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(54) **SHIP TANK SUPPORT STRUCTURE**

(57) A support structure of a ship tank, the ship tank being a horizontal type circular cylindrical tank (2) mounted on a ship and storing a liquefied gas, includes: a curved surface facing an outer peripheral surface of the tank; and a support unit (4) supporting the tank on the curved surface and extending in a circumferential direction of the tank. The support unit includes: a plurality of tubular elements (5) arranged in the circumferential direction of the tank such that an axial direction of each of the tubular elements coincides with a radial direction of

the tank; a plurality of inner members (6) each holding, on the outer peripheral surface of the tank, an end portion of a corresponding one of the tubular elements at the tank side; and a plurality of outer members (7) each holding, on the curved surface, an end portion of a corresponding one of the tubular elements at an opposite side to the tank. The plurality of inner members are fixed to the tank. The plurality of outer members are configured to be slidable on the curved surface in an axial direction of the tank.

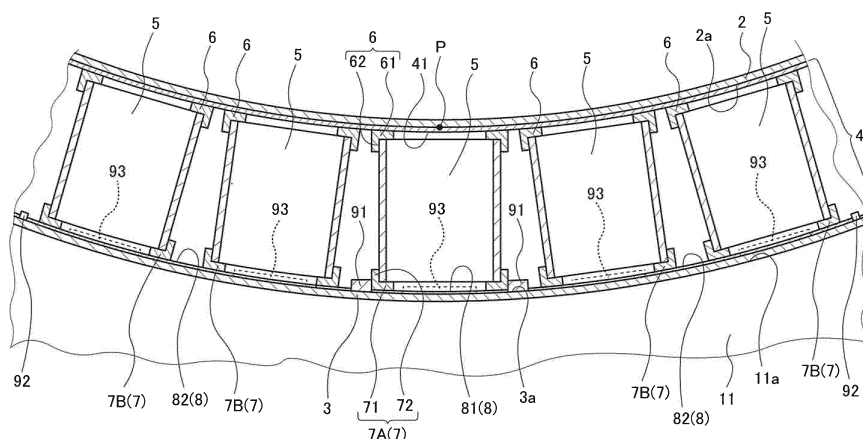


Fig. 3

Description

Technical Field

[0001] The present invention relates to a support structure of a tank mounted on a ship and storing a liquefied gas.

Background Art

[0002] Tanks in various shapes are used in liquefied gas carriers for marine transportation of a liquefied gas. Among these tanks, there is a case where a horizontal type circular cylindrical tank is supported by a pair of saddles spaced apart from each other in the axial direction of the tank. Each saddle has an arc-shaped supporting surface extending along the outer peripheral surface of the tank so that even when the ship swings (in a case where the axial direction of the tank coincides with the ship length direction, even when the ship rolls), the saddles can receive the load of the tank including the contents therein.

[0003] For example, Patent Literature 1 discloses a support structure of a tank, in which support units are interposed between the tank and supporting surfaces of respective saddles. Each support unit includes: a reinforcing plate joined to the outer peripheral surface of the tank; a plurality of partition walls arranged on the reinforcing plate in the circumferential direction of the tank; a pair of holding plates disposed on both sides of the partition walls; and block-shaped thermal-insulating liners fitted in respective rectangular spaces surrounded by the partition walls and the holding plates, the thermal-insulating liners being in contact with the supporting surface of the saddle. The tank, except its portions supported by the supports units, is covered with a thermal-insulating material.

[0004] Since a liquefied gas to be stored in the tank is a low-temperature gas, when the liquefied gas is fed into the tank, thermal contraction of the tank occurs. The thermal-insulating liners in the support structure disclosed in Patent Literature 1 are divided up in the circumferential direction of the tank so that a reduction in the diameter of the tank (i.e., deformation of the tank in its radial direction) due to the thermal contraction can be accommodated. Cuts are made in both ends of each thermal-insulating liner in the circumferential direction. The cuts in adjoining thermal-insulating liners form a groove, which is open toward the supporting surface of the saddle. A flexible thermal-insulating material is disposed in the groove.

[0005] Patent Literature 1 gives a description implying that when a reduction in the length of the tank (i.e., deformation of the tank in its axial direction) occurs due to thermal contraction, displacement of one of the support units in the axial direction of the tank is restricted while the other support unit is allowed to slide. This is based on the following technical feature: since the thermal-in-

ulating liners are block-shaped, the thermal-insulating liners can follow the tank and are thereby displaceable in the axial direction of the tank without requiring any special measures.

Citation List

Patent Literature

10 [0006] PTL 1: Japanese Patent No. 3708055

Summary of Invention

Technical Problem

[0007] In the case of a support unit as disclosed in Patent Literature 1 in which block-shaped thermal-insulating liners are used, there is a risk that a large amount of heat enters the tank from the outside via the thermal-insulating liners. In order to suppress evaporation of the liquefied gas during the transportation, it is desirable that heat transfer by the support unit be reduced. For example, it is conceivable to form a hollow support unit with a small cross-sectional area in order to reduce a heat transfer area. However, in the case of such a hollow support unit, the issue is what structure should be adopted so that the support unit can bear the load of the tank when the ship swings and so that the support unit can be displaced in the axial direction of the tank when a reduction in the length of the tank occurs due to thermal contraction.

[0008] In view of the above, an object of the present invention is to provide a support structure of a ship tank, the support structure including a hollow support unit capable of bearing the swinging of a ship and accommodating a reduction in the length of the tank due to thermal contraction.

Solution to Problem

[0009] In order to solve the above-described problems, a support structure of a ship tank according to the present invention is a support structure of a horizontal type circular cylindrical tank mounted on a ship and storing a liquefied gas. The support structure includes: a curved surface facing an outer peripheral surface of the tank; and a support unit supporting the tank on the curved surface and extending in a circumferential direction of the tank. The support unit includes: a plurality of tubular elements arranged in the circumferential direction of the tank such that an axial direction of each of the tubular elements coincides with a radial direction of the tank; a plurality of inner members each holding, on the outer peripheral surface of the tank, an end portion of a corresponding one of the tubular elements at the tank side; and a plurality of outer members each holding, on the curved surface, an end portion of a corresponding one of the tubular elements at an opposite side to the tank. The plurality of inner members are fixed to the tank. The

plurality of outer members are configured to be slidable on the curved surface in an axial direction of the tank.

[0010] The "circumferential direction of the tank" herein means a direction around the center of the tank on a plane perpendicular to the axial direction of the tank. The "radial direction of the tank" herein means a direction extending radially from the center of the tank on the plane perpendicular to the axial direction of the tank.

[0011] According to the above configuration, owing to the tubular elements arranged in the circumferential direction of the tank, the support unit extending in the circumferential direction of the tank is hollow. Since the axial direction of each tubular element coincides with the radial direction of the tank, even when the ship swings, the load of the tank including the contents therein is mainly dispersed as compressive force in the axial direction of each tubular element regardless of the orientation of the ship. Therefore, the support unit can bear the load of the tank even when the ship swings. Moreover, the inner members are fixed to the tank, and the outer members are slidable in the axial direction of the tank. This makes it possible to accommodate a reduction in the length of the tank due to thermal contraction.

[0012] Among the plurality of outer members, at least one outer member disposed near a lowest point of the tank may be a restricted outer member whose movement in the circumferential direction of the tank is restricted. Among the plurality of outer members, outer members positioned at both sides of the restricted outer member may be unrestricted outer members movable in the circumferential direction of the tank. According to this configuration, even when a reduction in the diameter of the tank occurs due to thermal contraction, the position of the restricted outer member in the circumferential direction of the tank does not change. Therefore, the reduction in the diameter of the tank can be caused to occur in a stable manner such that the lowest point of the tank serves as a reference point for the diameter reduction (i.e., serves as the center of the diameter reduction). In addition, since the unrestricted outer members positioned at both sides of the restricted outer member are movable in the circumferential direction of the tank, the unrestricted outer members can be moved together with the tubular elements.

[0013] The plurality of outer members may slide on a lubricating sheet fixed on the curved surface. According to this configuration, lubricity can be imparted to the curved surface with the lubricating sheet, which can be readily manufactured.

[0014] For example, the lubricating sheet may include: a base layer contacting the curved surface; and a lubricating layer formed on the base layer.

[0015] The lubricating sheet may be divided in the circumferential direction of the tank into a plurality of lubricating pieces. Each of the plurality of lubricating pieces may be fitted in an enclosure formed by coamings attached to the curved surface. According to this configuration, the lubricating pieces can be fixed in a simpler

manner than in a case where the lubricating pieces are fixed by bolting or welding.

[0016] Each of the plurality of tubular elements may be made of glass fiber reinforced plastic. According to this configuration, heat transfer via the tubular elements can be reduced significantly compared to a case where each of the tubular elements is made of a metal.

[0017] The curved surface may be an inner peripheral surface of an outer shell that encapsulates the tank such that a vacuum space is formed between the tank and the outer shell. According to this configuration, the liquefied gas can be kept at low temperatures for a long period of time owing to the vacuum space formed between the tank and the outer shell.

Advantageous Effects of Invention

[0018] The present invention makes it possible to provide a support structure of a ship tank, the support structure including a hollow support unit capable of bearing the swinging of a ship and accommodating a reduction in the length of the tank due to thermal contraction.

Brief Description of Drawings

[0019]

Fig. 1 is a side view of a liquefied gas carrier adopting a support structure of a ship tank according to one embodiment of the present invention.

Fig. 2 is a sectional view taken along line II-II of Fig. 1. Fig. 3 is a sectional front view near the center of a support unit.

Fig. 4 is a sectional plan view showing a small lubricating piece disposed at the center of the support unit and a restricted outer member on the small lubricating piece.

Fig. 5 is a sectional plan view showing large lubricating pieces disposed at both sides of the small lubricating piece and unrestricted outer members on the large lubricating pieces.

Fig. 6 is a sectional view of a lubricating piece.

Fig. 7A is a sectional front view and Fig. 7B is a sectional plan view, each showing another structure for restricting the movement of the restricted outer member in a circumferential direction.

Fig. 8 is a perspective view showing another structure for fixing a lubricating sheet.

Fig. 9 is a perspective view showing yet another structure for fixing the lubricating sheet.

Fig. 10 is a sectional view of a liquefied gas carrier adopting a support structure of a ship tank according to another embodiment.

Description of Embodiments

[0020] Fig. 1 and Fig. 2 show a liquefied gas carrier 1, which adopts a support structure of a ship tank according

to one embodiment of the present invention. In the present embodiment, two horizontal type circular cylindrical tanks 2, which are mounted on the liquefied gas carrier 1, are arranged side by side in the ship length direction. Each of the tanks 2 is encapsulated in an outer shell 3. In other words, each tank 2 and its outer shell 3 form a double shell.

[0021] Each tank 2 serves to store a liquefied gas 9. For example, the liquefied gas 9 is liquefied petroleum gas (LPG, about -45°C), liquefied ethylene gas (LEG, about -100°C), liquefied natural gas (LNG, about -160°C), or liquefied hydrogen (LH_2 , about -250°C).

[0022] Each tank 2 includes: a body portion extending in a transverse direction (ship length direction) with a constant cross-sectional shape; and hemispherical sealing portions sealing openings on both sides of the body portion. It should be noted that, alternatively, each sealing portion may have a flat shape parallel to the vertical direction, or may be dish-shaped. The outer shell 3 has such a shape that a space with a constant thickness is formed around the tank 2. In the present embodiment, the space between the outer shell 3 and the tank 2 is a vacuum space. However, as an alternative, the space between the outer shell 3 and the tank 2 may have an atmospheric pressure, and the space may be filled with a thermal-insulating material.

[0023] In a hull 12 of the liquefied gas carrier 1, a pair of saddles 11 spaced apart from each other in the axial direction of the tank 2 is provided for each tank 2. The pair of saddles 11 supports the body portion of the tank 2 via the outer shell 3 and support units 4. The support units 4 will be described below.

[0024] Each saddle 11 includes a supporting surface 11 a, which makes surface contact with the outer peripheral surface of the outer shell 3. In the present embodiment, when seen in the axial direction of the tank 2, the supporting surface 11 a extends from the lowest point of the outer shell 3 to both sides such that the supporting surface 11a extends by substantially 90 degrees to each side. In other words, the supporting surface 11 a forms a semicircular recess, in which substantially the half of the outer shell 3 is fitted. However, the angle by which the supporting surface 11 a of the saddle 11 extends to each side from the lowest point the outer shell 3 need not be substantially 90 degrees, but may be suitably set to a different angle.

[0025] A pair of support units 4 spaced apart from each other in the axial direction of the tank 2 is disposed between the outer shell 3 and the tank 2. The positions where the pair of support units 4 is disposed coincide with the positions where the pair of saddles 11 is disposed.

[0026] The inner peripheral surface of the outer shell 3 faces the outer peripheral surface of the tank 2, and corresponds to a curved surface of the present invention. Each support unit 4 supports the tank 2 on the inner peripheral surface of the outer shell 3. In the present embodiment, both the support units 4 have the same struc-

ture, and support the tank 2 such that the tank 2 is movable in the axial direction. The tank 2 is connected to the outer shell 3 by a connector (not shown) that is disposed at a position different from the positions of the support units 4, such that the positional relationship between the tank 2 and the outer shell 3 is fixed. When a reduction in the length of the tank 2 occurs due to thermal contraction, the connector serves as a reference point for the length reduction (i.e., serves as the center of the length reduction).

[0027] However, above either the fore-side saddle 11 or the aft-side saddle 11, instead of the support unit 4 supporting the tank 2 such that the tank 2 is movable in the axial direction, a support unit that fixes the positional relationship between the tank 2 and the outer shell 3 in the axial direction of the tank 2 may be disposed.

[0028] Each support unit 4 extends in the circumferential direction of the tank 2. In the present embodiment, since the space formed between the tank 2 and the outer shell 3 is a vacuum space as mentioned above, the outer peripheral surface of the tank 2 except its portions supported by the support units 4 is covered with a vacuum thermal-insulating material (not shown).

[0029] Specifically, as shown in Fig. 3, each support unit 4 includes: a plurality of tubular elements 5 arranged in the circumferential direction of the tank 2; a plurality of inner members 6 interposed between the tank 2 and the tubular elements 5; and a plurality of outer members 7 interposed between the outer shell 3 and the tubular elements 5.

[0030] The tubular elements 5 are disposed such that the axial direction of each tubular element 5 coincides with the radial direction of the tank 2. The wording "the axial direction of each tubular element 5 coincides with the radial direction of the tank 2" means that the axial direction of each tubular element 5 is substantially parallel to the radial direction of the tank 2 (e.g., the difference between the angles of these directions is not greater than 5 degrees). It should be noted that it is not essential that all the tubular elements 5 be arranged on a single straight line extending in the circumferential direction of the tank 2. The tubular elements 5 may be arranged zig-zag. In the present embodiment, the cross-sectional shape of each tubular element 5 is a circular shape. However, as an alternative, the cross-sectional shape of each tubular element 5 may be a polygonal shape.

[0031] In the present embodiment, each tubular element 5 is made of glass fiber reinforced plastic (GFRP). However, as an alternative, each tubular element 5 may be made of carbon fiber reinforced plastic (CFRP) or a different FRP (e.g., fabric reinforced phenolic resin), or may be made of a metal. In a case where the space formed between the tank 2 and the outer shell 3 is a vacuum space as in the present embodiment, it is desirable to perform plating treatment on each tubular element 5, such that a metal plating layer (not shown) is formed on each of the inner peripheral surface and the outer peripheral surface of the tubular element 5. The plating

layer serves to prevent release of outgas from the GFRP tubular element 5 facing the vacuum space.

[0032] On the outer peripheral surface 2a of the tank 2, each inner member 6 holds an end portion of a corresponding one of the tubular elements 5 at the tank 2 side (this end portion is hereinafter referred to as "the inner end portion"). In the present embodiment, a reinforcing plate 41 is disposed between the outer peripheral surface 2a of the tank 2 and all the inner members 6. The inner members 6 are fixed to the tank 2 via the reinforcing plate 41. The reinforcing plate 41 is a belt-like plate extending in the circumferential direction of the tank 2, and is joined to the outer peripheral surface 2a of the tank 2, for example, by welding. The inner members 6 are joined to the reinforcing plate 41, for example, by welding.

[0033] However, the method of fixing the inner members 6 to the tank 2 is not thus limited. For example, tubular members that allow the inner members 6 to fit therein may be joined to the reinforcing plate 41 by welding, and the inner members 6 may be fastened to the tubular members by pins or the like. Alternatively, stud bolts may be installed on the reinforcing plate 41, and the inner members 6 may be fixed by nuts screwed on the stud bolts.

[0034] In the present embodiment, each inner member 6 has a central opening such that the inner member 6 has an annular shape. Accordingly, the reinforcing plate 41 is exposed inside the tubular elements 5. It is desirable that the reinforcing plate 41 exposed inside the tubular elements 5 be covered with a vacuum thermal-insulating material. It should be noted that each inner member 6 need not have a central opening, but may be plate-shaped such that each inner member 6 blocks the opening of the corresponding tubular element 5 at the tank 2 side.

[0035] In order to hold the inner end portions of the tubular elements 5 by the inner members 6, the tubular elements 5 may be adhered to the inner members 6 by using an adhesive. However, in the case of a vacuum double-shell structure as in the present embodiment, there is a risk of release of outgas from the adhesive since the environment surrounding the adhesive is a vacuum environment. In the present embodiment, a fitting structure is adopted to prevent the risk.

[0036] The fitting structure adopted by the present embodiment is a structure in which the inner end portion of each tubular element 5 is fitted in the corresponding inner member 6. Specifically, each inner member 6 includes: a peripheral wall 62 overlapping the outer peripheral surface of the corresponding tubular element 5; and a ring portion 61 protruding radially inward from an end portion of the peripheral wall 62 at the tank 2 side and contacting an end face of the tubular element 5 at the tank 2 side. The peripheral wall 62 of each inner member 6 may be fastened to the corresponding tubular element 5 by pins or the like. However, conversely to the present embodiment, an alternative fitting structure may be adopted, in which each inner member 6 is fitted inside the inner end

portion of the corresponding tubular element 5. That is, the peripheral wall 62 of the inner member 6 may overlap the inner peripheral surface of the tubular element 5.

[0037] On the inner peripheral surface 3a of the outer shell 3, each outer member 7 holds an end portion of a corresponding one of the tubular elements 5 at the outer shell 3 side (this end portion is hereinafter referred to as "the outer end portion"). The outer members 7 are configured to be slidable on the inner peripheral surface 3a of the outer shell 3 in the axial direction of the tank 2.

[0038] In the present embodiment, a lubricating sheet 8 is disposed between the inner peripheral surface 3a of the outer shell 3 and all the outer members 7. The lubricating sheet 8 is a belt-like sheet extending in the circumferential direction of the tank 2, and is fixed on the inner peripheral surface 3a of the outer shell 3. The outer members 7 slide on the lubricating sheet 8.

[0039] In the present embodiment, each outer member 7 has a central opening such that the outer member 7 has an annular shape. Accordingly, the lubricating sheet 8 is exposed inside the tubular elements 5. However, each outer member 7 need not have a central opening, but may be plate-shaped such that each outer member 7 blocks the opening of the corresponding tubular element 5 at the outer shell 3 side.

[0040] Similar to the inner members 6, the outer members 7 also adopt a fitting structure from the viewpoint of avoiding the use of an adhesive. The fitting structure adopted by the present embodiment is a structure in which the outer end portion of each tubular element 5 is fitted in the corresponding outer member 7. Specifically, each outer member 7 has an L-shaped cross section and includes: a peripheral wall 72 overlapping the outer peripheral surface of the corresponding tubular element 5; and a ring portion 71 protruding radially inward from an end portion of the peripheral wall 72 at the outer shell 3 side and contacting an end face of the tubular element 5 at the outer shell 3 side. The peripheral wall 72 of each outer member 7 may be fastened to the corresponding tubular element 5 by pins or the like. However, conversely to the present embodiment, an alternative fitting structure may be adopted, in which each outer member 7 is fitted inside the outer end portion of the corresponding tubular element 5. That is, the peripheral wall 72 of the outer member 7 may overlap the inner peripheral surface of the tubular element 5.

[0041] Among the outer members 7, at least one outer member 7 disposed near the lowest point P of the tank 2 is a restricted outer member 7A whose movement in the circumferential direction of the tank 2 is restricted. Meanwhile, among the outer members 7, those positioned at both sides of the restricted outer member 7A are unrestricted outer members 7B movable in the circumferential direction of the tank 2. In the present embodiment, only the outer member 7 positioned directly below the lowest point P of the tank 2 is the restricted outer member 7A. However, alternatively, for example, the outer member 7 positioned directly below the lowest

point P of the tank 2 and both adjoining outer members 7, i.e., a total of three outer members 7, may be restricted outer members 7A.

[0042] As shown in Fig. 4, the restricted outer member 7A includes: four substantially triangular guide portions 73, which protrude opposite to the ring portion 71 from the end portion of the peripheral wall 72 at the outer shell 3 side in a manner to form a substantially square contour. On the other hand, as shown in Fig. 5, each unrestricted outer member 7B is such that the outer peripheral surface of the peripheral wall 72 forms a circular contour of the unrestricted outer member 7B. In other words, each unrestricted outer member 7B has an L-shaped cross section similar to the inner members 6, and the restricted outer member 7A includes L-shaped cross-sectional portions and T-shaped cross-sectional portions.

[0043] As shown in Fig. 4, in the circumferential direction of the tank 2, a pair of special coamings 91 is disposed at both sides of the restricted outer member 7A. The special coamings 91 are attached to the inner peripheral surface 3a of the outer shell 3, for example, by welding. For example, each of the special coamings 91 has a substantially rectangular cross-sectional shape, and the special coamings 91 extend in the axial direction of the tank 2 and are in contact with the guide portions 73 of the restricted outer member 7A. That is, the special coamings 91 restrict the movement of the restricted outer member 7A in the circumferential direction of the tank 2, and also guide the movement of the restricted outer member 7A in the axial direction of the tank 2.

[0044] On the other hand, as shown in Fig. 5, around each unrestricted outer member 7B, there is nothing being in contact with the unrestricted outer member 7B. Therefore, the unrestricted outer members 7B are freely movable in the axial direction and circumferential direction of the tank 2.

[0045] The lubricating sheet 8, which is sandwiched between the inner peripheral surface 3a of the outer shell 3 and all the outer members 7, has such a width that the lubricating sheet 8 extends in the axial direction of the tank 2 beyond both sides of each outer member 7. In the present embodiment, the lubricating sheet 8 is divided in the circumferential direction of the tank 2 into a plurality of lubricating pieces. The plurality of lubricating pieces include the following two types of lubricating pieces: a small lubricating piece 81 disposed at the center of the support unit 4 and receiving the restricted outer member 7A; and large lubricating pieces 82 disposed at both sides of the small lubricating piece 81 and each receiving two unrestricted outer members 7B. It should be noted that each of the large lubricating pieces 82 may receive three or more unrestricted outer members 7B. Alternatively, the lubricating sheet 8 may be divided into the same number of lubricating pieces as the number of outer members 7, such that each lubricating piece receives a corresponding one of the outer members 7.

[0046] As shown in Fig. 4 and Fig. 5, in the axial direction of the tank 2, a pair of normal coamings 93 is dis-

posed at both sides of each outer member 7. The normal coamings 93 are attached to the inner peripheral surface 3a of the outer shell 3, for example, by welding. For example, each of the normal coamings 93 has a rectangular cross-sectional shape and extends in the circumferential direction of the tank 2. As shown in Fig. 4, the small lubricating piece 81 is fitted in an enclosure formed by the above-described special coamings 91 and normal coamings 93.

[0047] In addition, normal coamings 92 are arranged such that one normal coaming 92 is disposed between every other pair of unrestricted outer members 7B. The normal coamings 92 are attached to the inner peripheral surface 3a of the outer shell 3, for example, by welding. For example, each of the normal coamings 92 has a rectangular cross-sectional shape and extends in the axial direction of the tank 2. As shown in Fig. 5, each of the large lubricating pieces 82 is fitted in an enclosure formed by a special coaming 91, normal coamings 93, and a normal coaming 92, or in an enclosure formed by normal coamings 93 and normal coamings 92.

[0048] In the present embodiment, as shown in Fig. 6, each of the small lubricating piece 81 and the large lubricating pieces 82 includes: a base layer 8a contacting the inner peripheral surface 3a of the outer shell 3; and a lubricating layer 8b formed on the base layer 8a. The base layer 8a is made of a material with sufficient strength (e.g., a metal such as stainless steel). The lubricating layer 8b is made of a material with high lubricity (e.g., a resin such as PEEK (polyether ether ketone) or PTFE (polytetrafluoroethylene) or a metal such as silver or molybdenum disulfide). However, each of the lubricating pieces may be a single-layered piece made of a material with high lubricity.

[0049] As described above, in the support structure of the tank according to the present embodiment, owing to the tubular elements 5 arranged in the circumferential direction of the tank 2, the support unit 4 extending in the circumferential direction of the tank 2 is hollow. Since the axial direction of each tubular element 5 coincides with the radial direction of the tank 2, even when the ship swings, the load of the tank 2 including the contents therein is mainly dispersed as compressive force in the axial direction of each tubular element 5 regardless of the orientation of the ship. Therefore, the support unit 4 can bear the load of the tank 2 even when the ship swings. Moreover, the inner members 6 are fixed to the tank 2, and the outer members 7 are slidable in the axial direction of the tank 2. This makes it possible to accommodate a reduction in the length of the tank 2 due to thermal contraction.

[0050] In the present embodiment, since the restricted outer member 7A is disposed at the center of the support unit 4, even when a reduction in the diameter of the tank 2 occurs due to thermal contraction, the position of the restricted outer member 7A in the circumferential direction of the tank 2 does not change. Therefore, the reduction in the diameter of the tank 2 can be caused to occur

in a stable manner such that the lowest point P of the tank 2 serves as a reference point for the diameter reduction (i.e., serves as the center of the diameter reduction). In addition, since the unrestricted outer members 7B positioned at both sides of the restricted outer member 7A are movable in the circumferential direction of the tank 2, the unrestricted outer members 7B can be moved together with the tubular elements 5.

[0051] In the present embodiment, the lubricating sheet 8 is fixed on the inner peripheral surface 3a of the outer shell 3. In this manner, lubricity can be imparted to the inner peripheral surface 3a of the outer shell 3 with the lubricating sheet, which can be readily manufactured.

[0052] Each of the lubricating pieces 81 and 82 forming the lubricating sheet 8 is fitted in an enclosure formed by the coamings. According to this configuration, the lubricating pieces 81 and 82 can be fixed in a simpler manner than in a case where the lubricating pieces are fixed by bolting or welding.

[0053] Since each of the tubular elements 5 is made of GFRP, heat transfer via the tubular elements 5 can be reduced significantly compared to a case where each of the tubular elements 5 is made of a metal. In addition, since the space formed between the tank 2 and the outer shell 3 is a vacuum space, the liquefied gas 9 can be kept at low temperatures for a long period of time.

(Variations)

[0054] The present invention is not limited to the above-described embodiment. Various modifications can be made without departing from the spirit of the invention.

[0055] For example, in the above-described embodiment, the movement of the restricted outer member 7A in the circumferential direction of the tank 2 is restricted by the special coamings 91 attached to the inner peripheral surface 3a of the outer shell 3. However, as an alternative, the special coamings 91 may be replaced by normal coamings 92 that form, together with normal coamings 93, the enclosure in which the small lubricating piece 81 is fitted, and separately from the normal coamings 92, guide pieces (not shown) that guide the movement of the restricted outer member 7A in the axial direction of the tank 2 may be attached to the inner peripheral surface 3a of the outer shell 3.

[0056] Alternatively, as shown in Figs. 7A and 7B, the movement of the restricted outer member 7A in the circumferential direction of the tank 2 may be restricted by guide pieces 85 attached to the base layer 8a of the lubricating sheet 8. In this case, the lubricating sheet 8 may be a single sheet that is continuous over its entire length. In addition, the lubricating layer 8b may be formed only between the guide pieces 85.

[0057] It is not essential that the lubricating sheet 8 be fixed on the inner peripheral surface 3a of the outer shell 3 by the coamings. For example, in a case where the lubricating sheet 8 is a single sheet continuous over its

entire length as shown in Fig. 8, a pair of guide pieces 94, which restricts the movement of the restricted outer member 7A in the circumferential direction of the tank 2, may be attached onto the inner peripheral surface 3a of the outer shell 3, and fitting holes 8c, in which the respective guide pieces 94 are fitted, may be formed in the lubricating sheet 8. In this manner, the single continuous lubricating sheet 8 can be fixed by utilizing the guide pieces 94.

[0058] Alternatively, as shown in Fig. 9, a pair of rails 95, each having an L-shaped cross section, may be attached onto the inner peripheral surface 3a of the outer shell 3, and the lubricating sheet 8 may be inserted in a space surrounded by the rails 95. In this case, the lubricating sheet 8 may be divided into a plurality of lubricating pieces, or may be a single sheet continuous over its entire length.

[0059] In addition, in a case where the pair of rails 95 is provided as shown in Fig. 9, a pair of guide pieces 96 may be attached to the rails 95 so as to connect these rails 95, and the movement of the restricted outer member 7A in the circumferential direction of the tank 2 may be restricted by these guide pieces 96.

[0060] Although not illustrated, for example, bolting or welding may be adopted as a method of fixing the lubricating sheet 8 on the inner peripheral surface 3a of the outer shell 3.

[0061] It should be noted that the outer members 7 can be configured to be slidable in the axial direction of the tank 2 without using the lubricating sheet 8. As one example, each outer member 7 may be made of a material with high lubricity. Alternatively, a lubricant such as lubricating oil may be applied onto the inner peripheral surface 3a of the outer shell 3 or onto a contact surface of each outer member 7 where the outer member 7 contacts the outer shell 3.

[0062] As shown in Fig. 10, the outer shell 3 may be eliminated. In this case, each support unit 4 may support the tank 2 on the supporting surface 11a of the corresponding saddle 11. That is, the curved surface of the present invention may be the supporting surface 11a of the saddle 11.

Reference Signs List

[0063]

2 tank

50 2a outer peripheral surface

3 outer shell

3a inner peripheral surface (curved surface)

4 support unit

5 tubular element

55 6 inner member

7 outer member

7A restricted outer member

7B unrestricted outer member

8 lubricating sheet
 8A, 8B lubricating piece
 91 to 93 coaming

Claims

1. A support structure of a ship tank, the ship tank being a horizontal type circular cylindrical tank mounted on a ship and storing a liquefied gas, the support structure comprising:

a curved surface facing an outer peripheral surface of the tank; and
 a support unit supporting the tank on the curved surface and extending in a circumferential direction of the tank, wherein
 the support unit includes:

a plurality of tubular elements arranged in the circumferential direction of the tank such that an axial direction of each of the tubular elements coincides with a radial direction of the tank;
 a plurality of inner members each holding, on the outer peripheral surface of the tank, an end portion of a corresponding one of the tubular elements at the tank side; and
 a plurality of outer members each holding, on the curved surface, an end portion of a corresponding one of the tubular elements at an opposite side to the tank,

the plurality of inner members are fixed to the tank, and
 the plurality of outer members are configured to be slidable on the curved surface in an axial direction of the tank.

2. The support structure of a ship tank according to claim 1, wherein
 among the plurality of outer members, at least one outer member disposed near a lowest point of the tank is a restricted outer member whose movement in the circumferential direction of the tank is restricted, and
 among the plurality of outer members, outer members positioned at both sides of the restricted outer member are unrestricted outer members movable in the circumferential direction of the tank.
3. The support structure of a ship tank according to claim 1 or 2, wherein
 the plurality of outer members slide on a lubricating sheet fixed on the curved surface.
4. The support structure of a ship tank according to claim 3, wherein

the lubricating sheet includes:

a base layer contacting the curved surface; and
 a lubricating layer formed on the base layer.

5. The support structure of a ship tank according to claim 3 or 4, wherein
 the lubricating sheet is divided in the circumferential direction of the tank into a plurality of lubricating pieces, and
 each of the plurality of lubricating pieces is fitted in an enclosure formed by coamings attached to the curved surface.
6. The support structure of a ship tank according to any one of claims 1 to 5, wherein
 each of the plurality of tubular elements is made of glass fiber reinforced plastic.
7. The support structure of a ship tank according to any one of claims 1 to 6, wherein
 the curved surface is an inner peripheral surface of an outer shell that encapsulates the tank such that a vacuum space is formed between the tank and the outer shell.

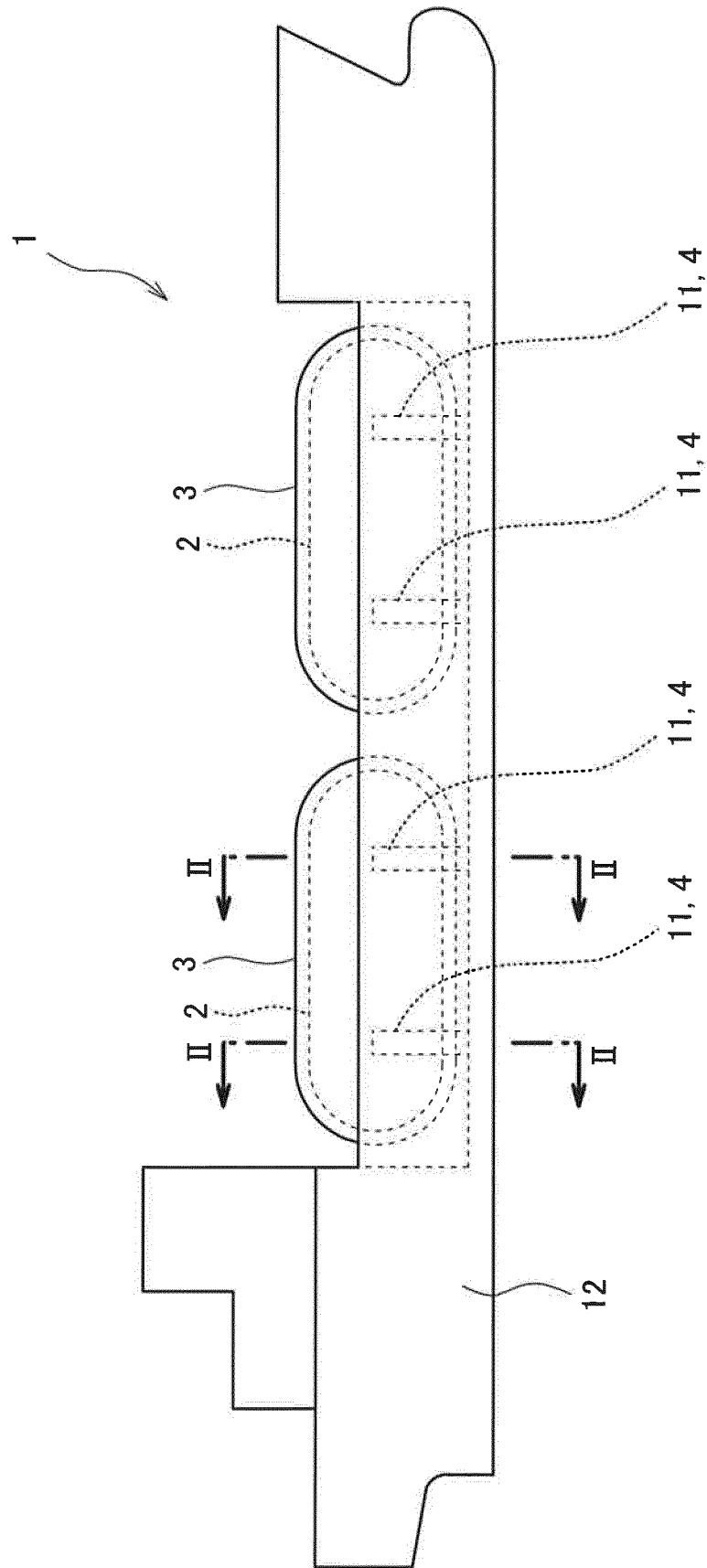


Fig. 1

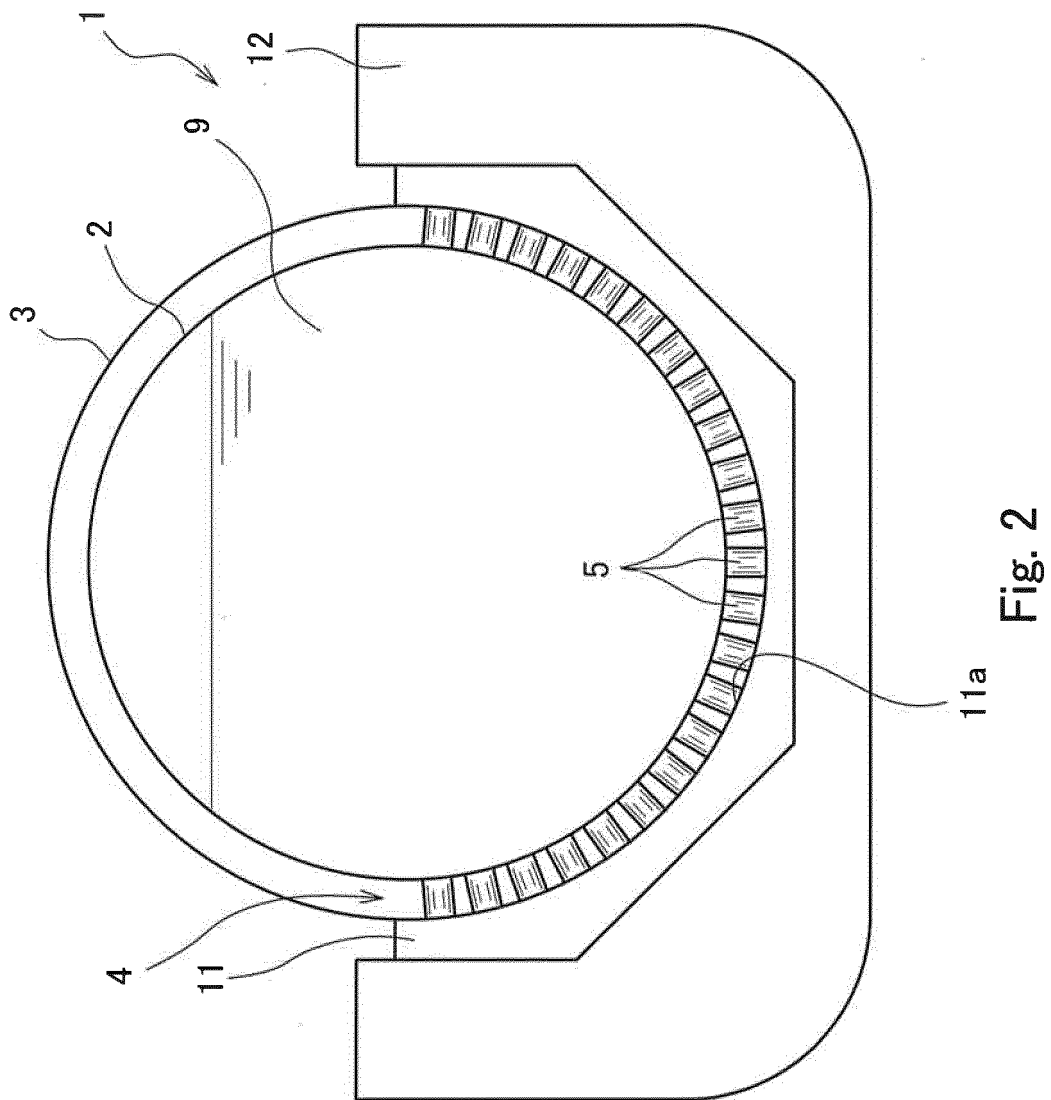


Fig. 2

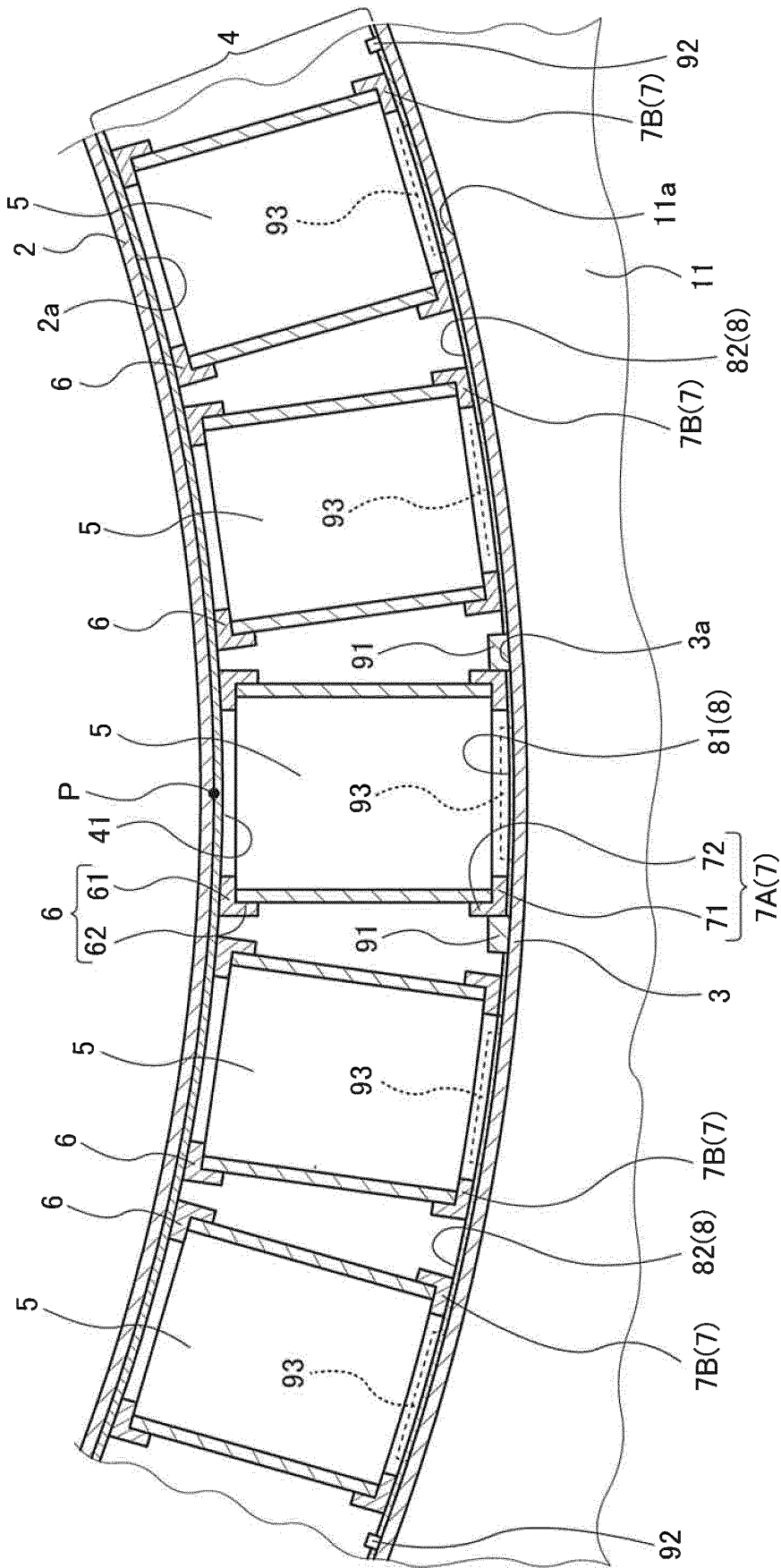


Fig. 3

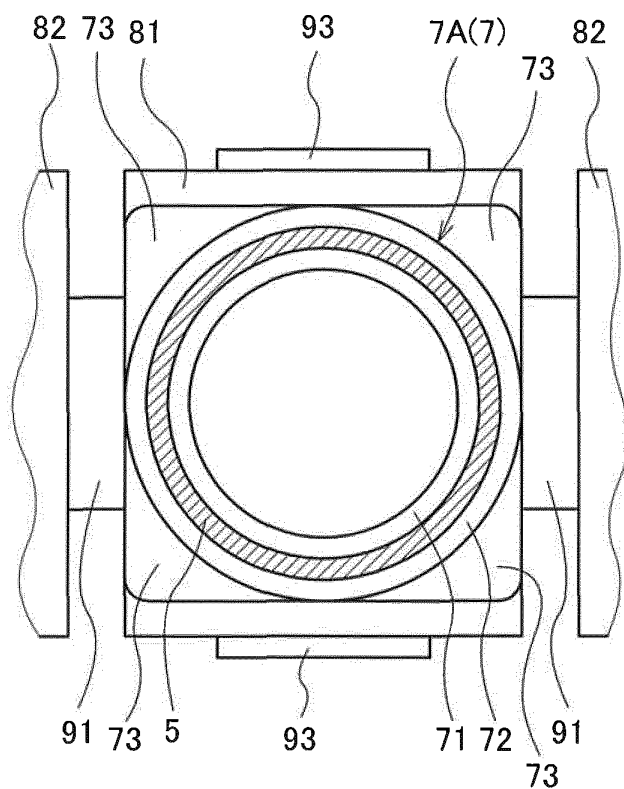


Fig. 4

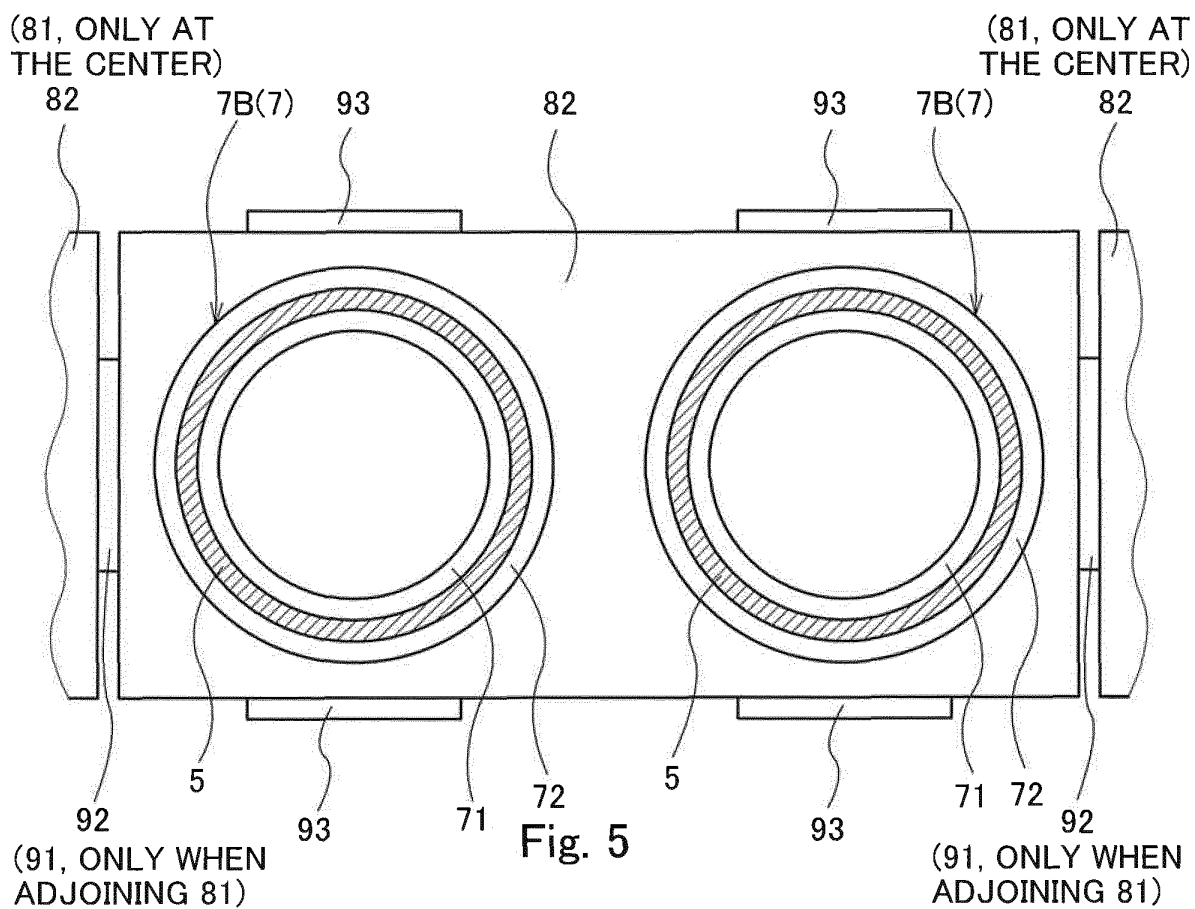


Fig. 5

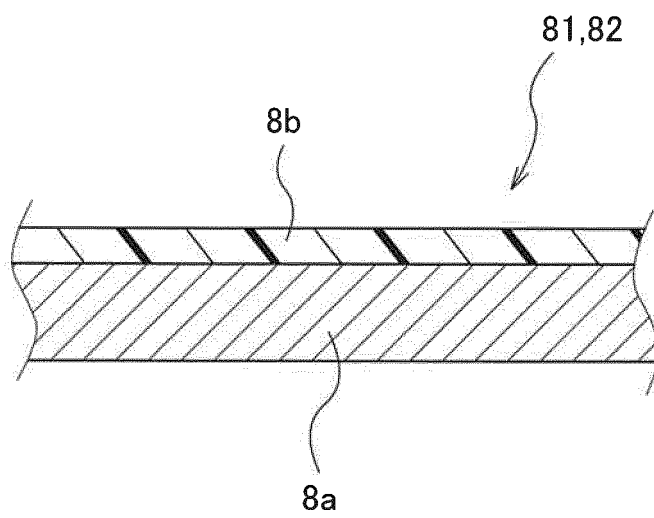


Fig. 6

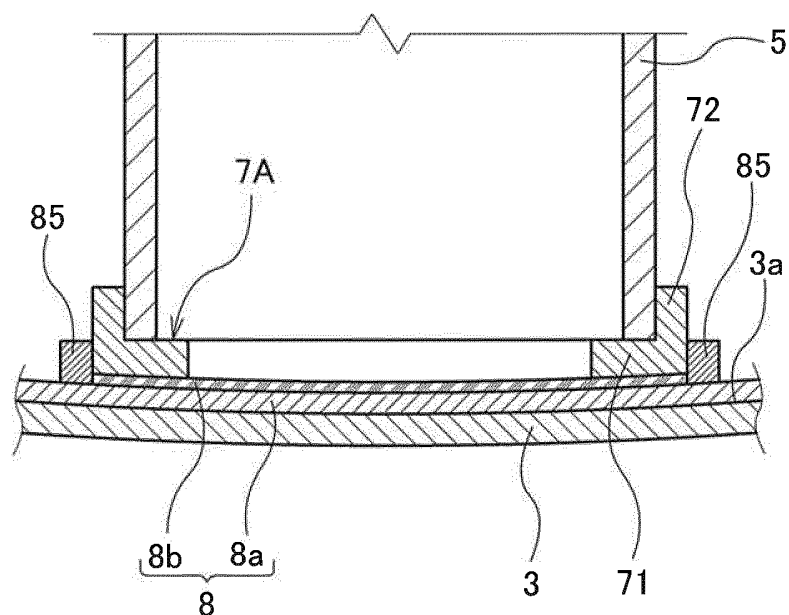


Fig. 7A

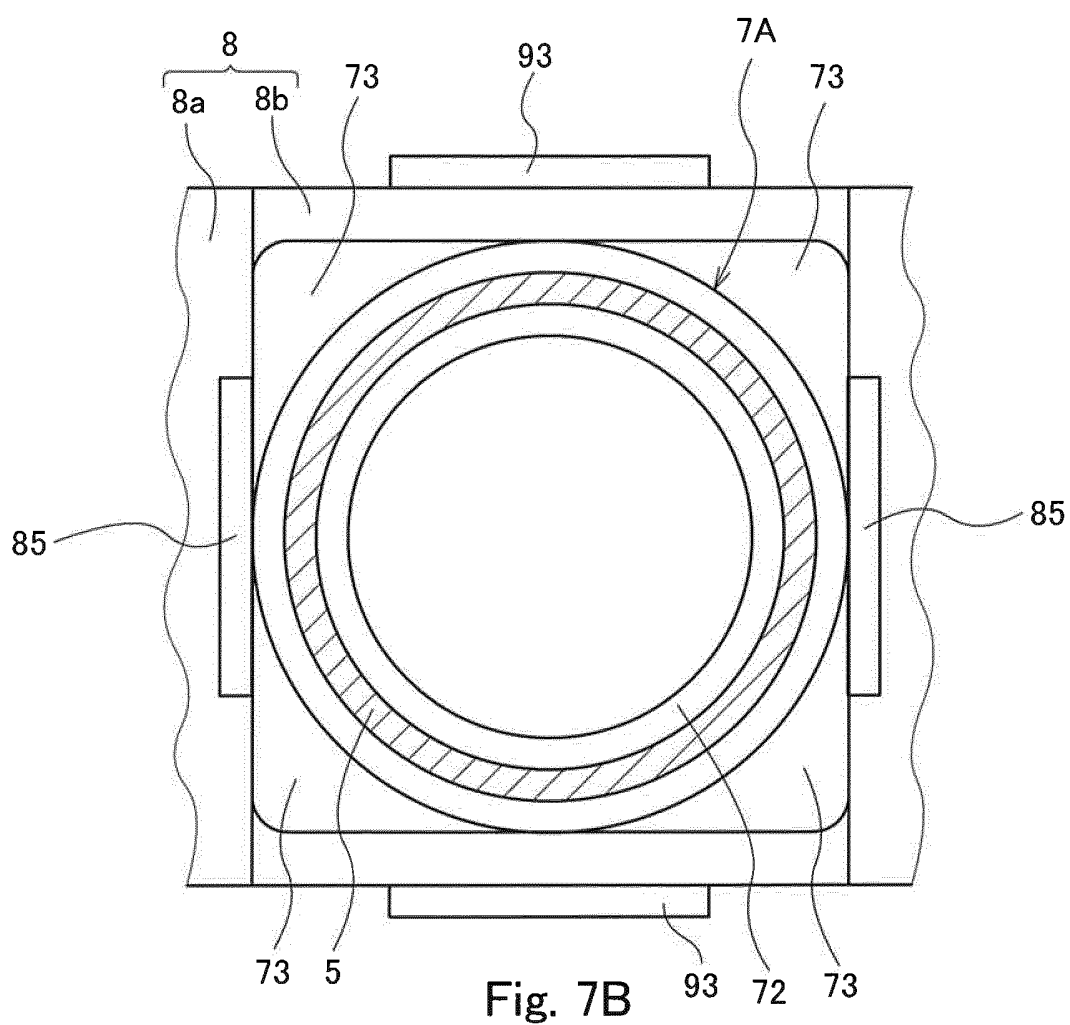


Fig. 7B

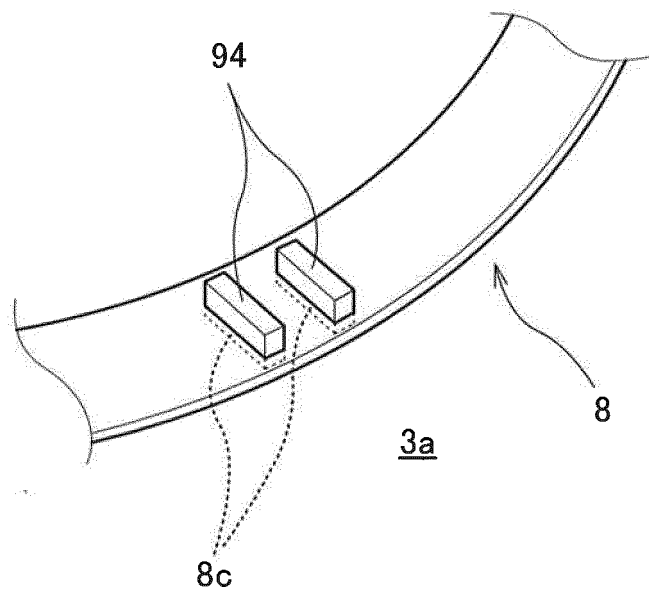


Fig. 8

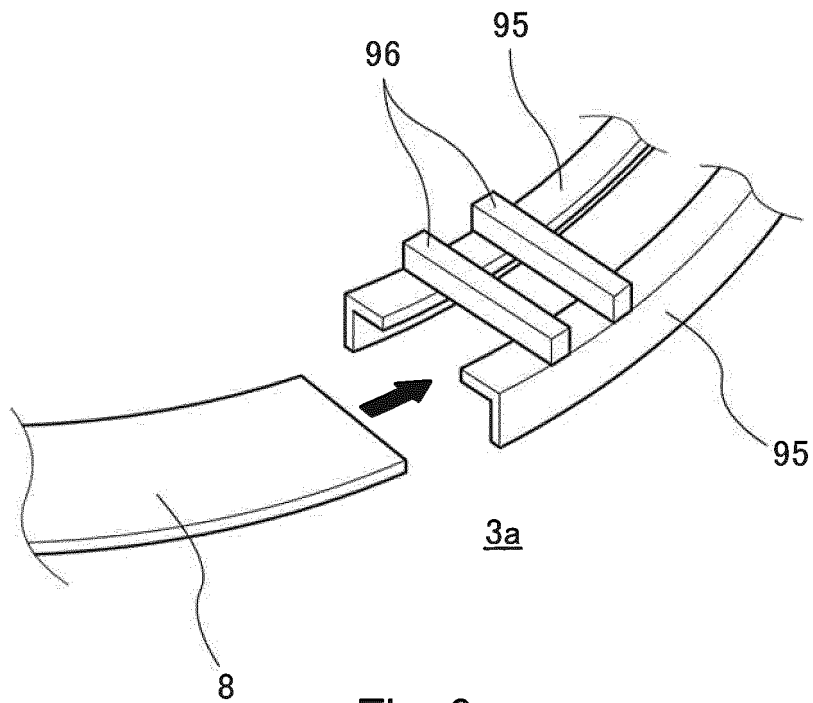
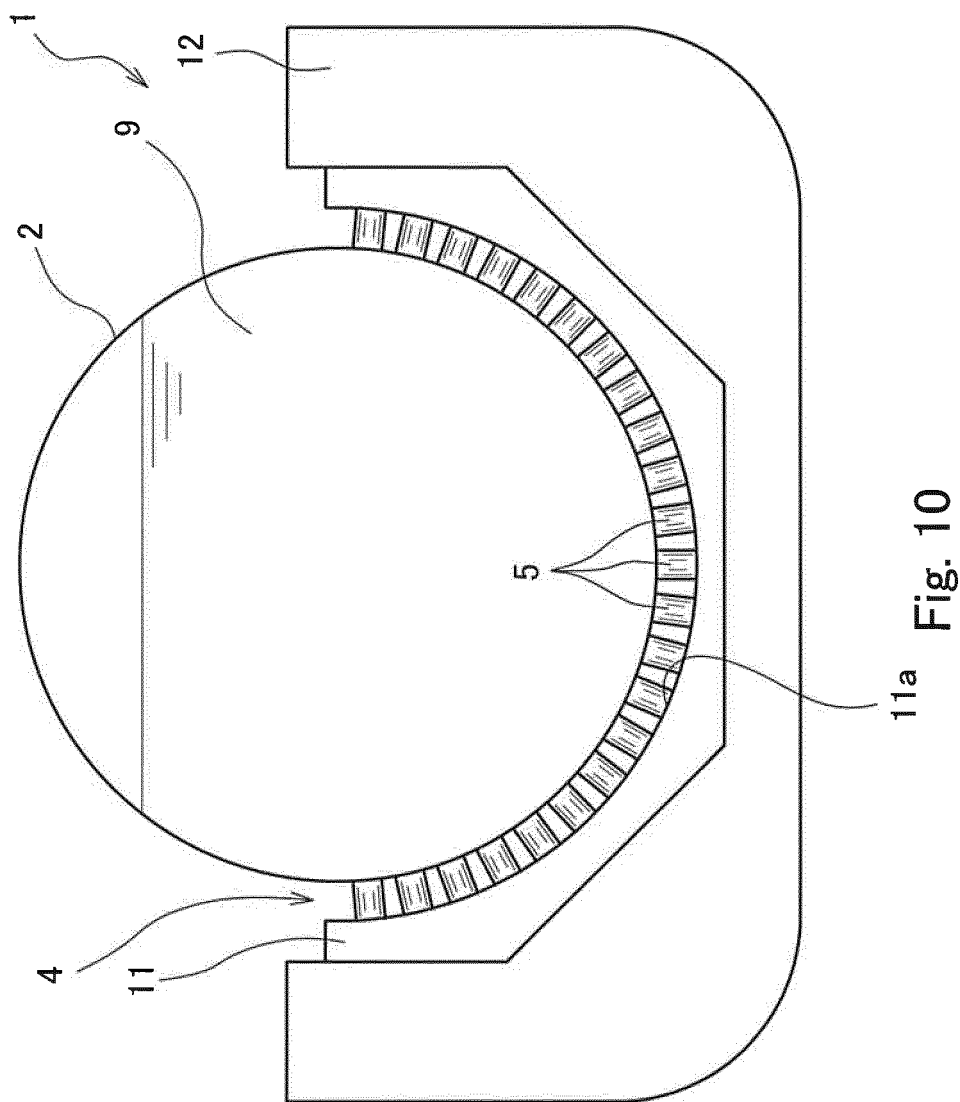


Fig. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/005259

A. CLASSIFICATION OF SUBJECT MATTER

F17C13/08(2006.01)i, B63B25/16(2006.01)i, B65D90/12(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)

F17C13/08, B63B25/16, B65D90/12

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 1996-2014

Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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	WO 2012/026479 A1 (IHI Marine United Inc.), 01 March 2012 (01.03.2012), entire text; all drawings & EP 2610161 A1 & JP 2012-045980 A	1-7
A	JP 2013-184504 A (Mitsui Engineering & Shipbuilding Co., Ltd.), 19 September 2013 (19.09.2013), entire text; all drawings (Family: none)	1-7
A	JP 40-010273 B1 (Mitsubishi Heavy Industries, Ltd.), 25 May 1965 (25.05.1965), entire text; all drawings (Family: none)	1-7

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

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Date of the actual completion of the international search
16 December 2014 (16.12.14)Date of mailing of the international search report
20 January 2015 (20.01.15)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/005259

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. 093526/1986 (Laid-open No. 203796/1987) (Ishikawajima-Harima Heavy Industries Co., Ltd.), 25 December 1987 (25.12.1987), entire text; all drawings (Family: none)	1-7
A	JP 3708055 B2 (Kawasaki Shipbuilding Corp.), 19 October 2005 (19.10.2005), entire text; all drawings (Family: none)	1-7
A	EP 2770241 A2 (HYUNDAI HEAVY INDUSTRIES CO., LTD.), 27 August 2014 (27.08.2014), paragraph [0074]; fig. 1 & JP 2014-530147 A & US 2014/0238052 A & WO 2013/058501 A2	7
A	JP 54-038082 A (Mitsui Engineering & Shipbuilding Co., Ltd.), 22 March 1979 (22.03.1979), page 2, upper left column, lines 6 to 16; fig. 1, 2 (Family: none)	7
E, A	WO 2014/174819 A1 (Kawasaki Heavy Industries, Ltd.), 30 October 2014 (30.10.2014), entire text; all drawings (Family: none)	1-7

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 3708055 B [0006]