulated wall 2D. Thus, it becomes possible to restrain power consumption to cool the interior of the storage compartment 4 to a predetermined temperature or lower (for example, -80°C or lower).

[0086] Further, a configuration is made such that only the thickness of the front insulated wall 2A is made smaller, while the thicknesses of the rear insulated wall 2B, the right insulated wall 2C, and the left insulated wall 2D are made greater than that of the front insulated wall 2A. This can minimize deterioration of the strength of the insulated case 2. Accordingly, reliability, such as failure tolerance and durability, of the ultra-low temperature freezer 1 can also be maintained.

[0087] Further, the ultra-low temperature freezer 1 according to an embodiment of the present disclosure is configured such that the insulating material 9 is mounted between the vacuum insulated panel 12 and the inner case 7 in the front insulated wall 2A.

[0088] Such an embodiment can minimize reduction in the temperature of the vacuum insulated panel 12 caused by the inner case 6 which is cooled to such a degree equivalent to the degree of cooling the interior of the storage compartment 4, thereby being able to minimize degradation of insulation performance caused by damage, such as crack, fracture, and rupture, occurring in the vacuum insulated panel 12. Consequently, reliability, such as failure tolerance and durability of the ultra-low temperature freezer 1 can be maintained.

[0089] It should be noted that the above embodiments of the present disclosure are simply to facilitate the understanding of the present disclosure and are not in any way to be construed as limiting the present disclosure. The present disclosure may variously be changed or altered without departing from its scope and encompass equivalents thereof.

[Reference Signs List]

[0090]

1	ultra-low temperature freezer
2	insulated case
2A	front insulated wall
2B	rear insulated wall
2C	right insulated wall
2D	left insulated wall
2E	insulated bottom
3	machinery compartment
3A	front panel
3B	side panel
3C	ventilation slits

	3D	rear panel
	4	storage compartment
	6	outer case
	6A	front wall
5	6B	rear wall
	6C	side wall
	6D	rear surface cover
	7	inner case
	8	breaker
10	9	insulating material
	12	vacuum insulated panel
	13	insulated door
	14	pivot member
	15	inner cover
15	15A	inner cover A
	15B	inner cover B
	16	handle portion
	21	operation panel
	50	storage rack
20	51	storage shelves
	52	handle
	100	first refrigerant circuit
	101	first compressor
	101a	oil cooler
25	102, 202	upstream condenser
	103, 203	pipe
	104, 204	downstream condenser
	105	first fan
	105a, 205a	fan motor
30	106, 206	dehydrator
	107, 207	shunt
	108, 110, 208, 210	decompressor
	109, 209	heat exchanger
	109a, 209a	outer tube
35	109b, 209b	inner tube
	111	first evaporator
	112, 212	buffer
	112a, 212a	capillary tube
	112b, 212b	expansion tank
40	150	refrigerant circuit
	200	second refrigerant circuit
	201	second compressor
	205	second fan
	211	second evaporator

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Claims

1. An ultra-low temperature freezer comprising:
 - an insulated case defining a storage compartment having an opening in an upper face; and
 - an insulated door configured to be able to open and close the opening so that the storage compartment can be seen from the front face side of the insulated case,
 - the front face of the insulated case having a thickness smaller than thicknesses of both side faces and a back face of the insulated case.
2. The ultra-low temperature freezer according to claim 1, wherein the insulated case includes

an inner case whose upper face is configured to be opened,
an outer case that surrounds the inner case,
an insulating material filled between the inner case and the outer case, and
a vacuum insulated panel mounted between the inner case and the outer case,

- 5 the vacuum insulated panel being mounted only to the front face of the insulated case.
3. The ultra-low temperature freezer according to claim 2, wherein
10 the vacuum insulated panel is mounted to the front face of the insulated case such that the insulating material is interposed between the inner case and the vacuum insulated panel.
4. The ultra-low temperature freezer according to any one of claims 1 to 3, wherein
15 the front face has a thickness equal to or greater than $1/4$ and equal to or smaller than $2/3$ of the thickness of the back face.
5. The ultra-low temperature freezer according to claim 4, wherein
the front face has a thickness equal to or smaller than a half of the thickness of the back face.

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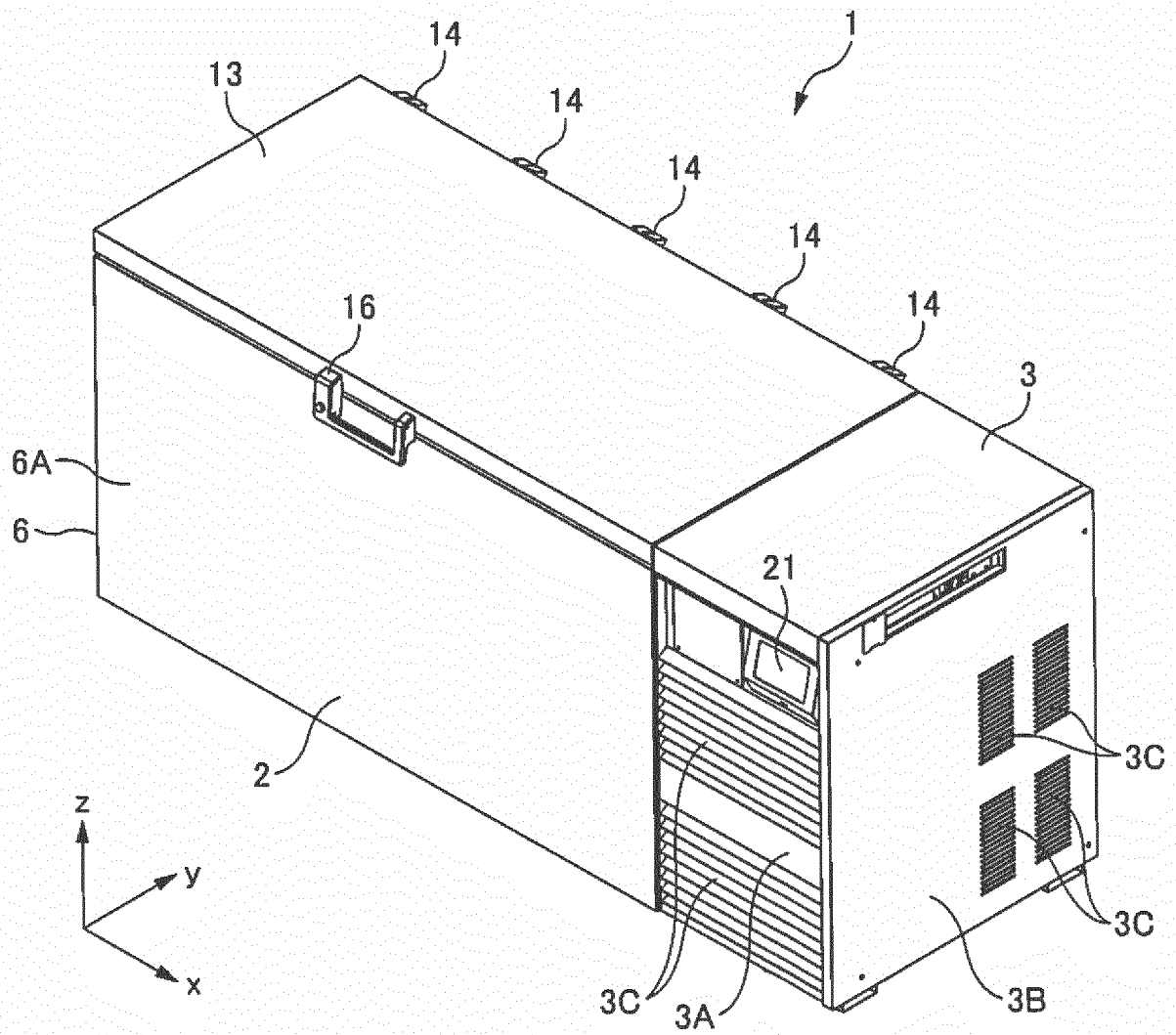


FIG. 1

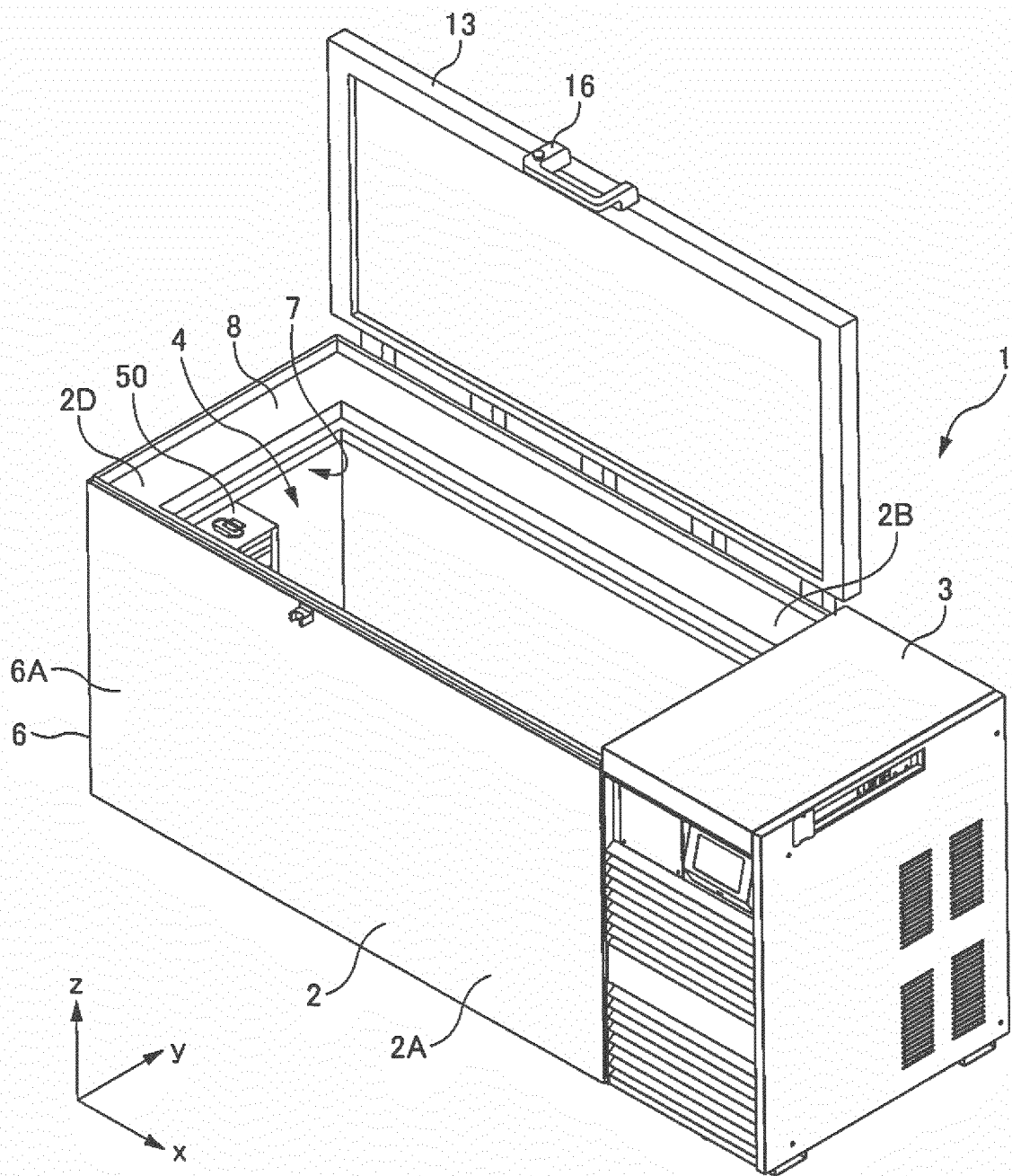


FIG. 2

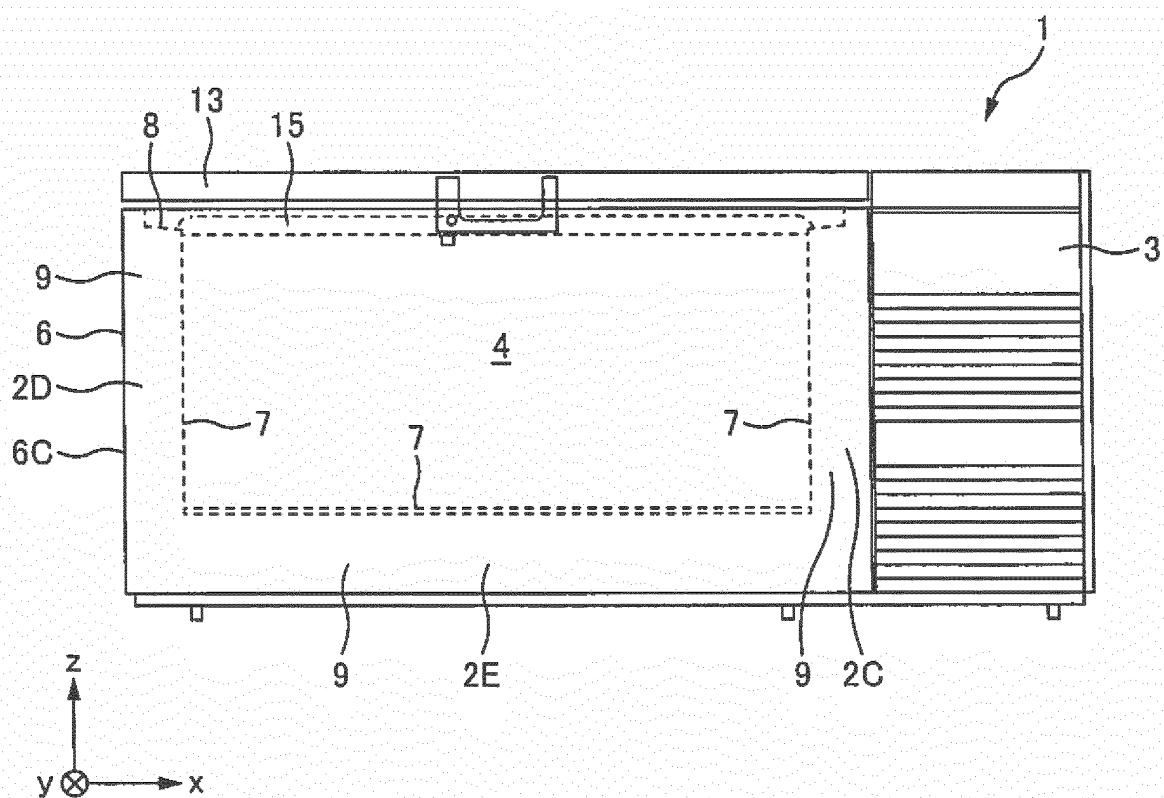


FIG. 3

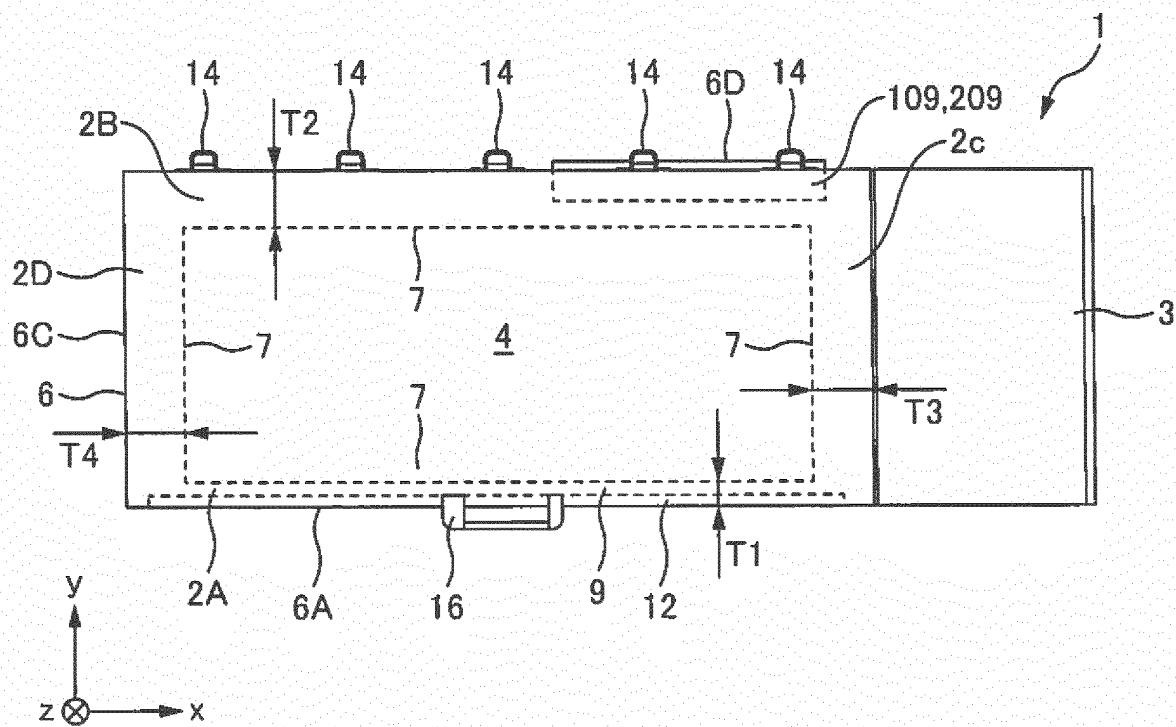


FIG. 4

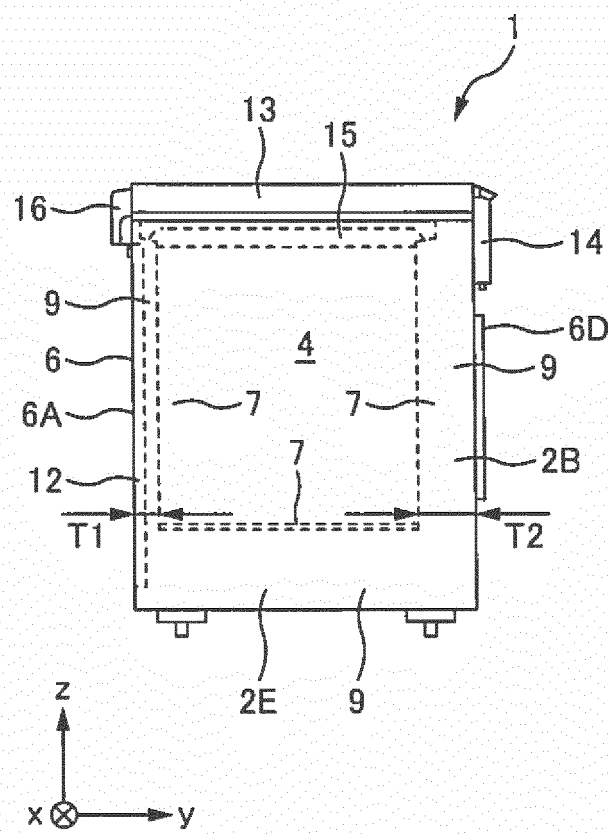


FIG. 5

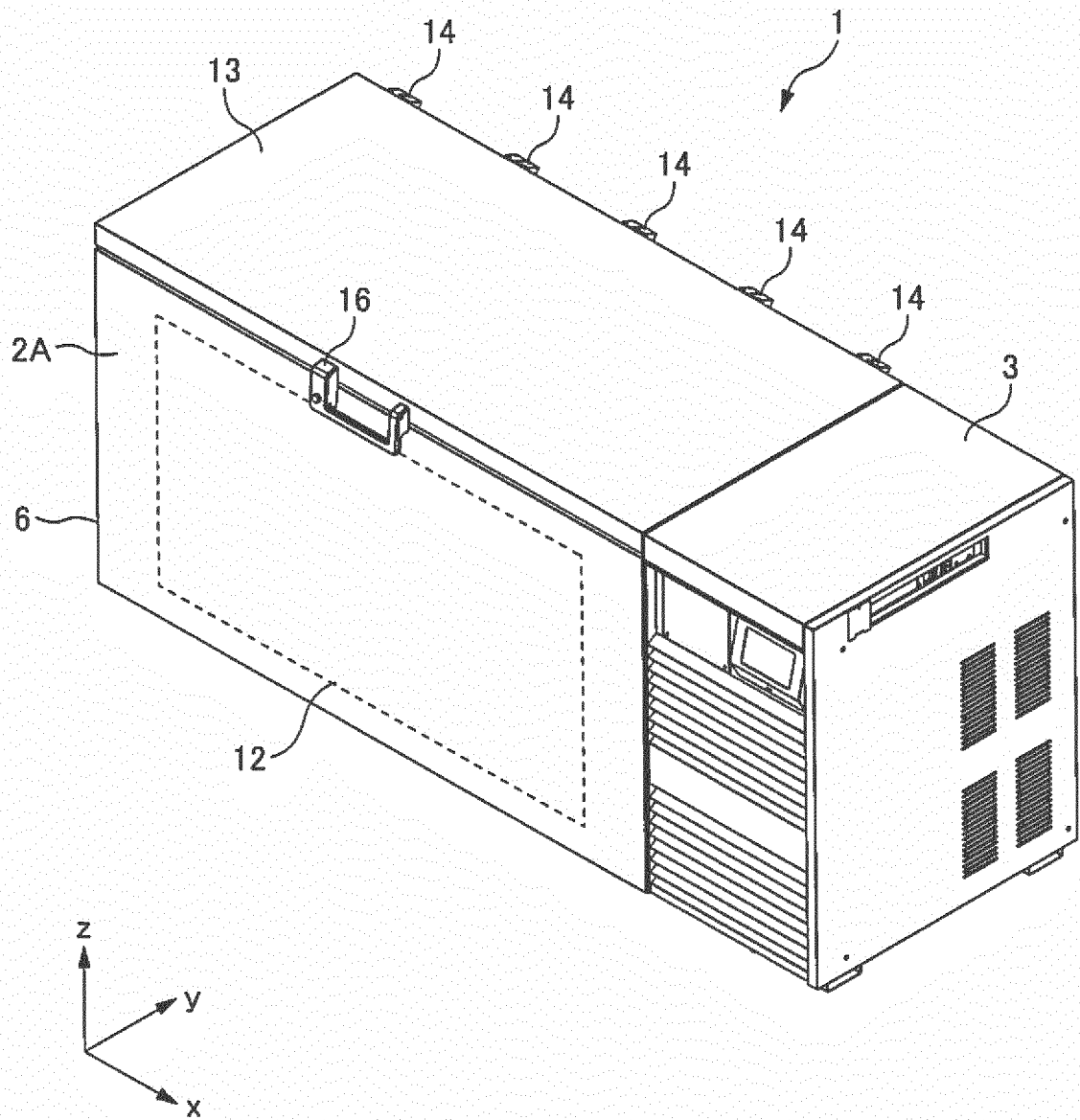


FIG. 6

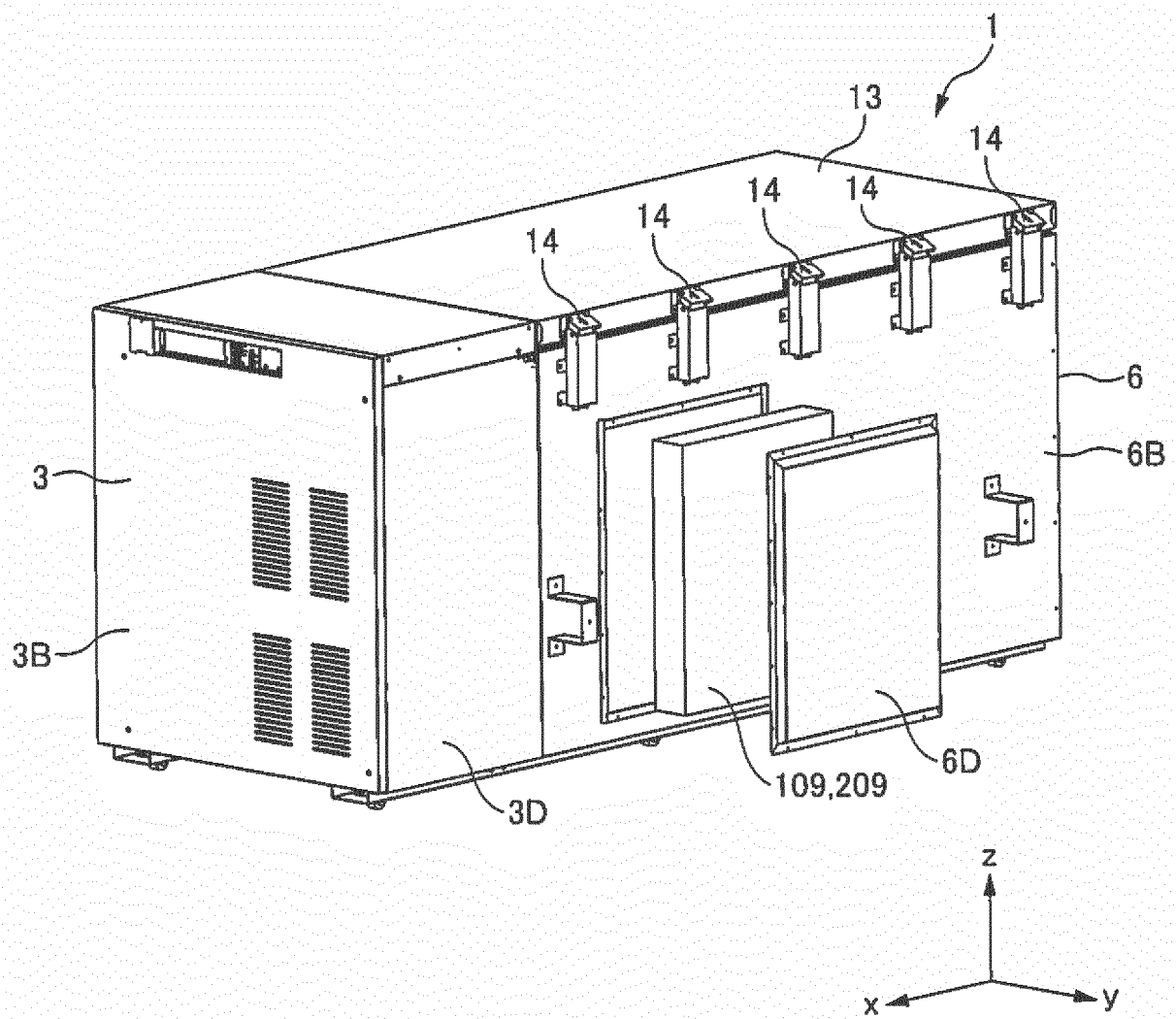


FIG. 7

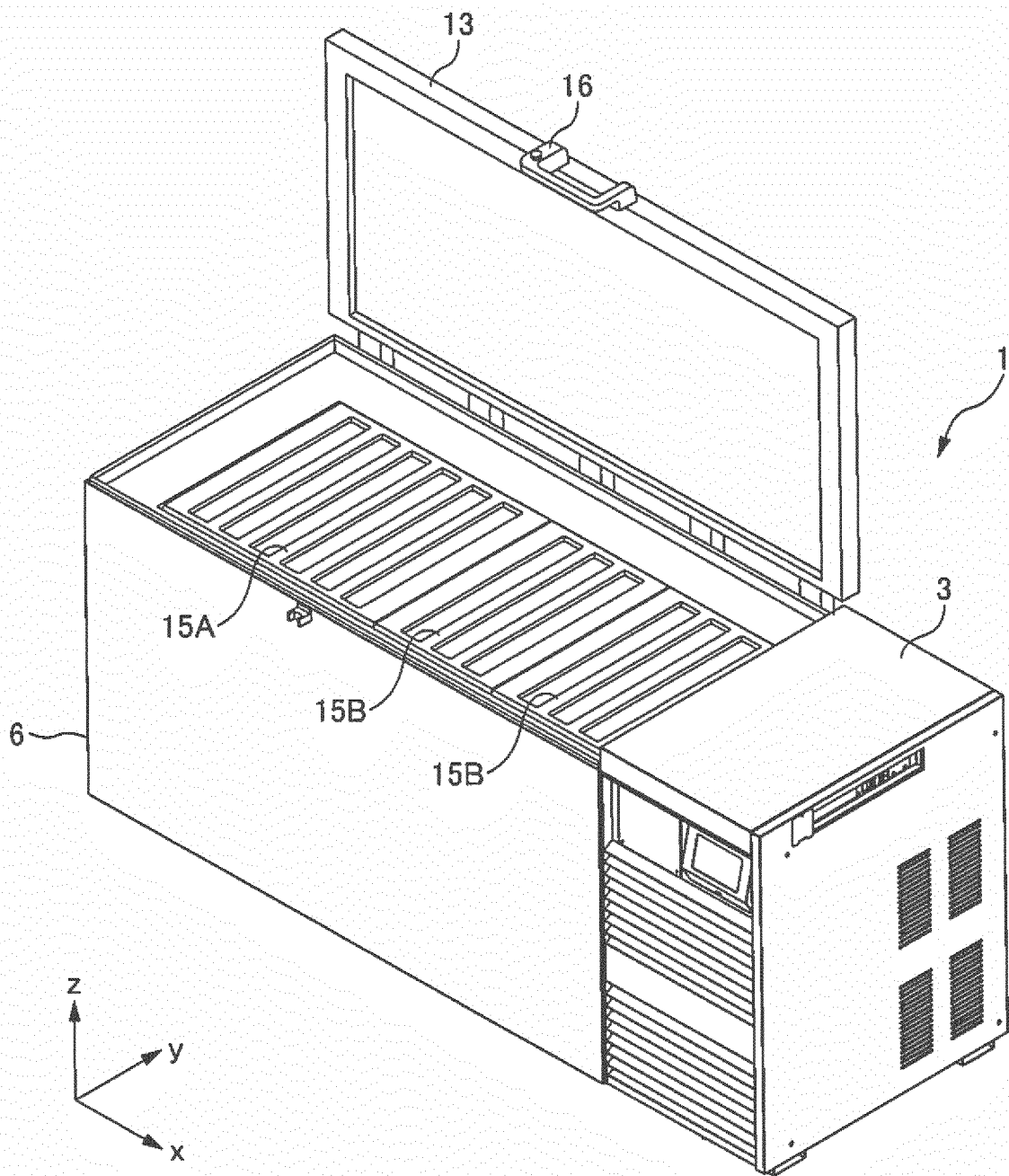


FIG. 8

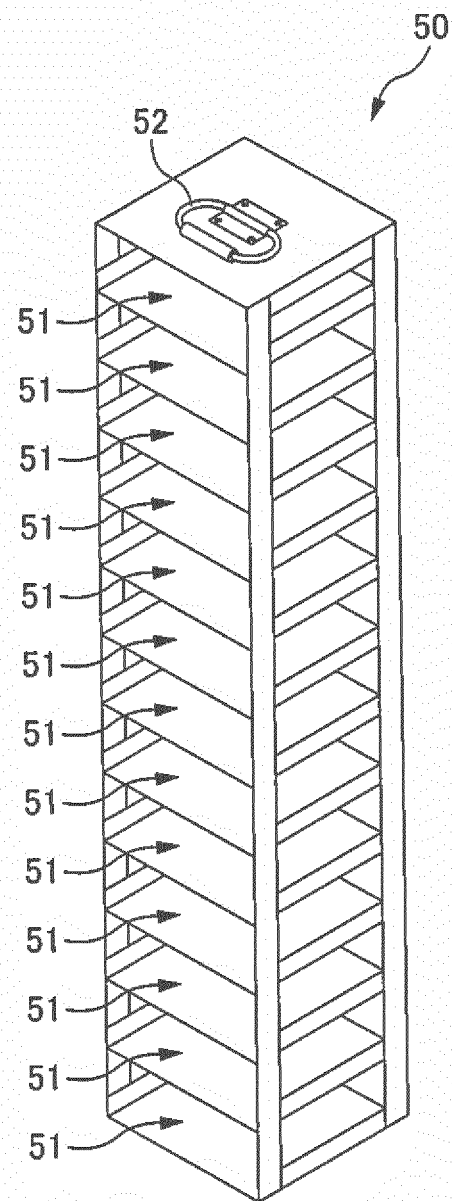


FIG. 9

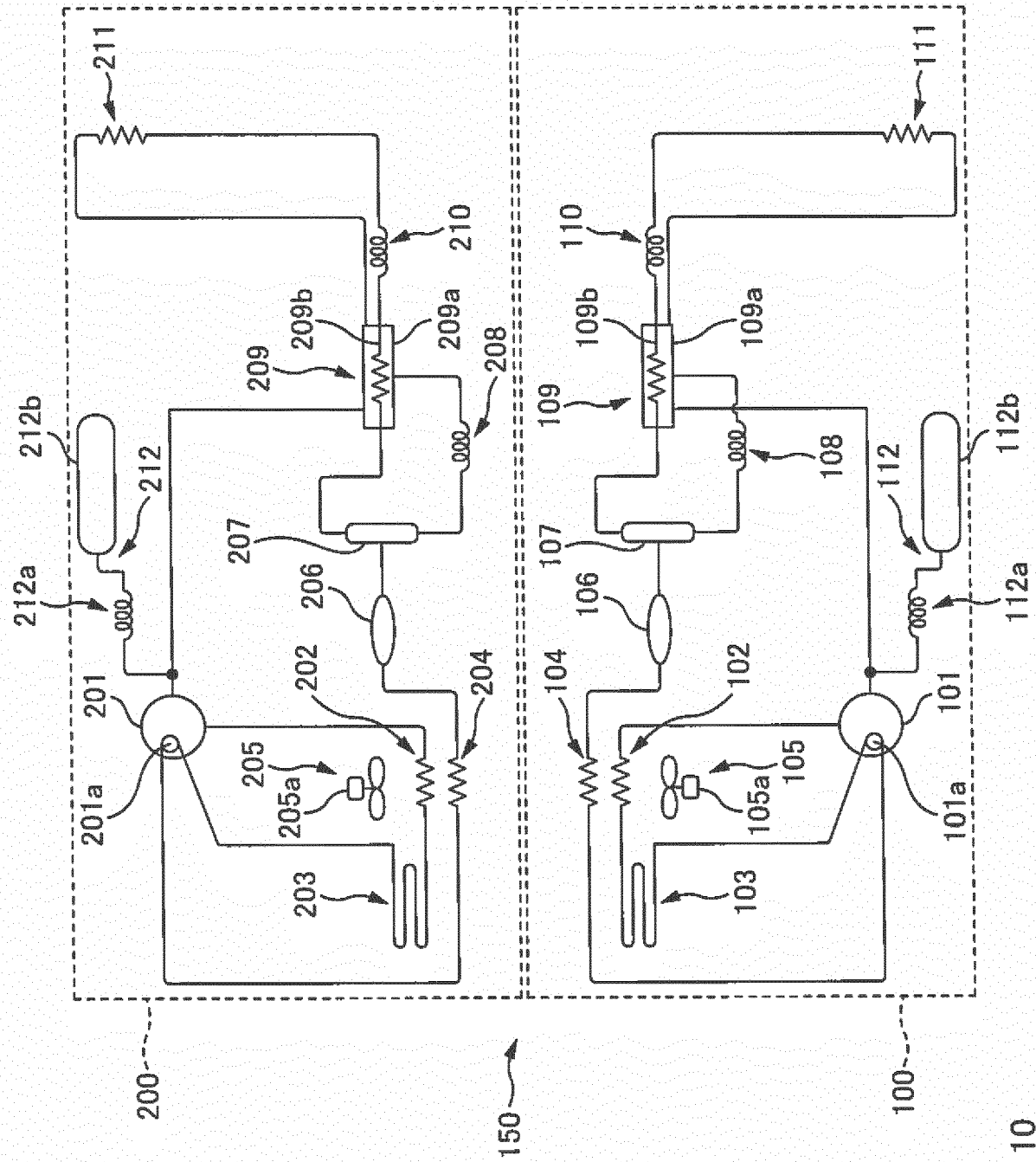


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/072588

A. CLASSIFICATION OF SUBJECT MATTER

F25D23/02(2006.01)i, F25D23/06(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25D19/00-19/04, F25D23/02-23/08

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2016
Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 57593/1981(Laid-open No. 169978/1982) (Sanyo Electric Co., Ltd.), 26 October 1982 (26.10.1982), entire text; all drawings (Family: none)	1-5
A	JP 2002-333255 A (Sanyo Electric Co., Ltd.), 22 November 2002 (22.11.2002), entire text; all drawings (Family: none)	1-5

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

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"&" document member of the same patent family

Date of the actual completion of the international search
30 September 2016 (30.09.16)

Date of mailing of the international search report
11 October 2016 (11.10.16)

Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/072588

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 1-44993 B2 (Sanyo Electric Co., Ltd.), 02 October 1989 (02.10.1989), entire text; all drawings (Family: none)	1-5
A	JP 5026736 B2 (Panasonic Healthcare Co., Ltd.), 19 September 2012 (19.09.2012), entire text; all drawings & US 2009/0113917 A1 & WO 2007/132804 A1 & EP 2019270 A1 & KR 10-2009-0008341 A & CN 101443603 A	1-5
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 145781/1988 (Laid-open No. 67855/1990) (ShinMaywa Industries, Ltd.), 23 May 1990 (23.05.1990), entire text; all drawings (Family: none)	1-5

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 5026736 B [0004]