US012392545B2

(12) United States Patent
Jung et al.

(10) Patent No.: US 12,392,545 B2
(45) Date of Patent: Aug. 19, 2025

(54) **VACUUM ADIABATIC BODY AND REFRIGERATOR**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **17/411,659**

(22) Filed: **Aug. 25, 2021**

(65) **Prior Publication Data**

US 2021/0404737 A1 Dec. 30, 2021

Related U.S. Application Data

(63) Continuation of application No. 15/749,132, filed as application No. PCT/KR2016/008519 on Aug. 2, 2016, now Pat. No. 11,137,201.

(30) **Foreign Application Priority Data**

Aug. 3, 2015 (KR) 10-2015-0109724

(51) **Int. Cl.**
F25D 23/08 (2006.01)
F16L 59/065 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***F25D 23/087*** (2013.01); ***F16L 59/065*** (2013.01); ***F25D 19/006*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC F25D 23/087; F25D 19/006; F25D 23/028; F25D 23/062; F25D 23/085; F25D 2201/14; F25D 2323/024; F16L 59/065
See application file for complete search history.

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(57) **ABSTRACT**

A vacuum adiabatic body includes: a first plate member defining at least one portion of a wall for a first space; a second plate member defining at least one portion of a wall for a second space having a different temperature from the first space; a sealing part sealing the first plate member and the second plate member to provide a third space that has a temperature between the temperature of the first space and the temperature of the second space and is in a vacuum state; a supporting unit maintaining the third space; a heat resistance unit for decreasing a heat transfer amount between the first plate member and the second plate member; an exhaust port through which a gas in the third space is exhausted; a side frame provided at an edge portion of the third space, the side frame having at least one portion defining a wall for the
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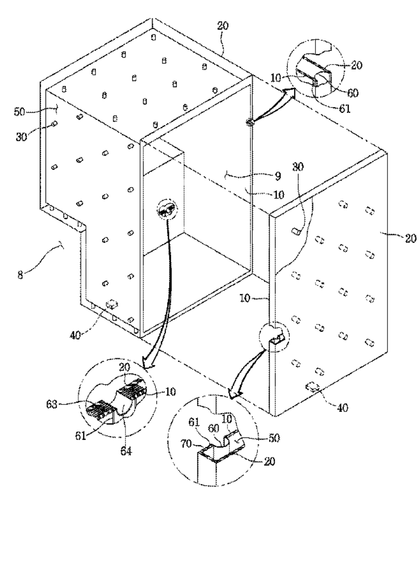

third space; and a peripheral frame fixed to the side frame to have a part mounted thereto. Accordingly, each part of the vacuum adiabatic body can be mounted without any interference, and an adiabatic effect can be improved.

19 Claims, 12 Drawing Sheets

(51) **Int. Cl.**
F25D 19/00 (2006.01)
F25D 23/02 (2006.01)
F25D 23/06 (2006.01)

(52) **U.S. Cl.**
CPC ***F25D 23/028*** (2013.01); ***F25D 23/062*** (2013.01); ***F25D 23/085*** (2013.01); *F25D 2201/14* (2013.01); *F25D 2323/024* (2013.01)

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United States Office Action dated Jan. 18, 2023 issued in co-pending related U.S. Appl. No. 16/942,213.
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U.S. Appl. No. 17/980,088, filed Nov. 3, 2022.
U.S. Appl. No. 17/072,231, filed Oct. 16, 2020.
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U.S. Notice of Allowance dated Mar. 23, 2023 issued in U.S. Appl. No. 16/953,846.
U.S. Appl. No. 16/942,213, filed Jul. 29, 2020.
U.S. Appl. No. 18/095,658, filed May 20, 2022.
U.S. Appl. No. 17/030,806, filed Sep. 24, 2020.
U.S. Appl. No. 16/710,720, filed Dec. 11, 2019.
U.S. Appl. No. 16/953,846, filed Nov. 20, 2020.
U.S. Appl. No. 17/155,430, filed Jan. 22, 2021.
Korean Office Action dated Jul. 31, 2023 issued in Application 10-2023-0020717.
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Chinese Office Action dated Aug. 30, 2023 issued in Application No. 202110718284.8.
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Korean Office Action dated Apr. 4, 2024 issued in Application No. 10-2023-0036738.
U.S. Office Action dated Nov. 18, 2024 issued in U.S. Appl. No. 18/095,658.
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Chinese Office Action dated Jun. 14, 2024 issued in Application No. 202010974212.5.
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U.S. Appl. No. 18/640,367, filed Apr. 19, 2024.
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U.S. Appl. No. 17/749,679, filed May 20, 2022.
U.S. Appl. No. 17/582,596, filed Jan. 24, 2022.
U.S. Appl. No. 18/508,279, filed Nov. 14, 2023.
U.S. Appl. No. 18/095,658, filed Jan. 11, 2023.
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U.S. Appl. No. 18/915,472, filed Oct. 15, 2024.
U.S. Appl. No. 18/416,453, filed Jan. 18, 2024.
U.S. Appl. No. 18/091,040, filed Dec. 29, 2022.
United States Office Action dated Dec. 22, 2022 issued in co-pending related U.S. Appl. No. 16/953,846.
Korean Office Action dated Oct. 22, 2024 issued in Application No. 10-2024-0110720.

* cited by examiner

FIG. 1

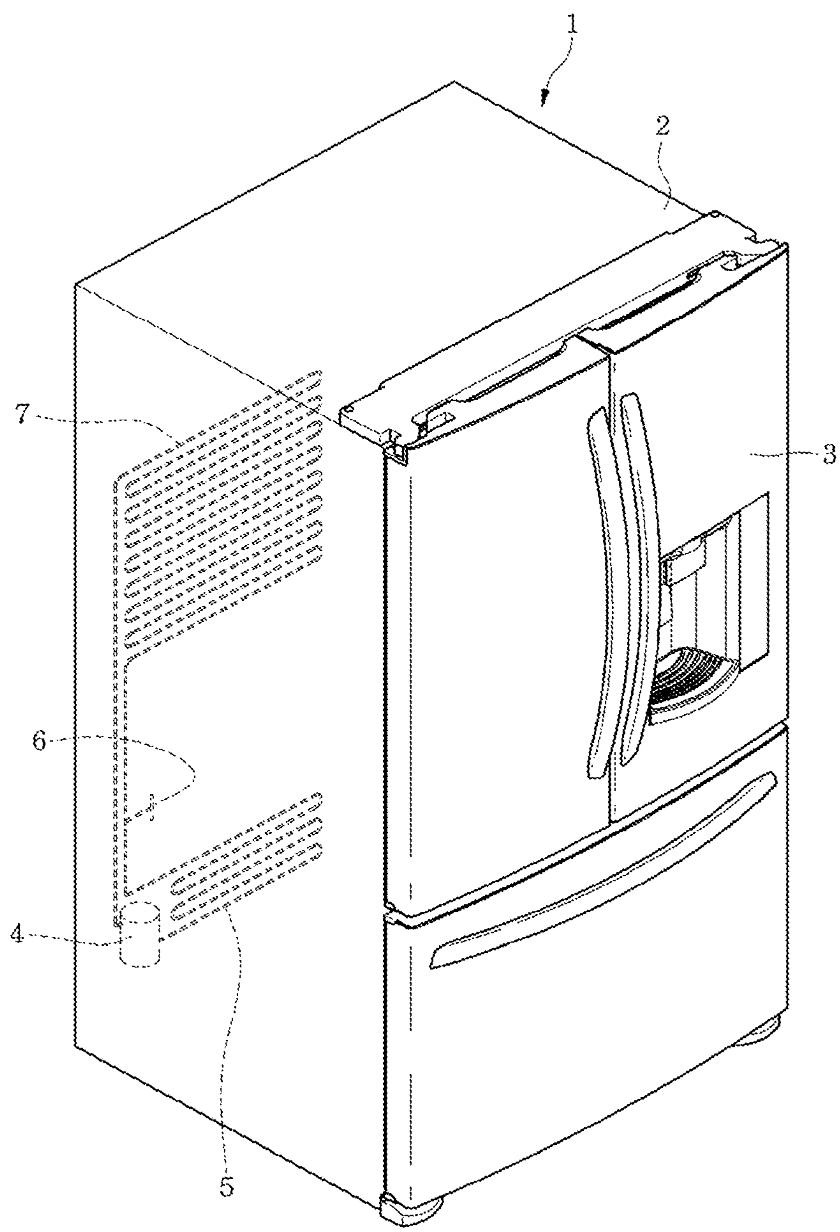
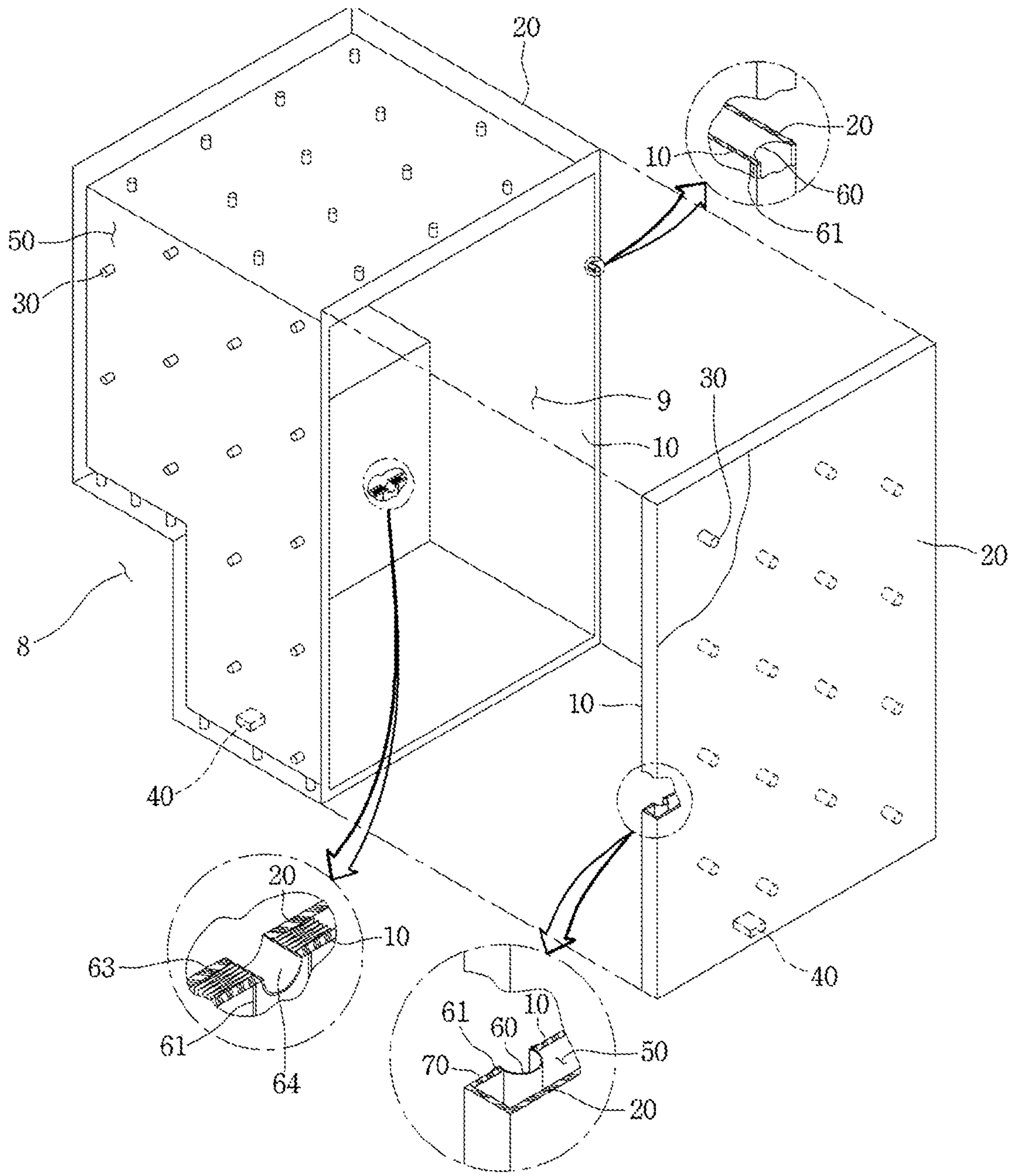


FIG. 2



20
20
10
60
61
50
30
9
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10
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50
70
20

FIG. 3

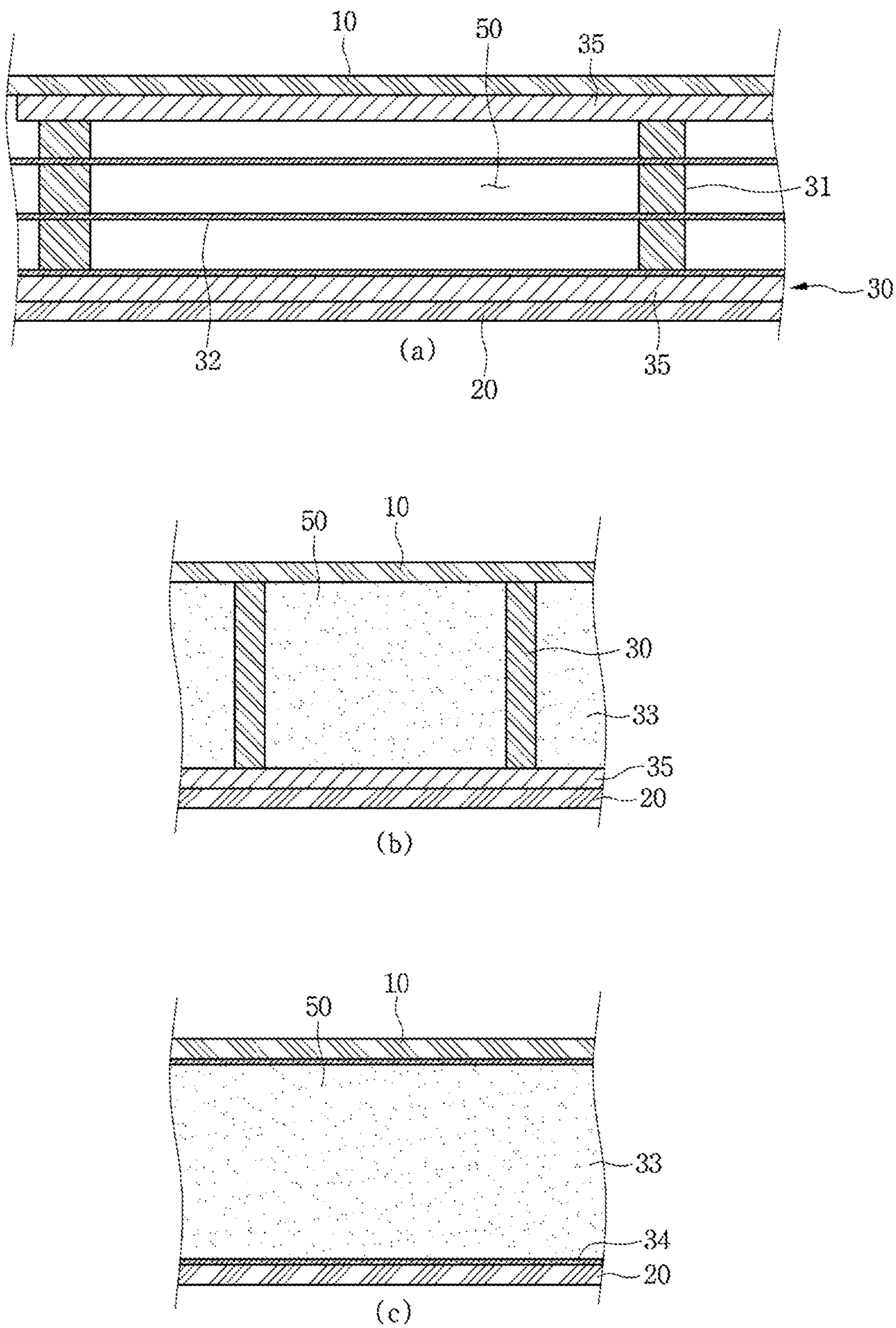
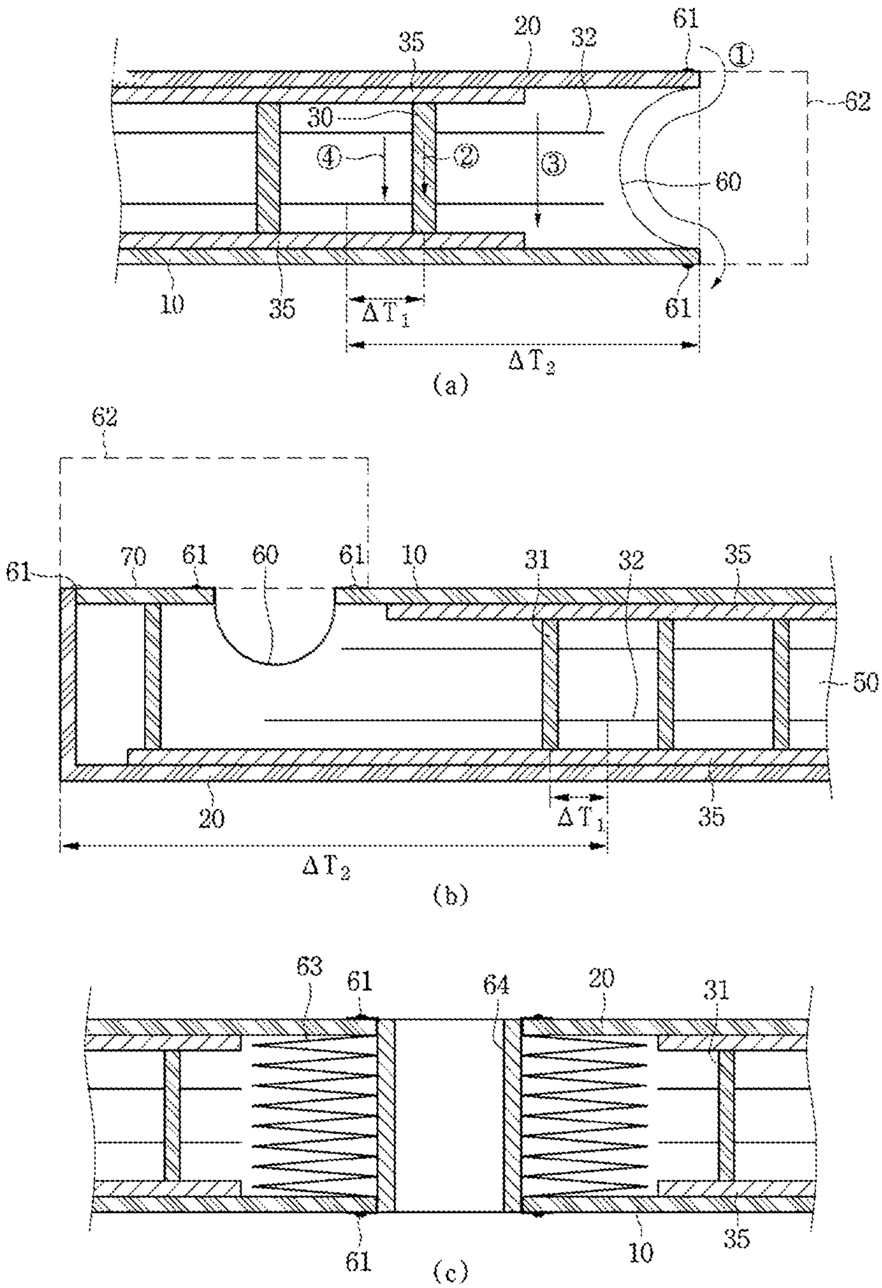


FIG. 4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①
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④
②
③
60
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ΔT1
ΔT2
(a)
62
61
70
61
60
61
10
31
32
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ΔT2
(b)
63
61
64
20
31
61
10
35
(c)

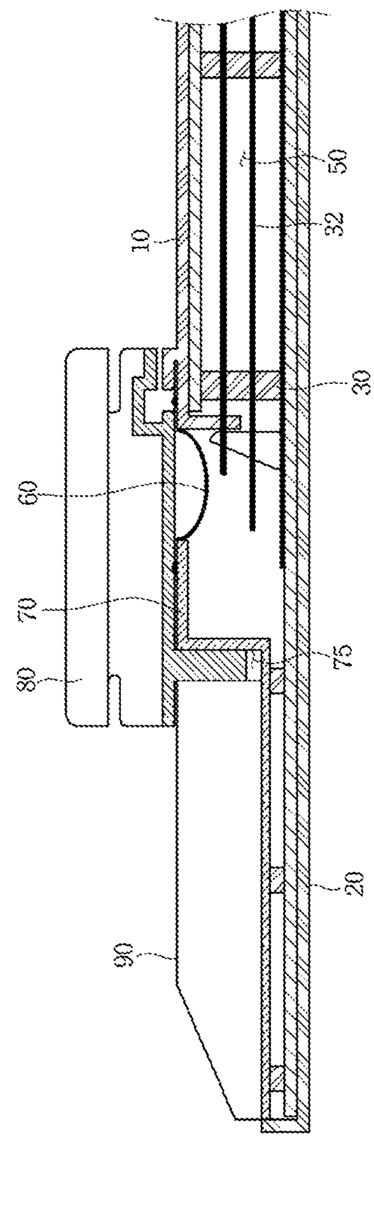


FIG. 5

FIG. 6

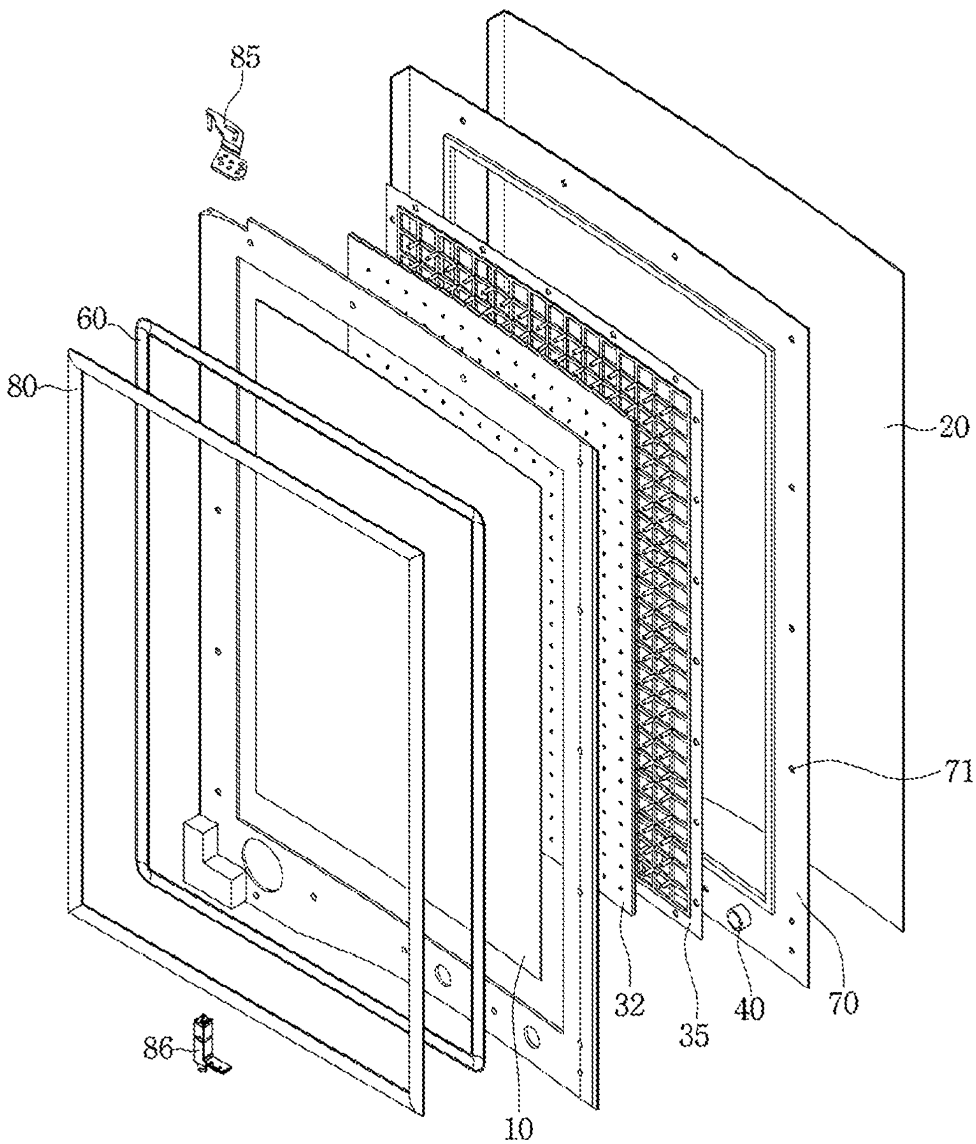


FIG. 7

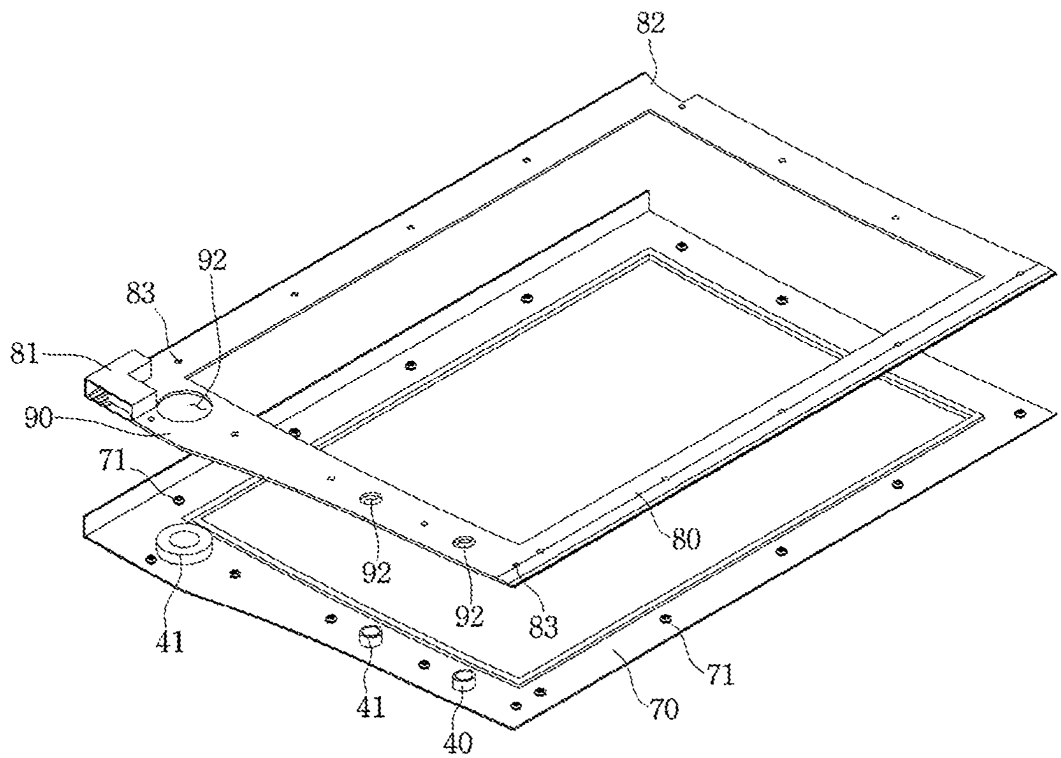


FIG. 8

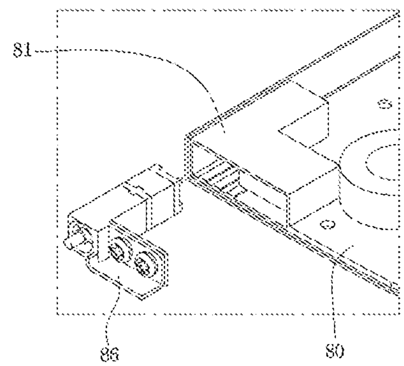


FIG. 9

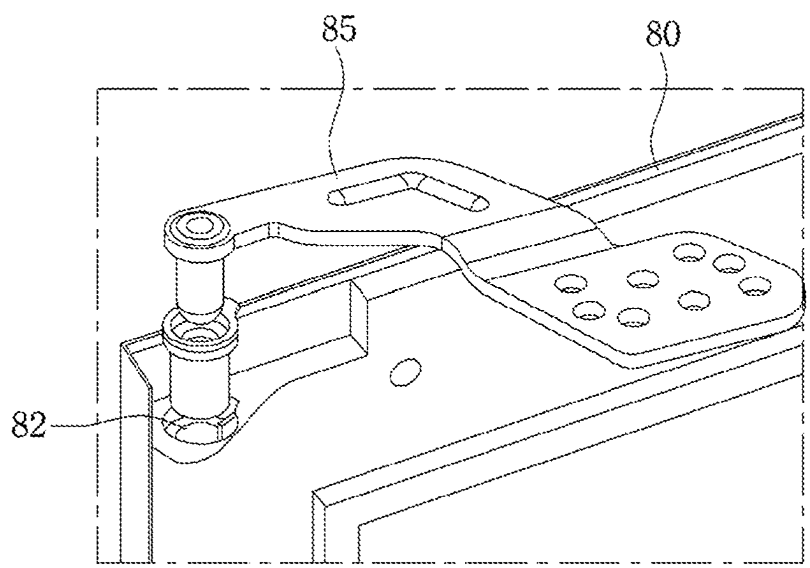
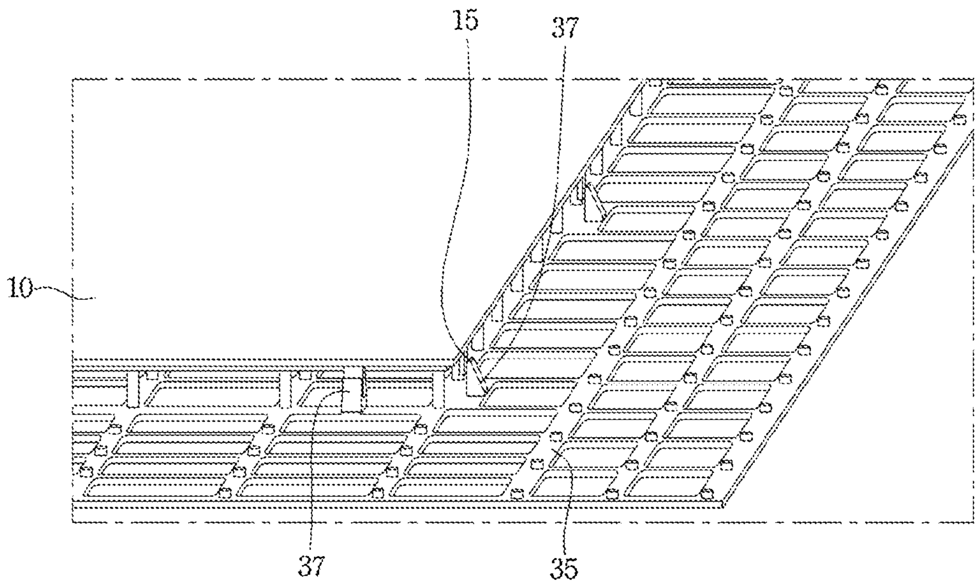


FIG. 10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37
10
37
35

FIG. 11

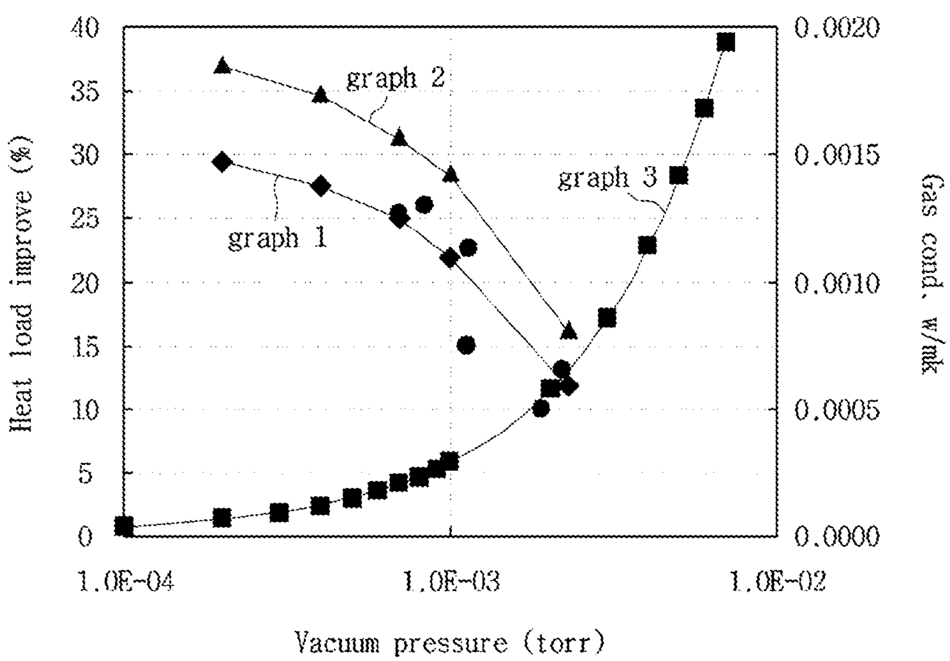

40
35
30
25
20
15
10
5
0
0.0020
0.0015
0.0010
0.0005
0.0000
graph 2
graph 1
graph 3
Heat load improve (%)
Gas cond. w/mk
1.0E-04
1.0E-03
1.0E-02
Vacuum pressure (torr)

FIG. 12

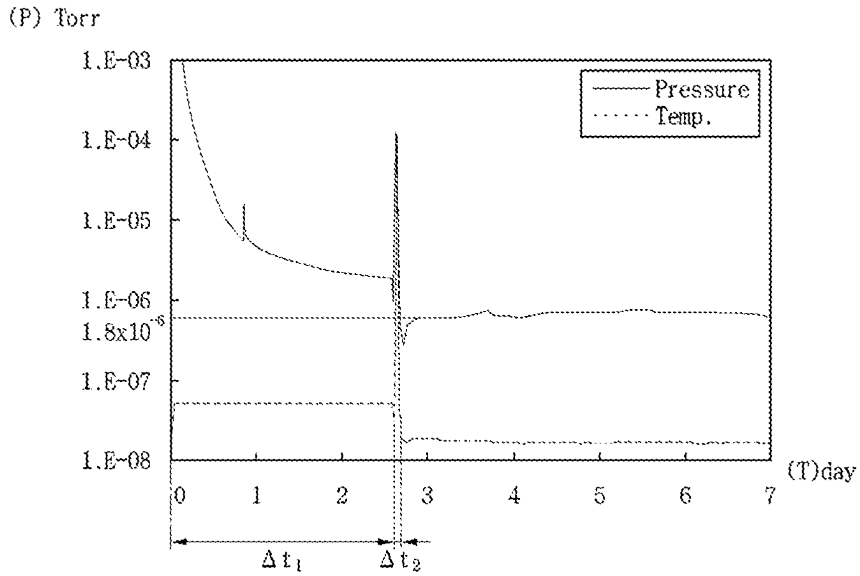

(P) Torr
1.E-03
1.E-04
1.E-05
1.E-06
$1.8x10^{-6}$
1.E-07
1.E-08
Pressure
Temp.
(T)day
0
1
2
3
4
5
6
7
Δt_1
Δt_2

FIG. 13

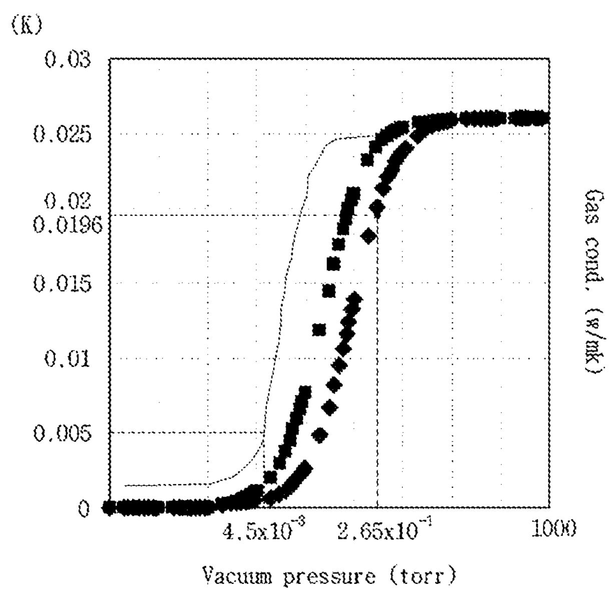

(K)
0.03
0.025
0.02
0.0196
0.015
0.01
0.005
0
$4.5x10^{-3}$
$2.65x10^{-1}$
1000
Vacuum pressure (torr)
Gas cond. (w/mk)

FIG. 14

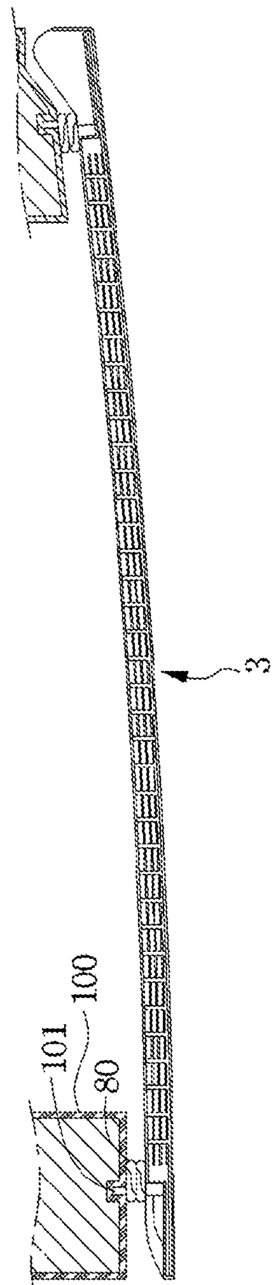
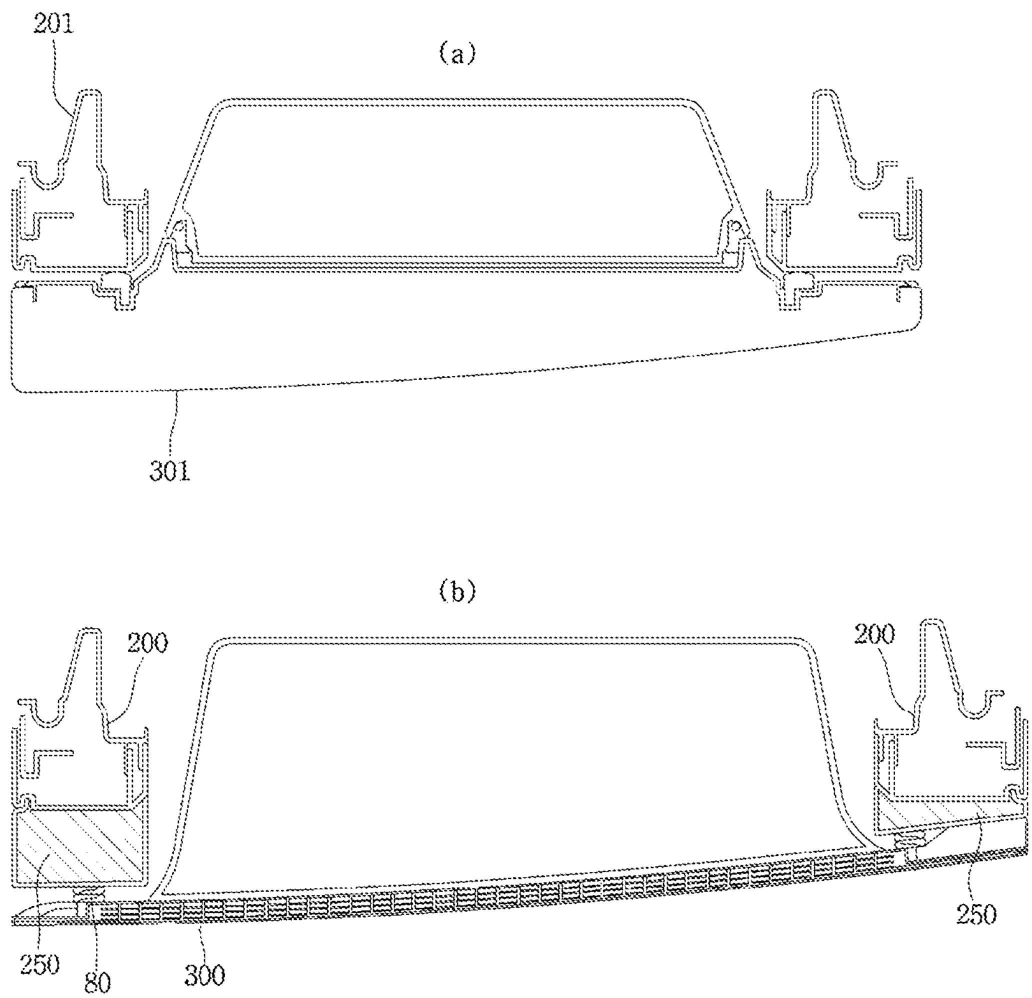


FIG. 15



VACUUM ADIABATIC BODY AND REFRIGERATOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a Continuation Application of U.S. patent application Ser. No. 15/749,132 filed Jan. 31, 2018, which claims is a U.S. National Stage Application under 35 U.S.C. § 371 of PCT Application No. PCT/KR2016/008519, filed Aug. 2, 2016, which claims priority to Korean Patent Application No. 10-2015-0109724, filed Aug. 3, 2015, whose entire disclosures are hereby incorporated by reference.

BACKGROUND

1. Field

The present disclosure relates to a vacuum adiabatic body and a refrigerator.

2. Background

The present disclosure relates to a vacuum adiabatic body and a refrigerator.

A vacuum adiabatic body is a product for suppressing heat transfer by vacuumizing the interior of a body thereof. The vacuum adiabatic body can reduce heat transfer by convection and conduction, and hence is applied to heating apparatuses and refrigerating apparatuses. In a typical adiabatic method applied to a refrigerator, although it is differently applied in refrigeration and freezing, a foam urethane adiabatic wall having a thickness of about 30 cm or more is generally provided. However, the internal volume of the refrigerator is therefore reduced.

In order to increase the internal volume of a refrigerator, there is an attempt to apply a vacuum adiabatic body to the refrigerator.

First, Korean Patent No. 10-0343719 (Reference Document 1) of the present applicant has been disclosed. According to Reference Document 1, there is disclosed a method in which a vacuum adiabatic panel is prepared and then built in walls of a refrigerator, and the exterior of the vacuum adiabatic panel is finished with a separate molding as Styrofoam (polystyrene). According to the method, additional foaming is not required, and the adiabatic performance of the refrigerator is improved. However, manufacturing cost is increased, and a manufacturing method is complicated. As another example, a technique of providing walls using a vacuum adiabatic material and additionally providing adiabatic walls using a foam filling material has been disclosed in Korean Patent Publication No. 10-2015-0012712 (Reference Document 2). According to Reference Document 2, manufacturing cost is increased, and a manufacturing method is complicated.

As another example, there is an attempt to manufacture all walls of a refrigerator using a vacuum adiabatic body that is a single product. For example, a technique of providing an adiabatic structure of a refrigerator to be in a vacuum state has been disclosed in U.S. Patent Laid-Open Publication No. US 2014/0226956 A1 (Reference Document 3).

However, it is difficult to obtain an adiabatic effect of a practical level by providing the walls of the refrigerator to be in a sufficient vacuum state. Specifically, it is difficult to prevent heat transfer at a contact portion between external and internal cases having different temperatures. Further, it is difficult to maintain a stable vacuum state. Furthermore, it is difficult to prevent deformation of the cases due to a sound pressure in the vacuum state. Due to these problems, the technique of Reference Document 3 is limited to cryogenic refrigerating apparatuses, and is not applied to refrigerating apparatuses used in general households.

Embodiments provide a vacuum adiabatic body and a refrigerator, which can obtain a sufficient adiabatic effect in a vacuum state and be applied commercially.

In one embodiment, a vacuum adiabatic body includes: a first plate member defining at least one portion of a wall for a first space; a second plate member defining at least one portion of a wall for a second space having a different temperature from the first space; a sealing part sealing the first plate member and the second plate member to provide a third space that has a temperature between the temperature of the first space and the temperature of the second space and is in a vacuum state; a supporting unit maintaining the third space; a heat resistance unit for decreasing a heat transfer amount between the first plate member and the second plate member; an exhaust port through which a gas in the third space is exhausted; a side frame provided at an edge portion of the third space, the side frame having at least one portion defining a wall for the third space; and a peripheral frame fixed to the side frame to have a part mounted thereto.

A boss may be provided to the side frame, and a hole aligned with the boss may be provided in the peripheral frame, so that the side frame and the peripheral frame are fastened to each other.

A gap part having a gasket fixed thereinto may be provided between the side frame and the peripheral frame. The heat resistance unit may include at least one conductive resistance sheet that is thinner than each of the first and second plate members and has at least one portion provided as a curved surface, to reduce conduction heat flowing along the wall for the third space. The gasket may be provided to cover the conductive resistance sheet.

At least one port may be provided to the side frame. An accommodating part for accommodating at least one portion of a protruding portion of the port may be provided in the peripheral frame.

A hinge mounting part having a hinge shaft fixed thereinto may be provided to the peripheral frame. The vacuum adiabatic body may include: a rib provided to the supporting unit; and a mounting end part provided to each of the first and second plate members, the mounting end part contacting the rib.

A vacuum space part may extend up to an edge portion of the vacuum adiabatic body. A gap of the vacuum space part, provided by the side frame, may be narrower than that of the vacuum space part provided in each of the first and second plate members.

In another embodiment, a vacuum adiabatic body includes: a first plate member defining at least one portion of a wall for a first space; a second plate member defining at least one portion of a wall for a second space having a different temperature from the first space; a sealing part sealing the first plate member and the second plate member to provide a third space that has a temperature between the temperature of the first space and the temperature of the second space and is in a vacuum state; a supporting unit maintaining the third space; a heat resistance unit for decreasing a heat transfer amount between the first plate member and the second plate member; an exhaust port through which a gas in the third space is exhausted; and a peripheral frame made of a resin material, the peripheral frame being mounted in the shape of a closed curve at an outer circumferential portion of the third space such that at least one part is mounted thereto, wherein, in heat transfer between the first and second plate members, solid conduction heat is greater than radiation transfer heat, and gas conduction heat is smallest.

The heat resistance unit may include a conductive resistance sheet to resist heat conduction flowing along a wall for the third space, and the conductive resistance sheet may provide, together with each of the first and second plate members, an outer wall of at least one portion of a first vacuum space part. The heat resistance unit may include at least one radiation resistance sheet provided in a plate shape inside the third space or may include a porous material to resist radiation heat transfer between the second plate member and the first plate member inside the third space.

A vacuum degree (or pressure) of the vacuum space part may be equal to or greater than 1.8×10^{-6} Torr and equal to or smaller than 2.65×10^{-1} Torr.

The sealing part may include a welding part. The supporting unit may include a bar supporting the first plate member and the second plate member or may include a porous material

In still another embodiment, a refrigerator includes: a main body provided with an internal space in which storage goods are stored; and a door provided to open/close the main body from an external space, wherein, in order to supply a refrigerant into the internal space, the refrigerator includes: a compressor for compressing the refrigerant; a condenser for condensing the compressed refrigerant; an expander for expanding the condensed refrigerant; and an evaporator for evaporating the expanded refrigerant to take heat, wherein at least one of the main body and the door includes a vacuum adiabatic body, wherein the vacuum adiabatic body includes: a first plate member defining at least one portion of a wall for the internal space; a second plate member defining at least one portion of a wall for the external space; a sealing part sealing the first plate member and the second plate member to provide a vacuum space part that has a temperature between a temperature of the internal space and a temperature of the external space and is in a vacuum state; a supporting unit maintaining the vacuum space part; a heat resistance unit for decreasing a heat transfer amount between the first plate member and the second plate member; an exhaust port through which a gas in the vacuum space part is exhausted; and a peripheral frame made of a resin material, the peripheral frame being mounted in the shape of a closed curve at an outer circumferential portion of the vacuum space part such that at least one part is mounted thereto.

A hinge mounting part having a hinge shaft fixed thereinto may be provided to the peripheral frame. The refrigerator may include a side frame made of a metallic material, the side frame being fastened to the peripheral frame, the side frame providing an outer wall for the vacuum space part. At least one port may be provided to the side frame. An accommodating part for accommodating at least one portion of a protruding portion of the port may be provided in the peripheral frame.

The heat resistance unit may include at least one conductive resistance sheet that is thinner than each of the first and second plate members and has at least one portion provided as a curved surface, to reduce conduction heat flowing along the wall for the vacuum space part. A gasket fixed to the main body may be provided to cover the conductive resistance sheet.

According to the present disclosure, it is possible to obtain a sufficient vacuum adiabatic effect. Further, a plurality of parts can be mounted by the peripheral frame, so that it is possible to improve the stability of a product and to avoid interference between parts.

The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

The above references are incorporated by reference herein where appropriate for appropriate teachings of additional or alternative details, features and/or technical background

BRIEF DESCRIPTION OF THE DRAWINGS

The embodiments will be described in detail with reference to the following drawings in which like reference numerals refer to like elements wherein:

FIG. **1** is a perspective view of a refrigerator according to an embodiment.

FIG. **2** is a view schematically showing a vacuum adiabatic body used in a main body and a door of the refrigerator.

FIG. **3** is a view showing various embodiments of an internal configuration of a vacuum space part.

FIG. **4** is a view showing various embodiments of conductive resistance sheets and peripheral parts thereof.

FIG. **5** is a view illustrating in detail a vacuum adiabatic body according to an embodiment.

FIG. **6** is an exploded perspective view of the vacuum adiabatic body according to the embodiment.

FIG. **7** is a view illustrating an alignment relationship between a side frame and a peripheral frame.

FIGS. **8** and **9** are views showing a state in which a hinge is inserted into the door.

FIG. **10** is a view showing a state in which a first plate member and a supporting unit are fastened to each other.

FIG. **11** illustrates graphs showing changes in adiabatic performance and changes in gas conductivity with respect to vacuum pressures by applying a simulation.

FIG. **12** illustrates graphs obtained by observing, over time and pressure, a process of exhausting the interior of the vacuum adiabatic body when a supporting unit is used.

FIG. **13** illustrates graphs obtained by comparing vacuum pressures and gas conductivities.

FIG. **14** is a schematic sectional view of a vacuum adiabatic body according to another embodiment.

FIG. **15** is a schematic sectional view illustrating a case where a vacuum adiabatic body is applied to a door-in-door refrigerator according to an embodiment, in which FIG. **15***a* illustrates a case where typical foaming urethane is applied and FIG. **15***b* illustrates a case where the vacuum adiabatic body is applied.

DETAILED DESCRIPTION

Reference will now be made in detail to the embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings.

In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific preferred embodiments in which the disclosure may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the disclosure, and it is understood that other embodiments may be utilized and that logical structural, mechanical, electrical, and chemical changes may be made without departing from the spirit or scope of the disclosure. To avoid detail not necessary to enable those skilled in the art to practice the disclosure, the description may omit certain information known to those skilled in the art. The following detailed description is, therefore, not to be taken in a limiting sense.

In the following description, the term 'vacuum pressure' means a certain pressure state lower than atmospheric pressure. In addition, the expression that a vacuum degree of A is higher than that of B means that a vacuum pressure of A is lower than that of B.

FIG. **1** is a perspective view of a refrigerator according to an embodiment.

Referring to FIG. **1**, the refrigerator **1** includes a main body **2** provided with a cavity **9** capable of storing storage goods and a door **3** provided to open/close the main body **2**. The door **3** may be rotatably or movably disposed to open/close the cavity **9**. The cavity **9** may provide at least one of a refrigerating chamber and a freezing chamber.

Parts constituting a freezing cycle may include those in which cold air is supplied into the cavity **9**. Specifically, the parts include a compressor **4** for compressing a refrigerant, a condenser **5** for condensing the compressed refrigerant, an expander **6** for expanding the condensed refrigerant, and an evaporator **7** for evaporating the expanded refrigerant to take heat. As a typical structure, a fan may be installed at a position adjacent to the evaporator **7**, and a fluid blown from the fan may pass through the evaporator **7** and then be blown into the cavity **9**. A freezing load is controlled by adjusting the blowing amount and blowing direction by the fan, adjusting the amount of a circulated refrigerant, or adjusting the compression rate of the compressor, so that it is possible to control a refrigerating space or a freezing space.

FIG. **2** is a view schematically showing a vacuum adiabatic body used in the main body and the door of the refrigerator. In FIG. **2**, a main body-side vacuum adiabatic body is illustrated in a state in which top and side walls are removed, and a door-side vacuum adiabatic body is illustrated in a state in which a portion of a front wall is removed. In addition, sections of portions at conductive resistance sheets are provided are schematically illustrated for convenience of understanding.

Referring to FIG. **2**, the vacuum adiabatic body includes a first plate member (or first plate) **10** for providing a wall of a low-temperature space, a second plate member (or second plate) **20** for providing a wall of a high-temperature space, and a vacuum space part (or vacuum space or cavity) **50** defined as a gap part (or gap or space) between the first and second plate members **10** and **20**. Also, the vacuum adiabatic body includes the conductive resistance sheets **60** and **63** for preventing heat conduction between the first and second plate members **10** and **20**. A sealing part (or seal or sealing joint) **61** for sealing the first and second plate members **10** and **20** is provided such that the vacuum space part **50** is in a sealing state. When the vacuum adiabatic body is applied to a refrigerating or heating cabinet, the first plate member **10** may be referred to as an inner case, and the second plate member **20** may be referred to as an outer case. A machine chamber **8** in which parts providing a freezing cycle are accommodated is placed at a lower rear side of the main body-side vacuum adiabatic body, and an exhaust port **40** for forming a vacuum state by exhausting air in the vacuum space part **50** is provided at any one side of the vacuum adiabatic body. In addition, a pipeline **64** passing through the vacuum space part **50** may be further installed so as to install a defrosting water line and electric lines.

The first plate member **10** may define at least one portion of a wall for a first space provided thereto. The second plate member **20** may define at least one portion of a wall for a second space provided thereto. The first space and the second space may be defined as spaces having different temperatures. Here, the wall for each space may serve as not only a wall directly contacting the space but also a wall not contacting the space. For example, the vacuum adiabatic body of the embodiment may also be applied to a product further having a separate wall contacting each space.

Factors of heat transfer, which cause loss of the adiabatic effect of the vacuum adiabatic body, are heat conduction between the first and second plate members **10** and **20**, heat radiation between the first and second plate members **10** and **20**, and gas conduction of the vacuum space part **50**.

Hereinafter, a heat resistance unit provided to reduce adiabatic loss related to the factors of the heat transfer will be provided. The heat resistance unit may also be referred to as a thermal insulator, or the like, that provides one or more structural means configured to provide thermal insulation. Meanwhile, the vacuum adiabatic body and the refrigerator of the embodiment do not exclude that another adiabatic means is further provided to at least one side of the vacuum adiabatic body. Therefore, an adiabatic means using foaming or the like may be further provided to another side of the vacuum adiabatic body.

FIG. **3** is a view showing various embodiments of an internal configuration of the vacuum space part.

First, referring to FIG. **3***a*, the vacuum space part **50** is provided in a third space having a different pressure from the first and second spaces, preferably, a vacuum state, thereby reducing adiabatic loss. The third space may be provided at a temperature between the temperature of the first space and the temperature of the second space. Since the third space is provided as a space in the vacuum state, the first and second plate members **10** and **20** receive a force contracting in a direction in which they approach each other due to a force corresponding to a pressure difference between the first and second spaces. Therefore, the vacuum space part **50** may be deformed in a direction in which it is reduced. In this case, adiabatic loss may be caused due to an increase in amount of heat radiation, caused by the contraction of the vacuum space part **50**, and an increase in amount of heat conduction, caused by contact between the plate members **10** and **20**.

A supporting unit (or support) **30** may be provided to reduce the deformation of the vacuum space part **50**. The supporting unit **30** includes bars **31**. The bars **31** may extend in a direction substantially vertical to the first and second plate members **10** and **20** so as to support a distance between the first and second plate members **10** and **20**. A support plate **35** may be additionally provided to at least one end of the bar **31**. The support plate **35** connects at least two bars **31** to each other, and may extend in a direction horizontal to the first and second plate members **10** and **20**. The support plate **35** may be provided in a plate shape, or may be provided in a lattice shape such that its area contacting the first or second plate member **10** or **20** is decreased, thereby reducing heat transfer. The bars **31** and the support plate **35** are fixed to each other at at least one portion, to be inserted together between the first and second plate members **10** and **20**. The support plate **35** contacts at least one of the first and second plate members **10** and **20**, thereby preventing deformation of the first and second plate members **10** and **20**. In addition, based on the extending direction of the bars **31**, a total sectional area of the support plate **35** is provided to be greater than that of the bars **31**, so that heat transferred through the bars **31** can be diffused through the support plate **35**.

A material of the supporting unit **30** may include a resin selected from the group consisting of PC, glass fiber PC, low outgassing PC, PPS, and LCP so as to obtain high compressive strength, low outgassing and water absorptance, low thermal conductivity, high compressive strength at high temperature, and excellent machinability.

A radiation resistance sheet **32** for reducing heat radiation between the first and second plate members **10** and **20** through the vacuum space part **50** will be described. The first and second plate members **10** and **20** may be made of a stainless material capable of preventing corrosion and providing a sufficient strength. The stainless material has a relatively high emissivity of 0.16, and hence a large amount of radiation heat may be transferred. In addition, the supporting unit **30** made of the resin has a lower emissivity than the plate members, and is not entirely provided to inner surfaces of the first and second plate members **10** and **20**. Hence, the supporting unit **30** does not have great influence on radiation heat. Therefore, the radiation resistance sheet **32** may be provided in a plate shape over a majority of the area of the vacuum space part **50** so as to concentrate on reduction of radiation heat transferred between the first and second plate members **10** and **20**. A product having a low emissivity may be preferably used as the material of the radiation resistance sheet **32**. In an embodiment, an aluminum foil having an emissivity of 0.02 may be used as the radiation resistance sheet **32**. Since the transfer of radiation heat cannot be sufficiently blocked using one radiation resistance sheet, at least two radiation resistance sheets **32** may be provided at a certain distance so as not to contact each other. In addition, at least one radiation resistance sheet may be provided in a state in which it contacts the inner surface of the first or second plate member **10** or **20**.

Referring to FIG. **3***b*, the distance between the plate members is maintained by the supporting unit **30**, and a porous material **33** may be filled in the vacuum space part **50**. The porous material **33** may have a higher emissivity than the stainless material of the first and second plate members **10** and **20**. However, since the porous material **33** is filled in the vacuum space part **50**, the porous material **33** has a high efficiency for resisting the radiation heat transfer.

In this embodiment, the vacuum adiabatic body can be manufactured without using the radiation resistance sheet **32**.

Referring to FIG. **3***c*, the supporting unit **30** maintaining the vacuum space part **50** is not provided. Instead of the supporting unit **30**, the porous material **33** is provided in a state in which it is surrounded by a film **34**. In this case, the porous material **33** may be provided in a state in which it is compressed so as to maintain the gap of the vacuum space part **50**. The film **34** is made of, for example, a PE material, and may be provided in a state in which holes are formed therein.

In this embodiment, the vacuum adiabatic body can be manufactured without using the supporting unit **30**. In other words, the porous material **33** can serve together as the radiation resistance sheet **32** and the supporting unit **30**.

FIG. **4** is a view showing various embodiments of the conductive resistance sheets and peripheral parts thereof. Structures of the conductive resistance sheets are briefly illustrated in FIG. **2**, but will be understood in detail with reference to FIG. **4**.

First, a conductive resistance sheet proposed in FIG. **4***a* may be preferably applied to the main body-side vacuum adiabatic body. Specifically, the first and second plate members **10** and **20** are to be sealed so as to vacuumize the interior of the vacuum adiabatic body. In this case, since the two plate members have different temperatures from each other, heat transfer may occur between the two plate members. A conductive resistance sheet **60** is provided to prevent heat conduction between two different kinds of plate members.

The conductive resistance sheet **60** may be provided with sealing parts **61** at which both ends of the conductive resistance sheet **60** are sealed to define at least one portion of the wall for the third space and maintain the vacuum state. The conductive resistance sheet **60** may be provided as a thin foil in units of micrometers so as to reduce the amount of heat conducted along the wall for the third space. The sealing parts)) **7** sealing part **61**. third spaceuce .y be provided as a thin foil stateve resistance sheet **60** are sealed to defining at least 61 may be provided as welding parts. That is, the conductive resistance sheet **60** and the plate members **10** and **20** may be fused to each other.

In order to cause a fusing action between the conductive resistance sheet **60** and the plate members **10** and **20**, the conductive resistance sheet **60** and the plate members **10** and **20** may be made of the same material, and a stainless material may be used as the material. The sealing parts **61** are not limited to the welding parts, and may be provided through a process such as cocking. The conductive resistance sheet **60** may be provided in a curved shape. Thus, a heat conduction distance of the conductive resistance sheet **60** is provided longer than the linear distance of each plate member, so that the amount of heat conduction can be further reduced.

A change in temperature occurs along the conductive resistance sheet **60**. Therefore, in order to block heat transfer to the exterior of the conductive resistance sheet **60**, a shielding part (or shield) **62** may be provided at the exterior of the conductive resistance sheet **60** such that an adiabatic action occurs. In other words, in the refrigerator, the second plate member **20** has a high temperature and the first plate member **10** has a low temperature. In addition, heat conduction from high temperature to low temperature occurs in the conductive resistance sheet **60**, and hence the temperature of the conductive resistance sheet **60** is suddenly changed. Therefore, when the conductive resistance sheet **60** is opened to the exterior thereof, heat transfer through the opened place may seriously occur.

In order to reduce heat loss, the shielding part **62** is provided at the exterior of the conductive resistance sheet **60**. For example, when the conductive resistance sheet **60** is exposed to any one of the low-temperature space and the high-temperature space, the conductive resistance sheet **60** does not serve as a conductive resistor as well as the exposed portion thereof, which is not preferable.

The shielding part **62** may be provided as a porous material contacting an outer surface of the conductive resistance sheet **60**. The shielding part **62** may be provided as an adiabatic structure, e.g., a separate gasket, which is placed at the exterior of the conductive resistance sheet **60**. The shielding part **62** may be provided as a portion of the vacuum adiabatic body, which is provided at a position facing a corresponding conductive resistance sheet **60** when the main body-side vacuum adiabatic body is closed with respect to the door-side vacuum adiabatic body. In order to reduce heat loss even when the main body and the door are opened, the shielding part **62** may be preferably provided as a porous material or a separate adiabatic structure.

A conductive resistance sheet proposed in FIG. **4***b* may be preferably applied to the door-side vacuum adiabatic body. In FIG. **4***b*, portions different from those of FIG. **4***a* are described in detail, and the same description is applied to portions identical to those of FIG. **4***a*. A side frame **70** is further provided at an outside of the conductive resistance sheet **60**. A part for sealing between the door and the main body, an exhaust port necessary for an exhaust process, a getter port for vacuum maintenance, and the like may be placed on the side frame **70**. This is because the mounting of parts is convenient in the main body-side vacuum adiabatic body, but the mounting positions of parts are limited in the door-side vacuum adiabatic body.

In the door-side vacuum adiabatic body, it is difficult to place the conductive resistance sheet **60** at a front end portion of the vacuum space part, i.e., a corner side portion of the vacuum space part. This is because, unlike the main body, a corner edge portion of the door is exposed to the exterior. More specifically, if the conductive resistance sheet **60** is placed at the front end portion of the vacuum space part, the corner edge portion of the door is exposed to the exterior, and hence there is a disadvantage in that a separate adiabatic part should be configured so as to heat-insulate the conductive resistance sheet **60**.

A conductive resistance sheet proposed in FIG. **4***c* may be preferably installed in the pipeline passing through the vacuum space part. In FIG. **4***c*, portions different from those of FIGS. **4***a* and **4***b* are described in detail, and the same description is applied to portions identical to those of FIGS. **4***a* and **4***b*. A conductive resistance sheet having the same shape as that of FIG. **4***a*, preferably, a wrinkled conductive resistance sheet (or folded conductive resistance sheet) **63** may be provided at a peripheral portion of the pipeline **64**. Accordingly, a heat transfer path can be lengthened, and deformation caused by a pressure difference can be prevented. In addition, a separate shielding part may be provided to improve the adiabatic performance of the conductive resistance sheet parate tion, a shielding part gthened, and deformation caused by a pressure difference can be prevented those edge portion of t.

A heat transfer path between the first and second plate members **10** and **20** will be described with reference back to FIG. **4***a*. Heat passing through the vacuum adiabatic body may be divided into surface conduction heat ① conducted along a surface of the vacuum adiabatic body, more specifically, the conductive resistance sheet **60**, supporter conduction heat ② conducted along the supporting unit **30** provided inside the vacuum adiabatic body, gas conduction heat (or convection) ③ conducted through an internal gas in the vacuum space part, and radiation transfer heat ④ transferred through the vacuum space part.

The transfer heat may be changed depending on various design dimensions. For example, the supporting unit may be changed such that the first and second plate members **10** and **20** can endure a vacuum pressure without being deformed, the vacuum pressure may be changed, the distance between the plate members may be changed, and the length of the conductive resistance sheet may be changed. The transfer heat may be changed depending on a difference in temperature between the spaces (the first and second spaces) respectively provided by the plate members. In the embodiment, a preferred configuration of the vacuum adiabatic body has been found by considering that its total heat transfer amount is smaller than that of a typical adiabatic structure formed by foaming polyurethane. In a typical refrigerator including the adiabatic structure formed by foaming the polyurethane, an effective heat transfer coefficient may be proposed as 19.6 mW/mK.

By performing a relative analysis on heat transfer amounts of the vacuum adiabatic body of the embodiment, a heat transfer amount by the gas conduction heat ③ can become smallest. For example, the heat transfer amount by the gas conduction heat ③ may be controlled to be equal to or smaller than 4% of the total heat transfer amount. A heat transfer amount by solid conduction heat defined as a sum of the surface conduction heat ① and the supporter conduction heat ② is largest. For example, the heat transfer amount by the solid conduction heat may reach 75% of the total heat transfer amount. A heat transfer amount by the radiation transfer heat ④ is smaller than the heat transfer amount by the solid conduction heat but larger than the heat transfer amount of the gas conduction heat ③. For example, the heat transfer amount by the radiation transfer heat ④ may occupy about 20% of the total heat transfer amount.

According to such a heat transfer distribution, effective heat transfer coefficients (eK: effective K) (W/mK) of the surface conduction heat ①, the supporter conduction heat ②, the gas conduction heat ③, and the radiation transfer heat ④ may have an order of Equation 1.

$$eK_{solid\ conduction\ heat} > eK_{radiation\ transfer\ heat} > eK_{gas\ conduction\ heat} \qquad \text{Equation 1}$$

Here, the effective heat transfer coefficient (eK) is a value that can be measured using a shape and temperature differences of a target product. The effective heat transfer coefficient (eK) is a value that can be obtained by measuring a total heat transfer amount and a temperature at least one portion at which heat is transferred. For example, a calorific value (W) is measured using a heating source that can be quantitatively measured in the refrigerator, a temperature distribution (K) of the door is measured using heat respectively transferred through a main body and an edge of the door of the refrigerator, and a path through which heat is transferred is calculated as a conversion value (m), thereby evaluating an effective heat transfer coefficient.

The effective heat transfer coefficient (eK) of the entire vacuum adiabatic body is a value given by k=QL/AΔT. Here, Q denotes a calorific value (W) and may be obtained using a calorific value of a heater. A denotes a sectional area (m2) of the vacuum adiabatic body, L denotes a thickness (m) of the vacuum adiabatic body, and ΔT denotes a temperature difference.

For the surface conduction heat, a conductive calorific value may be obtained through a temperature difference (ΔT) between an entrance and an exit of the conductive resistance sheet **60** or **63**, a sectional area (A) of the conductive resistance sheet, a length (L) of the conductive resistance sheet, and a thermal conductivity (k) of the conductive resistance sheet (the thermal conductivity of the conductive resistance sheet is a material property of a material and can be obtained in advance). For the supporter conduction heat, a conductive calorific value may be obtained through a temperature difference (ΔT) between an entrance and an exit of the supporting unit **30**, a sectional area (A) of the supporting unit, a length (L) of the supporting unit, and a thermal conductivity (k) of the supporting unit. Here, the thermal conductivity of the supporting unit is a material property of a material and can be obtained in advance. The sum of the gas conduction heat ③, and the radiation transfer heat ④ may be obtained by subtracting the surface conduction heat and the supporter conduction heat from the heat transfer amount of the entire vacuum adiabatic body. A ratio of the gas conduction heat ③, and the radiation transfer heat ④ may be obtained by evaluating radiation transfer heat when no gas conduction heat exists by remarkably lowering a vacuum degree of the vacuum space part **50**.

When a porous material is provided inside the vacuum space part **50**, porous material conduction heat ⑤ may be a sum of the supporter conduction heat ② and the radiation transfer heat ④. The porous material conduction heat ⑤ may be changed depending on various variables including a kind, an amount, and the like of the porous material.

According to an embodiment, a temperature difference ΔT1 between a geometric center formed by adjacent bars **31** and a point at which each of the bars **31** is located may be preferably provided to be less than 0.5° C. Also, a temperature difference ΔT2 between the geometric center formed by the adjacent bars **31** and an edge portion of the vacuum adiabatic body may be preferably provided to be less than 0.5° C. In the second plate member **20**, a temperature difference between an average temperature of the second plate and a temperature at a point at which a heat transfer path passing through the conductive resistance sheet **60** or **63** meets the second plate may be largest.

For example, when the second space is a region hotter than the first space, the temperature at the point at which the heat transfer path passing through the conductive resistance sheet meets the second plate member becomes lowest. Similarly, when the second space is a region colder than the first space, the temperature at the point at which the heat transfer path passing through the conductive resistance sheet meets the second plate member becomes highest.

This means that the amount of heat transferred through other points except the surface conduction heat passing through the conductive resistance sheet should be controlled, and the entire heat transfer amount satisfying the vacuum adiabatic body can be achieved only when the surface conduction heat occupies the largest heat transfer amount. To this end, a temperature variation of the conductive resistance sheet may be controlled to be larger than that of the plate member.

Physical characteristics of the parts constituting the vacuum adiabatic body will be described. In the vacuum adiabatic body, a force by vacuum pressure is applied to all of the parts. Therefore, a material having a strength (N/m2) of a certain level may be preferably used.

Under such circumferences, the plate members **10** and **20** and the side frame **70** may be preferably made of a material having a sufficient strength with which they are not damaged by even vacuum pressure. For example, when the number of bars **31** is decreased so as to limit the support conduction heat, deformation of the plate member occurs due to the vacuum pressure, which may be a bad influence on the external appearance of refrigerator. The radiation resistance sheet **32** may be preferably made of a material that has a low emissivity and can be easily subjected to thin film processing. Also, the radiation resistance sheet **32** is to ensure a strength high enough not to be deformed by an external impact. The supporting unit **30** is provided with a strength high enough to support the force by the vacuum pressure and endure an external impact, and is to have machinability. The conductive resistance sheet **60** may be preferably made of a material that has a thin plate shape and can endure the vacuum pressure.

In an embodiment, the plate member, the side frame, and the conductive resistance sheet may be made of stainless materials having the same strength. The radiation resistance sheet may be made of aluminum having a weaker strength that the stainless materials. The supporting unit may be made of resin having a weaker strength than the aluminum.

Unlike the strength from the point of view of materials, analysis from the point of view of stiffness is required. The stiffness (N/m) is a property that would not be easily deformed. Although the same material is used, its stiffness may be changed depending on its shape. The conductive resistance sheets **60** or **63** may be made of a material having a prescribed strength, but the stiffness of the material is preferably low so as to increase heat resistance and minimize radiation heat as the conductive resistance sheet is uniformly spread without any roughness when the vacuum pressure is applied. The radiation resistance sheet **32** requires a stiffness of a certain level so as not to contact another part due to deformation. Particularly, an edge portion of the radiation resistance sheet may generate conduction heat due to drooping caused by the self-load of the radiation resistance sheet. Therefore, a stiffness of a certain level is required. The supporting unit **30** requires a stiffness high enough to endure a compressive stress from the plate member and an external impact.

In an embodiment, the plate member and the side frame may preferably have the highest stiffness so as to prevent deformation caused by the vacuum pressure. The supporting unit, particularly, the bar may preferably have the second highest stiffness. The radiation resistance sheet may preferably have a stiffness that is lower than that of the supporting unit but higher than that of the conductive resistance sheet. The conductive resistance sheet may be preferably made of a material that is easily deformed by the vacuum pressure and has the lowest stiffness.

Even when the porous material **33** is filled in the vacuum space part **50**, the conductive resistance sheet may preferably have the lowest stiffness, and the plate member and the side frame may preferably have the highest stiffness.

FIG. **5** is a view illustrating in detail a vacuum adiabatic body according to an embodiment. FIG. **5** shows a view of a distal end region of the vacuum space and the peripheral adiabatic part **90**. The embodiment proposed in FIG. **5** may be preferably applied to the door-side vacuum adiabatic body, and the description of the vacuum adiabatic body shown in FIG. **4***b* among the vacuum adiabatic bodies shown in FIG. **4** may be applied to portions to which specific descriptions are not provided.

Referring to FIG. **5**, the vacuum adiabatic body may include a first plate member **10**, a second plate member **20**, a conductive resistance sheet **60**, and a side frame **70**, which are parts that enable a vacuum space part **50** to be separated from an external atmospheric space.

The side frame **70** is formed in a bent shape, and may be provided such that the height of the side frame **70** is lowered at an outer portion, i.e., an edge portion or distal end portion when viewed from the entire shape of the vacuum adiabatic body is lowered. According to the above-described shape, a predetermined space is ensured without any volume loss at an outside of the portion at which the height of the side frame **70** is low, so that a peripheral frame **90** can be placed at the outside. Hinges **85** and **86** (see FIG. **6**) and an addition such as a door switch or a latch may be mounted to the peripheral frame **90**.

One end of the side frame **70** is fastened to the conductive resistance sheet **60** by a sealing part **61**, and the other end of the side frame **70** is fastened to the second plate member **20** at an edge portion of the vacuum adiabatic body. According to the above-described configuration, the vacuum space part **50** extends up to the edge portion of the vacuum adiabatic body, so that the adiabatic effect of the vacuum adiabatic body can be entirely improved. Further, although dew may be formed by cold air transferred along the side frame **70**, this is not visible to a user, and deformation of the second plate member **20**, which occurs in welding of the side frame, is not visible to the user, so that a sense of beauty and aesthetics is improved.

A supporting unit **30** is provided inside the vacuum space part **50**, to maintain a gap of the vacuum space part **50**. Also, a radiation resistance sheet **32** is provided inside the vacuum space part **50**, to obtain an adiabatic effect against radiation heat transfer through the inside of the vacuum space part **50**.

Gap parts (or gap or space) **75** may be provided at a predetermined gap between the peripheral frame **90** and both side portions of the side frame **70**. One portion of a gasket **80** is inserted into the gap part **75** such that the position of the gasket **80** can be fixed. The one portion of the gasket **80** may be firmly fixed in a forcible insertion manner. The gasket **80** at least covers the conductive resistance sheet **60**, so that it is possible to reduce adiabatic loss caused through an outer surface of the conductive resistance sheet **60**. The gasket **80** is inserted into even the end of the gap part **75**, so that it is possible to prevent adiabatic performance from being degraded through the gap part **75**.

FIG. **6** is an exploded perspective view of the vacuum adiabatic body according to the embodiment.

Referring to FIG. **6**, the first plate member **10**, the second plate member **20**, and the side frame **70** are provided, thereby providing their internal space as the vacuum space part **50**. The conductive resistance sheet **60** is provided at a contact portion between the side frame **70** and the first plate member **10**, to shield heat conduction between the side frame **70** and the first plate member **10**.

The peripheral frame **90** is mounted to the side frame **70**. As already described above, the predetermined gap parts **75** are interposed between the peripheral frame **90** and the side frame **70**, so that the position of the gasket **80** can be fixed by inserting the one portion of the gasket **80** into the gap part **75**. To this end, the peripheral frame **90** may be provided in the shape of a closed curve surrounding the side frame **70**.

An exhaust port **40** and a getter port **41** (see FIG. **7**) may be provided at predetermined positions of the side frame **70**. Since the exhaust port **40** and the getter port **41** are protruding structures, the exhaust port **40** and the getter port **41** may interfere with other parts therearound. In this case, at least one portion of the peripheral frame **90** is provided as high as a height of the ports **40** and **41**, thereby avoiding the interference with other parts.

The side frame **70** may be provided with bosses **71**. The bosses **71** may be fastened to the side frame **70** through welding or the like. Deformation occurring as the bosses **71** are fastened to the side frame **70** is covered by the peripheral frame **90**, not to be exposed to the exterior.

The peripheral frame **90** may be made of a material such as resin. The peripheral frame **90** may be provided with a hinge mounting part mounted to the side frame **70**, the hinge mounting part having hinges mounted thereto, so that an upper hinge **85** and a lower hinge **86** can be mounted to the hinge mounting part. The hinge mounting part is provided, so that hinge shafts of the hinges **85** and **86** can be fixed to the door of the refrigerator, i.e., the vacuum adiabatic body according to the embodiment. As a plurality of structures for operations of the hinge, such as a torsion spring, are built in the hinge shaft, the hinge shaft has a certain volume. Thus, the hinge mounting part having a size capable of accommodating the volume can be provided to the peripheral frame **90**.

The supporting unit **30** for maintaining the gap of the vacuum space part **50** is provided inside the vacuum space part **50**. The radiation resistance sheet **32** may be provided to obtain a radiation adiabatic effect.

FIG. **7** is a view illustrating an alignment relationship between the side frame and the peripheral frame.

Referring to FIG. **7**, the side frame **70** is provided with the getter port **41** and the exhaust port **40** as structures protruding at a predetermined distance. A plurality of bosses **71** may be provided in an inner surface of the side frame **70**. The peripheral frame **90** is provided with accommodating parts (or hole, recess) **92** in which the respective ports **40** and **41** can be accommodated, so that the ports **40** and **41** are placed inside the accommodating parts **92**, respectively. Thus, the ports **40** and **41** do not interfere with other parts. Holes **83** are provided in the peripheral frame **90** such that the holes **83** and the boss **71** are aligned with each other. As a screw is inserted through the hole **83** and the boss **71**, the side frame **70** and the peripheral frame **90** can be fixed to each other.

A lower hinge mounting part (or hinge mount or bracket) **81** and an upper hinge mounting part **82** are provided with predetermined sizes at sides of the peripheral frame **90**, respectively. The hinge mounting parts **81** and **82** are provided to have sizes and strengths, where the hinge shafts of the hinges **85** and **86** can be inserted and supported, respectively. Thus, the existing hinges can be applied as they are. In this case, the manufacturing method of the typical refrigerator provided by foaming polyurethane can be applied as it is, thereby reducing manufacturing cost.

FIGS. **8** and **9** are views showing a state in which a hinge is inserted. A hinge shaft that enables an operation of each of the hinges **85** and **86** to be performed occupies a majority of the volume of the hinge. In FIGS. **8** and **9**, it can be seen that the hinge shafts are inserted and fixed into the hinge mounting parts **81** and **82**, respectively. Since the peripheral frame **90** is made of resin, the peripheral frame **90** may be manufactured in various forms according to standards of hinges.

FIG. **10** is a view showing a state in which the first plate member and the supporting unit are fastened to each other.

Referring to FIG. **10**, a rib **37** may be provided on any one surface of the supporting unit **30**, and a mounting end part (or protrusion or tab) **15** may be provided to the first plate member **10** at a position corresponding to the rib **37**. When the first plate member **10** is placed at the regular position on the supporting unit **30**, the rib **37** and the mounting end part **15** may correspond to each other while contacting each other. Thus, the first plate member **10** and the supporting unit **30** can be assembled in a state in which they are fastened to each other, and it is convenient to align the first plate member **10** and the supporting unit **30** with each other.

Hereinafter, a vacuum pressure preferably determined depending on an internal state of the vacuum adiabatic body. As already described above, a vacuum pressure is to be maintained inside the vacuum adiabatic body so as to reduce heat transfer. At this time, it will be easily expected that the vacuum pressure is preferably maintained as low as possible so as to reduce the heat transfer.

The vacuum space part may resist the heat transfer by applying only the supporting unit **30**. Alternatively, the porous material **33** may be filled together with the supporting unit in the vacuum space part **50** to resist the heat transfer. Alternatively, the vacuum space part may resist the heat transfer not by applying the supporting unit **30** but by applying the porous material **33**.

The case where only the supporting unit is applied will be described.

FIG. **11** illustrates graphs showing changes in adiabatic performance and changes in gas conductivity with respect to vacuum pressures by applying a simulation.

Referring to FIG. **11**, it can be seen that, as the vacuum pressure is decreased, i.e., as the vacuum degree is increased, a heat load in the case of only the main body (Graph 1) or in the case where the main body and the door are joined together (Graph 2) is decreased as compared with that in the case of the typical product formed by foaming polyurethane, thereby improving the adiabatic performance. However, it can be seen that the degree of improvement of the adiabatic performance is gradually lowered. Also, it can be seen that, as the vacuum pressure is decreased, the gas conductivity (Graph 3) is decreased. However, it can be seen that, although the vacuum pressure is decreased, the ratio at which the adiabatic performance and the gas conductivity are improved is gradually lowered. Therefore, it is preferable that the vacuum pressure is decreased as low as possible. However, it takes long time to obtain excessive vacuum pressure, and much cost is consumed due to excessive use of a getter. In the embodiment, an optimal vacuum pressure is proposed from the above-described point of view.

FIG. **12** illustrates graphs obtained by observing, over time and pressure, a process of exhausting the interior of the vacuum adiabatic body when the supporting unit is used.

Referring to FIG. **12**, in order to create the vacuum space part **50** to be in the vacuum state, a gas in the vacuum space part **50** is exhausted by a vacuum pump while evaporating a latent gas remaining in the parts of the vacuum space part **50** through baking. However, if the vacuum pressure reaches a certain level or more, there exists a point at which the level of the vacuum pressure is not increased any more ($\Delta t1$). After that, the getter is activated by disconnecting the vacuum space part **50** from the vacuum pump and applying heat to the vacuum space part **50** ($\Delta t2$). If the getter is activated, the pressure in the vacuum space part **50** is decreased for a certain period of time, but then normalized to maintain a vacuum pressure of a certain level. The vacuum pressure that maintains the certain level after the activation of the getter is approximately 1.8×10^{-6} Torr.

In the embodiment, a point at which the vacuum pressure is not substantially decreased any more even though the gas is exhausted by operating the vacuum pump is set to the lowest limit of the vacuum pressure used in the vacuum adiabatic body, thereby setting the minimum internal pressure of the vacuum space part **50** to 1.8×10^{-6} Torr.

FIG. **13** illustrates graphs obtained by comparing vacuum pressures and gas conductivities.

Referring to FIG. **13**, gas conductivities with respect to vacuum pressures depending on sizes of a gap in the vacuum space part **50** are represented as graphs of effective heat transfer coefficients (eK). Effective heat transfer coefficients (eK) were measured when the gap in the vacuum space part **50** has three sizes of 2.76 mm, 6.5 mm, and 12.5 mm. The gap in the vacuum space part **50** is defined as follows. When the radiation resistance sheet **32** exists inside vacuum space part **50**, the gap is a distance between the radiation resistance sheet **32** and the plate member adjacent thereto. When the radiation resistance sheet **32** does not exist inside vacuum space part **50**, the gap is a distance between the first and second plate members.

It can be seen that, since the size of the gap is small at a point corresponding to a typical effective heat transfer coefficient of 0.0196 W/mK, which is provided to a adiabatic material formed by foaming polyurethane, the vacuum pressure is 2.65×10^{-1} Torr even when the size of the gap is 2.76 mm. Meanwhile, it can be seen that the point at which reduction in adiabatic effect caused by gas conduction heat is saturated even though the vacuum pressure is decreased is a point at which the vacuum pressure is approximately 4.5×10^{-3} Torr. The vacuum pressure of 4.5×10^{-3} Torr can be defined as the point at which the reduction in adiabatic effect caused by gas conduction heat is saturated. Also, when the effective heat transfer coefficient is 0.1 W/mK, the vacuum pressure is 1.2×10^{-2} Torr.

When the vacuum space part **50** is not provided with the supporting unit but provided with the porous material, the size of the gap ranges from a few micrometers to a few hundreds of micrometers. In this case, the amount of radiation heat transfer is small due to the porous material even when the vacuum pressure is relatively high, i.e., when the vacuum degree is low. Therefore, an appropriate vacuum pump is used to adjust the vacuum pressure. The vacuum pressure appropriate to the corresponding vacuum pump is approximately 2.0×10^{-4} Torr. Also, the vacuum pressure at the point at which the reduction in adiabatic effect caused by gas conduction heat is saturated is approximately 4.7×10^{-2} Torr. Also, the pressure where the reduction in adiabatic effect caused by gas conduction heat reaches the typical effective heat transfer coefficient of 0.0196 W/mK is 730 Torr.

When the supporting unit and the porous material are provided together in the vacuum space part, a vacuum pressure may be created and used, which is middle between the vacuum pressure when only the supporting unit is used and the vacuum pressure when only the porous material is used.

FIG. **14** is a schematic sectional view of a vacuum adiabatic body according to another embodiment.

Referring to FIG. **14**, this embodiment may be preferably applied when the gasket **80** is directly fastened to the vacuum adiabatic body such as when it is difficult to provide the gap part **75** according to the size and volume of a member mounted at a peripheral portion of the vacuum adiabatic body. In this case, there may be provided a structure in which a separate groove for mounting of the gasket **80** is formed in a fixing part **100**. When the vacuum adiabatic body available for the door is closed with respect to the fixing part **100**, the gasket **80** preferably serves as the shielding part **62** by covering at least the conductive resistance sheet **60**.

In the case of a main body in which a storage space is formed in a refrigerator or a refrigerator equipped with a plurality of doors, the fixing part **100** may be provided as an inner door.

FIG. **15** is a schematic sectional view illustrating a case where a vacuum adiabatic body is applied to a door-in-door refrigerator according to an embodiment. FIG. **15***a* illustrates a case where typical foaming urethane is applied, and FIG. **15***b* illustrates a case where the vacuum adiabatic body is applied.

Referring to FIG. **15**, the door-in-door refrigerator includes a first door **300** or **301** placed at the outside thereof and a second door **200** or **201** placed at the inside thereof. The typical foaming urethane is applied to the first door **301**, and hence the width in the front-rear direction, where a basket is placed, may be narrowed. On the other hand, the first door **300** of the embodiment can be manufactured as a slim door, and hence it can be expected that the width in the front-rear direction, where a basket is placed, will be widened. In order to maximize such an advantage of the slim door, it is preferably considered that the width of the second door **200** in the front-rear direction is provided to be long. For example, a door expanding part (or door spacer) **250** may be provided to compensate the second door **200** for a thickness corresponding to a width decreased as the door using the typical foaming urethane is replaced with the slim door of the embodiment. The door expanding part **250** may be equipped with parts necessary for an operation thereof. Alternatively, an additional adiabatic material may be provided in the door expanding part **250** so as to obtain an adiabatic effect.

In the description of the present disclosure, a part for performing the same action in each embodiment of the vacuum adiabatic body may be applied to another embodiment by properly changing the shape or dimension of the other embodiment. Accordingly, still another embodiment can be easily proposed. For example, in the detailed description, in the case of a vacuum adiabatic body suitable as a door-side vacuum adiabatic body, the vacuum adiabatic body may be applied as a main body-side vacuum adiabatic body by properly changing the shape and configuration of a vacuum adiabatic body.

Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

The vacuum adiabatic body proposed in the present disclosure may be preferably applied to refrigerators. However, the application of the vacuum adiabatic body is not limited to the refrigerators, and may be applied in various apparatuses such as cryogenic refrigerating apparatuses, heating apparatuses, and ventilation apparatuses.

According to the present disclosure, the vacuum adiabatic body can be industrially applied to various adiabatic apparatuses. The adiabatic effect can be enhanced, so that it is possible to improve energy use efficiency and to increase the effective volume of an apparatus.

Any reference in this specification to "one embodiment," "an embodiment," "example embodiment," etc., means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. The appearances of such phrases in various places in the specification are not necessarily all referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with any embodiment, it is submitted that it is within the purview of one skilled in the art to effect such feature, structure, or characteristic in connection with other ones of the embodiments.

Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

What is claimed is:

1. A vacuum adiabatic body comprising:

a first plate having a first temperature;

a second plate having a second temperature different than the first temperature;

a seal that seals the first plate and the second plate to provide an inner space, the inner space including a main portion and a side portion, and the inner space to be provided in a vacuum state;

a shielding part provided as an adiabatic structure and outside the inner space;

a peripheral frame being mounted in a shape of a closed curve at an outer circumferential portion of the inner space, the shielding part having at least one portion fixed to the peripheral frame;

a side frame including a portion that extends from the first plate toward the second plate and defines at least one portion of a wall for the inner space; and

a conductive resistance sheet provided to reduce heat transfer between the first plate and the second plate,

wherein the shielding part is disposed adjacent to the first plate, the shielding part is disposed on a first side of the first plate, and the inner space and the second plate are disposed on a second side of the first plate, opposite to the first side of the first plate, such that the inner space is between the second plate and the second side of the first plate,

wherein the shielding part is arranged in parallel with the first plate, or the shielding part includes a portion overlapping the first plate in a thickness direction of the inner space,

wherein the shielding part is provided to cover the conductive resistance sheet in order to reduce adiabatic loss caused through an outer surface of the conductive resistance sheet,

wherein the shielding part is fixed or inserted into a gap part provided outside the peripheral frame, and

wherein the gap part is provided between the peripheral frame and at least one of the first plate, the second plate or the side frame.

2. The vacuum adiabatic body according to claim 1, further comprising a support provided in the inner space to maintain a gap in the thickness direction of the inner space between the second plate and the first plate,

wherein the shielding part includes a portion overlapping the support in the thickness direction of the inner space.

3. The vacuum adiabatic body according to claim 1, wherein the shielding part is fixed in a forcible insertion manner.

4. The vacuum adiabatic body according to claim 1, comprising a fixing part provided to a portion of the vacuum adiabatic body,

the fixing part having a groove for mounting the shielding part.

5. The vacuum adiabatic body according to claim 1, wherein the shielding part is fixed or inserted into the gap part provided outside the peripheral frame, in order to prevent adiabatic performance from being degraded through the gap part.

6. The vacuum adiabatic body according to claim 1, wherein the shielding part is provided to contact at least the conductive resistance sheet.

7. The vacuum adiabatic body according to claim 1, wherein one side of the conductive resistance sheet is disposed between the side frame and the shielding part, and another side of the conductive resistance sheet is disposed between the first plate and the shielding part.

8. A vacuum adiabatic body comprising:

a first plate having a first temperature;

a second plate having a second temperature different than the first temperature;

a seal that seals the first plate and the second plate to provide an inner space, the inner space including a main portion and a side portion, and the inner space to be provided in a vacuum state;

a shielding part provided as an adiabatic structure and outside the inner space;

a peripheral frame being mounted in a shape of a closed curve at an outer circumferential portion of the inner space, the shielding part having at least one portion fixed to the peripheral frame; and

a conductive resistance sheet provided to reduce heat transfer between the first plate and the second plate,

wherein the shielding part is disposed adjacent to the first plate, the shielding part is disposed on a first side of the first plate, and the inner space and the second plate are disposed on a second side of the first plate, opposite to the first side of the first plate, such that the inner space is between the second plate and the second side of the first plate,

wherein the shielding part is arranged in parallel with the first plate, or the shielding part includes a portion overlapping the first plate in a thickness direction of the inner space,

wherein the shielding part is provided to cover the conductive resistance sheet in order to reduce adiabatic loss caused through an outer surface of the conductive resistance sheet,

wherein the shielding part is fixed or inserted into a gap part provided outside the peripheral frame, and

wherein the shielding part is inserted into an end of the gap part.

9. The vacuum adiabatic body according to claim **8**, wherein the shielding part is inserted into the end of the gap part, in order to prevent adiabatic performance from being degraded through the gap part.

10. The vacuum adiabatic body according to claim **8**, a thickness of the peripheral frame is thinner than a maximum thickness of the inner space.

11. The vacuum adiabatic body according to claim **8**, wherein the peripheral frame is fixed on a portion of the vacuum adiabatic body, the peripheral frame including a hole through which a fixture is to pass.

12. The vacuum adiabatic body according to claim **8**, the peripheral frame is provided in a shape being bent.

13. The vacuum adiabatic body according to claim **8**, the peripheral frame is previously formed separate molded product.

14. The vacuum adiabatic body according to claim **8**, the peripheral frame is provided in one body without being separated from each other.

15. The vacuum adiabatic body according to claim **8**, the peripheral frame is made of a resin material.

16. The vacuum adiabatic body according to claim **8**, comprising a spacer as an additional adiabatic material provided behind the shielding part.

17. The vacuum adiabatic body according to claim **16**, the spacer has a first portion and a second portion that is smaller than the first portion, the first portion that does not contact the shielding part and the second portion that contacts the shielding part.

18. The vacuum adiabatic body according to claim **17**, comprising an air gap that is provided between the spacer and the first plate, and provided between an inner edge of the spacer and an inner edge of the shielding part,

wherein a length of the air gap that is provided between the spacer and the first plate is shorter than a length of the air gap that is provided between the inner edge of the spacer and the inner edge of the shielding part.

19. The vacuum adiabatic body according to claim **8**, further comprising a radiation resistance sheet configured to reduce heat radiation between the first and second plates through the inner space,

wherein the shielding part is overlapped with the radiation resistance sheet in the thickness direction of the inner space or is spaced apart from the radiation resistance sheet.

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