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(54) DOUBLE-SHELL TANK FOR SHIP, AND SHIP

(57) A double-shell ship tank includes: an inner shell including an inner shell main part storing a liquefied gas and an inner shell dome protruding upward from the inner shell main part; an outer shell including an outer shell main part surrounding the inner shell main part and an outer shell dome surrounding the inner shell dome; and at least three support mechanisms disposed around the inner shell dome between the inner shell and the outer shell. Each of the support mechanisms includes: a first support member fixed to one of the inner shell and the outer shell, the first support member including a first supporting surface parallel to a reference plane that includes a central axis of the inner shell dome; a second support member fixed to the other one of the inner shell and the outer shell, the second support member including a second supporting surface facing the first supporting surface; and an insulating member interposed between the first supporting surface and the second supporting surface, the insulating member being fixed to the second supporting surface and sliding along the first supporting surface. One of the first support member and the second support member, the one support member being fixed to the inner shell, is positioned on the reference plane.

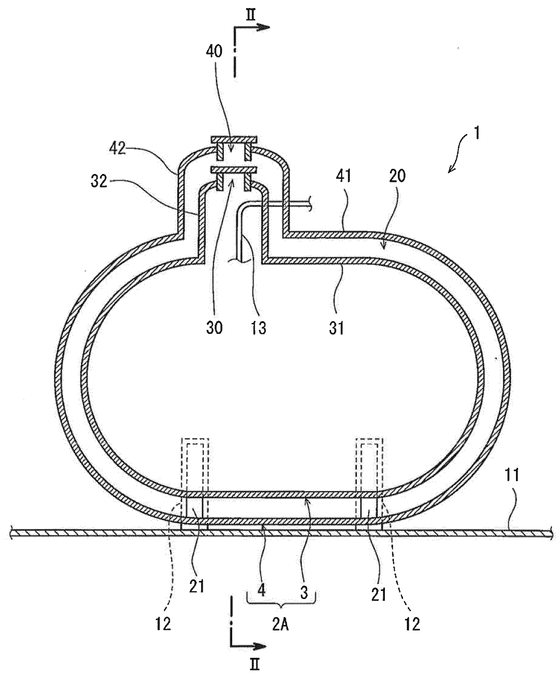

Fig. 1

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Description

Technical Field

[0001] The present invention relates to a double-shell ship tank mounted on a ship and a ship including the double-shell ship tank.

Background Art

[0002] For example, a double-shell tank for a liquefied gas is mounted on a ship, such as a liquefied gas carrier. In such a double-shell ship tank, a thermal insulating layer (e.g., a vacuum thermal insulating layer) is formed between the inner shell and the outer shell (see Patent Literature 1, for example).

[0003] To be more specific, the inner shell includes an inner shell main part storing a liquefied gas and an inner shell dome protruding upward from the inner shell main part, and the outer shell includes an outer shell main part surrounding the inner shell main part and an outer shell dome surrounding the inner shell dome. The inner shell dome is intended for putting pipes penetrating the inner shell into one place. These pipes are disposed such that they penetrate the inner shell dome and the outer shell dome.

Citation List

Patent Literature

[0004] PTL 1: Japanese Laid-Open Patent Application Publication No. 2015-4383

Summary of Invention

Technical Problem

[0005] In a double-shell ship tank, it is desirable to restrict the relative position between the inner shell dome and the outer shell dome in the radial direction of the inner shell dome (hereinafter, "dome-to-dome relative position"), because if the dome-to-dome relative position is not restricted, when the ship swings, the inner shell is displaced relative to the outer shell due to inertial force, and thereby a stress is repeatedly applied to the pipes that penetrate the inner shell dome and the outer shell dome. In addition, when a liquefied gas is fed into the inner shell, the temperature of the entire inner shell is lowered. As a result, thermal contraction of the inner shell dome occurs in the axial direction and the radial direction. Therefore, it is necessary to restrict the dome-to-dome relative position while allowing the thermal contraction of the inner shell dome.

[0006] In view of the above, an object of the present invention is to provide: a double-shell ship tank capable of restricting the dome-to-dome relative position while allowing the thermal contraction of the inner shell dome; and a ship including the double-shell ship tank.

Solution to Problem

[0007] In order to solve the above-described problems, a double-shell ship tank according to the present invention includes: an inner shell including an inner shell main part storing a liquefied gas and an inner shell dome protruding upward from the inner shell main part; an outer shell including an outer shell main part surrounding the inner shell main part and an outer shell dome surrounding the inner shell dome; and at least three support mechanisms disposed around the inner shell dome between the inner shell and the outer shell. Each of the support mechanisms includes: a first support member fixed to one of the inner shell and the outer shell, the first support member including a first supporting surface parallel to a reference plane that includes a central axis of the inner shell dome; a second support member fixed to the other one of the inner shell and the outer shell, the second support member including a second supporting surface facing the first supporting surface; and an insulating member interposed between the first supporting surface and the second supporting surface, the insulating member being fixed to the second supporting surface and sliding along the first supporting surface. One of the first support member and the second support member, the one support member being fixed to the inner shell, is positioned on the reference plane.

[0008] According to the above configuration, the at least three support mechanisms are disposed around the inner shell dome, and the insulating member included in each support mechanism is movable in a direction parallel to the reference plane that includes the central axis of the inner shell dome. This makes it possible to restrict the dome-to-dome relative position while allowing thermal contraction of the inner shell dome in the axial direction and the radial direction.

[0009] The first support member may be a plate whose one main surface is the first supporting surface, and the second support member may be a plate whose one main surface is the second supporting surface. According to this configuration, the first support member and the second support member can be fabricated at low cost.

[0010] The first support member may be fixed to the outer shell dome or the outer shell main part, and the second support member may be fixed to the inner shell dome or the inner shell main part. According to this configuration, the temperature of the first supporting surface is kept at substantially ordinary temperatures. Therefore, the sliding performance between the insulating member and the first supporting surface can be designed under ordinary temperature conditions.

[0011] The insulating member may be tubular and may extend in a direction orthogonal to the reference plane. According to this configuration, entry of heat from the outside of the outer shell into the inner shell via the insulating member can be suppressed.

[0012] Each of the support mechanisms may include a first holding member that holds one end of the tubular insulating member and a second holding member that holds another end of the tubular insulating member. The tubular insulating member may be in contact with the first supporting surface via the first holding member, and may be fixed to the second supporting surface via the second holding member. According to this configuration, one end of the simple-shaped tubular insulating member can be readily fixed to the second supporting surface by using the second holding member. In addition, the first holding member, which holds the other end of the tubular insulating member, can be contacted with the first supporting surface over a large area. This makes it possible to allow the tubular insulating member to make smooth sliding movement together with the first holding member.

[0013] A lubricating liner may be sandwiched between the first holding member and the first supporting surface. According to this configuration, favorable sliding ability can be obtained with a simple configuration.

[0014] The insulating member may be made of glass fiber reinforced plastic. According to this configuration, the entry of heat via the insulating member can be further suppressed.

[0015] The second support member may be a plate whose one main surface and another main surface each serve as the second supporting surface. Each of the support mechanisms may include a pair of the first support members disposed at both sides of the second support member. According to this configuration, each support mechanism alone can restrict the inner shell dome in the circumferential direction.

[0016] Each of the support mechanisms may include one first support member and one second support member. A positional relationship between the one first support member and the one second support member may be reversed between adjacent support mechanisms among the at least three support mechanisms. This configuration makes it possible to simplify the structure of each support mechanism while restricting the dome-to-dome relative position and restricting the inner shell dome in the circumferential direction, and facilitate position adjustment between the support mechanisms.

[0017] Each of the support mechanisms may include one first support member and one second support member. The at least three support mechanisms may be four or more support mechanisms, and in each one of at least four pairs of the support mechanisms that are adjacent to each other, a positional relationship between the one first support member and the one second support member may be reversed between the adjacent support mechanisms. This configuration also makes it possible to simplify the structure of each support mechanism while restricting the dome-to-dome relative position and restricting the inner shell dome in the circumferential direction.

[0018] A space between the inner shell and the outer shell may be a vacuum space. According to this configuration, the liquefied gas can be kept at low temperatures for a long period of time.

[0019] The inner shell main part may be cylindrical and may extend in a horizontal direction. The at least three support mechanisms may be four support mechanisms that are disposed between the inner shell dome and the outer shell dome, each support mechanism being disposed at a position that is away from the central axis of the inner shell dome in an angular direction of 45 degrees relative to an axial direction of the inner shell main part. According to this configuration, the distances from the inner shell main part to all the support mechanisms can be made equal to each other. Consequently, loads exerted on all the support mechanisms can be made uniform.

[0020] A ship according to the present invention includes the above-described double-shell ship tank.

Advantageous Effects of Invention

[0021] The present invention makes it possible to restrict the dome-to-dome relative position while allowing thermal contraction of the inner shell dome.

Brief Description of Drawings

[0022]

Fig. 1 is a vertical sectional view of a double-shell ship tank according to Embodiment 1 of the present invention.

Fig. 2 is a sectional view showing an essential part of Fig. 1 in an enlarged manner.

Fig. 3 is a horizontal sectional view schematically showing support mechanisms, the view being taken along line III-III of Fig. 2.

Fig. 4 is a horizontal sectional view of one support mechanism.

Figs. 5A and 5B are vertical sectional views taken along line VA-VA and line VB-VB of Fig. 4, respectively.

Fig. 6 is a horizontal sectional view schematically showing support mechanisms according to one variation of Embodiment 1.

Fig. 7 is a horizontal sectional view schematically showing support mechanisms of a double-shell ship tank according to Embodiment 2 of the present invention.

Fig. 8 is a horizontal sectional view schematically showing support mechanisms of a double-shell ship tank according to Embodiment 3 of the present invention.

Description of Embodiments

(Embodiment 1)

[0023] Fig. 1 shows a double-shell ship tank 2A mounted on a ship 1, such as a liquefied gas carrier, according to Embodiment 1 of the present invention.

[0024] Specifically, the double-shell tank 2A includes an inner shell 3 and an outer shell 4. The outer shell 4 surrounds a space 20 formed around the inner shell 3. In the present embodiment, the space 20 between the inner shell 3 and the outer shell 4 is a vacuum space. However, as an alternative, the space 20 between the inner shell 3 and the outer shell 4 may be filled with a gas having low thermal conductivity, such as argon gas.

[0025] The inner shell 3 includes an inner shell main part 31 storing a liquefied gas and an inner shell dome 32 protruding upward from the inner shell main part 31. In the present embodiment, the axial direction of the inner shell dome 32 is parallel to the vertical direction. However, as an alternative, the axial direction of the inner shell dome 32 may be slightly inclined relative to the vertical direction. In the present embodiment, the inner shell dome 32 is provided with a manhole 30 intended for inspection of the inside of the inner shell. However, as an alternative, the inner shell main part 31 may be provided with the manhole 30.

[0026] In the present embodiment, the inner shell main part 31 is cylindrical and extends in the horizontal direction. However, as an alternative, the inner shell main part 31 may be spherical or rectangular, for example. To be more specific, the inner shell main part 31 includes: a body portion that extends laterally with a constant cross-sectional shape; and hemispherical sealing portions that seal openings on both sides of the body portion. Alternatively, each sealing portion may have a flat shape perpendicular to the body portion or may be dish-shaped.

[0027] For example, the liquefied gas stored in the inner shell main part 31 is liquefied petroleum gas (LPG, about -45°C), liquefied ethylene gas (LEG, about -100°C), liquefied natural gas (LNG, about -160°C), liquefied hydrogen (LH_2, about -250°C), or liquefied helium (LHe, about -270°C).

[0028] The outer shell 4 includes an outer shell main part 41 surrounding the inner shell main part 31 and an outer shell dome 42 surrounding the inner shell dome 32. That is, the outer shell main part 41 has the shape of the inner shell main part 31, but is larger than the inner shell main part 31, and the outer shell dome 42 has the shape of the inner shell dome 32, but is larger than the inner shell dome 32. Alternatively, the shape of the outer shell dome 42 may be slightly different from the shape of the inner shell dome 32. The outer shell dome 42 is provided with a manhole 40 at a position corresponding to the position of the inner shell dome 32.

[0029] A pair of outer bases 12 spaced apart from each other in the axial direction of the outer shell main part 41 is provided on a ship bottom 11, and the outer shell main part 41 is supported by the outer bases 12. Between the inner shell main part 31 and the outer shell main part 41, a pair of inner bases 21 is disposed at positions corresponding to the positions of the outer bases 12. The inner bases 21 support the inner shell main part 31 in such a manner that the inner shell main part 31 is slidable in the axial direction thereof. The inner bases 21 support the inner shell main part 31 in such a slidable manner so as to accommodate thermal contraction of the inner shell main part 31 in the axial direction when the liquefied gas is fed into the inner shell 3.

[0030] The double-shell tank 2A is provided with various pipes 13, such as a liquefied gas pipe and an electric wire pipe. The pipes 13 penetrate the inner shell dome 32 and the outer shell dome 42. It should be noted that Fig. 1 shows only one pipe that represents the pipes 13.

[0031] Next, the inner shell dome 32 and the outer shell dome 42 are described in detail with reference to Fig. 2 and Fig. 3.

[0032] In the present embodiment, each of the inner shell dome 32 and the outer shell dome 42 has a round sectional shape. However, as an alternative, each of the inner shell dome 32 and the outer shell dome 42 may have an ellipsoidal sectional shape, for example. In the present embodiment, the inner shell dome 32 has a central axis 36, which coincides with the central axis of the outer shell dome 42. However, as an alternative, the central axis 36 of the inner shell dome 32 may deviate from the central axis of the outer shell dome 42.

[0033] The inner shell dome 32 includes: a peripheral wall 33 extending upward from the inner shell main part 31; and a dish-shaped ceiling wall 34, which is raised upward from the upper end of the peripheral wall 33. Similarly, the outer shell dome 42 includes: a peripheral wall 43 extending upward from the outer shell main part 41; and a dish-shaped ceiling wall 44, which is raised upward from the upper end of the peripheral wall 43. It should be noted that the ceiling walls 34 and 44 may have a different shape, for example, a hemispherical shape or a flat plate shape. The ceiling walls 34 and 44 are provided with the aforementioned manholes 30 and 40, respectively.

[0034] In the present embodiment, a bellows pipe 45 is incorporated in the peripheral wall 43 of the outer shell dome 42, and the peripheral wall 43 is divided by the bellows pipe 45 into a base portion 43A and a distal end portion 43B. The aforementioned pipes 13 penetrate the peripheral wall 33 of the inner shell dome 32 and the distal end portion 43B of the peripheral wall 43 of the outer shell dome 42. Alternatively, the pipes 13 may penetrate the ceiling wall 34 of the inner shell dome 32 and the ceiling wall 44 of the outer shell dome 42. Further alternatively, the pipes 13 may be bent at a position between the inner shell dome 32 and the outer shell dome 42, and may penetrate the peripheral wall 33 of the inner shell dome 32 and the ceiling wall 44 of the outer shell dome 42, or may penetrate the ceiling wall 34 of the inner shell dome 32 and the peripheral wall 43 of the outer shell dome 42.

[0035] A first annular plate 22 is fixed to the inner peripheral surface of the distal end portion 43B of the peripheral wall 43 of the outer shell dome 42. A second annular plate 23 facing the first annular plate 22 is fixed to the outer peripheral surface of the peripheral wall 43 of the inner shell dome 32. In the illustrated example, the second annular plate 23 is positioned below the first annular plate 22. However, as an alternative, the second annular plate 23 may be positioned above the first annular plate 22. The first annular plate 22 and the second annular plate 23 are coupled together by a plurality of coupling members 25. Each coupling member 25 may be pillar-shaped or block-shaped. Accordingly, when the liquefied gas is fed into the inner shell 3, the inner shell main part 31 thermally contracts, and the inner shell dome 32 moves downward. At the time, the upper portion of the outer shell dome 42 also moves downward together with the inner shell dome 32, causing the bellows pipe 45 to be compressed.

[0036] A tubular blocking member 24, which partitions off the space 20 in the outer shell dome 42 into a lower region and an upper region, is disposed between the first annular plate 22 and the second annular plate 23. The blocking member 24 is intended for reducing the volume open to the atmosphere when the manhole 40 is opened. However, the position of the blocking member 24 is not limited to this example. As an alternative example, a tubular protrusion may be provided on each of the ceiling wall 34 of the inner shell dome 32 and the ceiling wall 44 of the outer shell dome 42 such that the tubular protrusions form a double pipe surrounding the manholes 30 and 40, and the blocking member 24 formed as an annular plate may be disposed between these protrusions. As another alternative example, a plurality of first projection pieces arranged at intervals in the circumferential direction may be provided instead of the first annular plate 22, and a plurality of second projection pieces facing the first projection pieces may be provided instead of the second annular plate 23.

[0037] Between the peripheral wall 33 of the inner shell dome 32 and the base portion 43A of the peripheral wall 43 of the outer shell dome 42, at least three support mechanisms 5 are disposed around the inner shell dome 32. These support mechanisms 5 are intended for restricting the dome-to-dome relative position (the relative position between the inner shell dome 32 and the outer shell dome 42 in the radial direction of the inner shell dome 32). In the present embodiment, four support mechanisms 5 are provided. Each of the support mechanisms 5 is disposed at a position that is away from the central axis 36 of the inner shell dome 32 in an angular direction of 45 degrees relative to the axial direction D of the inner shell main part 31. However, the angular pitches between the support mechanisms 5 need not be equal to each other, but may be unequal to each other.

[0038] In the present embodiment, each support mechanism 5 includes: a pair of first support members 6 fixed to the outer shell dome 42; one second support member 7 fixed to the inner shell dome 32. The second support member 7 is positioned on a reference plane 50 (i.e., a plane that is defined by the axial direction and the radial direction of the inner shell dome 32), which includes the central axis 36 of the inner shell dome 32. The first support members 6 are disposed at both sides of the second support member 7.

[0039] Each first support member 6 includes, on the second support member 7 side, a first supporting surface 61 parallel to the reference plane 50. The second support member 7 includes a pair of second supporting surfaces 71 facing the respective first supporting surfaces 61. In the present embodiment, each first support member 6 is a plate whose one main surface is the first supporting surface 61, and the second support member 7 is a plate whose one main surface and another main surface are the second supporting surfaces 71. It should be noted that each first support member 6 need not be a plate, but may have any shape, so long as each first support member 6 includes the first supporting surface 61. However, if each of the first support members 6 and the second support member 7 is a plate, the first and the second support members 6 and 7 can be fabricated at low cost.

[0040] The second support member 7 protrudes outward in the radial direction from the peripheral wall 33 of the inner shell dome 32. That is, the second supporting surfaces 71 are parallel to the reference plane 50. At a position where each support mechanism 5 is present, a doubling plate 35 is joined to the peripheral wall 33 of the inner shell dome 32, and the second support member 7 is fixed to the peripheral wall 33 via the doubling plate 35. However, the doubling plate 35 may be eliminated, and the second support member 7 may be directly fixed to the peripheral wall 33. Meanwhile, each first support member 6 is fixed to the base portion 43A of the peripheral wall 43 of the outer shell dome 42, and protrudes from the base portion 43A toward the peripheral wall 33 of the inner shell dome 32 in parallel to the second support member 7.

[0041] To be more specific, as shown in Fig. 4 and Fig. 5B, on the distal end of a main surface (outer main surface) of each first support member 6, the main surface being the opposite surface to the first supporting surface 61, a reinforcing plate 62 extending in the axial direction of the inner shell dome 32 is joined perpendicularly to the first supporting surface 61. Between the reinforcing plate 62 and the base portion 43A, ribs 63 are provided, which are connected to the upper and lower ends of the outer main surface of the first support member 6.

[0042] As shown in Fig. 4 and Fig. 5A, on the distal end of each second supporting surface 71 of the second support member 7, a reinforcing plate 72 extending in the axial direction of the inner shell dome 32 is joined perpendicularly to the second supporting surface 71. Between the reinforcing plate 72 and the doubling plate 35, ribs 73 are provided, which are connected to the upper and lower ends of the second supporting surface 71.

[0043] An insulating member 55 is interposed between each second supporting surface 71 and the corresponding first supporting surface 61. In the present embodiment, the insulating member 55 is tubular and extends in a direction orthogonal to the reference plane 50. It should be noted that the axial direction of the insulating member 55 need not be parallel to the direction orthogonal to the reference plane 50, but may be slightly inclined relative to the direction orthogonal to the reference plane 50. The tubular insulating member 55 may have a round sectional shape or a polygonal sectional shape.

[0044] In the present embodiment, each tubular insulating member 55 is made of glass fiber reinforced plastic (GFRP). However, as an alternative, each tubular insulating member 55 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.

[0045] One end and the other end of the tubular insulating member 55 are held by a first holding member 8A and a second holding member 8B, respectively. The insulating member 55 is in contact with the first supporting surface 61 via the first holding member 8A, and is fixed to the second supporting surface 71 via the second holding member 8B. The insulating member 55 slides along the first supporting surface 61 together with the first holding member 8A. Fig. 3 previously referred to schematically shows each support mechanism 5. In Fig. 3, the sliding movement of the insulating member 55 along the first supporting surface 61 is represented by a gap between the insulating member 55 and the first supporting surface 61 (in Fig. 3, the ribs 63 and 73 are indicated by two-dot chain lines, and the holding members 8A and 8B are omitted).

[0046] When the liquefied gas is fed into the inner shell 3, the temperature of the second support member 7, the second holding member 8B, and the insulating member 55 is lowered, and the second support member 7, the second holding member 8B, and the insulating member 55 thermally contract, which may result in formation of a gap between the first holding member 8A and the first supporting surface 61. That is, the term "slide" or "sliding movement" herein means not only relative movement between two objects that are in physical contact with each other, but also relative movement between two objects that are not in physical contact with each other.

[0047] In the present embodiment, each of the first holding member 8A and the second holding member 8B has a shape that allows the tubular insulating member 55 to be inserted therein. Specifically, each holding member includes: a tubular portion 82, in which the tubular insulating member 55 is fitted; and a bottom portion 81, which contacts with an end surface of the tubular insulating member 55. In the present embodiment, an opening is formed at the center of the bottom portion 81. However, it is not essential that the opening be formed. The tubular portion 82 is coupled to the insulating member 55 by a pin 56. Alternatively, each holding member may have a shape that allows the holding member to be inserted in the tubular insulating member 55. Further alternatively, each holding member and the insulating member 55 may be coupled together, for example, by screws or rivets.

[0048] A lubricating liner 51 is sandwiched between the first holding member 8A and the first supporting surface 61. The thickness of the lubricating liner 51 is not particularly limited, and the lubricating liner 51 may be thin or thick. The lubricating liner 51 is fixed to the first supporting surface 61, for example, by screws. Alternatively, the lubricating liner 51 may be fixed to the first holding member 8A. The lubricating liner 51 is made of a favorably slidable material (e.g., fluorine resin or molybdenum disulfide).

[0049] As described above, in the double-shell ship tank 2A of the present embodiment, at least three support mechanisms 5 are disposed around the inner shell dome 32, and the insulating members 55 included in each support mechanism 5 are movable in a direction parallel to the reference plane 50. This makes it possible to restrict the dome-to-dome relative position (the relative position between the inner shell dome 32 and the outer shell dome 42 in the radial direction of the inner shell dome 32) while allowing thermal contraction of the inner shell dome 32 in the axial direction and the radial direction.

[0050] In addition, since each insulating member 55 is made of GFRP in the present embodiment, entry of heat via the insulating member 55 can be further suppressed.

[0051] Moreover, in each support mechanism 5, the pair of first support members 6 is disposed at both sides of the second support member 7. Therefore, each support mechanism 5 alone can restrict the inner shell dome 32 in the circumferential direction.

[0052] Furthermore, since the space 20 between the inner shell 3 and the outer shell 4 is a vacuum space, the liquefied gas can be kept at low temperatures for a long period of time.

<Variations>

[0053] Hereinafter, variations of Embodiment 1 are described. The variations described below, except the second variation, are applicable also as variations of Embodiments 2 and 3 described below.

[0054] Assume that the axial direction D and the width direction of the inner shell main part 31 are the front-rear direction and the right-left direction, respectively. In this case, the four support mechanisms 5 may be disposed such that two of them are positioned at the front and rear of the central axis 36 of the inner shell dome 32, respectively, and the other two are positioned at the right and left of the central axis 36 of the inner shell dome 32, respectively. In this case, however, although the upper surface of the inner shell main part 31 is straight in the front-rear direction, the upper surface of the inner shell main part 31 is curved in the right-left direction, and for this reason, the distance from the inner shell main part 31 to the right and left support mechanisms 5 is greater than the distance from the inner shell main part 31 to the front and rear support mechanisms 5. In this respect, by adopting the layout as in the above-described embodiment, the distances from the inner shell main part 31 to all the support mechanisms 5 can be made equal to each other. Consequently, loads exerted on all the support mechanisms 5 can be made uniform.

[0055] As in a double-shell ship tank 2B according to one variation shown in Fig. 6, each support mechanism 5 may include: one first support member 6 fixed to the inner shell dome 32 and positioned on the reference plane 50; and a pair of second support members 7 fixed to the outer shell dome 42 and disposed at both sides of the first support member 6. In this case, each second support member 7 need not be a plate, but may have any shape, so long as each second support member 7 includes the second supporting surface 71. However, if the first support members 6 are fixed to the outer shell 4 and the second support member 7 is fixed to the inner shell 3 as in the above-described embodiment, the temperature of each first supporting surface 61 is kept at substantially ordinary temperatures. Therefore, the sliding performance between the insulating member 55 and the first supporting surface 61 can be designed under ordinary temperature conditions.

[0056] It is not essential that the second supporting surface 71 of the second support member 7 be parallel to the reference plane 50. For example, in a case where an end portion of the insulating member 55 is cut away diagonally, the second supporting surface 71 may be inclined relative to the reference plane 50, such that the second supporting surface 71 extends along the end portion of the insulating member 55. In this case, it will suffice if the second support member 7 positioned on the reference plane 50 is disposed such that the reference plane 50 passes through at least part of the second support member 7.

[0057] The insulating member 55 may be a solid-core block. However, if the insulating member 55 is tubular as in the above-described embodiment, entry of heat from the outside of the outer shell 4 into the inner shell 3 via the insulating member 55 can be suppressed. It should be noted that in a case where the insulating member 55 is a solid-core block, the insulating member 55 may be directly fixed to the second supporting surface 71, and may be directly slid on the first supporting surface 61.

[0058] In a case where flanges are provided on both ends of the tubular insulating member 55, the insulating member 55 can be directly fixed to the second supporting surface 71, and can be directly slid on the first supporting surface 61. However, by adopting the configuration as in the above-described embodiment, one end of the simple-shaped tubular insulating member 55 can be readily fixed to the second supporting surface 71 by using the second holding member 8B. In addition, the first holding member 8A, which holds the other end of the tubular insulating member 55, can be contacted with the first supporting surface 61 over a large area. This makes it possible to allow the tubular insulating member 55 to make smooth sliding movement together with the first holding member 8A.

[0059] It is not essential that the lubricating liner 51 be sandwiched between the first holding member 8A and the first supporting surface 61. For example, the first holding member 8A can be made of a resin with favorable sliding ability. Alternatively, in a case where the first holding member 8A is made of a metal, a lubricant may be applied onto the first supporting surface 61, which contacts with the first holding member 8A. However, if the lubricating liner 51 is sandwiched between the first holding member 8A and the first supporting surface 61 as in the above-described embodiment, favorable sliding ability can be obtained with a simple configuration.

[0060] The support mechanisms 5 may be disposed between the peripheral wall 33 of the inner shell dome 32 and the distal end portion 43B of the peripheral wall 43 of the outer shell dome 42. In this case, the insulating member 55 may make the sliding movement only in a direction orthogonal to the central axis 36 of the inner shell dome 32.

[0061] It is not essential that the bellows pipe 45 be incorporated in the peripheral wall 43 of the outer shell dome 42. In a case where no bellows pipe 45 is incorporated in the peripheral wall 43, when the liquefied gas is fed into the inner shell 3 and the inner shell main part 31 thermally contracts, the movement of the inner shell dome 32 in the axial direction is allowed by deflection of the pipes 13.

(Embodiment 2)

[0062] Next, a double-shell ship tank 2C according to Embodiment 2 of the present invention is described with reference to Fig. 7. It should be noted that, in the present embodiment and the following Embodiment 3, the same components as those described in Embodiment 1 are denoted by the same reference signs as those used in Embodiment 1, and repeating the same descriptions is avoided.

[0063] In the present embodiment, each support mechanism 5 includes: one first support member 6 fixed to the outer shell dome 42; a pair of second support members 7 fixed to the inner shell dome 32. The pair of second support members 7 is disposed at both sides of the first support member 6, and each second support member 7 is positioned on the corresponding reference plane 50, which includes the central axis 36 of the inner shell dome 32. Each second support member 7 is a plate protruding outward in the radial direction from the peripheral wall 33 of the inner shell dome 32, and includes the second supporting surface 71 parallel to the reference plane 50. The first support member 6 is substantially trapezoidal when seen in the axial direction of the inner shell dome 32, and includes a pair of first supporting surfaces 61, each of which is parallel to the corresponding reference plane 50. Embodiment 2 is the same as Embodiment 1 in the following point: the tubular insulating members 55 are in contact with the first supporting surfaces 61 via the first holding members 8A, and are fixed to the second supporting surfaces 71 via the second holding members 8B.

[0064] The present embodiment provides the same advantageous effects as those provided by Embodiment

1.

[0065] It should be noted that, although not illustrated, each support mechanism 5 may include: a pair of first support members 6, each of which is fixed to the inner shell dome 32 and positioned on the corresponding reference plane 50; and one second support member 7 (substantially trapezoidal when seen in the axial direction of the inner shell dome 32) fixed to the outer shell dome 42 and disposed between the first support members 6. In this case, each first support member 6 need not be a plate, but may have any shape, so long as each first support member 6 includes the first supporting surface 61. However, if the first support member 6 is fixed to the outer shell 4 and the second support members 7 are fixed to the inner shell 3 as in the above-described embodiment, the temperature of each first supporting surface 61 is kept at substantially ordinary temperatures. Therefore, the sliding performance between the insulating member 55 and the first supporting surface 61 can be designed under ordinary temperature conditions.

(Embodiment 3)

[0066] Next, a double-shell ship tank 2D according to Embodiment 3 of the present invention is described with reference to Fig. 8.

[0067] In the present embodiment, each support mechanism 5 includes: one first support member 6 fixed to the outer shell dome 42; and one second support member 7 fixed to the inner shell dome 32 and positioned on the reference plane 50. For this reason, the support mechanisms 5 are arranged such that they are symmetrically identical with each other alternately. In other words, the positional relationship between the first support member 6 and the second support member 7 is reversed between adjacent support mechanisms among the four support mechanisms 5. Embodiment 3 is the same as Embodiment 1 in the following point: the tubular insulating member 55 is in contact with the first supporting surface 61 via the first holding member 8A, and is fixed to the second supporting surface 71 via the second holding member 8B. It should be noted that the first support member 6 need not be a plate, but may have any shape, so long as the first support member 6 includes the first supporting surface 61. Similarly, the second support member 7 need not be a plate, but may have any shape, so long as the second support member 7 includes the second supporting surface 71.

[0068] The present embodiment provides the same advantageous effects as those provided by Embodiment 1. Additionally, the present embodiment makes it possible to simplify the structure of each support mechanism 5 while restricting the dome-to-dome relative position and restricting the inner shell dome 32 in the circumferential direction, and facilitate position adjustment between the support mechanisms 5. It should be noted that, in the present embodiment, it is desirable that the number of support mechanisms 5 be an even number in order to realize the symmetry. If the number of support mechanisms 5 is an even number, in each pair of adjacent support mechanisms 5 (e.g., in a case where the number of support mechanisms 5 is four, in each one of four pairs of adjacent support mechanisms 5), the positional relationship between the first support member 6 and the second support member 7 is reversed between the adjacent support mechanisms 5. On the other hand, if the number of support mechanisms 5 is an odd number, in each pair of adjacent support mechanisms 5 except one pair of adjacent support mechanisms 5 (e.g., in a case where the number of support mechanisms 5 is five, in each one of four pairs of adjacent support mechanisms 5), the positional relationship between the first support member 6 and the second support member 7 is reversed between the adjacent support mechanisms 5.

[0069] It should be noted that, although not illustrated, each support mechanism 5 may include: one first support member 6 fixed to the inner shell dome 32 and positioned on the reference plane 50; and one second support member 7 fixed to the outer shell dome 42. However, if the first support member 6 is fixed to the outer shell 4 and the second support member 7 is fixed to the inner shell 3 as in the above-described embodiment, the temperature of the first supporting surface 61 is kept at substantially ordinary temperatures. Therefore, the sliding performance between the insulating member 55 and the first supporting surface 61 can be designed under ordinary temperature conditions.

[0070] It is not essential that the support mechanisms 5 be arranged such that they are symmetrically identical with each other alternately. For example, assume that the number of support mechanisms 5 is four or more. In this case, so long as the positional relationship between the first support member 6 and the second support member 7 is reversed between the adjacent support mechanisms 5 in each one of at least four pairs of adjacent support mechanisms 5, the structure of each support mechanism 5 can be simplified while restricting the dome-to-dome relative position and restricting the inner shell dome 32 in the circumferential direction. For example, in a case where the number of support mechanisms 5 is six and the support mechanisms 5 are each categorized into A or B depending on the orientation of each support mechanism 5, the support mechanisms 5 may be arranged in the circumferential direction as follows: A1 → A2 → B1 → A3 → B2 → B3 → (A1). In this case, in each one of four pairs (A2 and B1, B1 and A3, A3 and B2, B3 and Al) of adjacent support mechanisms 5, the positional relationship between the first support member 6 and the second support member 7 is reversed between the adjacent support mechanisms 5.

(Other Embodiments)

[0071] The present invention is not limited to the above-described Embodiments 1 to 3. Various modifications can be made without departing from the spirit of the present invention.

[0072] For example, the support mechanisms 5 need not be disposed between the inner shell dome 32 and the outer shell dome 42, but may be disposed between the inner shell main part 31 and the outer shell main part 41. Specifically, the first support members 6 may be fixed to one of the inner shell main part 31 and the outer shell main part 41, and the second support members 7 may be fixed to the other one of the inner shell main part 31 and the outer shell main part 41. In this case, between the first support members 6 and the second support members 7, those fixed to the inner shell main part 31 are each positioned on the corresponding reference plane 50.

[0073] It is not essential that all the support mechanisms 5 be disposed at the same height position. Alternatively, the support mechanisms 5 may be disposed such that, for example, their positions are vertically shifted from each other alternately.

Reference Signs List

[0074]

1 ship
2A to 2D double-shell ship tank
3 inner shell
31 inner shell main part
32 inner shell dome
36 central axis
4 outer shell
41 outer shell main part
42 outer shell dome
5 support mechanism
50 reference plane
51 lubricating liner
55 insulating member
6 first support member
61 first supporting surface
7 second support member
71 second supporting surface
8A first holding member
8B second holding member

Claims

1. A double-shell ship tank comprising:

an inner shell including an inner shell main part storing a liquefied gas and an inner shell dome protruding upward from the inner shell main part;
an outer shell including an outer shell main part surrounding the inner shell main part and an outer shell dome surrounding the inner shell dome; and
at least three support mechanisms disposed around the inner shell dome between the inner shell and the outer shell, wherein
each of the support mechanisms includes:

a first support member fixed to one of the inner shell and the outer shell, the first support member including a first supporting surface parallel to a reference plane that includes a central axis of the inner shell dome;
a second support member fixed to the other one of the inner shell and the outer shell, the second support member including a second supporting surface facing the first supporting surface; and
an insulating member interposed between the first supporting surface and the second supporting surface, the insulating member being fixed to the second supporting surface and sliding along the first supporting surface, and

one of the first support member and the second support member, the one support member being fixed to the inner shell, is positioned on the reference plane.

2. The double-shell ship tank according to claim 1, wherein
the first support member is a plate whose one main surface is the first supporting surface, and
the second support member is a plate whose one main surface is the second supporting surface.

3. The double-shell ship tank according to claim 1 or 2, wherein
the first support member is fixed to the outer shell dome or the outer shell main part, and
the second support member is fixed to the inner shell dome or the inner shell main part.

4. The double-shell ship tank according to any one of claims 1 to 3, wherein
the insulating member is tubular and extends in a direction orthogonal to the reference plane.

5. The double-shell ship tank according to claim 4, wherein
each of the support mechanisms includes a first holding member that holds one end of the tubular insulating member and a second holding member that holds another end of the tubular insulating member, and
the tubular insulating member is in contact with the first supporting surface via the first holding member, and is fixed to the second supporting surface via the second holding member.

6. The double-shell ship tank according to claim 5, wherein a lubricating liner is sandwiched between the first holding member and the first supporting surface.

7. The double-shell ship tank according to any one of claims 1 to 6, wherein
the insulating member is made of glass fiber reinforced plastic.

8. The double-shell ship tank according to any one of claims 1 to 7, wherein
the second support member is a plate whose one main surface and another main surface each serve as the second supporting surface, and
each of the support mechanisms includes a pair of the first support members disposed at both sides of the second support member.

9. The double-shell ship tank according to any one of claims 1 to 7, wherein
each of the support mechanisms includes one first support member and one second support member, and
a positional relationship between the one first support member and the one second support member is reversed between adjacent support mechanisms among the at least three support mechanisms.

10. The double-shell ship tank according to any one of claims 1 to 7, wherein
each of the support mechanisms includes one first support member and one second support member,
the at least three support mechanisms comprise four or more support mechanisms, and in each one of at least four pairs of the support mechanisms that are adjacent to each other, a positional relationship between the one first support member and the one second support member is reversed between the adjacent support mechanisms.

11. The double-shell ship tank according to any one of claims 1 to 10, wherein
a space between the inner shell and the outer shell is a vacuum space.

12. The double-shell ship tank according to any one of claims 1 to 11, wherein
the inner shell main part is cylindrical and extends in a horizontal direction,
the at least three support mechanisms comprise four support mechanisms that are disposed between the inner shell dome and the outer shell dome, each support mechanism being disposed at a position that is away from the central axis of the inner shell dome in an angular direction of 45 degrees relative to an axial direction of the inner shell main part.

13. A ship comprising the double-shell ship tank according to any one of claims 1 to 12.

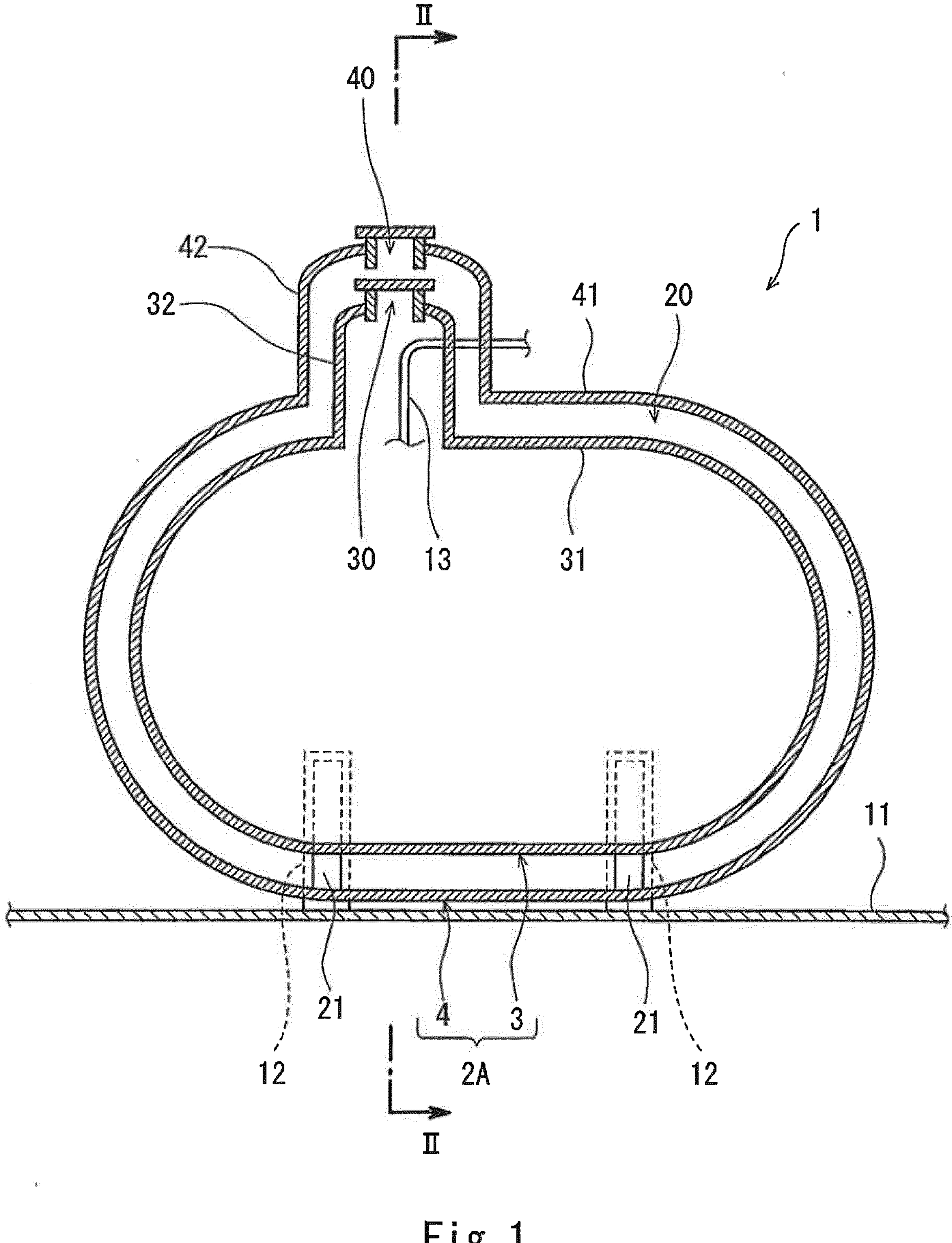
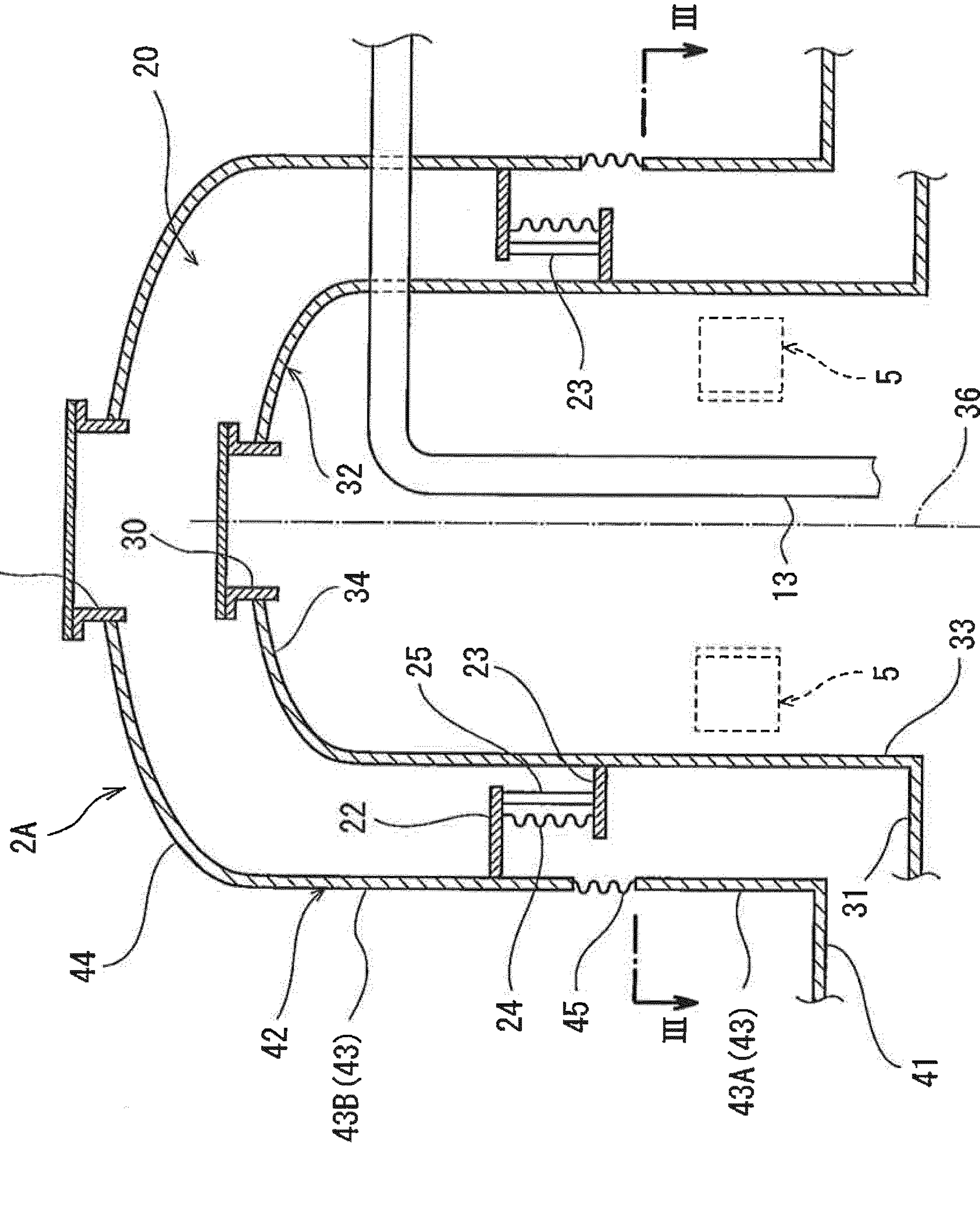


Fig. 1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III
23
5
36
32
30
40
34
13
33
25
23
5
2A
22
44
42
43B (43)
24
45
III
43A (43)
41
31

Fig. 2

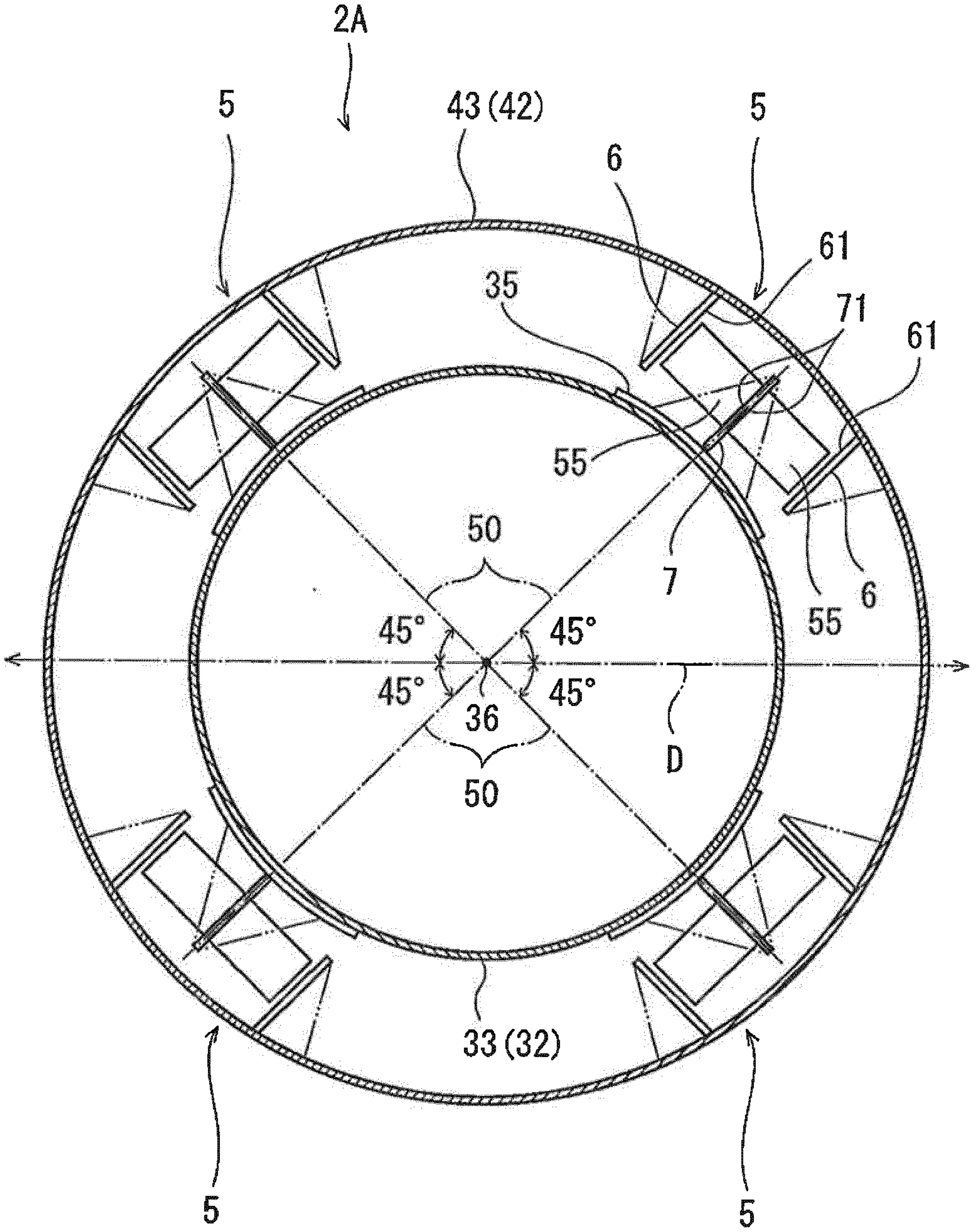
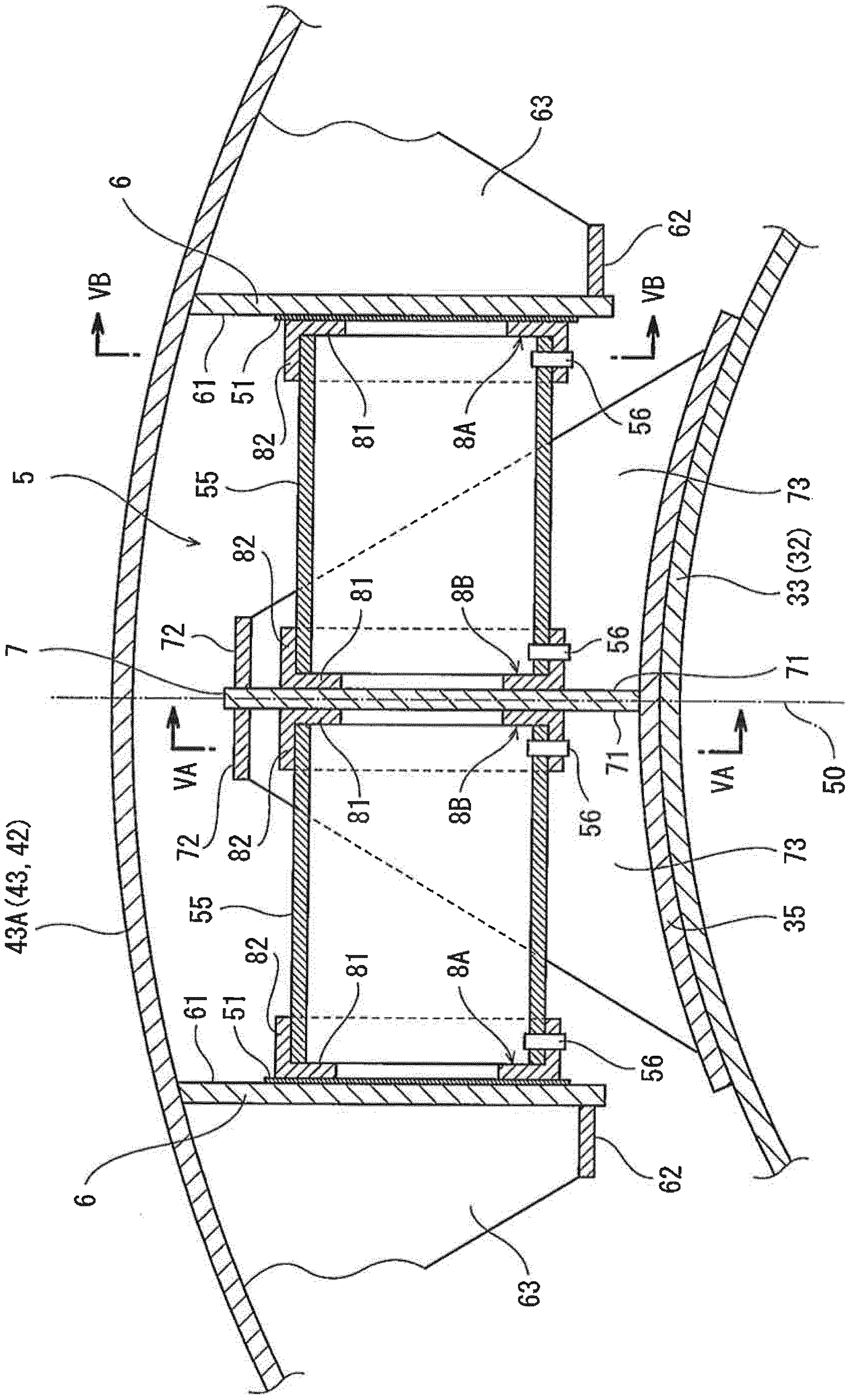


Fig. 3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6
62
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VB
61
51
82
81
8A
56
5
55
73
33 (32)
82
81
8B
72
56
7
71
71
VA
VA
50
72
82
81
8B
56
43A (43, 42)
73
55
35
82
81
8A
61
51
56
6
62
63

Fig. 4

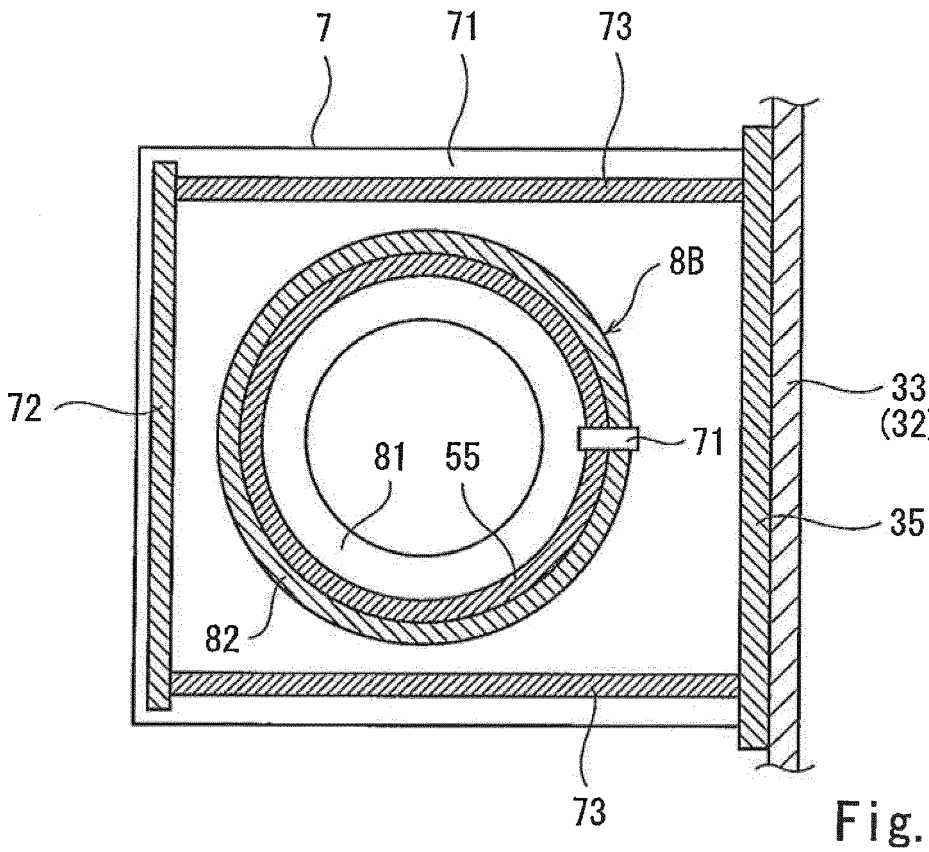
7
71
73
8B
72
33
(32)
71
81
55
35
82
73

Fig. 5A

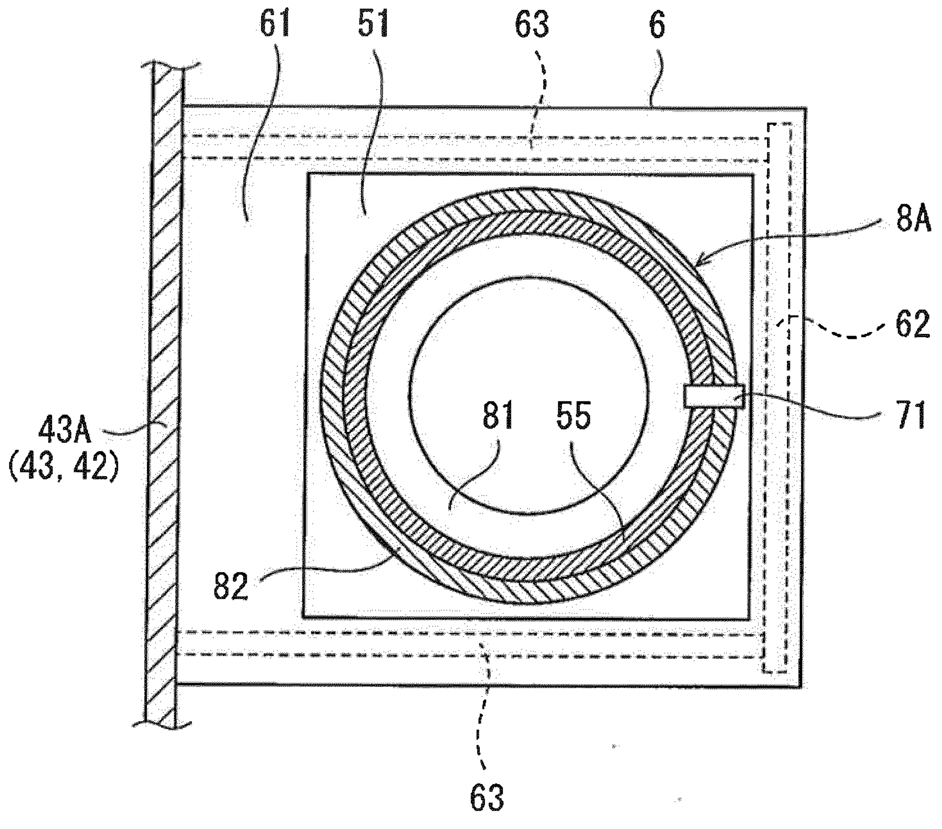
61
51
63
6
8A
62
71
81
55
43A
(43, 42)
82
63

Fig. 5B

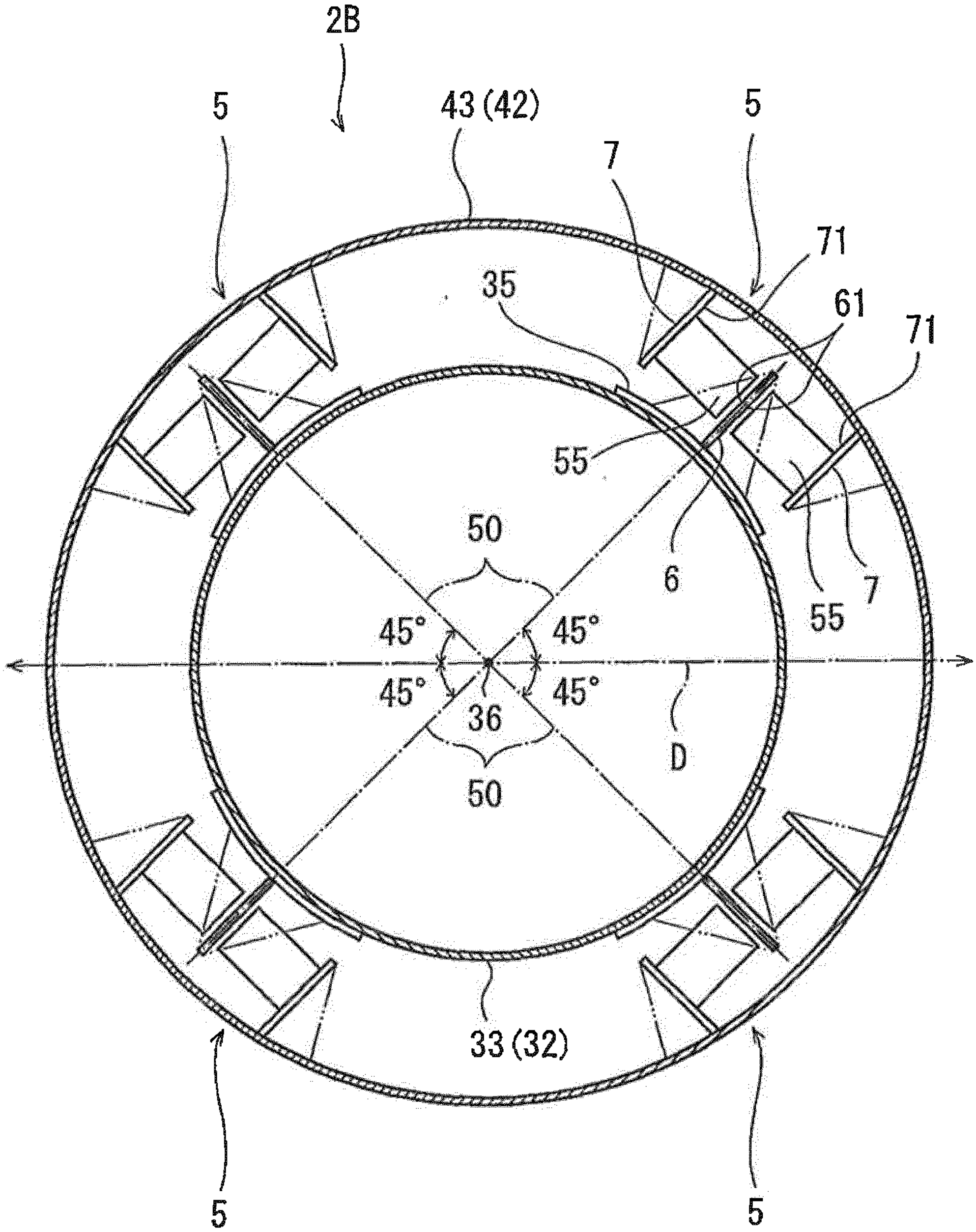

Fig. 6

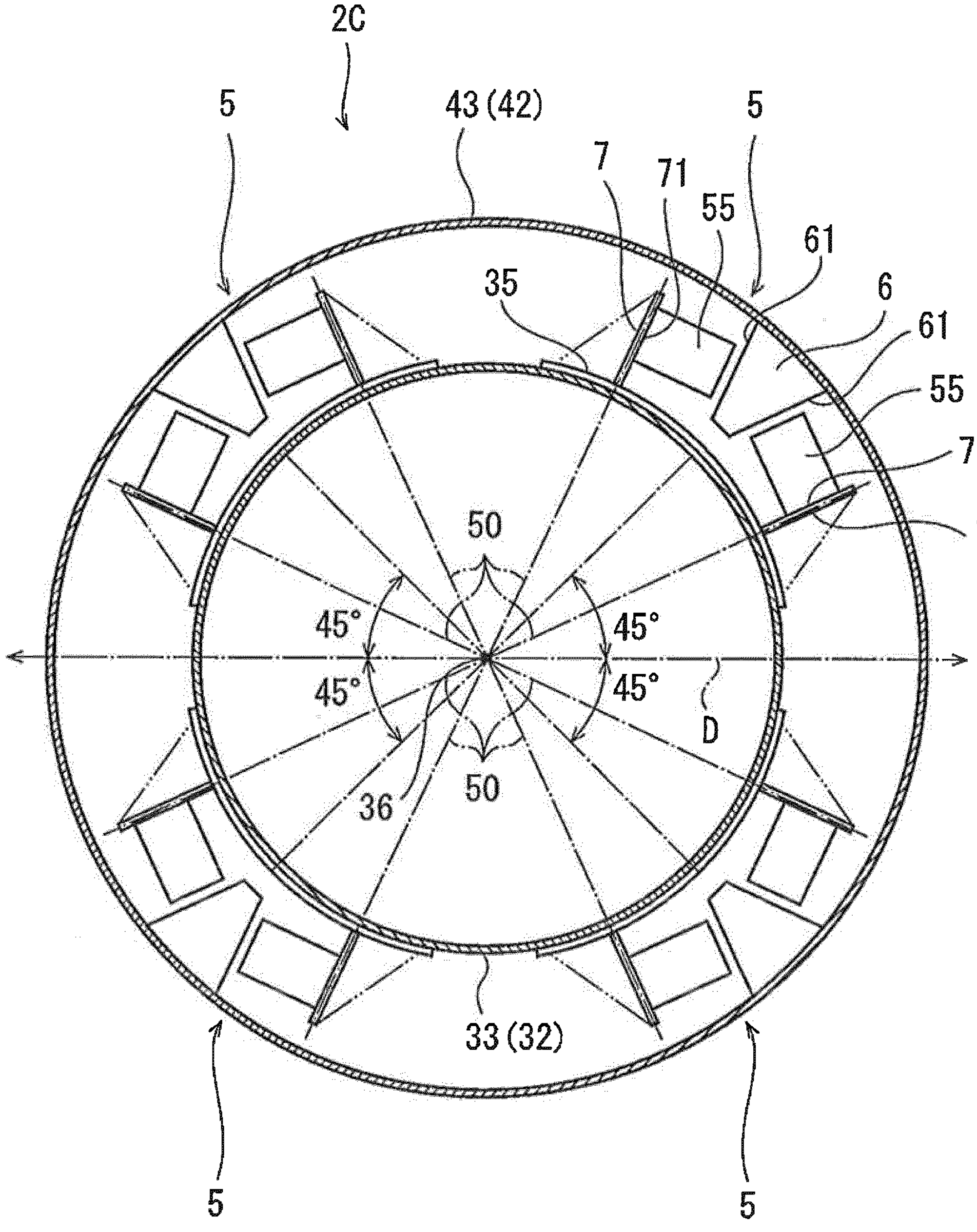

Fig. 7

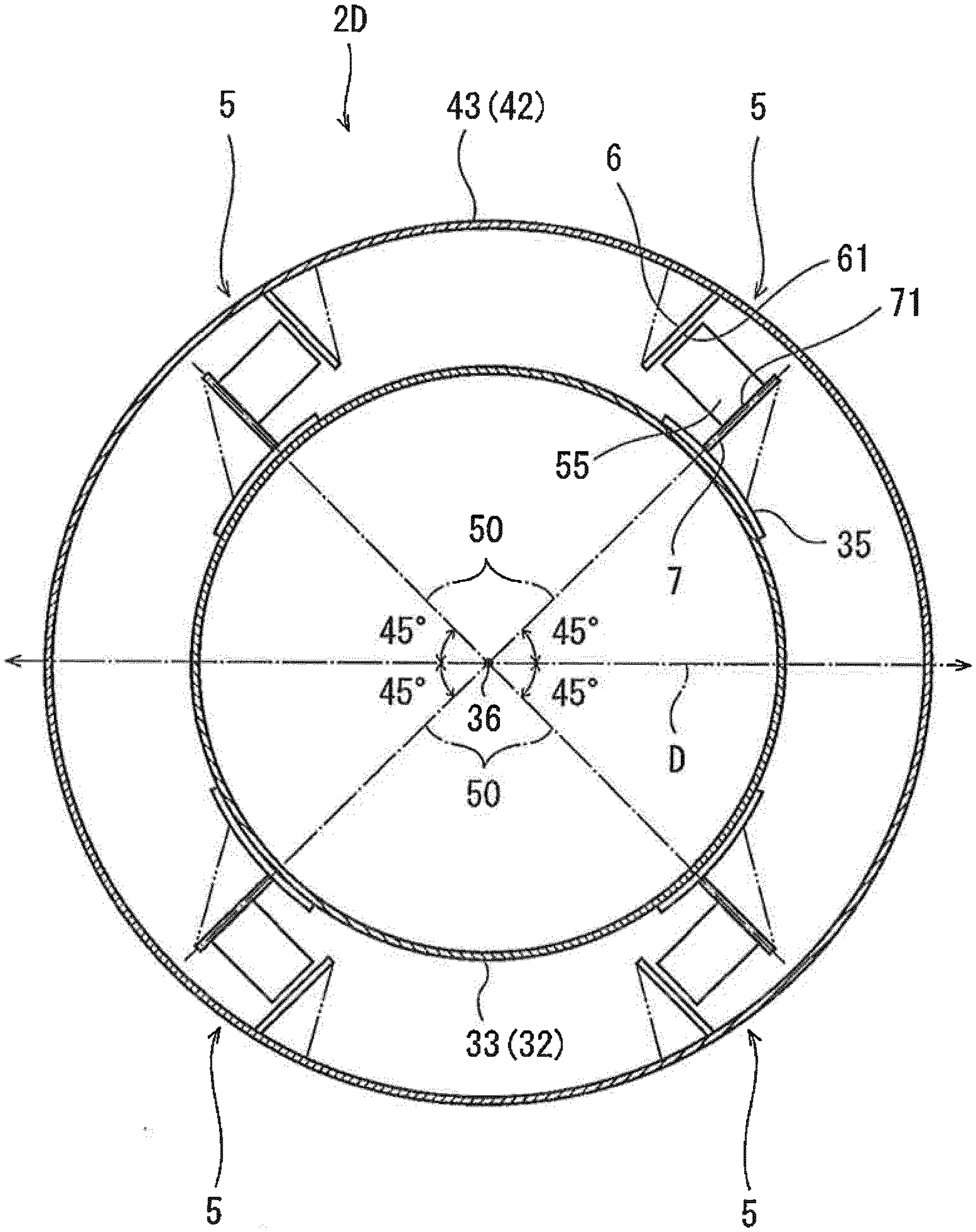

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/081095

A. CLASSIFICATION OF SUBJECT MATTER
B63B25/16(2006.01)i, *F17C13/08*(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, F17C13/08

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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2015-004383 A (Kawasaki Heavy Industries, Ltd.), 08 January 2015 (08.01.2015), claim 8; paragraphs [0024] to [0063]; fig. 1 to 6 & WO 2014/203471 A1 & EP 3012508 A1 paragraphs [0024] to [0063]; fig. 1 to 6 & CN 105308382 A & KR 10-2016-0012221 A	1-5 6-13
Y	WO 2014/174820 A1 (Kawasaki Heavy Industries, Ltd.), 30 October 2014 (30.10.2014), paragraph [0048]; fig. 4 & US 2016/0075412 A1 paragraph [0056]; fig. 4 & CN 105102875 A & KR 10-2015-0143797 A	6-13

☒ 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	Date of mailing of the international search report
22 November 2016 (22.11.16)	13 December 2016 (13.12.16)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/081095

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. 159310/1985(Laid-open No. 068099/1987) (Ishikawajima-Harima Heavy Industries Co., Ltd.), 28 April 1987 (28.04.1987), (Family: none)	1-13
A	JP 2012-500371 A (TGE Marine Gas Engineering GmbH), 05 January 2012 (05.01.2012), & WO 2010/020431 A1 & CN 102159870 A & KR 10-2011-0049872 A	1-13

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2015004383 A **[0004]**