

DESCRIPTION

Title of Invention

VACUUM THERMAL INSULATOR AND REFRIGERATOR

Technical Field

5 [0001]

The present invention relates to vacuum thermal insulators or the like, and in particular, relates to ear folding for a vacuum thermal insulator to be included in a refrigerator.

Background Art

10 [0002]

Home appliances are strongly required to achieve energy saving. For refrigerators, for example, a space defined between an outer case and an inner case of a refrigerator is filled with heat insulating foam, thereby preventing leakage of cold air from the refrigerator and entry of heat into the refrigerator. To further achieve energy saving in the refrigerators, there is an increasing demand for heat insulating materials having excellent thermal insulation performance.

15 [0003]

For example, a recently developed refrigerator has a structure in which a space defined between an outer case and an inner case of the refrigerator is filled with not only heat insulating foam but also a vacuum thermal insulator. This structure is made such that the space receiving the vacuum thermal insulator is filled with the heat insulating foam supplied through an injection port located in a rear surface of the refrigerator. The refrigerator can provide reliable thermal insulation. The vacuum thermal insulator is formed by inserting a core, serving as a spacer, into an enclosure having gas barrier properties, depressurizing the enclosure in, for example, a compression manner, and sealing the enclosure.

20 [0004]

In this case, for example, the core of the vacuum thermal insulator is shaped to fit in a space. A peripheral portion of the enclosure is subjected to, for example, welding, so that air does not enter the enclosure after the depressurization. The

welded peripheral portion is a projection (ear), in which the core is not disposed, that is, a redundant portion.

[0005]

If the ear of the vacuum thermal insulator, which is to be disposed in the space between the outer case and the inner case of the refrigerator, is left, for example, the ear may interfere with filling of the space with heat insulating foam and the amount of heat insulating foam may be increased. A recently developed refrigerator includes a vacuum thermal insulator such that an ear of the vacuum thermal insulator is folded and fixed (ear folding) and the vacuum thermal insulator is attached to the refrigerator (refer to Patent Literature 1, for example).

Citation List

Patent Literature

[0006]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2013-245909

Summary of Invention

Technical Problem

[0007]

After the attachment of the vacuum thermal insulator with the folded ear, for example, the space between the outer case and the inner case is filled with heat insulating foam. At this time, air in the space may be partially released, so that the air may remain in the space. The remaining air may accumulate in, for example, the folded ear of the vacuum thermal insulator because the air has no path to escape. If the refrigerator with the accumulated air is operated, the accumulated air may expand or contract and apply a force to wall surfaces of the inner and outer cases, causing deformation of inner and outer walls of the refrigerator. For example, in the related art in Patent Literature 1, processing, such as ear cutting, is performed but any measures against the air is not taken.

[0008]

The present invention has been made to overcome the above-described problems and aims to provide a vacuum thermal insulator capable of avoiding deformation caused by ear folding while contributing to a reduction in power consumption and a refrigerator including the vacuum thermal insulator.

5 Solution to Problem

[0009]

To overcome the above-described problems, an embodiment of the present invention provides a vacuum thermal insulator that includes: a core; and an enclosure containing the core and having a depressurized inside, the enclosure including inside
10 a main body portion in which the core is contained and a peripheral portion in which the core is not disposed, and the peripheral portion including a fixed portion that is folded over the main body portion and fixed to the main body portion and an unfixed portion that is not fixed to the main body portion.

[0010]

15 *An embodiment of the present invention provides a refrigerator including an outer case, an inner case, and the above-described vacuum thermal insulator. The vacuum thermal insulator having a surface with a folded ear is disposed in a space between the outer case and the inner case such that the surface with the folded ear faces the inner case.*

20 Advantageous Effects of Invention

[0011]

According to an embodiment of the present invention, a vacuum thermal insulator can be provided in which an unfixed portion, in which a peripheral portion is not fixed, formed by ear folding of the vacuum thermal insulator prevents air from
25 accumulating between the peripheral portion and a main body portion.

Consequently, for example, a refrigerator including the vacuum thermal insulator can be prevented from being deformed due to, for example, the expansion of air.

Brief Description of Drawings

[0012]

[Fig. 1] Fig. 1 is a front perspective view of a refrigerator 100 according to Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 is a diagram explaining an internal configuration of the refrigerator 100 according to Embodiment 1 of the present invention.

5 [Fig. 3] Fig. 3 is a diagram illustrating the configuration of a refrigerator box 1a in Embodiment 1 of the present invention.

[Fig. 4] Fig. 4 is a first diagram illustrating an exemplary relationship between a radiating pipe 16 and a vacuum thermal insulator 41 in Embodiment 1 of the present invention.

10 [Fig. 5] Fig. 5 is a second diagram illustrating the exemplary relationship between the radiating pipe 16 and the vacuum thermal insulator 41 in Embodiment 1 of the present invention.

[Fig. 6] Fig. 6 includes diagrams explaining a process of making the vacuum thermal insulator 41 in Embodiment 1 of the present invention in chronological order.

15 [Fig. 7] Fig. 7 is a diagram explaining an ear 46 in Embodiment 1 of the present invention.

[Fig. 8] Fig. 8 is a first diagram explaining ear folding in Embodiment 1 of the present invention.

20 [Fig. 9] Fig. 9 is a second diagram explaining ear folding in Embodiment 1 of the present invention.

[Fig. 10] Fig. 10 is a diagram explaining an unfixed portion 49 in Embodiment 1 of the present invention.

[Fig. 11] Fig. 11 is a diagram illustrating an inner case 30 in Embodiment 1 of the present invention.

25 [Fig. 12] Fig. 12 is a perspective view explaining a procedure of forming heat insulating foam 40 in the refrigerator 100 according to Embodiment 1 of the present invention.

[Fig. 13] Fig. 13 is a diagram illustrating fill paths for the heat insulating foam 40 in each side of the refrigerator 100 according to Embodiment 1 of the present invention.

[Fig. 14] Fig. 14 is a diagram illustrating a positional relationship between the vacuum thermal insulator 41 adjacent to a rear surface and injection ports 23 in Embodiment 1 of the present invention.

[Fig. 15] Fig. 15 is a diagram illustrating exemplary arrangement of the injection ports 23 in a rear plate 22 in Embodiment 2 of the present invention.

[Fig. 16] Fig. 16 is a diagram illustrating a positional relationship between the vacuum thermal insulator 41 adjacent to the rear surface and the injection ports 23 in Embodiment 2 of the present invention.

[Fig. 17] Fig. 17 is a diagram illustrating another arrangement of the injection ports 23 in the rear plate 22 in Embodiment 2 of the present invention.

[Fig. 18] Fig. 18 is a first diagram illustrating an exemplary shape of a recess 42 in Embodiment 3 of the present invention.

[Fig. 19] Fig. 19 is a second diagram illustrating another exemplary shape of the recess 42 in Embodiment 3 of the present invention.

Description of Embodiments [0013]

Vacuum heat insulators and other components in Embodiments of the present invention will be described with reference to the drawings. Note that components designated by the same reference signs in the drawings are the same components or equivalents. This note applies to Embodiments described below. Furthermore, note that the forms of components described in the specification are intended to be illustrative only and are not intended to be limited to those described in the specification. In particular, combination patterns of the components are not intended to be limited to those in Embodiments. A component in one Embodiment can be used in another Embodiment. As used herein, the term "upward" or "upper" refers to the upward direction or upper part or level in the drawings and the term "downward" or "lower" refers to the downward direction or lower part or level in the drawings. For the sake of easy understanding, the terms representing directions, such as "right", "left", "front", and "rear" will be appropriately used. These terms are used herein only for the purpose of convenience of description, and should not be construed as

limiting the present invention of this application. The term "height direction" as used herein refers to a vertical direction of a refrigerator as viewed from the front and the term "width direction" as used herein refers to a lateral direction of the refrigerator as viewed from the front. Furthermore, note that the size relationship between the components in the drawings may differ from the actual one.

[0014]

Embodiment 1

Fig. 1 is a front perspective view of a refrigerator 100 according to Embodiment 1 of the present invention. Fig. 2 is a diagram explaining an internal configuration of the refrigerator 100 according to Embodiment 1 of the present invention. The refrigerator 100 illustrated in Figs. 1 and 2 receives items to be stored, such as food, and keeps the items cold (at 10 degrees C or lower) or freezes the items (at -12 degrees C or lower). The refrigerator 100 includes a refrigerator main body 1 and a plurality of doors.

[0015]

The refrigerator main body 1 has a plurality of spaces, serving as storage compartments (rooms). The refrigerator 100 in Embodiment 1 has, as storage compartments, a refrigerator compartment 2, freezer compartments (an ice compartment 3, a first freezer compartment 4, and a second freezer compartment 5), and a vegetable compartment 6 arranged in that order from the top. Each storage compartment has a front opening and the opening is enclosed with an openable door. Refrigerator compartment doors 7 and 8 are two laterally arranged doors that constitute a double door, and enclose the refrigerator compartment 2. An ice compartment door 9, a first freezer compartment door 10, and a second freezer compartment door 11 are drawer doors that enclose the ice compartment 3, the first freezer compartment 4, and the second freezer compartment 5, respectively. A vegetable compartment door 12 is a drawer door that encloses the vegetable compartment 6. Each drawer door can be pulled out together with a receiving case that receives the stored items.

[0016]

The refrigerator 100 according to Embodiment 1 includes a refrigerant circuit (refrigeration cycle apparatus) to cool spaces inside the storage compartments. The refrigerant circuit includes a cooler 14, a compressor 15, a condenser, and a capillary tube, which are connected by pipes. Fig. 2 illustrates the cooler 14 and the compressor 15. The compressor 15 sucks refrigerant, compresses the refrigerant into a high temperature, high pressure state, and discharges the refrigerant. The condenser allows the refrigerant to dissipate heat such that the refrigerant condenses and liquefies. In Embodiment 1, a radiating pipe 16, which will be described later, functions as a condenser. The capillary tube (capillary), serving as an expansion device, reduces the pressure of the refrigerant passing through the capillary tube to expand the refrigerant. The cooler 14 allows the refrigerant to exchange heat with air such that the refrigerant evaporates and gasifies. The air cooled by the cooler 14 is delivered to the storage compartments by a fan (not illustrated). The volume of cold air (or the volume of air) delivered to each storage compartment is regulated by a motor-driven opening-closing damper (not illustrated) disposed in an air passage between the cooler 14 and the storage compartment.

[0017]

For the refrigerant circulated in the refrigeration cycle apparatus, isobutane (R600a) is used in Embodiment 1. Although any other refrigerant may be used, isobutane has advantages in that, for example, it does not destroy the ozone layer when wasted and has low global warming potential.

[0018]

As illustrated in Fig. 1, a control board 13, serving as a controller, controls a temperature in each of the storage compartments and a rotation speed of the compressor 15 in the refrigerator 100, for example. The control board 13 is disposed in upper rear part of the refrigerator main body 1.

[0019]

Fig. 3 is a diagram explaining the configuration of a refrigerator box 1a in Embodiment 1 of the present invention. The refrigerator box 1a includes an outer case 20, serving as a shell of the refrigerator main body 1, and an inner case 30 that

separates and defines the storage compartments. The outer case 20 includes, at least, side plates 21 and a rear plate 22. Each of the side plates 21 and the rear plate 22 is made of a steel plate having a thickness of approximately 0.4 to approximately 0.5 mm.

5 [0020]

The outer case 20 includes R-shaped bends 21a (inner-case catches) 21a, at which the inner case 30 is fastened to the outer case 20, such that each R-shaped bend 21a is disposed at a front opening of the refrigerator box 1a. Each R-shaped bend 21a of the outer case 20 and a fastener 31a of the inner case 30 elastically
10 deform and the R-shaped bend 21a pinches the fastener 31a, so that the inner case 30 is fastened to the outer case 20.

[0021]

The refrigerator box 1a of the refrigerator 100 according to Embodiment 1 includes heat insulating foam 40 and vacuum thermal insulators 41 arranged between
15 the outer case 20 and the inner case 30 to insulate the inside of the refrigerator 100 against heat.

[0022]

The vacuum thermal insulators 41 are fixed to inner surfaces of the side plates 21 and the rear plate 22 of the refrigerator. A space between the outer case 20 and
20 the inner case 30 is filled with the heat insulating foam 40. Fixing the vacuum thermal insulators 41 to the side plates 21 and the rear plate 22 prevents the heat insulating foam 40 from entering between the vacuum thermal insulators 41, the side plates 21, and the rear plate 22. Consequently, the vacuum thermal insulators 41 can produce a thermal insulation effect. Filling of the space with the heat insulating
25 foam 40 will be described later.

[0023]

Figs. 4 and 5 are diagrams illustrating an exemplary relationship between the radiating pipe 16 and the vacuum thermal insulator 41 in Embodiment 1 of the present invention. As described above, the vacuum thermal insulators 41 in
30 Embodiment 1 are fixed to the inner surfaces of at least the side plates 21 and the

rear plate 22. For the vacuum thermal insulators 41 to be fixed to the side plates 21, each vacuum thermal insulator 41 encloses the radiating pipe 16, serving as a condenser, and the vacuum thermal insulator 41 and the radiating pipe 16 are fixed together to the side plate 21.

5 [0024]

As described above, the radiating pipe 16 functions as a condenser and allows the refrigerant to dissipate heat to the outside of the refrigerator 100 through the side plate 21. In Embodiment 1, the radiating pipe 16 is a copper pipe having a diameter of approximately 4.0 to approximately 5.0 mm. The radiating pipe 16 to be fixed to each side plate 21 is formed by repeatedly bending one copper pipe such that long portions of the bent pipe extend in the vertical direction. This form provides a long refrigerant passage within a limited range. In this case, two adjacent copper pipe portions arranged by bending are spaced from each other on centers by a distance or dimension W1. The shape, material, and dimensions of the radiating pipe 16 are not limited to those illustrated in Figs. 4 and 5.

15 [0025]

The vacuum thermal insulator 41 blocks external heat to prevent the heat from entering the refrigerator 100. In addition, the vacuum thermal insulator 41 enclosing the radiating pipe 16 insulates the refrigerator 100 against heat radiated from the refrigerant. The vacuum thermal insulator 41 has recesses 42 for enclosing the radiating pipe 16. As described above, the distance between two adjacent copper pipe portions arranged by bending the copper pipe is the dimension W1. Therefore, the distance between two adjacent recesses 42 is also represented by the dimension W1. Each recess 42 has a depth (height) represented by a dimension D1. The dimension D1 is set greater than or equal to the diameter of the radiating pipe 16 so that the following appearance defect is not caused. For example, if the vacuum thermal insulator 41 contacts and presses the radiating pipe 16 against, for example, the side plate 21 during filling of the space with the heat insulating foam 40, an appearance defect would occur. In Embodiment 1, the recesses 42 have a width, represented by a dimension L1, ranging from 40 to 70 mm.

The dimension L1 of the width of the recesses 42 is based on an assembly tolerance that may occur during manufacture of refrigerators. Examples of the assembly tolerance include a production error in forming the recesses 42, an attachment error in attaching the vacuum thermal insulator 41 to the side plate 21, a bend in the radiating pipe 16 in the side plate 21, and an attachment error in attaching the radiating pipe 16 to the side plate 21. The dimension L1 of the width of the recesses 42 is set so that the recesses 42 can receive the radiating pipe 16 if such an error occurs.

[0026]

<Configuration of Vacuum Heat Insulator 41>

The vacuum thermal insulator 41 includes an enclosure 43 and a core 44. The enclosure 43 encloses and protects the core 44. Furthermore, the enclosure 43 keeps its inside in a vacuum state. Examples of materials for the enclosure 43 include a metallized laminate film including a plastic layer for welding. The core 44 is a stack of sheets 45. In Embodiment 1, the core 44 is formed by stacking the sheets 45 in three layers, as will be described later. Typical examples of materials for the sheets 45 include glass wool, glass fiber, alumina fiber, silica alumina fiber, and natural fiber, such as cotton.

[0027]

Fig. 6 includes diagrams explaining a process of making the vacuum thermal insulator 41 in Embodiment 1 of the present invention in chronological order. The procedure of making the vacuum thermal insulator 41 will now be described with reference to Fig. 6. Although the thickness of each of the sheets 45 and the core 44 actually changes during the process, the illustrated thickness is not changed in Fig. 6. Fig. 6 illustrates an example. For example, the number of sheets 45, such as first sheets 45a, 45b, and 45c arranged on a second sheet 45d, is not limited to that in this example.

[0028]

First, inorganic fiber of raw cotton, serving as a material for the core 44, is dried. The dried inorganic fiber is cut into pieces having predetermined dimensions,

thus forming the first sheets 45a, 45b, and 45c, the second sheet 45d, and a third sheet 45e. As illustrated in Fig. 6(a), the first sheets 45a, 45b, and 45c, the second sheet 45d, and the third sheet 45e are stacked in three layers, thus forming the core 44. In this case, the second sheet 45d is disposed on top of the third sheet 45e.

5 The first sheets 45a, 45b, and 45c are arranged on top of the second sheet 45d. Adjusting the arrangement of the first sheets 45a, 45b, and 45c adjusts the dimension L1 of the width of each recess 42. Furthermore, the thickness of the first sheets 45a, 45b, and 45c is adjusted so that the first sheets 45a, 45b, and 45c have a thickness of 5 mm after the depressurization. As illustrated in Fig. 6(b), the core 44 is
10 enclosureed with the enclosure 43. In this example, the enclosure 43 is bag-shaped. A peripheral portion of the enclosure 43 has an opening for insertion of the core 44. The peripheral portion other than the opening is an ear 46 formed by welding. The ear 46 having a width of 20 to 50 mm extends from, for example, edges of the vacuum thermal insulator 41.

15 [0029]

The core 44 enclosureed with the enclosure 43 is placed in a vacuum chamber (not illustrated). While the core 44 is being pressed by a pressing machine 50, air in the enclosure 43 is released through the opening, which is not welded, of the enclosure 43, thus compressing the core 44 to a predetermined thickness. When
20 the inside of the enclosure 43 enters, for example, a vacuum state, a welding machine 60 welds the opening of the enclosure 43 to close the opening as illustrated in Fig. 6(c), so that the ear 46 is formed such that the ear 46, serving as the peripheral portion, extends around the vacuum thermal insulator 41.

[0030]

25 For example, the core 44 in Embodiment 1 has the recesses 42. If the enclosure 43 is sealed while the air in the recesses 42 remains unreleased, the core 44 would deform in the atmosphere and the recesses 42 would decrease in height. Furthermore, the deformation would cause the opposite surface of the core 44 from the surface having the recesses 42 to have irregularities. This would lead to a
30 reduction in thermal insulation performance. For this reason, the pressing machine

50 is allowed to have protrusions shaped to fit in the recesses 42 so that the air in the recesses 42 is released during pressing. As illustrated in Fig. 6(d), the vacuum thermal insulator 41 is made in the above-described manner.

[0031]

5 Fig. 7 is a diagram explaining the ear 46 in Embodiment 1 of the present invention. As described above, the vacuum thermal insulator 41 is shaped by, for example, welding the enclosure 43, thus providing the ear 46, which does not contain the core 44, extending around the vacuum thermal insulator 41 and a vacuum thermal insulator main body 47 that contains the core 44. The ear 46 is part that does not
10 contribute to thermal insulation. For example, if the vacuum thermal insulator 41 is fixed between the outer case 20 and the inner case 30 while the ear 46 remains extended, the vacuum thermal insulator main body 47, which is useful for thermal insulation, would decrease in area. In addition, the extended ear 46 would interfere with filling of the space with the heat insulating foam 40.

15 [0032]

Figs. 8 and 9 are diagrams each explaining ear folding in Embodiment 1 of the present invention. Fig. 8 is a diagram illustrating normal ear folding. Fig. 9 is a diagram illustrating ear folding for the core 44 including processed part 44a subjected to pressing. In Embodiment 1, folding of the ear 46 (ear folding) is performed to
20 prevent the ear 46 from extending. In this case, the ear 46 is folded over the surface opposite the surface having the recesses 42 (or the surface to face the inner case 30). Part, including an edge 46a, of the folded ear 46 is fixed to the vacuum thermal insulator main body 47 containing the core 44 by using tape 48. The part fixed with the tape 48 serves as a fixed part. Although the edge 46a is fixed with the tape 48 in
25 Embodiment 1, the edge 46a can be fixed by, for example, welding. The air tends to accumulate in the folded ear, in particular in the processed part 44a, as illustrated in Fig. 9.

[0033]

Fig. 10 is a diagram explaining an unfixed portion 49 in Embodiment 1 of the
30 present invention. In Embodiment 1, at least one unfixed portion 49, where the edge

46a of the ear 46 is not fixed with the tape 48, is formed upon ear folding. The unfixed portion 49 is an air escape portion where the interface between the ear 46 and the vacuum thermal insulator main body 47 formed by ear folding is not completely sealed with the tape 48. For the position of the unfixed portion 49, for example, the unfixed portion 49 is formed in the folded ear in the longitudinal direction of the vacuum thermal insulator 41. Furthermore, as will be described later, it is preferred to position the unfixed portion 49 in consideration of fill paths, through which the space between the outer case 20 and the inner case 30 is filled with the heat insulating foam 40. In Embodiment 1, the unfixed portion 49 is formed in middle part of the vacuum thermal insulator 41 in the longitudinal direction of the vacuum thermal insulator 41 such that the unfixed portion 49 is located adjacent to a front surface (or the doors) of the refrigerator 100.

[0034]

If the fixed portion where the edge 46a of the ear 46 is fixed with the tape 48 has a small area, the tape 48 would tend to unstick. Furthermore, a liquid raw material of polyurethane foam, which is a material for the heat insulating foam 40, would enter between the ear 46 and the vacuum thermal insulator main body 47 and the liquid raw material would fail to reach a place (space) to be filled with the heat insulating foam 40. Such a space would fail to be filled with the heat insulating foam 40. It is therefore basically preferred that the unfixed portion 49 have a small area.

[0035]

Fig. 11 is a diagram illustrating the inner case 30 in Embodiment 1 of the present invention. As illustrated in Fig. 11, the inner case 30 in Embodiment 1 has a spacer 34 protruding from an outer surface of the inner case 30. The position of the unfixed portion 49 in the above-described vacuum thermal insulator 41 corresponds to the position of the spacer 34. Since the ear 46 in the unfixed portion 49 is not fixed, the ear 46 in this part may separate from the vacuum thermal insulator 41. The separating ear 46 may block the space between the outer case 20 and the inner case 30 and interfere with filling of the space with the heat insulating foam 40. For this reason, the spacer 34 reduces or eliminates the expansion of the unfixed ear 46

in the unfixed portion 49 to leave the space between the outer case 20 and the inner case 30. With this configuration, filling of the space between the outer case 20 and the inner case 30 with the heat insulating foam 40 is not interfered.

[0036]

5 For the spacer 34, for example, a die for the inner case 30 may include a portion corresponding to the spacer 34. The spacer 34 can be formed as part of the inner case 30 by molding using the die. The spacer 34 can be formed of tape or polystyrene foam and be attached to the inner case 30.

[0037]

10 Fig. 12 is a perspective view explaining a procedure of forming the heat insulating foam 40 in the refrigerator 100 according to Embodiment 1 of the present invention. In Embodiment 1, the rear plate 22 of the refrigerator box 1a has injection ports 23 (23a to 23d) at four corners. The polyurethane foam liquid raw material, which is the material for the heat insulating foam 40, is injected through the injection
15 ports 23a to 23d.

[0038]

The vacuum thermal insulators 41 are previously temporarily fixed to an inner surface of the outer case 20 by, for example, welding or aluminum tape. As the polyurethane foam liquid raw material foams, the space is filled with the heat
20 insulating foam 40, so that the vacuum thermal insulators 41 are pressed against and fixed to the inner surface of the outer case 20 by the heat insulating foam 40.

[0039]

Fig. 13 is a diagram illustrating the fill paths for the heat insulating foam 40 in each side of the refrigerator 100 according to Embodiment 1 of the present invention.
25 A polyurethane foam injection head 70 is attached to each of the injection ports 23a to 23d to inject the polyurethane foam liquid raw material into the port. The injected polyurethane foam liquid raw material spreads over the space between the outer case 20 and the inner case 30 of the refrigerator box 1a to reach a front end of the refrigerator box 1a, and begins to foam.

30 [0040]

As illustrated in Fig. 13, in first paths in the side of the refrigerator 100, the polyurethane foam liquid raw material flows from a rear surface of the refrigerator 100 to the front surface thereof, flows to central part of the refrigerator 100 in the front surface, and then foams such that the space is filled with the heat insulating foam 40.

5 In second paths, the polyurethane foam liquid raw material flows to central part of the refrigerator 100 in the rear surface of the refrigerator 100, flows from the rear surface of the refrigerator 100 to the front surface thereof, and then foams such that the space is filled with the heat insulating foam 40.

[0041]

10 For example, if the unfixed portion 49 is filled with the heat insulating foam 40 before the air between the ear 46 and the vacuum thermal insulator main body 47 is released, the air would be trapped between the ear 46 and the vacuum thermal insulator main body 47. For this reason, it is preferred that the unfixed portion 49 be located in a position corresponding to the last portion (space) to be filled with the heat

15 insulating foam 40. In Embodiment 1, as described above, the unfixed portion 49 is formed in the middle part of the vacuum thermal insulator 41 in the longitudinal direction of the vacuum thermal insulator 41 such that the unfixed portion 49 is located adjacent to the front surface of the refrigerator 100. This location is the farthest position from the injection ports 23a and 23b. Forming the unfixed portion

20 49 allows the air between the ear 46 and the vacuum thermal insulator main body 47 to escape.

[0042]

Fig. 14 is a diagram illustrating a positional relationship between the vacuum thermal insulator 41 adjacent to the rear surface and the injection ports 23 in

25 Embodiment 1 of the present invention. As illustrated in Fig. 14, for example, two unfixed portions 49 of the ear 46 are formed in the vacuum thermal insulator 41 to be fixed adjacent to the rear surface on the basis of the fill paths for the heat insulating foam 40. In the vacuum thermal insulator 41 in Embodiment 1, the unfixed portions 49 of the vacuum insulator 41 are located so as to correspond to the midpoint

between the injection ports 23a and 23c and the midpoint between the injection ports 23b and 23d.

[0043]

As described above, since the unfixed portion 49, where the ear 46 is not fixed, is formed upon ear folding in Embodiment 1, the vacuum thermal insulator 41 can be provided which eliminates the possibility that the air may accumulate between the ear 46 and the vacuum thermal insulator main body 47. The refrigerator 100 can be accordingly provided which eliminates the possibility that the outer case 20 and the inner case 30 of the refrigerator 100 may be pressed and deformed due to the expansion or contraction of accumulated air caused by operation of the refrigerator 100. In addition, no accumulation of air results in a reduction in portion (space) that is not filled with the heat insulating foam 40. Thus, the refrigerator 100 having good thermal insulation performance can be provided.

[0044]

Furthermore, the arrangement of the injection ports 23a to 23d for injecting the polyurethane foam liquid raw material at the four corners of the rear plate 22 results in an increase in area of enclosure of the vacuum thermal insulators 41, thus improving the thermal insulation performance.

[0045]

Embodiment 2

Fig. 15 is a diagram illustrating exemplary arrangement of the injection ports 23 in the rear plate 22 in Embodiment 2 of the present invention. In the refrigerator 100 according to Embodiment 1, the injection ports 23a to 23d are arranged at the four corners of the rear plate 22. In Fig. 15, the injection ports 23a to 23d are arranged at two upper corners of the rear plate 22 and two positions in central part of the rear plate 22, that is, four positions in total.

[0046]

Fig. 16 is a diagram illustrating a positional relationship between the vacuum thermal insulator 41 adjacent to the rear surface and the injection ports 23 in Embodiment 2 of the present invention. Referring to Fig. 16, the unfixed portions 49

of the vacuum thermal insulator 41 are located so as to correspond to the midpoint between the injection ports 23a and 23c and the midpoint between the injection ports 23b and 23d.

[0047]

5 Fig. 17 is a diagram illustrating another exemplary arrangement of the injection ports 23 in the rear plate 22 in Embodiment 2 of the present invention. In Fig. 17, the injection ports 23a and 23b are arranged at two positions in the central part of the rear plate 22.

[0048]

10 As described above, according to Embodiment 2, since the unfixed portions 49 of the vacuum thermal insulator 41 are located in relation to the positions of the injection ports 23 in Embodiment 2, the air can be prevented from accumulating between the ear 46 and the vacuum thermal insulator main body 47.

[0049]

15 *Embodiment 3*

 Figs. 18 and 19 are diagrams each illustrating an exemplary shape of the recess 42 in Embodiment 3 of the present invention. In Embodiment 1, the recess 42 has a rectangular cross-sectional shape. The recess 42 may have any other cross-sectional shape. For example, the recess 42 can have a triangular cross-sectional shape as illustrated in Fig. 18. Furthermore, the recess 42 can have a semi-oval cross-sectional shape as illustrated in Fig. 19.

Reference Signs List

[0050]

1 refrigerator main body 1a refrigerator box 2 refrigerator compartment
25 3 ice compartment 4 first freezer compartment 5 second freezer compartment
6 vegetable compartment 7, 8 refrigerator compartment door 9 ice
compartment door 10 first freezer compartment door 11 second freezer
compartment door 12 vegetable compartment door 13 control board 14
cooler 15 compressor 16 radiating pipe 20 outer case 21 side plate
30 21a R-shaped bend 22 rear plate 23, 23a, 23b, 23c, 23d injection port 30

inner case 31a fastener 34 spacer 40 heat insulating foam 41 vacuum
thermal insulator 42 recess 43 enclosure 44 core 44a processed part
45 sheet 45a, 45b, 45c first sheet 45d second sheet 45e third sheet 46
ear 46a edge 47 vacuum thermal insulator main body 48 tape 49 unfixed
5 portion 50 pressing machine 60 welding machine 70 polyurethane foam
injection head 100 refrigerator

CLAIMS

[Claim 1]

A vacuum thermal insulator comprising:

a core; and

5 an enclosure containing the core and having a depressurized inside,
the enclosure including inside a main body portion in which the core is
contained and a peripheral portion in which the core is not disposed, and

the peripheral portion including

10 a fixed portion that is folded over the main body portion and fixed to the
main body portion and

an unfixed portion that is not fixed to the main body portion.

[Claim 2]

The vacuum thermal insulator of claim 1, wherein the fixed portion and the
unfixed portion include an edge of the peripheral portion.

[Claim 3]

A refrigerator comprising:

an outer case;

an inner case; and

the vacuum thermal insulator of claim 1 or 2,

20 wherein the vacuum thermal insulator has a surface with the folded peripheral
portion and is disposed in a space between the outer case and the inner case such
that the surface with the folded peripheral portion faces the inner case.

[Claim 4]

25 The refrigerator of claim 3, wherein the inner case includes a spacer configured
to hold the unfixed portion of the peripheral portion.

[Claim 5]

The refrigerator of claim 3 or 4, wherein the outer case has injection ports for
injecting a foam thermal insulation material filled between the outer case and the
inner case at two or more positions.

[Claim 6]

The refrigerator of claim 5, wherein
two injection ports of the injection ports are arranged at two positions in a
height direction of the refrigerator, and
the vacuum thermal insulator has the unfixed portion located at a position
5 substantially in a midpoint between the two injection ports.

[Claim 7]

The refrigerator of claim 5, wherein
the injection ports are arranged at two positions in a width direction of the
refrigerator, and
10 the vacuum thermal insulator has the unfixed portion located at a position
substantially in a midpoint between the two injection ports.