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(54) **STRUCTURE FOR TANK DOME FLANGE SECTION**

(57) The present invention can suppress a temperature increase of a low-temperature liquefied gas stored in a tank main body portion.

A tank dome flange portion structure (21) is provided at a liquefied gas tank and includes: a tank main body portion configured to store a low-temperature liquefied gas; a tank dome (3) provided at an upper portion of the tank main body portion; a flange portion (22) projecting substantially horizontally from the tank dome (3); a tank cover (6) configured to cover the tank main body portion with a space (5) therebetween; and an expansion rubber portion (11) provided between the flange portion (22) and an upper opening edge portion of the tank cover (6) and configured to seal the space (5). A heat transfer suppressing material portion made of fiber reinforced plastic is provided at at least a predetermined portion of the flange portion (22), the predetermined portion being located between a side wall (3a) of the tank dome (3) and the expansion rubber portion (11).

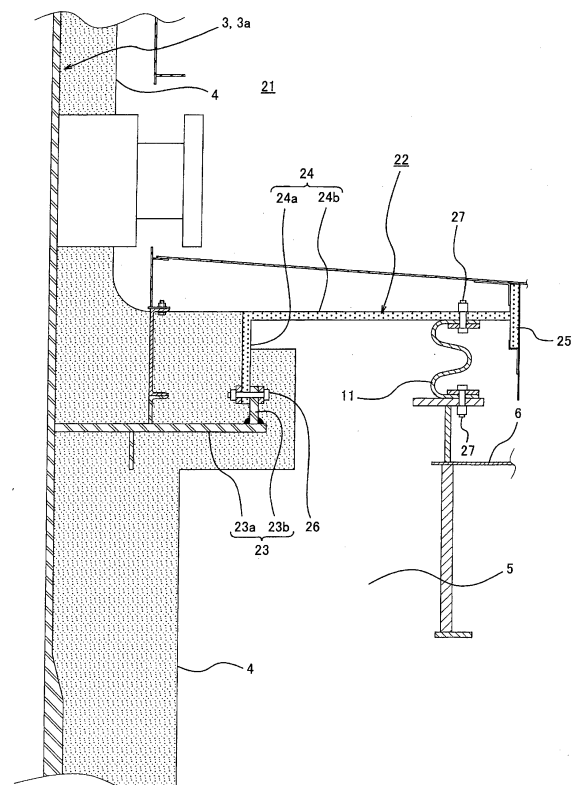


Fig. 1

**Description****Technical Field**

5     **[0001]** The present invention relates to a tank dome flange portion structure provided at a liquefied gas carrier tank in which a liquefied gas, such as a low-temperature liquefied natural gas (LNG), is stored.

**Background Art**

10    **[0002]** Fig. 17 shows one example of a liquefied gas tank provided at the conventional liquefied gas carrier. A liquefied gas tank 1 includes a horizontally-long tank main body portion 2 and a tank dome 3 provided at an upper portion of the tank main body portion 2. The tank main body portion 2 includes a horizontal cylindrical body portion 2a. Both opening portions of the body portion 2a are respectively closed by lid bodies 2b each having a substantially semispherical shape.

15    **[0003]** The tank dome 3 includes a vertical cylindrical side wall 3a. An upper opening portion of the side wall 3a is closed by a lid body 3b having a substantially semispherical shape. In addition, although not shown, for example, a plurality of pipes through which a liquefied gas is supplied to and discharged from the tank main body portion 2 are attached to the tank dome 3.

20    **[0004]** Further, as shown in Fig. 17, a thermal insulation member 4 is provided on the surface of the liquefied gas tank 1. Thus, heat of outside air is prevented from being transferred to the liquefied gas tank 1. Then, a tank cover 6 configured to cover the thermal insulation member 4 with a space 5 therebetween is provided at the tank main body portion 2. In addition, a dome cover (not shown) configured to cover the thermal insulation member 4 with a space therebetween is provided at the tank dome 3.

25    **[0005]** As shown in Fig. 18, a flange portion 8 is provided on the side wall 3a of the tank dome 3. The flange portion 8 is an annular plate body and projects substantially horizontally from an outer surface of the side wall 3a of the tank dome 3.

30    **[0006]** Next, a tank dome flange portion structure 10 of a spherical liquefied gas tank 9 provided at a liquefied gas carrier will be explained in reference to Figs. 19A and 19B (see PTL 1, for example).

35    **[0007]** The liquefied gas tank 9 shown in Figs. 19A and 19B and the liquefied gas tank 1 shown in Fig. 17 are different from each other regarding the shape of the tank main body portion 2. The other components are the same as each other, so that explanations thereof are omitted.

40    **[0008]** As shown in Fig. 19A, the tank dome flange portion structure 10 is configured such that an annular expansion rubber portion 11 is provided between an upper opening edge portion of the tank cover 6 and a lower surface of the annular flange portion 8. The expansion rubber portion 11 has a function of sealing the space 5 formed inside the tank main body portion 2, the flange portion 8, and the like, regardless of the thermal expansion and thermal contraction of the tank main body portion 2, the flange portion 8, and the like. Thus, the expansion rubber portion 11 seals the space 5.

**Citation List****Patent Literature**

45    **[0009]** PTL 1: Japanese Laid-Open Utility Model Application Publication No. 62-12593

**Summary of Invention****Technical Problem**

50    **[0010]** In the conventional tank dome flange portion structure 10 shown in Figs. 19A and 19B, the flange portion 8 is made of a metal. Therefore, the heat of the outside air is transferred to the metal flange portion 8 to be transferred to the tank dome 3 and the tank main body portion 2, and this causes a temperature increase of the liquefied gas stored in the tank main body portion 2.

55    **[0011]** To prevent this temperature increase, it is necessary to increase the use amount of thermal insulation materials including the thermal insulation member 4 provided at the tank main body portion 2, the tank dome 3, the flange portion 8, and the like.

60    **[0012]** The present invention was made to solve the above problems, and an object of the present invention is to provide a tank dome flange portion structure capable of suppressing the temperature increase of a low-temperature liquefied gas stored in a tank main body portion.

## Solution to Problem

**[0013]** A tank dome flange portion structure according to the present invention is provided at a liquefied gas tank and includes: a flange portion projecting outward from an outer surface of a side wall of a tank dome provided at a tank main body portion configured to store a low-temperature liquefied gas; a tank cover configured to cover the tank main body portion with a space therebetween; and an expansion rubber portion provided between the flange portion and the tank cover and configured to seal the space, wherein a heat transfer suppressing material portion made of fiber reinforced plastic is provided at at least a predetermined portion of the flange portion, the predetermined portion being located between the side wall of the tank dome and the expansion rubber portion.

**[0014]** According to the liquefied gas tank at which the tank dome flange portion structure according to the present invention is provided, the tank main body portion can store the low-temperature liquefied gas, and a pipe through which the liquefied gas is supplied to and discharged from the tank is attached to the tank dome. The tank cover and the flange portion cover the tank main body portion with the space between the tank main body portion and each of the tank cover and the flange portion. Then, since the expansion rubber portion is deformable, the expansion rubber portion can seal the inner space of the tank cover regardless of the thermal expansion and thermal contraction of the tank main body portion, the tank dome, and the flange portion.

**[0015]** According to the tank dome flange portion structure of the present invention, since the heat transfer suppressing material portion made of the fiber reinforced plastic is provided at the predetermined portion of the flange portion, the heat of the outside air can be prevented from being transferred from the outer peripheral edge portion side of the flange portion to the low-temperature tank dome side. With this, the temperature increase of the liquefied gas stored in the tank main body portion can be suppressed.

**[0016]** Since the heat transfer suppressing material portion is provided at at least the predetermined portion, located between the side wall of the tank dome and the expansion rubber portion, of the flange portion, it is possible to prevent a phenomenon in which the expansion rubber portion is cooled down by the low-temperature tank dome, and this causes low-temperature embrittlement of the expansion rubber portion.

**[0017]** In the tank dome flange portion structure according to the present invention, a thermal contraction absorbing portion configured to absorb deformation caused by thermal contraction of portions including the flange portion and the tank dome is provided at at least the portion, located between the side wall of the tank dome and the expansion rubber portion, of the flange portion.

**[0018]** With this, even if the thermal contraction of the tank main body portion, the tank dome, and the flange portion is caused by the low-temperature liquefied gas stored in the tank main body portion, and the outer peripheral side portion of the flange portion deforms in such a direction as to be pulled inward, this deformation by the thermal contraction can be absorbed by the thermal contraction absorbing portion. Thus, a load generated at a coupled portion where the fiber reinforced plastic heat transfer suppressing material portion of the flange portion and the other portion are coupled to each other can be reduced.

**[0019]** In the tank dome flange portion structure according to the present invention, the heat transfer suppressing material portion is formed in a range from the predetermined portion of the flange portion to an outer peripheral edge portion of the flange portion.

**[0020]** With this, the amount of heat of the outside air transferred from the outer peripheral edge portion side of the flange portion to the low-temperature tank dome side can be effectively suppressed.

**[0021]** In the tank dome flange portion structure according to the present invention, the thermal contraction absorbing portion is formed such that a cross section thereof in a radial direction of the flange portion has a bent shape including a substantially L shape or a substantially U shape.

**[0022]** With this, if the outer peripheral side portion of the flange portion deforms by the thermal contraction of the tank dome, the flange portion, and the like in such a direction as to be pulled inward, the thermal contraction absorbing portion having the bent shape including the substantially L-shaped or substantially U-shaped cross section can deform in such a direction that, for example, the angle of the L shape or the width of the U shape increases. With this, while adopting a simple configuration, the force of the deformation of the flange portion based on the thermal contraction can be absorbed, and the deformation of the outer peripheral side portion of the flange portion can be suppressed.

**[0023]** In the tank dome flange portion structure according to the present invention, the thermal contraction absorbing portion is formed at the heat transfer suppressing material portion, or the heat transfer suppressing material portion is formed at the thermal contraction absorbing portion.

**[0024]** With this, the heat transfer suppressing material portion can have both a thermal contraction absorbing function and a heat transfer suppressing function, or the thermal contraction absorbing portion can have both the thermal contraction absorbing function and the heat transfer suppressing function. Therefore, the configuration can be simplified.

**[0025]** In the tank dome flange portion structure according to the present invention, the flange portion is configured such that a coupling part and the heat transfer suppressing material portion are formed by integral molding, the coupling part being located on the tank dome side of the heat transfer suppressing material portion made of the fiber reinforced

plastic.

**[0026]** With this, the airtightness of the coupled portion can be surely secured, and the productivity of the flange portion can be improved.

**[0027]** In the tank dome flange portion structure according to the present invention, the heat transfer suppressing material portion and an inner peripheral side portion, located on the tank dome side of the heat transfer suppressing material portion made of the fiber reinforced plastic, of the flange portion are formed such that: the inner peripheral side portion of the flange portion is constituted by a coupling part and a base end part; the heat transfer suppressing material portion and the coupling part are molded integrally; and the coupling part molded integrally with the heat transfer suppressing material portion is coupled to the base end part coupled to the side wall of the tank dome.

**[0028]** As above, by integrating the heat transfer suppressing material portion and the coupling part to form a composite part, the heat transfer suppressing material portion made of the fiber reinforced plastic and the coupling part can be surely coupled to each other. Therefore, the airtightness of the coupled portion can be easily secured. Then, the coupling part integrated with the heat transfer suppressing material portion is coupled to the base end part coupled to the side wall of the tank dome. With this, the degree of freedom of the positioning of the coupled portion where the coupling part and the base end portion are coupled to each other improves.

**[0029]** In the tank dome flange portion structure according to the present invention, an inner peripheral side portion of the flange portion is made of a metal, the inner peripheral side portion being located on the tank dome side of the heat transfer suppressing material portion made of the fiber reinforced plastic.

**[0030]** Since the metal inner peripheral side portion is made of a metal, the flange portion and the side wall of the tank dome can be welded to each other. Thus, the conventional process can be used.

**[0031]** In the tank dome flange portion structure according to the present invention, the heat transfer suppressing material portion is made of glass fiber reinforced plastic or carbon fiber reinforced plastic.

**[0032]** With this, the glass fiber reinforced plastic or the carbon fiber reinforced plastic may be used as the material of the heat transfer suppressing material portion depending on the required strength and thermal insulation performance of the heat transfer suppressing material portion.

#### Advantageous Effects of Invention

**[0033]** According to the tank dome flange portion structure of the present invention, the heat transfer from the outside air can be reduced, and the temperature increase of the liquefied gas stored in the tank main body portion can be suppressed.

#### Brief Description of Drawings

**[0034]**

[Fig. 1] Fig. 1 is a longitudinal sectional view showing a tank dome flange portion structure according to Embodiment 1 of the present invention.

[Figs. 2A and 2B] Fig. 2A is a diagram showing the result of a temperature distribution simulation of respective portions of the tank dome flange portion structure according to Embodiment 1, and Fig. 2B is a diagram in which a thermal insulation member is removed from Fig. 2A.

[Fig. 3] Fig. 3 is a longitudinal sectional view showing a state where a tank dome and a flange portion shown in Fig. 1 have deformed by thermal contraction.

[Figs. 4A and 4B] Fig. 4A is a partial cross-sectional perspective view of a simulation model showing a state before the thermal contraction of the tank dome and the flange portion shown in Fig. 1. Fig. 4B is a partial cross-sectional enlarged perspective view of a simulation model showing the flange portion shown in Fig. 4A.

[Figs. 5A and 5B] Fig. 5A is a partial cross-sectional perspective view showing the result of a simulation showing a state where the thermal contraction of the tank dome and the flange portion shown in Fig. 4A has occurred, and Fig. 5B is a partial cross-sectional enlarged perspective view showing the result of a simulation showing the flange portion shown in Fig. 5A.

[Figs. 6A and 6B] Fig. 6A is a diagram showing the result of the temperature distribution simulation of respective portions of the tank dome flange portion structure according to Embodiment 2 of the present invention, and Fig. 6B is a diagram showing the result of the temperature distribution simulation of the tank dome and the flange portion shown in Fig. 6A.

[Fig. 7] Fig. 7 is a longitudinal sectional view showing a state where the tank dome and the flange portion shown in Fig. 6B have deformed by thermal contraction.

[Figs. 8A and 8B] Fig. 8A is a diagram showing the result of the temperature distribution simulation of respective portions of a conventional tank dome flange portion structure, and Fig. 8B is a diagram showing the result of the

temperature distribution simulation of the tank dome and the flange portion shown in Fig. 8A.

[Fig. 9] Fig. 9 is a partial longitudinal sectional view showing the tank dome flange portion structure according to Embodiment 3 of the present invention.

[Fig. 10] Fig. 10 is a partial longitudinal sectional view showing the tank dome flange portion structure according to Embodiment 4 of the present invention.

[Fig. 11] Fig. 11 is a partial longitudinal sectional view showing the tank dome flange portion structure according to Embodiment 5 of the present invention.

[Fig. 12] Fig. 12 is a partial longitudinal sectional view showing the tank dome flange portion structure according to Embodiment 6 of the present invention.

[Fig. 13] Fig. 13 is a partial longitudinal sectional view showing the tank dome flange portion structure according to Embodiment 7 of the present invention.

[Fig. 14] Fig. 14 is a partial longitudinal sectional view showing the tank dome flange portion structure according to Embodiment 8 of the present invention.

[Fig. 15] Fig. 15 is a partial longitudinal sectional view showing the tank dome flange portion structure according to Embodiment 9 of the present invention.

[Fig. 16] Fig. 16 is a partial longitudinal sectional view showing the tank dome flange portion structure according to Embodiment 10 of the present invention.

[Fig. 17] Fig. 17 is a schematic longitudinal sectional view showing a conventional substantially cylindrical liquefied gas tank.

[Fig. 18] Fig. 18 is a partial enlarged perspective view showing the tank dome provided at the conventional liquefied gas tank shown in Fig. 17.

[Figs. 19A and 19B] Fig. 19A is a partial longitudinal sectional view showing the tank dome flange portion structure of another conventional spherical liquefied gas tank, and Fig. 19B is a plan view of the tank dome shown in Fig. 19A.

## Description of Embodiments

**[0035]** Hereinafter, Embodiment 1 of a tank dome flange portion structure according to the present invention will be explained in reference to Figs. 1 to 5B. A tank dome flange portion structure 21 of the present embodiment is provided at a liquefied gas tank configured to store a liquefied gas, such as a low-temperature liquefied natural gas (LNG). The following will explain an example in which the tank dome flange portion structure 21 is applied to the conventional liquefied gas tank 1 shown in Fig. 17. Therefore, the same reference signs are used for the same components as in the conventional liquefied gas tank 1, and detailed explanations thereof are omitted.

**[0036]** The tank dome flange portion structure 21 of the present embodiment is applied to, for example, a liquefied gas tank provided at a liquefied gas carrier.

**[0037]** The liquefied gas tank 1 to which the tank dome flange portion structure 21 shown in Fig. 1 is applied includes: the tank main body portion 2 (see Fig. 17) configured to store the low-temperature liquefied gas; the tank dome 3 provided at an upper portion of the tank main body portion 2; and the tank cover 6 configured to cover the tank main body portion 2 with a space therebetween.

**[0038]** As shown in Fig. 1, a flange portion 22 includes an inner peripheral side portion 23 and an outer peripheral side portion 24.

**[0039]** As shown in Fig. 1, the tank dome flange portion structure 21 includes: the annular flange portion 22 projecting substantially horizontally from the outer surface of the side wall 3a of the tank dome 3; and the annular expansion rubber portion 11 provided between the lower surface of the flange portion 22 and the upper opening edge portion of the tank cover 6 and configured to seal the space 5.

**[0040]** The inner peripheral side portion 23 of the flange portion 22 is provided on the tank dome 3 side and includes a base end portion 23a and a coupling portion 23b, both of which are made of a metal (such as an aluminum alloy). The base end portion 23a is an annular plate body, and an inner peripheral edge portion thereof is joined to the outer surface of the side wall 3a of the tank dome 3, made of a metal (such as an aluminum alloy), by welding or the like. Thus, the base end portion 23a projects substantially horizontally from the outer surface of the side wall 3a. The coupling portion 23b is a short cylindrical body and extends in a vertical direction, and a lower end portion thereof is joined to an upper surface of an outer peripheral edge portion of the base end portion 23a by welding or the like.

**[0041]** As shown in Fig. 1, the outer peripheral side portion 24 is provided outside the inner peripheral side portion 23 and is made of fiber reinforced plastic (hereinafter, FRP) by integral molding. The outer peripheral side portion 24 is formed such that a cross section thereof in a radial direction of the flange portion 22 has a substantially L shape. The outer peripheral side portion 24 includes a vertical portion 24a and a horizontal portion 24b. A short cylindrical reinforcement portion 25 is provided at an outer peripheral edge portion of the horizontal portion 24b. Further, a lower portion of the vertical portion 24a is joined to the coupling portion 23b by the integral molding.

**[0042]** Since the coupling portion 23b (the inner peripheral side portion 23) and the vertical portion 24a (the outer

peripheral side portion 24) are joined to each other as above, the airtightness of this coupled portion is secured. As shown in Fig. 1, the coupling portion 23b is provided outside the vertical portion 24a. With this, as described below, if the thermal contraction of the tank dome 3, the inner peripheral side portion 23 of the flange portion 22, and the like occurs, the coupling portion 23b of the inner peripheral side portion 23 deforms in an inner direction (in such a direction that the airtightness is secured) toward the vertical portion 24a of the outer peripheral side portion 24. As a result, the airtightness therebetween can be prevented from being lost by the thermal contraction of the tank dome 3 and the like.

**[0043]** Further, as shown in Fig. 1, the thermal insulation member 4 having a predetermined thickness is provided on the entire outer surface of the tank dome 3. Then, the entire surface of the inner peripheral side portion 23 of the flange portion 22 is also covered with the thermal insulation member 4. In addition, an inner peripheral surface of the vertical portion 24a of the outer peripheral side portion 24 of the flange portion 22 and an outer peripheral surface of the lower portion of the vertical portion 24a are also covered with the thermal insulation member 4. As shown in Fig. 1, the thermal insulation member 4 is not provided on upper and lower surfaces of the horizontal portion 24b of the outer peripheral side portion 24 of the flange portion 22. This is because the horizontal portion 24b itself has a thermal insulation property, and the horizontal portion 24b and the metal inner peripheral side portion 23 are spaced apart from each other.

**[0044]** As above, since the metal inner peripheral side portion 23 and a part of the vertical portion 24a are covered with the thermal insulation member 4, the heat of the outside air can be prevented from being transferred through the metal inner peripheral side portion 23 into the tank dome 3 side.

**[0045]** The expansion rubber portion 11 shown in Fig. 1 is an annular deformable rubber-like elastic body. The expansion rubber portion 11 is provided between the lower surface of an outer peripheral portion of the outer peripheral side portion 24 of the flange portion 22 and the upper opening edge portion of the tank cover 6. An upper portion of the expansion rubber portion 11 is coupled to the lower surface of the outer peripheral portion of the flange portion 22 by bolts 27, and a lower portion thereof is coupled to the upper opening edge portion of the tank cover 6 by the bolts 27.

**[0046]** Next, a heat transfer suppressing material portion included in the tank dome flange portion structure 21 will be explained in reference to Fig. 1.

**[0047]** The heat transfer suppressing material portion prevents the heat of the outside air from being transferred through the flange portion 22 to the tank dome 3. This function can be achieved by forming the outer peripheral side portion 24 of the flange portion 22 as the heat transfer suppressing material portion made of FRP having low thermal conductivity.

**[0048]** As the FRP that is the material of the outer peripheral side portion 24 of the flange portion 22, glass fiber reinforced plastic (hereinafter, GFRP) or carbon fiber reinforced plastic (hereinafter, CFRP) may be used.

**[0049]** These GFRP and CFRP are extremely lower in thermal conductivity than a metal, such as an aluminum alloy or stainless steel. Therefore, in a case where the outer peripheral side portion 24 of the flange portion 22 is made of, for example, GFRP, the outer peripheral side portion 24 can serve as the heat transfer suppressing material portion.

**[0050]** Here, as shown in Fig. 1, the flange portion 22 is not entirely made of FRP, that is, the inner peripheral side portion 23 is made of a metal. This is because the inner peripheral side portion 23 can be welded to the side wall 3a of the metal tank dome 3, and the conventional process can be used.

**[0051]** Fig. 2A is a diagram showing the result of a temperature distribution simulation of respective portions of the tank dome flange portion structure 21 shown in Fig. 1, and Fig. 2B is a diagram showing the result of the temperature distribution simulation of the tank dome 3 and the flange portion 22 shown in Fig. 2A.

**[0052]** As is clear from Figs. 2A and 2B, the horizontal portion 24b of the FRP outer peripheral side portion 24 of the flange portion 22 and the upper portion of the vertical portion 24a of the FRP outer peripheral side portion 24 of the flange portion 22 have a substantially outside air temperature. However, since the FRP outer peripheral side portion 24 is low in thermal conductivity, almost no heat is transferred to the lower portion of the vertical portion 24a and the coupling portion 23b coupled thereto, which are covered with the thermal insulation member 4. Therefore, each of the temperature of the lower portion of the vertical portion 24a and the temperature of the coupling portion 23b coupled thereto is slightly higher than the temperature of the tank dome 3 but is a low temperature. Then, the temperature of the base end portion 23a of the metal inner peripheral side portion 23 of the flange portion 22 is substantially equal to the temperature of the tank dome 3, that is, a low temperature. Therefore, it is clear that almost no heat of the outside air is transferred through the flange portion 22 to the tank dome 3.

**[0053]** Next, the actions of the tank dome flange portion structure 21 configured as above will be explained. First, according to the liquefied gas tank at which the tank dome flange portion structure 21 shown in Fig. 1 is provided, the tank main body portion 2 (see Fig. 17) can store the low-temperature liquefied gas, and a pipe (not shown) through which the liquefied gas is supplied to and discharged from the liquefied gas tank is attached to the tank dome 3. The tank cover 6 and the flange portion 22 can cover the tank main body portion 2 with the space 5 between the tank main body portion 2 and each of the tank cover 6 and the flange portion 22. Then, since the expansion rubber portion 11 is deformable, the expansion rubber portion 11 can seal the inner space 5 of the tank cover 6 regardless of the thermal expansion and thermal contraction of the tank main body portion 2, the tank dome 3, and the flange portion 22.

**[0054]** Therefore, the airtightness of the inner space 5 of the tank cover 6 can be secured, and for example, a nitrogen

gas or the like can be appropriately, airtightly sealed in the space 5.

**[0055]** According to the tank dome flange portion structure 21 configured as above, as shown in Fig. 1, the outer peripheral side portion 24 of the flange portion 22 is made of FRP, and the outer peripheral side portion 24 serves as the heat transfer suppressing material portion. Therefore, the heat of the outside air can be prevented from being transferred from the outer peripheral edge portion side of the flange portion 22 to the low-temperature tank dome 3 side.

**[0056]** The heat transfer suppressing material portion is formed in a range from a predetermined portion between the outer surface of the side wall 3a of the tank dome 3 and the expansion rubber portion 11 to the outer peripheral edge portion of the flange portion 22. Therefore, the amount of heat of the outside air transferred from the outer peripheral edge portion side of the flange portion 22 to the low-temperature tank dome 3 side can be effectively suppressed.

**[0057]** With this, the temperature increase of the liquefied gas stored in the tank main body portion 2 can be effectively suppressed.

**[0058]** Since the outer peripheral side portion 24 of the flange portion 22 is made of FRP, the heat transfer suppressing material portion is provided at at least a predetermined portion of the flange portion 22, the predetermined portion being located between the side wall 3a of the tank dome 3 and the expansion rubber portion 11. Therefore, it is possible to prevent a phenomenon in which the expansion rubber portion 11 is cooled down by the low-temperature tank dome 3, and this causes low-temperature embrittlement of the expansion rubber portion 11.

**[0059]** Next, a thermal contraction absorbing portion included in the tank dome flange portion structure 21 will be explained in reference to Fig. 1.

**[0060]** The thermal contraction absorbing portion suppresses the deformation of the outer peripheral side portion 24 of the flange portion 22 when the portions including the tank dome 3 and the flange portion 22 are cooled down by the liquefied gas stored in the tank main body portion 2, and this causes the thermal contraction of those portions. As shown in Fig. 1, the thermal contraction absorbing portion is provided at at least a portion of the flange portion 22, the portion being located between the side wall 3a of the tank dome 3 and the expansion rubber portion 11.

**[0061]** More specifically, the thermal contraction absorbing portion is formed such that a cross section thereof in the radial direction of the flange portion 22 has a bent shape that is a substantially L shape. Further, the thermal contraction absorbing portion is a portion including a bent portion where the horizontal portion 24b and vertical portion 24a of the outer peripheral side portion 24 of the flange portion 22 are coupled to each other.

**[0062]** The thermal contraction absorbing portion shown in Fig. 1 is formed such that the cross section thereof in the radial direction of the flange portion 22 has the bent shape that is the substantially L shape. Therefore, as shown in Fig. 3, if the thermal deformation of the outer peripheral side portion 24 of the flange portion 22 occurs by the thermal contraction of the tank dome 3, the flange portion 22, and the like in such a direction that the outer peripheral side portion 24 is pulled inward, the thermal contraction absorbing portion having the substantially L-shaped cross section can deform inward such that the angle of the thermal contraction absorbing portion increases.

**[0063]** With this, while adopting a simple configuration, the deformation of the outer peripheral side portion 24 of the flange portion 22 can be suppressed by partial deformation of the thermal contraction absorbing portion when the entire flange portion 22 deforms based on the thermal deformation.

**[0064]** Further, a load generated at the coupled portion where the FRP heat transfer suppressing material portion (the outer peripheral side portion 24) of the flange portion 22 and the inner peripheral side portion 23 are coupled to each other can be reduced.

**[0065]** As shown in Fig. 1, the thermal contraction absorbing portion is formed at the heat transfer suppressing material portion. Therefore, the heat transfer suppressing material portion can have both a thermal contraction absorbing function and a heat transfer suppressing function. Thus, the configuration can be simplified.

**[0066]** Although not shown, instead of the above, the heat transfer suppressing material portion may be formed at the thermal contraction absorbing portion. In this case, the thermal contraction absorbing portion can have both the thermal contraction absorbing function and the heat transfer suppressing function. Thus, the configuration can be simplified.

**[0067]** Next, Figs. 4A, 4B, 5A, and 5B will be explained. Fig. 4A is a partial cross-sectional perspective view of a simulation model showing a state before the thermal contraction of the tank dome 3 and the flange portion 22 shown in Fig. 1. Fig. 4B is a partial cross-sectional enlarged perspective view of the result of a simulation showing the flange portion 22 shown in Fig. 4A. Fig. 5A is a partial cross-sectional perspective view of the result of a simulation showing a state where the thermal contraction of the tank dome 3 and the flange portion 22 shown in Fig. 4A has occurred.

**[0068]** Fig. 5B is a partial cross-sectional enlarged perspective view of the result of a simulation showing the flange portion 22 shown in Fig. 5A.

**[0069]** In the flange portion 22 shown in Figs. 5A and 5B, the amount of displacement of the tank in a radially inward direction is denoted by a color density. The lighter the color becomes, the larger the amount of displacement becomes.

**[0070]** As shown in Fig. 5B, in a state where the thermal contraction of the tank dome 3 and the flange portion 22 has occurred, the amount of displacement of each of the outer peripheral side portion 24, reinforcement portion 25, and thermal contraction absorbing portion of the flange portion 22 becomes large, and especially the amount of displacement of the vertical portion 24a becomes large. Therefore, it is clear that the vertical portion 24a has absorbed the thermal

contraction.

**[0071]** Next, the results of the temperature distribution simulations of a tank dome flange portion structure 31 and the like of Embodiment 2 and the like of the present invention and an example in which the tank dome 3, a flange portion 32, and the like have deformed by the thermal contraction will be explained in reference to Figs. 6A to 8B.

**[0072]** Fig. 6A is a diagram showing the result of the temperature distribution simulation of respective portions of the tank dome flange portion structure 31 according to Embodiment 2. Fig. 6B is a diagram showing the result of the temperature distribution simulation of the tank dome 3 and the flange portion 32 shown in Fig. 6A. Fig. 7 is a longitudinal sectional view showing a state where the tank dome 3 and the flange portion 32 shown in Fig. 6B have deformed by the thermal contraction.

**[0073]** The tank dome flange portion structure 31 according to Embodiment 2 shown in Figs. 6A, 6B, and 7 and the tank dome flange portion structure 21 according to Embodiment 1 shown in Figs. 2A, 2B, and 3 are different from each other in that: in Embodiment 1 shown in Fig. 2B, the thermal contraction absorbing portion having the substantially L-shaped cross section is provided; and in Embodiment 2 shown in Fig. 6B, such a thermal contraction absorbing portion is not provided. Other than this, Embodiment 2 is the same as Embodiment 1, so that a repetition of the same explanation is avoided.

**[0074]** The flange portion 32 of the tank dome flange portion structure 31 according to Embodiment 2 shown in Figs. 6A and 6B includes an inner peripheral side portion 33 and an outer peripheral side portion 34. Each of the inner peripheral side portion 33 and the outer peripheral side portion 34 is formed by an annular flat plate body. The inner peripheral side portion 33 is made of a metal, such as an aluminum alloy, as with Embodiment 1. The outer peripheral side portion 34 is made of FRP as with Embodiment 1 and serves as the heat transfer suppressing material portion. Although not shown, an outer peripheral edge portion of the inner peripheral side portion 33 and an inner peripheral edge portion of the outer peripheral side portion 34 vertically overlap each other to be coupled to each other by a plurality of bolts, penetrating therethrough in the vertical direction, such that the airtightness is maintained. Contacting surfaces of those portions 33 and 34 are joined to each other by, for example, the integral molding and airtightly sealed.

**[0075]** Further, as shown in Fig. 6A, the thermal insulation member 4 having a predetermined thickness is provided on the entire outer surface of the tank dome 3. Then, the entire surface of the inner peripheral side portion 33 of the flange portion 32 and the inner peripheral edge portion of the outer peripheral side portion 34 are also covered with the thermal insulation member 4.

**[0076]** As is clear from Figs. 6A and 6B, the temperature of the FRP outer peripheral side portion 34 of the flange portion 32 is a substantially outside air temperature. However, since the FRP outer peripheral side portion 34 is low in thermal conductivity, almost no heat is transferred to the inner peripheral edge portion of the outer peripheral side portion 34 covered with the thermal insulation member 4. Therefore, the temperature of the inner peripheral edge portion of the outer peripheral side portion 34 is slightly higher than the temperature of the tank dome 3 but is a low temperature. On this account, the temperature of the metal inner peripheral side portion 33 of the flange portion 32 is a low temperature substantially equal to the temperature of the tank dome 3. Thus, it is clear that almost no heat of the outside air is transferred through the flange portion 32 to the tank dome 3.

**[0077]** Fig. 8A is a diagram showing the result of the temperature distribution simulation of respective portions of the conventional tank dome flange portion structure 10 shown in, for example, Figs. 19A and 19B. Fig. 8B is a diagram showing the result of the temperature distribution simulation of the tank dome 3 and the flange portion 8 shown in Fig. 8A.

**[0078]** The flange portion 8 of the conventional tank dome flange portion structure 10 shown in Figs. 8A and 8B is formed by one annular flat plate body, and the material thereof is a metal, such as an aluminum alloy.

**[0079]** As shown in Fig. 8A, the thermal insulation member 4 having a predetermined thickness is provided on the entire outer surface of the tank dome 3. Then, the entire surface of a portion of the flange portion 8 is also covered with the thermal insulation member 4, the portion extending from a substantially radially middle portion of the flange portion 8 to the tank dome 3 side.

**[0080]** As is clear from Figs. 8A and 8B, in the conventional tank dome flange portion structure 10, the flange portion 8 is made of a metal and high in thermal conductivity, and the heat transfer suppressing material portion is not provided. Therefore, although the portion, located on the tank dome 3 side, of the flange portion 8 is covered with the thermal insulation member 4, the heat of the outside air is transferred to the flange portion 8 covered with the thermal insulation member 4, and the inner peripheral edge portion of the flange portion 8 increases in temperature. Thus, it is clear that the amount of heat of the outside air transferred to the tank dome 3 herein is larger than that in each of Embodiments 1 and 2.

**[0081]** Next, a method of manufacturing the flange portion 22 provided at the tank dome 3 shown in Fig. 1 will be explained. Before the flange portion 22 is welded to the side wall 3a of the tank dome 3, the flange portion 22 includes: the FRP outer peripheral side portion 24 (in which the thermal contraction absorbing portion is configured by the heat transfer suppressing material portion); a base end part (base end portion) 23a constituting the inner peripheral side portion 23 made of a metal; and a coupling part (coupling portion) 23b constituting the inner peripheral side portion 23 made of a metal. Therefore, first, the base end part (base end portion) 23a and the coupling part (coupling portion) 23b

are manufactured.

**[0082]** Next, a composite part is manufactured by integrating the heat transfer suppressing material portion and the coupling part 23b using, for example, a shaping die. Here, in order that the heat transfer suppressing material portion and the coupling part 23b obtained by the integral molding can be joined to each other, for example, the surface of the coupling part 23b made of a metal is subjected to surface roughening. With this, the FRP that is the heat transfer suppressing material portion can be joined to the surface of the coupling part 23b.

**[0083]** In addition, as shown in Fig. 1, the base end part 23a constituting the inner peripheral side portion 23 made of a metal is welded to the outer surface of the side wall 3a of the tank dome 3. After that, as shown in Fig. 1, the coupling part 23b formed integrally with the heat transfer suppressing material portion is welded to a desired position of the base end part 23a coupled to the side wall 3a of the tank dome 3. Thus, the flange portion 22 can be provided at the tank dome 3.

**[0084]** As above, by integrating the heat transfer suppressing material portion and the coupling part 23b to manufacture the composite part, the degree of freedom of the positioning of the coupled portion where the coupling part 23a and the metal coupling part 23b are coupled to each other improves. Therefore, the quality of the joining improves, and the airtightness of the joined portion where the FRP heat transfer suppressing material portion and the metal coupling part 23b are joined to each other can be easily secured by the integrated composite part.

**[0085]** With this, the airtightness of the space 5 in the tank cover 6 can be surely secured.

**[0086]** Next, a tank dome flange portion structure 38 according to Embodiment 3 of the present invention will be explained in reference to Fig. 9. Embodiment 3 shown in Fig. 9 and Embodiment 1 shown in Fig. 1 are different from each other in that: in Embodiment 1 shown in Fig. 1, the outer peripheral side portion 24 and reinforcement portion 25 of the flange portion 22 are made of FRP by the integral molding; and in Embodiment 3 shown in Fig. 9, an outer peripheral portion 40 of an outer peripheral side portion 42 of a flange portion 39 is made of a metal, such as an aluminum alloy, and the outer peripheral portion 40 and an outer peripheral side portion main body 41 made of FRP are coupled to each other by the bolts 27. Other than these, Embodiment 3 is the same as Embodiment 1 shown in Fig. 1. Therefore, the same reference signs are used for the same components, and explanations thereof are omitted. With this, a pipe support (not shown) configured to suppress vibrations of the pipe can be welded to the outer peripheral portion 40.

**[0087]** The outer peripheral side portion main body 41 shown in Fig. 9 serves as the heat transfer suppressing material portion. The thermal contraction absorbing portion is constituted by the outer peripheral side portion main body 41 including the vertical portion 24a.

**[0088]** As shown in Fig. 9, the coupling portion 23b is provided outside the vertical portion 24a in the radial direction. Instead of this, the coupling portion 23b may be provided inside the vertical portion 24a in the radial direction.

**[0089]** Fig. 10 shows a tank dome flange portion structure 54 according to Embodiment 4 of the present invention. Embodiment 4 shown in Fig. 10 and Embodiment 1 shown in Fig. 1 are different from each other regarding a flange portion 55 and the flange portion 22.

**[0090]** In the flange portion 22 of Embodiment 1 shown in Fig. 1, the coupling portion 23b of the annular inner peripheral side portion 23 and the vertical portion 24a of the annular outer peripheral side portion 24 are coupled to each other by a plurality of bolts 26, penetrating therethrough in a horizontal direction, so as to overlap each other at outer and inner sides.

**[0091]** In the flange portion 55 of Embodiment 4 shown in Fig. 10, the coupling portion 23b of the annular inner peripheral side portion 23 and the vertical portion 24a of the annular outer peripheral side portion 24 are coupled to each other by a coupling structure described below.

**[0092]** Each of the coupling portion 23b of the inner peripheral side portion 23 and the vertical portion 24a of the outer peripheral side portion 24 is bent so as to have a substantially L-shaped cross section. Two annular horizontal portions 56 and 57 bent to be parallel to the horizontal direction are coupled to each other by a plurality of bolts 26, penetrating therethrough in the vertical direction, so as to vertically overlap each other. Other than this, Embodiment 4 is the same as Embodiment 1 shown in Fig. 1. Therefore, the same reference signs are used for the same components, and explanations thereof are omitted.

**[0093]** The outer peripheral side portion 24 shown in Fig. 10 serves as the thermal contraction absorbing portion and also serves as the heat transfer suppressing material portion. As shown in Fig. 10, the horizontal portions 56 and 57 are provided outside the inner space 5 of the tank cover 6. However, instead of this, the horizontal portions 56 and 57 may be provided on the inner space 5 side of the tank cover 6.

**[0094]** Fig. 11 shows a tank dome flange portion structure 61 according to Embodiment 5 of the present invention. A flange portion 62 of the tank dome flange portion structure 61 according to Embodiment 5 shown in Fig. 11 includes an inner peripheral side portion 63, an outer peripheral side portion 64, a heat transfer suppressing material portion 65, and thermal contraction absorbing portions 66 and 67. Then, each of the inner peripheral side portion 63 and the outer peripheral side portion 64 is formed by an annular flat plate body and made of a metal, such as an aluminum alloy. As with Embodiment 1, the heat transfer suppressing material portion 65 is made of FRP.

**[0095]** As shown in Fig. 11, the heat transfer suppressing material portion 65 has a substantially short cylindrical shape, and a cross section thereof in the radial direction has a substantially Z shape. Contacting surfaces of an upper horizontal portion 65a of the heat transfer suppressing material portion 65 and an inner peripheral portion of the outer

peripheral side portion 64 are joined to each other by, for example, the integral molding and fastened to each other by bolts 68 such that the airtightness is maintained. In addition, contacting surfaces of a lower horizontal portion 65b of the heat transfer suppressing material portion 65 and an outer peripheral portion of the inner peripheral side portion 63 are joined to each other with, for example, adhesive and fastened to each other by the bolts 68 such that the airtightness is maintained.

**[0096]** Further, as shown in Fig. 11, the thermal insulation member 4 having a predetermined thickness is provided on the entire outer surface of the tank dome 3. Then, the inner peripheral side portion 63 and heat transfer suppressing material portion 65 of the flange portion 62 are also covered with the thermal insulation member 4. Lower and upper end portions of the heat transfer suppressing material portion 65 respectively serve as the thermal contraction absorbing portions 66 and 67.

**[0097]** As shown in Fig. 11, in a case where the outer peripheral side portion 64 is made of a metal, such as an aluminum alloy, a pipe support (not shown) can be welded to the outer peripheral side portion 64, as explained in Embodiment 3 shown in Fig. 9.

**[0098]** Fig. 12 shows a tank dome flange portion structure 72 according to Embodiment 6 of the present invention. Embodiment 6 shown in Fig. 12 and Embodiment 5 shown in Fig. 11 are different from each other regarding a flange portion 73 and the flange portion 62.

**[0099]** In the flange portion 62 of Embodiment 5 shown in Fig. 11, the heat transfer suppressing material portion 65 is formed such that the cross section thereof in the radial direction has the substantially Z shape. In the flange portion 73 of Embodiment 6 shown in Fig. 12, a heat transfer suppressing material portion 74 is formed such that a cross section thereof in the radial direction has a substantially I shape. A horizontal portion 65a provided at an upper end portion of the heat transfer suppressing material portion 74 and extending in radially inward and outward directions is fastened to the outer peripheral side portion 64 by the bolts 68, and a horizontal portion 65b provided at a lower end portion of the heat transfer suppressing material portion 74 and extending in radially inward and outward directions is fastened to the inner peripheral side portion 63 by the bolts 69.

**[0100]** Other than this, Embodiment 6 is the same as Embodiment 5 shown in Fig. 11. Therefore, the same reference signs are used for the same components, and explanations thereof are omitted.

**[0101]** Fig. 13 shows tank dome flange portion structure 46 according to Embodiment 7 of the present invention. Embodiment 7 shown in Fig. 13 and Embodiment 2 shown in Figs. 6A, 6B, and 7 are different from each other regarding a flange portion 47 and the flange portion 32.

**[0102]** In the flange portion 32 of Embodiment 2 shown in Figs. 6A and 6B, the outer peripheral edge portion of the annular inner peripheral side portion 33 and the inner peripheral edge portion of the annular outer peripheral side portion 34 are coupled to each other by a plurality of bolts (not shown), penetrating therethrough in the vertical direction, so as to vertically overlap each other.

**[0103]** In the flange portion 47 of Embodiment 7 shown in Fig. 13, each of the outer peripheral edge portion of the annular inner peripheral side portion 33 and the inner peripheral edge portion of the annular outer peripheral side portion 34 is bent so as to have a substantially L-shaped cross section. Two short cylindrical vertical portions 48 and 49 bent to be parallel to the vertical direction are coupled to each other by a plurality of bolts 50, penetrating therethrough in the horizontal direction, so as to overlap each other at inner and outer sides. Other than this, Embodiment 7 is the same as Embodiment 2 shown in Figs. 6A and 6B. Therefore, the same reference signs are used for the same components, and explanations thereof are omitted.

**[0104]** Two bent portions, each having a substantially L-shaped cross section, of the flange portion 47 serve as thermal contraction absorbing portions 51. The outer peripheral side portion 34 serves as the heat transfer suppressing material portion.

**[0105]** With this, even if the thermal deformation of the inner peripheral side portion 33 of the flange portion 47 shown in Fig. 13 occurs in such a direction that the inner peripheral side portion 33 is pulled toward the tank dome 3, and the two thermal contraction absorbing portions 51 each having the substantially L shape deform in such a direction as to be separated from each other, the thermal contraction based on the thermal deformation can be absorbed, and the deformation of the outer peripheral side portion 34 of the flange portion 47 can be suppressed.

**[0106]** The two short cylindrical vertical portions 48 and 49 shown in Fig. 13 project toward an upper side of the flange portion 47 and are not provided in the inner space 5 of the tank cover 6. Therefore, a large number of bolt holes formed on these two vertical portions 48 and 49 are unlikely to become a cause of the deterioration of the airtightness of the inner space 5.

**[0107]** Fig. 14 shows a tank dome flange portion structure 77 according to Embodiment 8 of the present invention. Embodiment 8 shown in Fig. 14 and Embodiment 2 shown in Figs. 6A and 6B are different from each other regarding a flange portion 78 and the flange portion 32.

**[0108]** At the outer peripheral side portion 34 of the flange portion 32 of Embodiment 2 shown in Figs. 6A and 6B, a thermal contraction absorbing portion 79 is not provided. However, at an outer peripheral side portion 80 of the flange portion 78 of Embodiment 8 shown in Fig. 14, the thermal contraction absorbing portion 79 is provided. Other than this,

Embodiment 8 is the same as Embodiment 2 shown in Figs. 6A and 6B. Therefore, the same reference signs are used for the same components, and explanations thereof are omitted.

[0109] The thermal contraction absorbing portion 79 of the outer peripheral side portion 80 of the flange portion 78 of Embodiment 8 shown in Fig. 14 is formed such that a cross section thereof in the radial direction of the flange portion 78 has a substantially U shape. In a case where the thermal contraction absorbing portion 79 has such a substantially U shape, and even if the thermal deformation of the outer peripheral side portion 80 of the flange portion 78 occurs by the thermal contraction of the tank dome 3, the flange portion 78, and the like in such a direction that the outer peripheral side portion 80 is pulled inward, the thermal contraction absorbing portion 79 having the substantially U-shaped cross section can deform so as to stretch. With this, the deformation of the outer peripheral side portion 80 of the flange portion 78 can be suppressed. The outer peripheral side portion 80 is made of FRP and serves as the heat transfer suppressing material portion.

[0110] Next, a tank dome flange portion structure 83 according to Embodiment 9 of the present invention will be explained in reference to Fig. 15. Embodiment 9 shown in Fig. 15 and Embodiment 2 shown in Figs. 6A and 6B are different from each other in that: in Embodiment 2 shown in Figs. 6A and 6B, the outer peripheral side portion 34 of the flange portion 32 is made of FRP by the integral molding; and in Embodiment 9 shown in Fig. 15, an outer peripheral portion 85 of the outer peripheral side portion 34 of a flange portion 84 is made of a metal, such as an aluminum alloy, and the outer peripheral portion 85 is fastened and fixed to an outer peripheral side portion main body 86, made of FRP, by the bolts 27. Other than this, Embodiment 9 is the same as Embodiment 2 shown in Figs. 6A and 6B. Therefore, the same reference signs are used for the same components, and explanations thereof are omitted.

[0111] As shown in Fig. 15, in a case where the outer peripheral portion 85 is made of a metal, a pipe support (not shown) can be welded to the outer peripheral portion 85, as explained in Embodiment 3 shown in Fig. 9.

[0112] Fig. 16 shows a tank dome flange portion structure 89 according to Embodiment 10 of the present invention. Embodiment 10 shown in Fig. 16 and Embodiment 2 shown in Figs. 6A and 6B are different from each other regarding a flange portion 90 and the flange portion 32.

[0113] In the flange portion 32 of Embodiment 2 shown in Figs. 6A and 6B, the outer peripheral edge portion of the annular inner peripheral side portion 33 and the inner peripheral edge portion of the annular outer peripheral side portion 34 are coupled to each other by a plurality of bolts, penetrating therethrough in the vertical direction, so as to vertically overlap each other.

[0114] In the flange portion 90 of Embodiment 10 shown in Fig. 16, short cylindrical joined portions 91 and 92 are respectively fixed to the outer peripheral edge portion of the annular inner peripheral side portion 33 and the inner peripheral edge portion of the annular outer peripheral side portion 34. These two short cylindrical joined portions 91 and 92 are coupled to each other by a plurality of bolts, penetrating therethrough in the horizontal direction, in a state where an outer peripheral surface of the joined portion 91 and an inner peripheral surface of the joined portion 92 overlap each other. Other than this, Embodiment 10 is the same as Embodiment 2 shown in Figs. 6A and 6B. Therefore, the same reference signs are used for the same components, and explanations thereof are omitted.

[0115] These two short cylindrical joined portions 91 and 92 shown in Fig. 16 project toward both upper and lower sides of the flange portion 90, and upper portions and lower portions of the joined portions 91 and 92 are fastened to each other by a large number of bolts. The inner peripheral side portion 33 and outer peripheral side portion 34 of the flange portion 90 are provided between the bolt fastened at the upper portions of the joined portions 91 and 92 and the bolt fastened at the lower portions of the joined portions 91 and 92. Therefore, even if the flange portion 90 deforms by the thermal contraction of the tank dome 3, the airtightness of the inner space 5 of the tank cover 6 can be surely secured.

[0116] In the above embodiments, to secure the airtightness of the joined portion where the metal portion and FRP portion of the flange portion are joined to each other, the metal portion and the FRP portion may be joined to each other by the integral molding or with the adhesive.

[0117] Although not shown, in each drawing, the configuration in which the flange portion of each embodiment and the thermal insulation member 4 configured to cover the flange portion are provided on the side wall 3a of the tank dome 3 may be changed to have an upper and lower symmetry configuration (upside-down configuration).

## Industrial Applicability

[0118] As above, the tank dome flange portion structure according to the present invention has an excellent effect of being able to suppress the temperature increase of the low-temperature liquefied gas stored in the tank main body portion. Thus, the present invention is suitably applied to such a tank dome flange portion structure.

## Reference Signs List

[0119]

## EP 2 682 337 A1

|    |                        |                                                                                                |
|----|------------------------|------------------------------------------------------------------------------------------------|
|    | 1                      | liquefied gas tank                                                                             |
|    | 2                      | tank main body portion                                                                         |
|    | 2a                     | body portion                                                                                   |
|    | 2b                     | lid body                                                                                       |
| 5  | 3                      | tank dome                                                                                      |
|    | 3a                     | side wall                                                                                      |
|    | 3b                     | lid body                                                                                       |
|    | 4                      | thermal insulation member                                                                      |
|    | 5                      | space                                                                                          |
| 10 | 6                      | tank cover                                                                                     |
|    | 8                      | flange portion                                                                                 |
|    | 11                     | expansion rubber portion                                                                       |
|    | 12                     | pipe                                                                                           |
|    | 21                     | tank dome flange portion structure                                                             |
| 15 | 22                     | flange portion                                                                                 |
|    | 23                     | inner peripheral side portion                                                                  |
|    | 23a                    | base end portion (base end part)                                                               |
|    | 23b                    | coupling portion (coupling part)                                                               |
|    | 24                     | outer peripheral side portion (heat transfer suppressing material portion, thermal contraction |
| 20 |                        | absorbing portion)                                                                             |
|    | 24a                    | vertical portion                                                                               |
|    | 24b                    | horizontal portion                                                                             |
|    | 25                     | reinforcement portion                                                                          |
|    | 26, 27, 35, 50, 68, 69 | bolt                                                                                           |
| 25 | 31                     | tank dome flange portion structure                                                             |
|    | 32                     | flange portion                                                                                 |
|    | 33                     | inner peripheral side portion                                                                  |
|    | 34                     | outer peripheral side portion                                                                  |
|    | 38                     | tank dome flange portion structure                                                             |
| 30 | 39                     | flange portion                                                                                 |
|    | 40                     | outer peripheral portion                                                                       |
|    | 41                     | outer peripheral side portion main body (heat transfer suppressing material portion)           |
|    | 42                     | outer peripheral side portion                                                                  |
|    | 46                     | tank dome flange portion structure                                                             |
| 35 | 47                     | flange portion                                                                                 |
|    | 48, 49                 | vertical portion                                                                               |
|    | 51                     | thermal contraction absorbing portion                                                          |
|    | 54                     | tank dome flange portion structure                                                             |
|    | 55                     | flange portion                                                                                 |
| 40 | 56, 57                 | horizontal portion                                                                             |
|    | 61                     | tank dome flange portion structure                                                             |
|    | 62                     | flange portion                                                                                 |
|    | 63                     | inner peripheral side portion                                                                  |
|    | 64                     | outer peripheral side portion                                                                  |
| 45 | 65                     | heat transfer suppressing material portion                                                     |
|    | 65a, 65b               | horizontal portion                                                                             |
|    | 66, 67                 | thermal contraction absorbing portion                                                          |
|    | 72                     | tank dome flange portion structure                                                             |
|    | 73                     | flange portion                                                                                 |
| 50 | 74                     | heat transfer suppressing material portion                                                     |
|    | 77                     | tank dome flange portion structure                                                             |
|    | 78                     | flange portion                                                                                 |
|    | 79                     | thermal contraction absorbing portion                                                          |
|    | 80                     | outer peripheral side portion                                                                  |
| 55 | 83                     | tank dome flange portion structure                                                             |
|    | 84                     | flange portion                                                                                 |
|    | 85                     | outer peripheral portion                                                                       |
|    | 86                     | outer peripheral side portion main body                                                        |

89 tank dome flange portion structure  
 90 flange portion  
 91, 92 joined portion

5

## Claims

1. A tank dome flange portion structure provided at a liquefied gas tank,  
 the tank dome flange portion structure comprising:

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a flange portion projecting outward from an outer surface of a side wall of a tank dome provided at a tank main body portion configured to store a low-temperature liquefied gas;  
 a tank cover configured to cover the tank main body portion with a space therebetween; and  
 an expansion rubber portion provided between the flange portion and the tank cover and configured to seal the space, wherein  
 a heat transfer suppressing material portion made of fiber reinforced plastic is provided at at least a predetermined portion of the flange portion, the predetermined portion being located between the side wall of the tank dome and the expansion rubber portion.

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2. The tank dome flange portion structure according to claim 1, wherein a thermal contraction absorbing portion configured to absorb thermal contraction of portions including the flange portion and the tank dome is provided at at least the portion, located between the side wall of the tank dome and the expansion rubber portion, of the flange portion.

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3. The tank dome flange portion structure according to claim 1, wherein the heat transfer suppressing material portion is formed in a range from the predetermined portion of the flange portion to an outer peripheral edge portion of the flange portion.

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4. The tank dome flange portion structure according to claim 2, wherein the thermal contraction absorbing portion is formed such that a cross section thereof in a radial direction of the flange portion has a bent shape including a substantially L shape or a substantially U shape.

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5. The tank dome flange portion structure according to claim 2, wherein the thermal contraction absorbing portion is formed at the heat transfer suppressing material portion, or the heat transfer suppressing material portion is formed at the thermal contraction absorbing portion.

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6. The tank dome flange portion structure according to claim 1, wherein the flange portion is configured such that a coupling part and the heat transfer suppressing material portion are formed by integral molding, the coupling part being located on the tank dome side of the heat transfer suppressing material portion made of the fiber reinforced plastic.

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7. The tank dome flange portion structure according to claim 1, wherein the heat transfer suppressing material portion and an inner peripheral side portion, located on the tank dome side of the heat transfer suppressing material portion made of the fiber reinforced plastic, of the flange portion are formed such that: the inner peripheral side portion of the flange portion is constituted by a coupling part and a base end part; the heat transfer suppressing material portion and the coupling part are molded integrally; and the coupling part molded integrally with the heat transfer suppressing material portion is coupled to the base end part coupled to the side wall of the tank dome.

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8. The tank dome flange portion structure according to claim 1, wherein an inner peripheral side portion of the flange portion is made of a metal, the inner peripheral side portion being located on the tank dome side of the heat transfer suppressing material portion made of the fiber reinforced plastic.

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9. The tank dome flange portion structure according to claim 1, wherein the heat transfer suppressing material portion is made of glass fiber reinforced plastic or carbon fiber reinforced plastic.

55

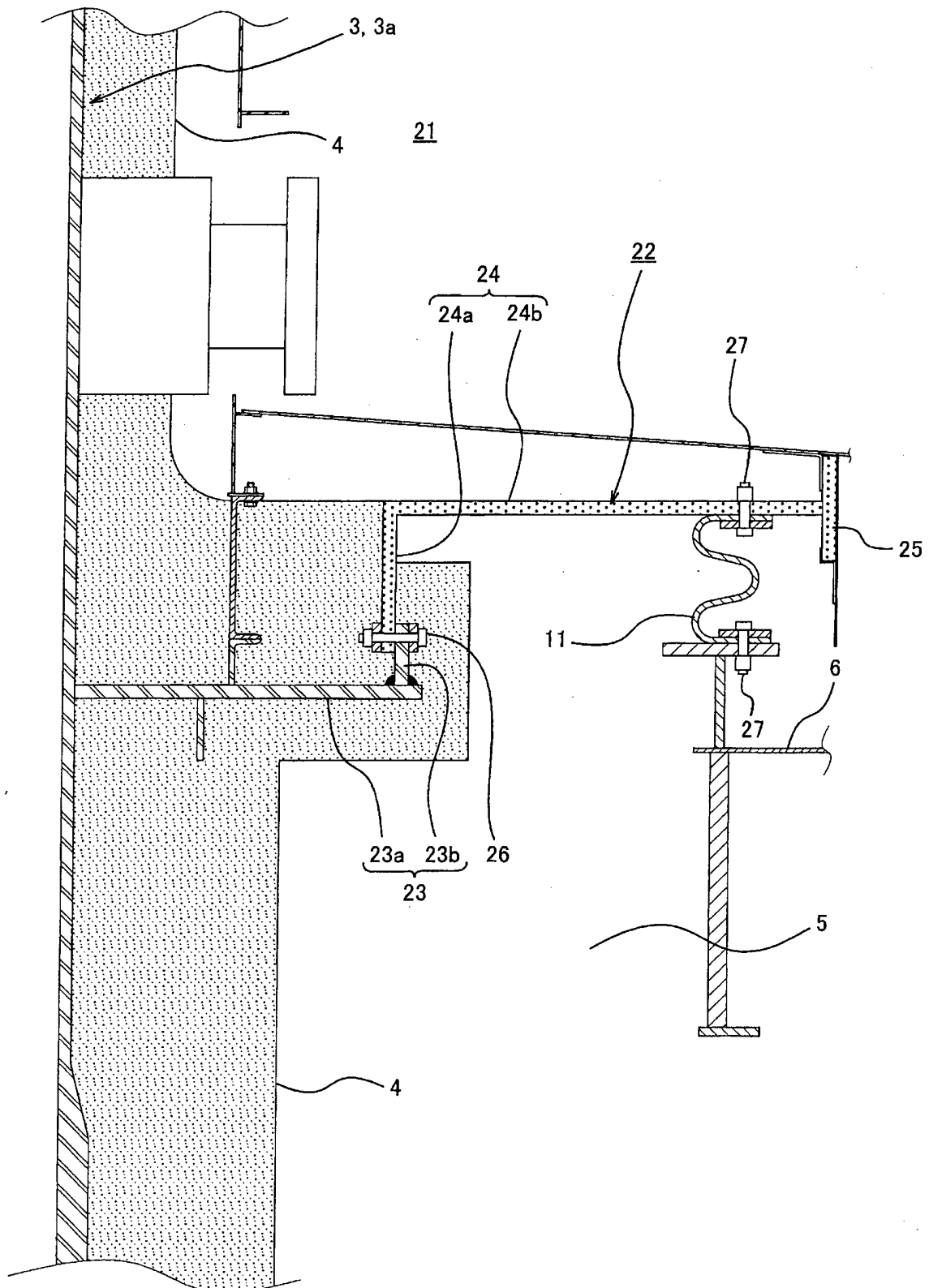


Fig. 1

Fig. 2A

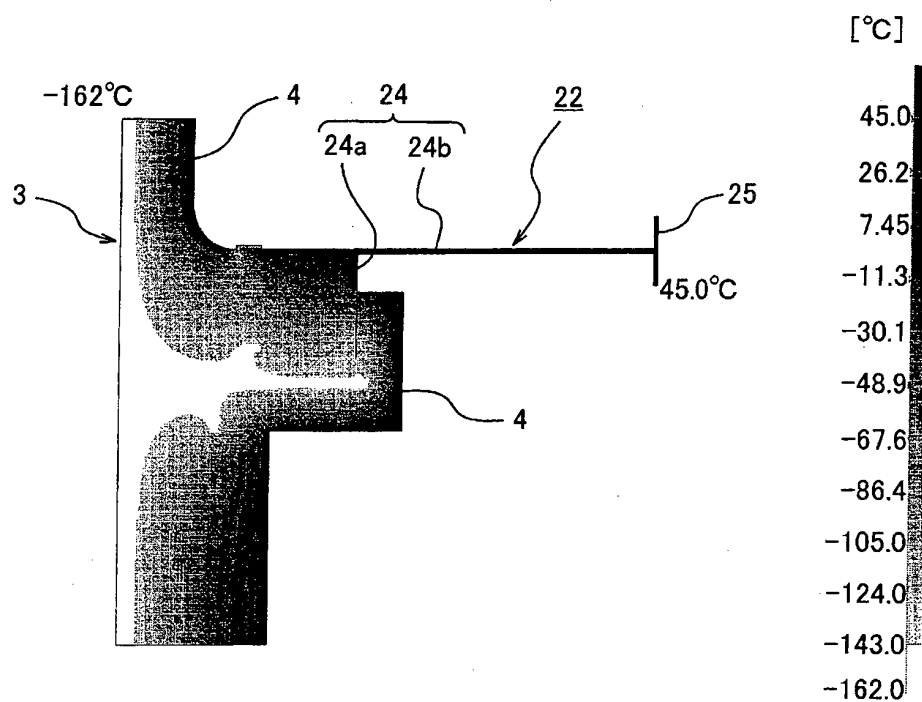
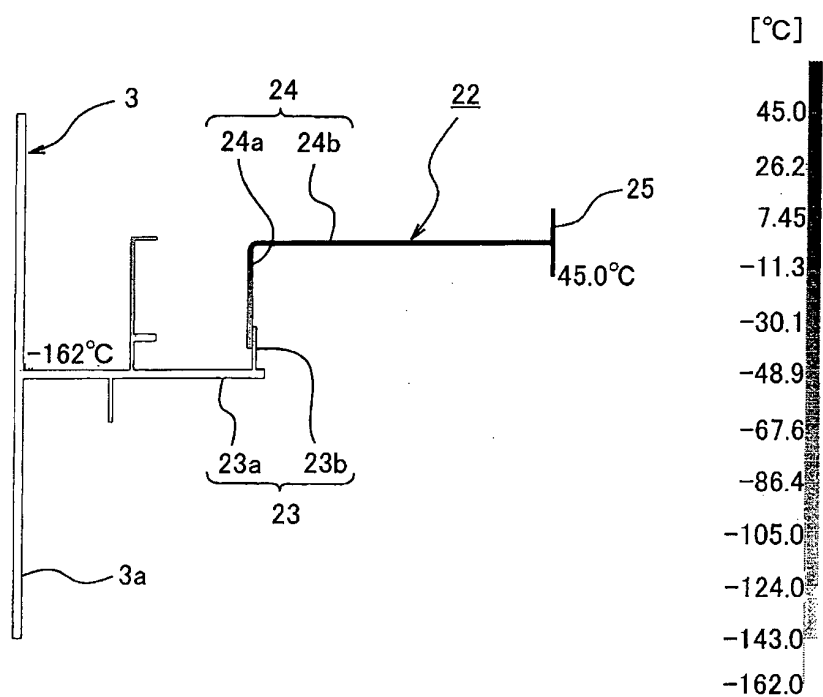


Fig. 2B



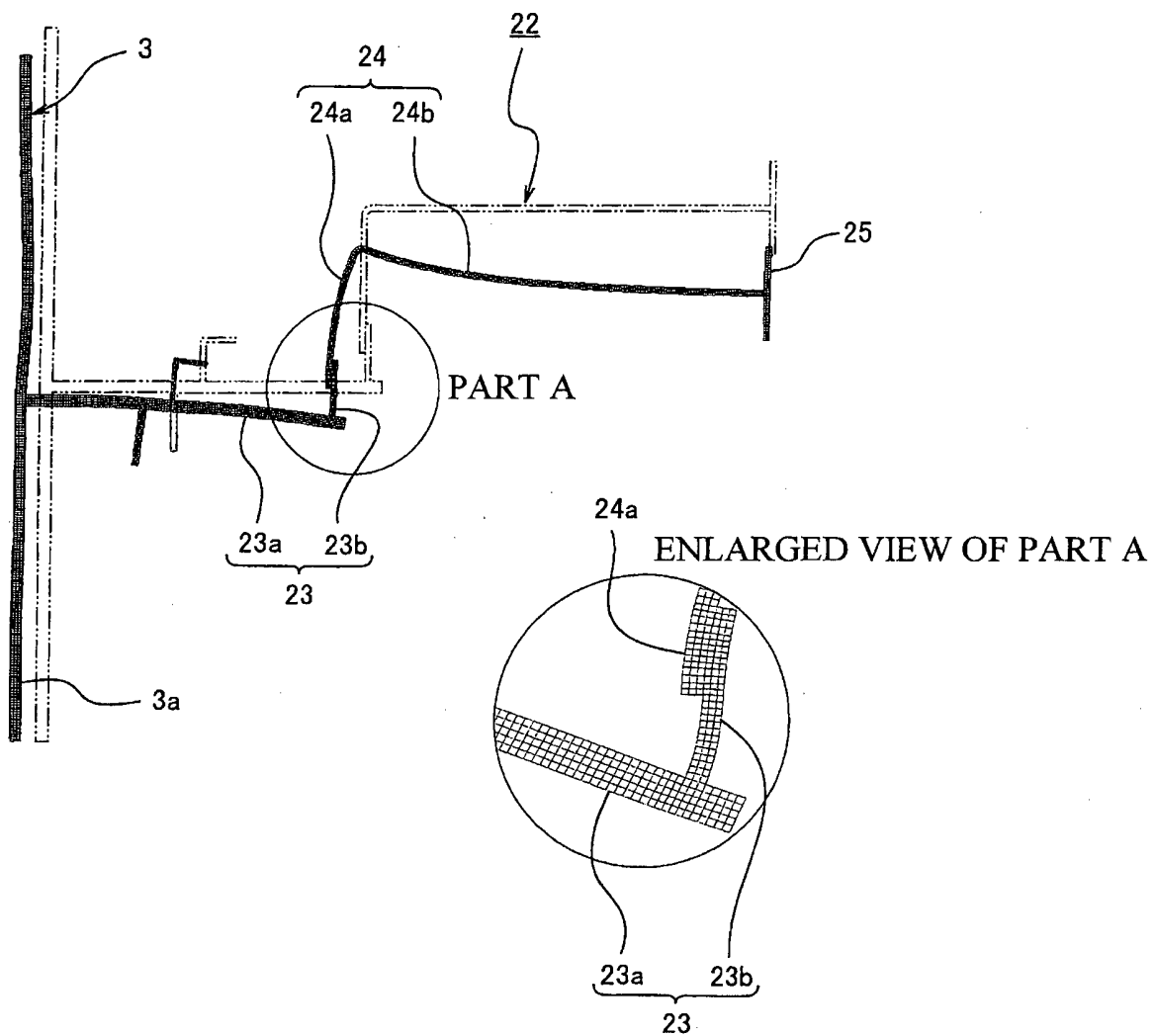


Fig. 3

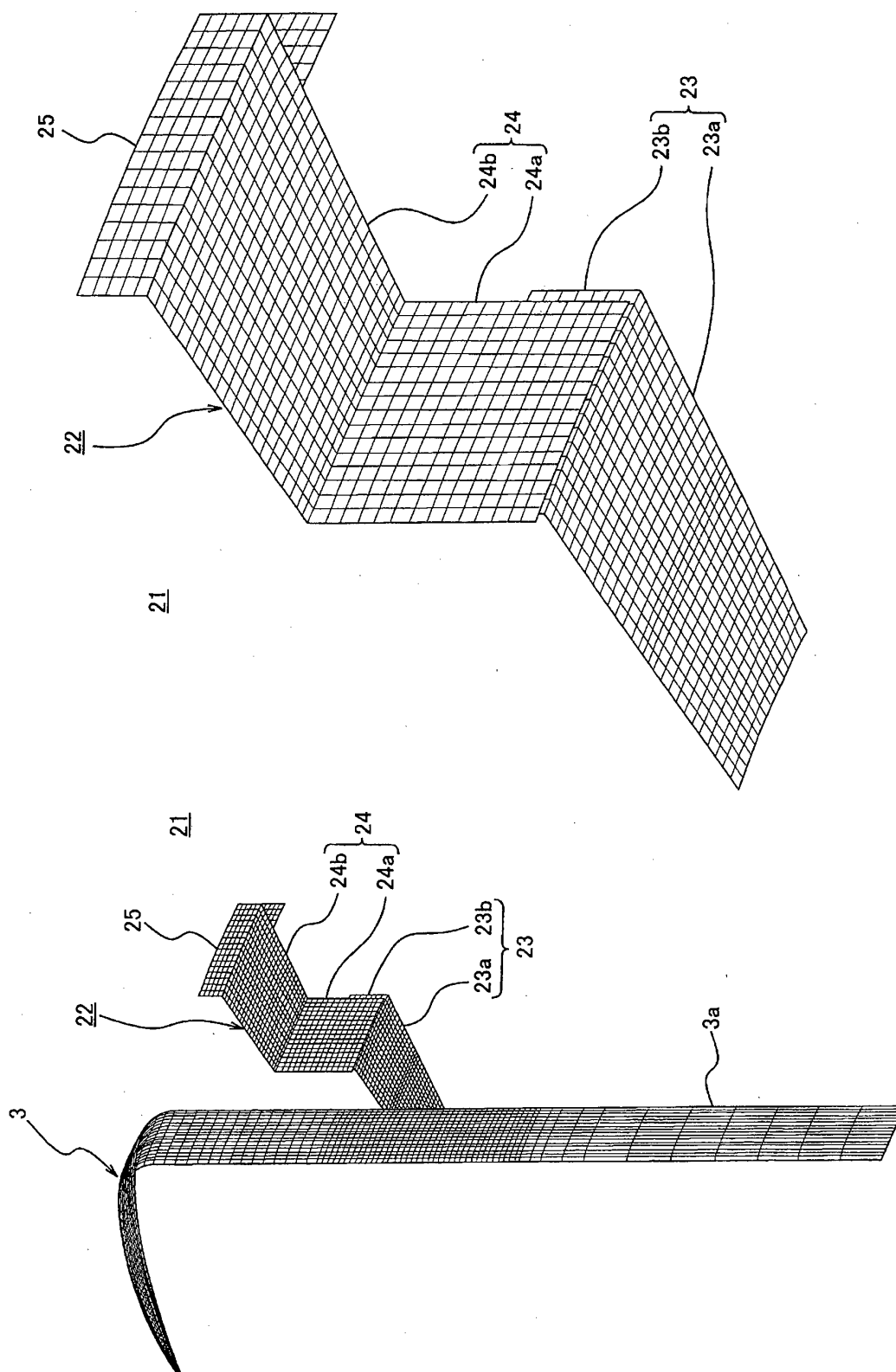


Fig. 4B

Fig. 4A

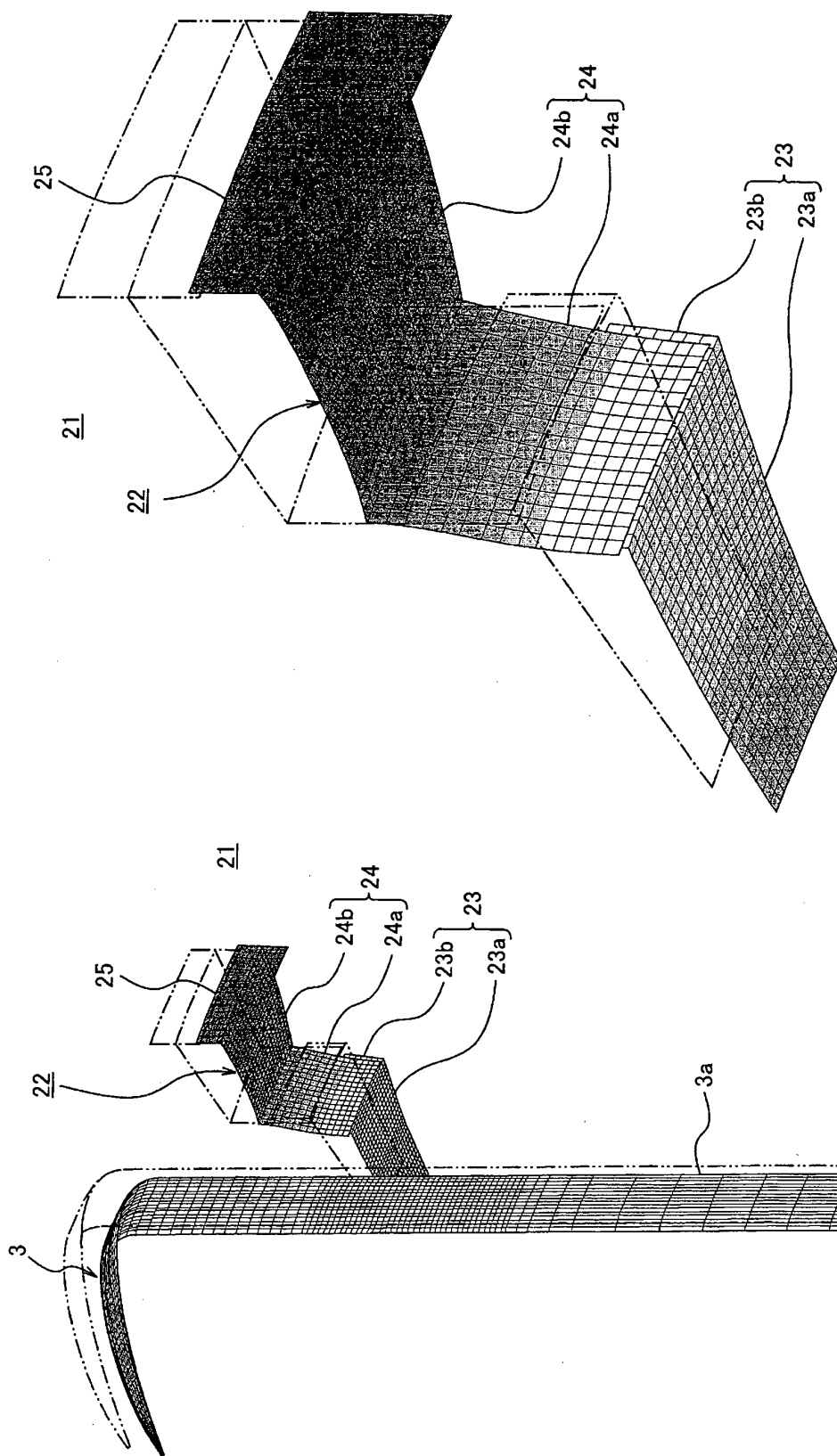


Fig. 5B

Fig. 5A

Fig. 6A

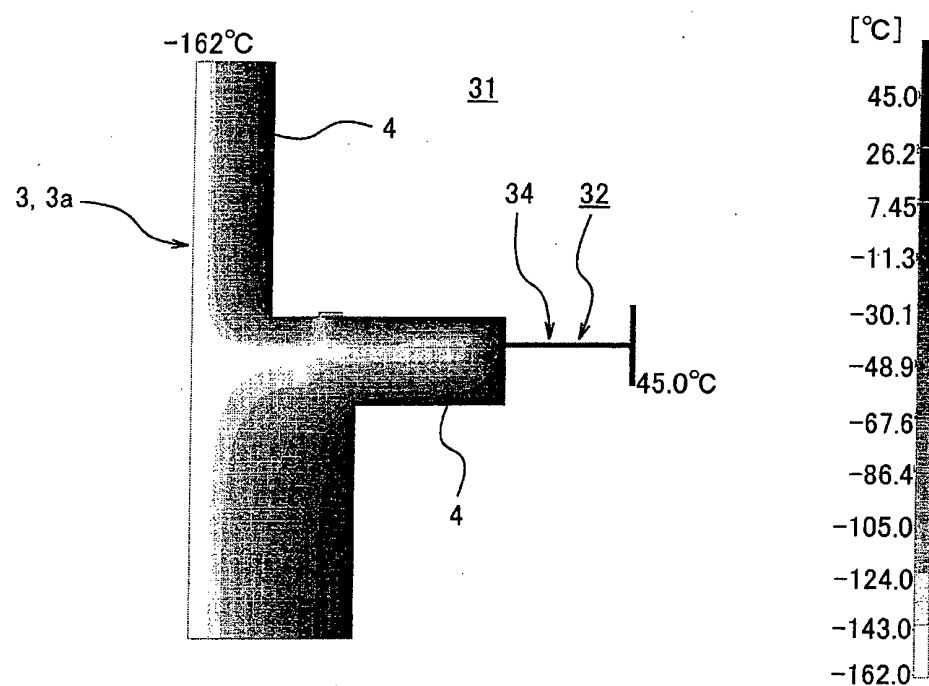
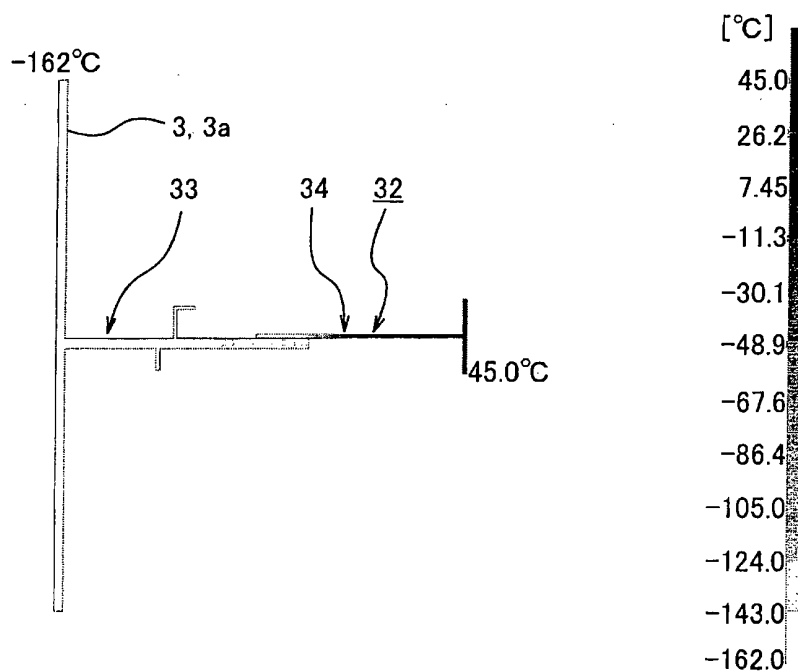


Fig. 6B



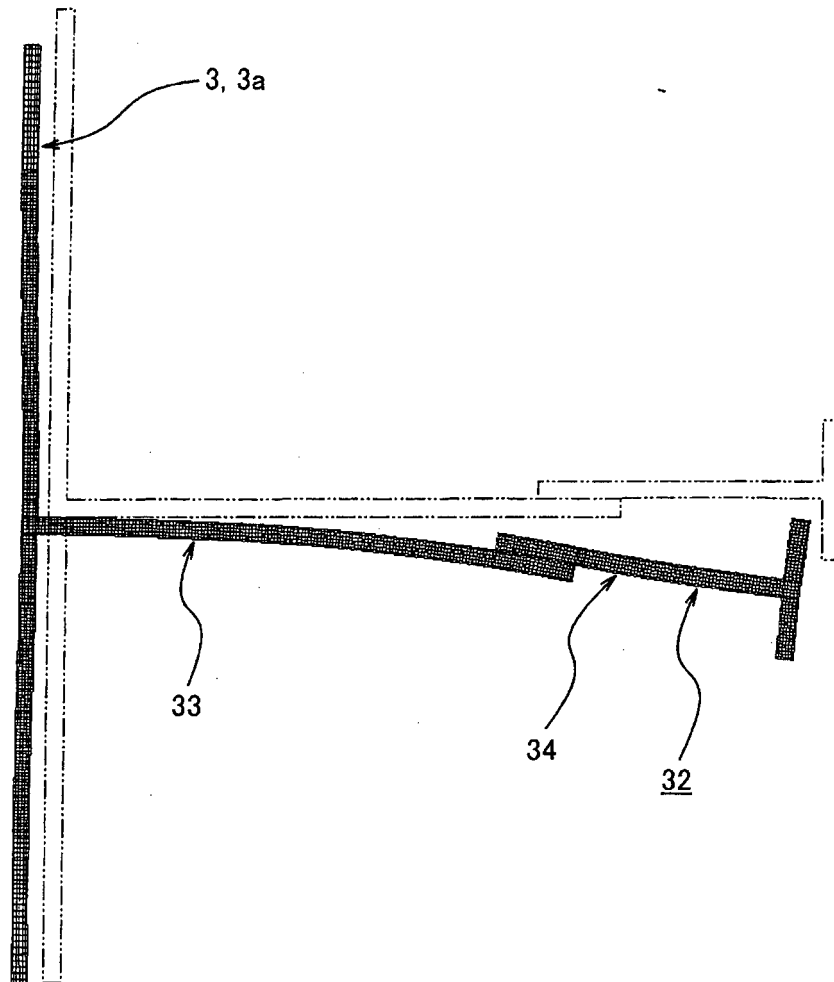


Fig. 7

Fig. 8A

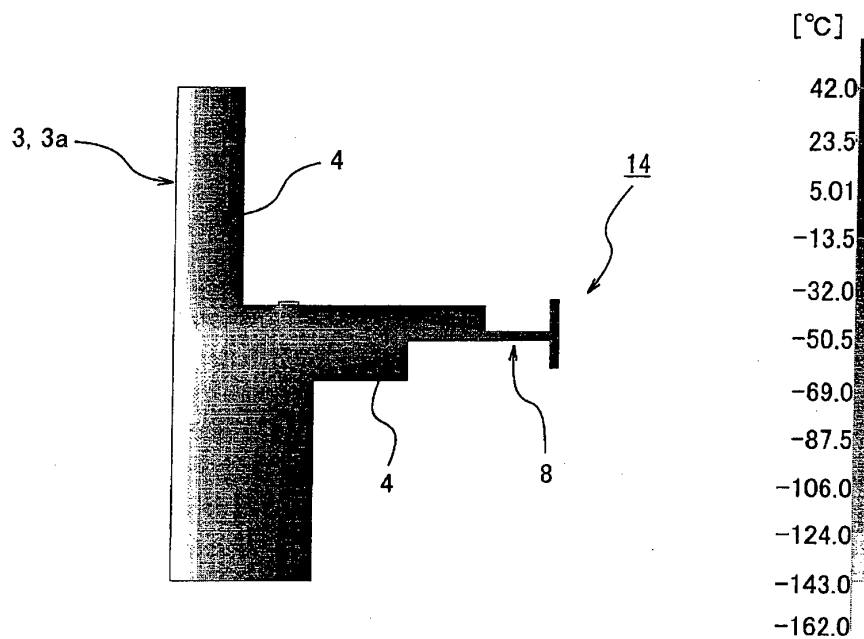
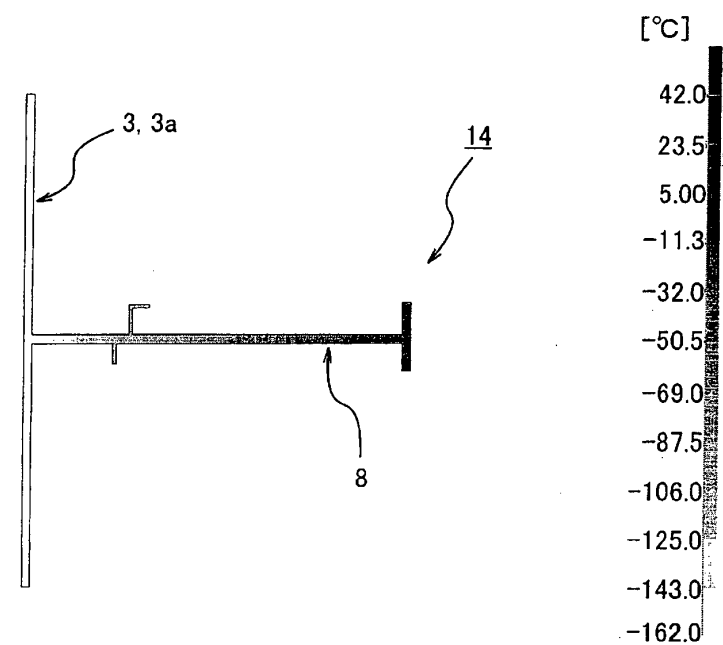


Fig. 8B



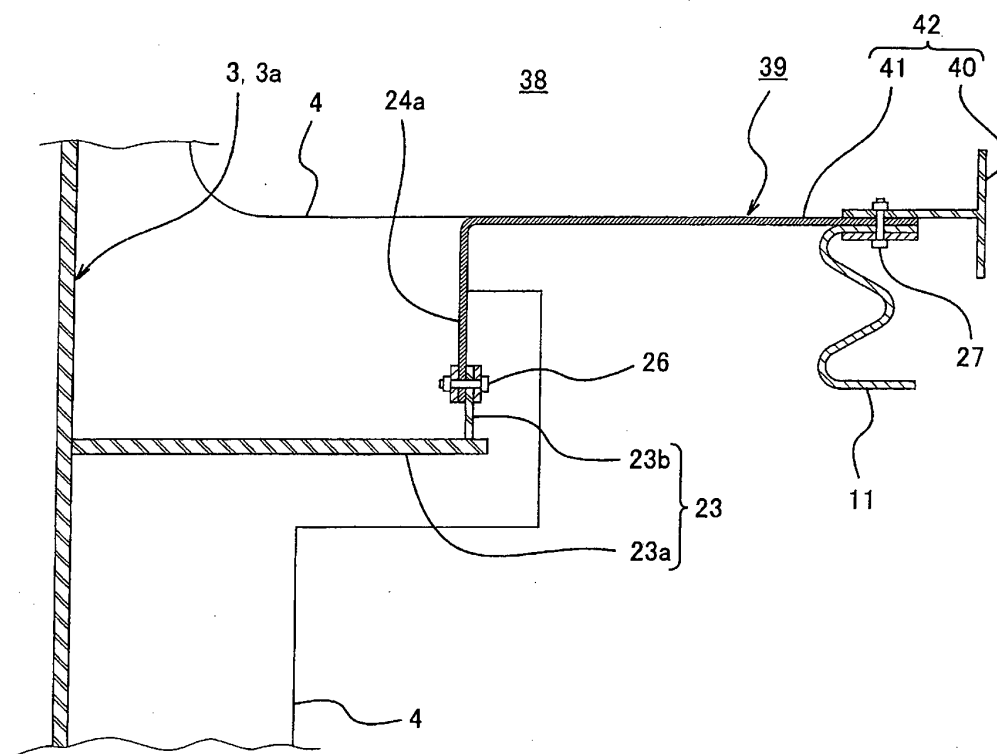


Fig. 9

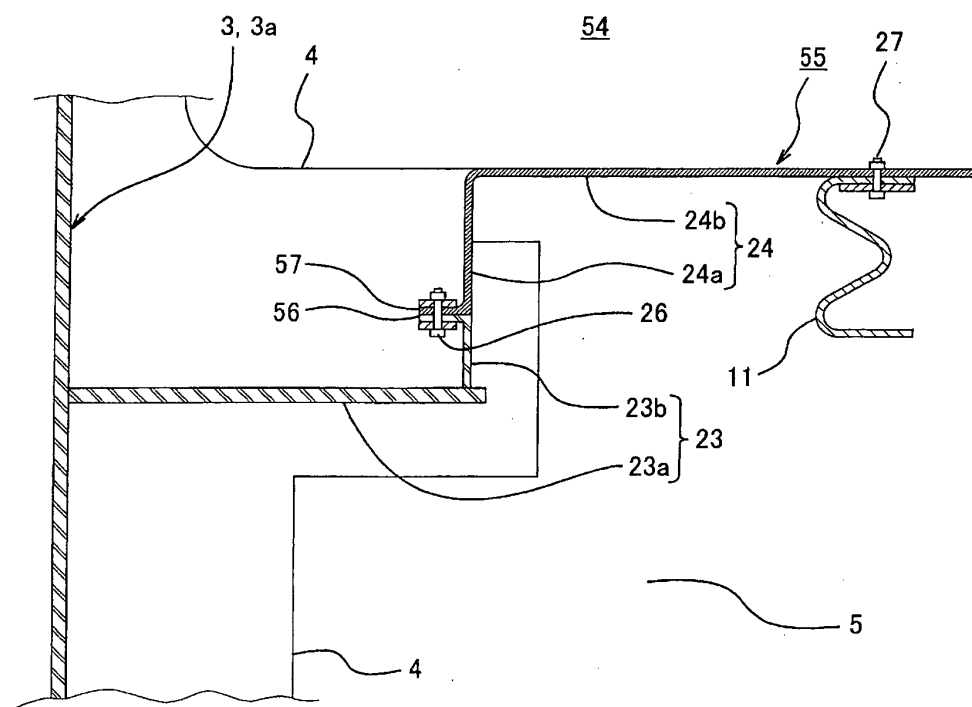


Fig. 10

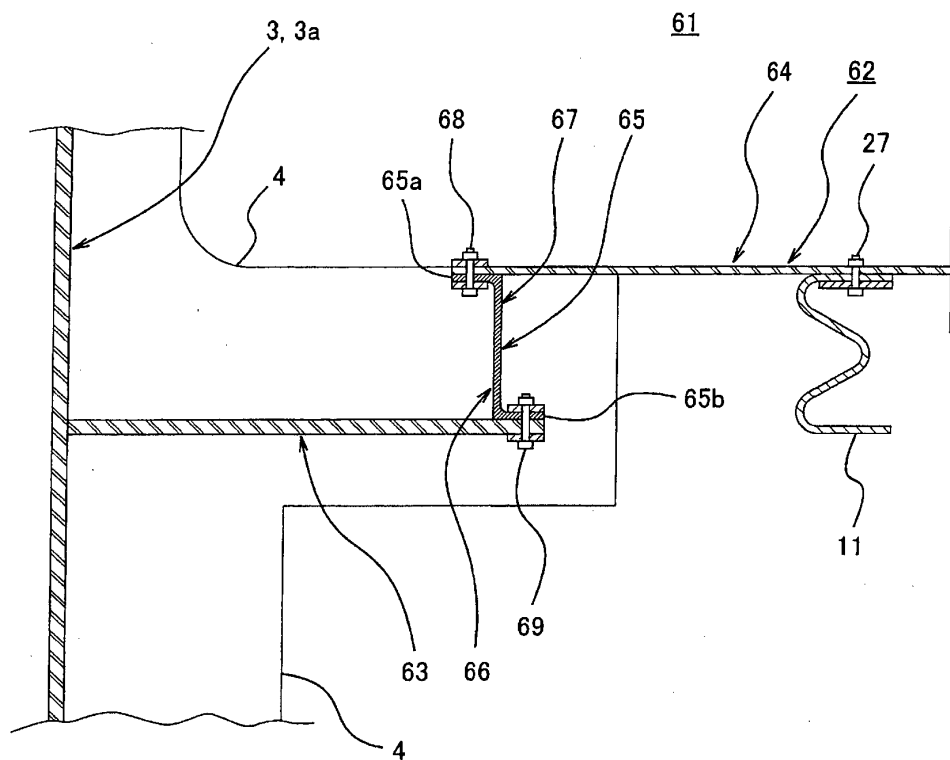


Fig. 11

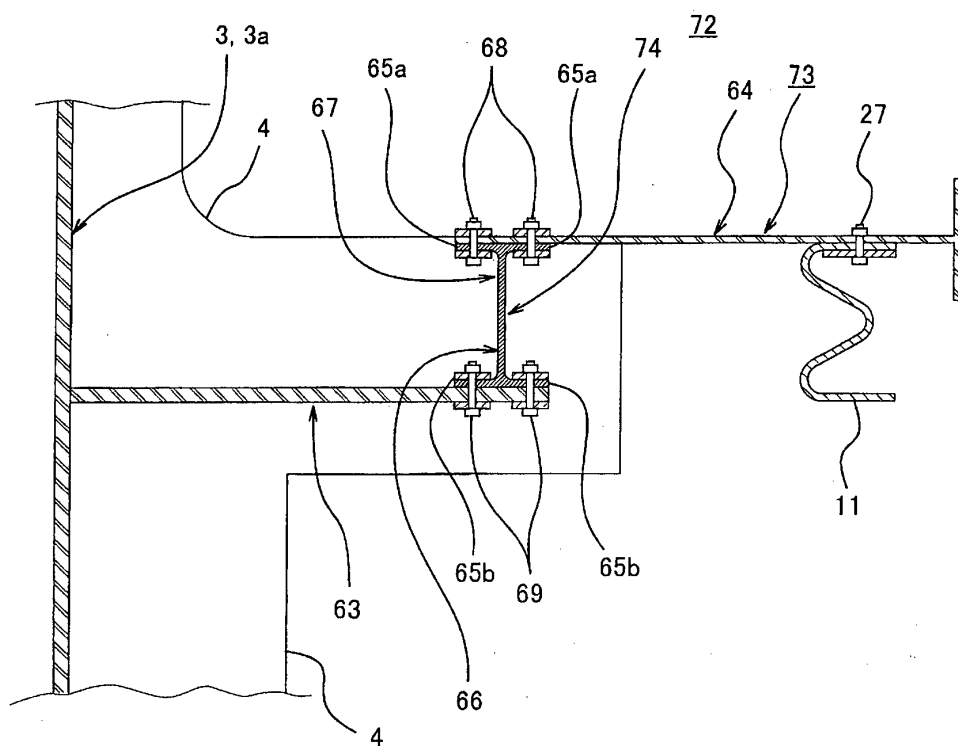


Fig. 12

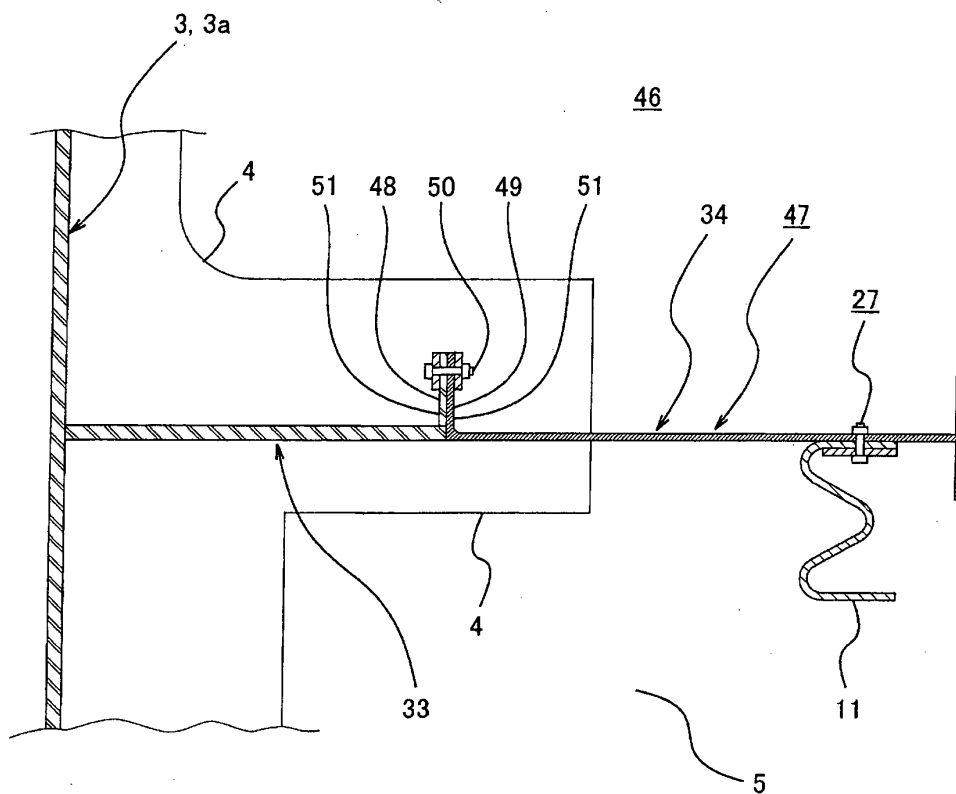


Fig. 13

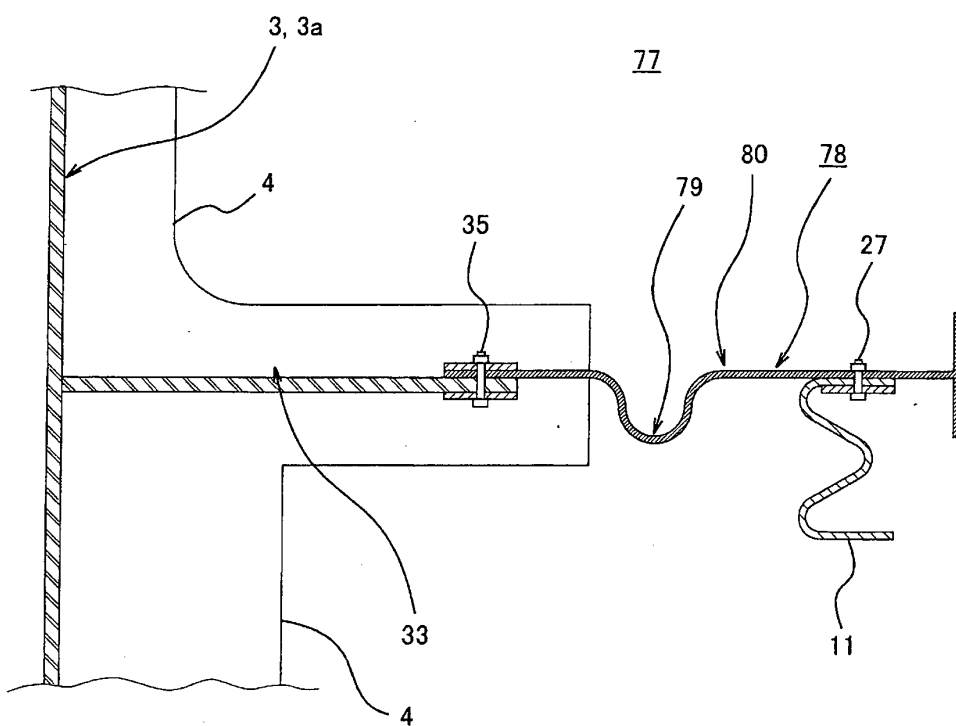


Fig. 14

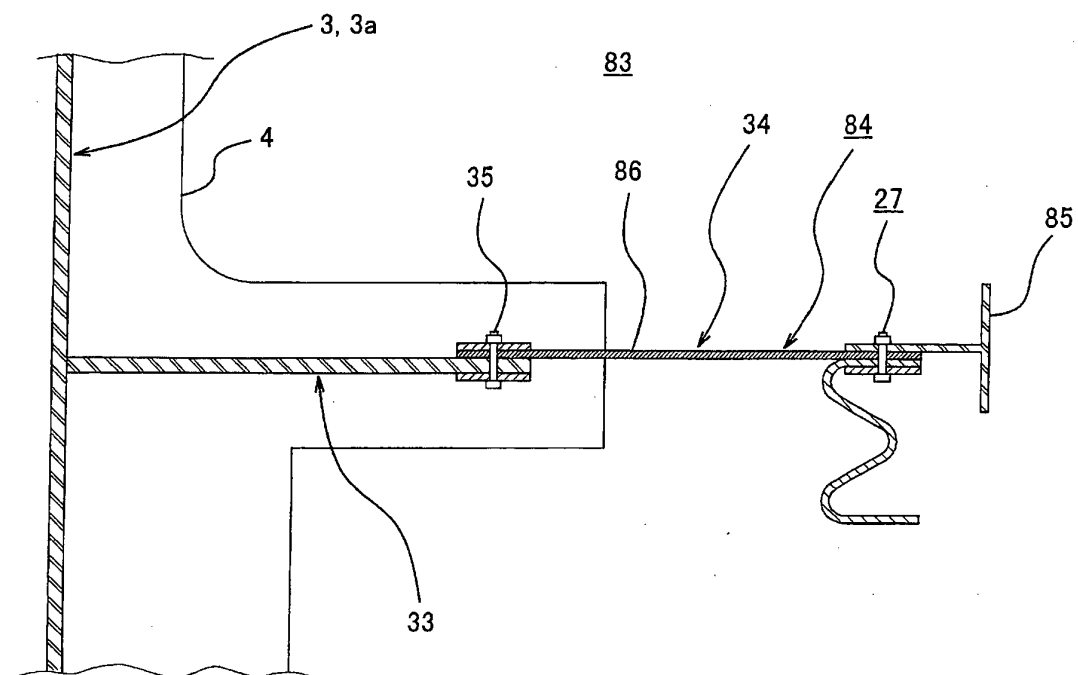


Fig. 15

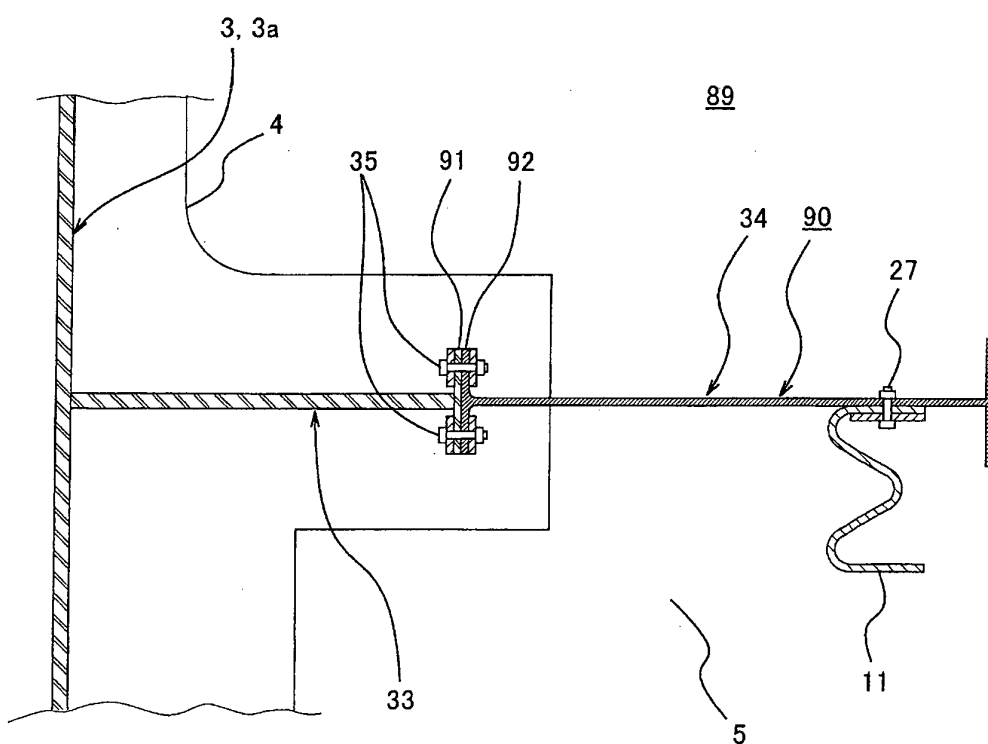


Fig. 16

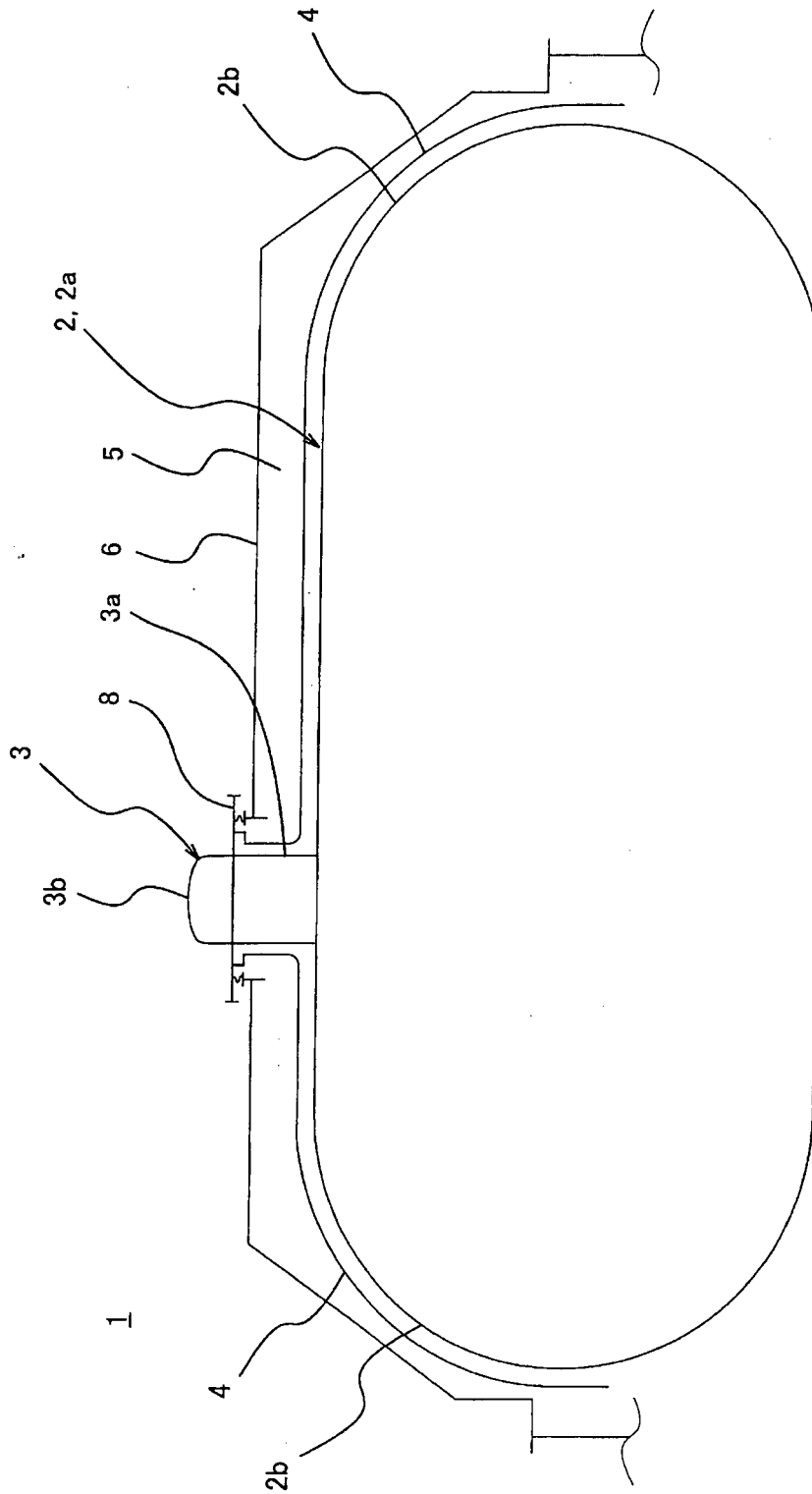


Fig. 17

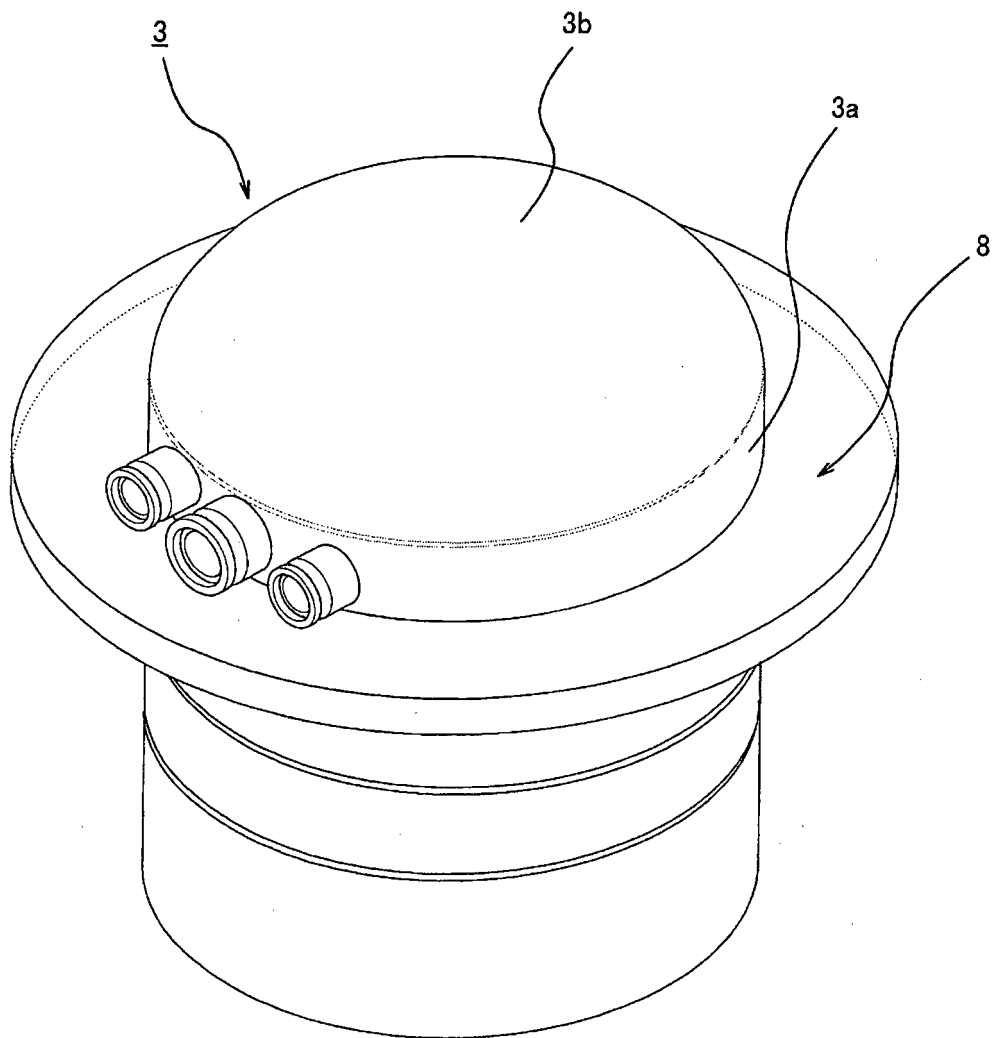


Fig. 18

Fig. 19A

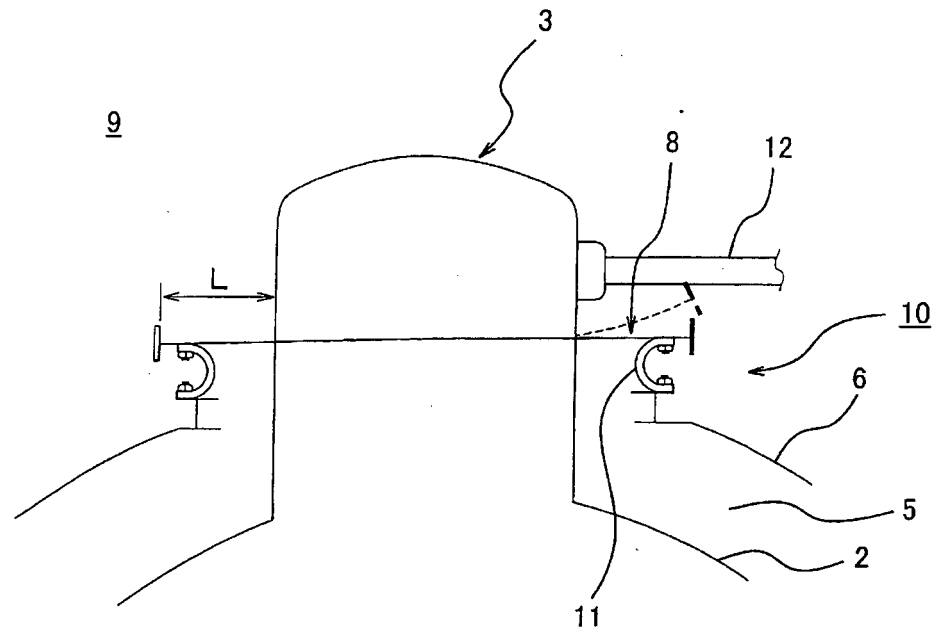
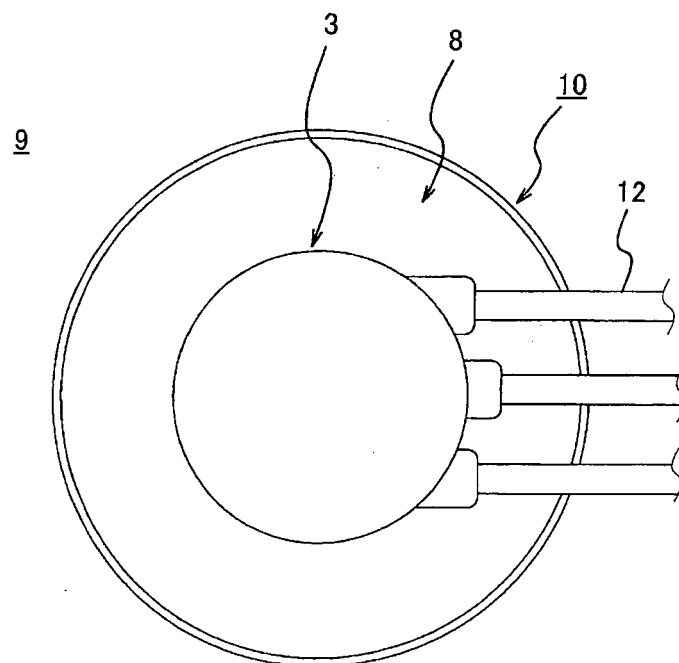


Fig. 19B



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/001060

## A. CLASSIFICATION OF SUBJECT MATTER

B63B25/16 (2006.01) i

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

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B63B25/16

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

|                           |           |                            |           |
|---------------------------|-----------|----------------------------|-----------|
| Jitsuyo Shinan Koho       | 1922-1996 | Jitsuyo Shinan Toroku Koho | 1996-2012 |
| Kokai Jitsuyo Shinan Koho | 1971-2012 | Toroku Jitsuyo Shinan Koho | 1994-2012 |

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                                             | Relevant to claim No. |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| A         | Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 103650/1985 (Laid-open No. 12593/1987) (Mitsubishi Heavy Industries, Ltd.), 26 January 1987 (26.01.1987), specification, page 2, lines 5 to 14; page 5, lines 1 to 12; fig. 1 to 3 (Family: none) | 1-9                   |

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

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search  
10 May, 2012 (10.05.12)Date of mailing of the international search report  
22 May, 2012 (22.05.12)Name and mailing address of the ISA/  
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/001060

| C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                                                                                                                                                                                                                                                     |                       |
|-------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Category*                                             | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                                                                  | Relevant to claim No. |
| A                                                     | Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 124461/1984 (Laid-open No. 38295/1986)<br>(Mitsubishi Heavy Industries, Ltd.),<br>10 March 1986 (10.03.1986),<br>specification, page 5, line 4 to page 6, line 13; page 7, lines 6 to 8; fig. 1 to 2<br>(Family: none) | 1-9                   |
| A                                                     | JP 7-215274 A (Ishikawajima-Harima Heavy Industries Co., Ltd.),<br>15 August 1995 (15.08.1995),<br>paragraphs [0010] to [0014]; fig. 1 to 3<br>(Family: none)                                                                                                                                                                       | 1-9                   |
| A                                                     | JP 8-99689 A (Mitsubishi Heavy Industries, Ltd.),<br>16 April 1996 (16.04.1996),<br>paragraphs [0010] to [0016]; fig. 1, 8<br>(Family: none)                                                                                                                                                                                        | 1-9                   |

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**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 62012593 A [0009]