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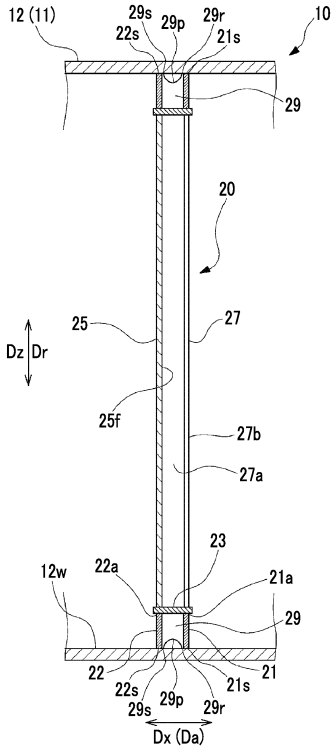
(54) TANK AND SHIP

(57) This tank comprises a tank body, a pair of annular members, a cylindrical member, a partition wall, and a plurality of ribs. The tank body has a cylindrical portion extending in the horizontal direction. The pair of annular members are longitudinally spaced apart on the inner side of the cylindrical portion in the radial direction. The annular members are circumferentially continuous along the inner wall surface of the cylindrical portion and fixed to the inner wall surface. The cylindrical member is disposed radially inward of the pair of annular members and has a cylindrical shape extending in the longitudinal direction. The partition wall is disposed radially inward of the cylindrical member and closes at least a portion of the inside of the cylindrical member in the radial direction. The outer periphery of the partition wall is joined to the cylindrical member. The plurality of ribs extend along the partition wall surface facing one longitudinal side of the partition wall and are fixed to the partition wall surface.

FIG. 4



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Description

Technical Field

[0001] The present disclosure relates to a tank and a ship.

Background Art

[0002] PTL 1 discloses a ship including a horizontally disposed substantially cylindrical tank (hereinafter, simply referred to as a cylindrical tank). In a case where a liquid is accommodated in such a cylindrical tank, the liquid in the cylindrical tank shakes due to a shaking of the ship. For example, in a cylindrical tank, a large pressure may act on the cylindrical tank or on a member provided in the cylindrical tank due to so-called sloshing in which a liquid shakes in a longitudinal direction of the cylindrical tank, and may have an adverse effect. Therefore, a bulkhead is disposed in the cylindrical tank along a plane intersecting the longitudinal direction of the cylindrical tank.

[0003] PTL 1 discloses a configuration in which the cylindrical tank includes two bulkheads (circular porous bulkheads) adjacent to each other and a frame structure of an intersecting reinforcing material disposed between the two bulkheads and welded to the two bulkheads. In this configuration, an outer peripheral portion of the circular porous bulkhead is joined to an inner peripheral surface of the tank by welding.

Citation List

Patent Literature

[0004] [PTL 1] PCT Japanese Translation Patent Publication No. 2009-541118

Summary of Invention

Technical Problem

[0005] Meanwhile, the bulkhead of the cylindrical tank as disclosed in PTL 1 has the outer peripheral portion joined to the inner peripheral surface of the cylindrical tank by welding. Therefore, if an excessive pressure acts on the bulkhead from a liquid in the cylindrical tank, there is a possibility that a welded portion between the bulkhead and the tank or the tank itself may be damaged.

[0006] The present disclosure has been made to solve the above problems, and an object of the present disclosure is to provide a tank and a ship capable of suppressing an influence on a joint portion between a bulkhead and the tank or on the tank itself even in a case where an excessive pressure acts on the bulkhead.

Solution to Problem

[0007] In order to solve the above problems, a tank according to the present disclosure includes a tank body, a pair of annular members, a cylindrical member, a bulkhead, and a plurality of ribs. The tank body has a cylindrical portion extending in a longitudinal direction as a horizontal direction. The pair of annular members are disposed inside the cylindrical portion in a radial direction at an interval in the longitudinal direction. The pair of annular members are continuous in a circumferential direction along an inner wall surface of the cylindrical portion, respectively. The pair of annular members are fixed to the inner wall surface. The cylindrical member is disposed inside the pair of annular members in the radial direction. The cylindrical member has a cylindrical shape extending in the longitudinal direction. The cylindrical member connects inner peripheral edge portions of the pair of annular members to each other. The bulkhead is disposed inside the cylindrical member in the radial direction. The bulkhead closes at least a part of the inside of the cylindrical member in the radial direction. The bulkhead has an outer peripheral portion joined to the cylindrical member. The plurality of ribs extend along a bulkhead surface of the bulkhead facing one side in the longitudinal direction. The plurality of ribs are fixed to the bulkhead surface.

[0008] A ship according to the present disclosure includes the tank as described above.

Advantageous Effects of Invention

[0009] According to a tank and a ship of the present disclosure, even in a case where an excessive pressure acts on a bulkhead, it is possible to suppress an influence on a joint portion between the bulkhead and the tank or on the tank itself.

Brief Description of Drawings

[0010]

Fig. 1 is a plan view illustrating a schematic configuration of a ship including a tank according to an embodiment of the present disclosure.

Fig. 2 is a sectional view taken along line II-II in Fig. 1.

Fig. 3 is a perspective view illustrating a swash bulkhead provided in the tank according to the embodiment of the present disclosure.

Fig. 4 is a sectional view of the swash bulkhead.

Fig. 5 is a view of the swash bulkhead as viewed from one side in a longitudinal direction.

Fig. 6 is a view schematically illustrating a case where a pressure acts on the swash bulkhead from the other side to the one side in the longitudinal direction.

Fig. 7 is a view schematically illustrating a case where a pressure acts on the swash bulkhead from

the one side to the other side in the longitudinal direction. Description of Embodiments

[0011] Hereinafter, a tank and a ship according to an embodiment of the present disclosure will be described with reference to Figs. 1 to 7.

(Configuration of Ship)

[0012] As illustrated in Fig. 1, a ship 1 in an embodiment of the present disclosure transports, for example, a liquefied gas such as liquefied natural gas (LNG) or liquefied petroleum gas (LPG). The ship 1 includes at least a hull 2 and a tank 10.

(Configuration of Hull)

[0013] The hull 2 has a pair of broadsides 3A and 3B, a bottom (not illustrated), and an upper deck 5 which form an outer shell thereof. The broadsides 3A and 3B have a pair of broadside plates respectively forming the left and right broadsides. The bottom (not illustrated) has a bottom plate connecting the broadsides 3A and 3B. The pair of broadsides 3A and 3B and the bottom (not illustrated) cause the outer shell of the hull 2 to have a U-shape in a cross section orthogonal to a bow-stern direction Da. The upper deck 5 is, for example, a completely open deck exposed outward. In the hull 2, a superstructure 7 having an accommodation space is formed on the upper deck 5 on a stern 2b side. The hull 2 exemplified in the present embodiment has a tank storage compartment (hold) 8 between the upper deck 5 on a bow 2a side from the superstructure 7 and the bottom (in other words, inside the hull 2).

(Configuration of Tank)

[0014] A plurality of the tanks 10 are disposed in the tank storage compartment 8. In the present embodiment, the plurality of tanks 10 disposed in the tank storage compartment 8 are disposed at intervals in the bow-stern direction Da.

[0015] As illustrated in Fig. 2, the tank 10 includes a tank body 11 and a swash bulkhead 20.

[0016] The tank body 11 internally accommodates a liquefied gas L. The tank body 11 includes a cylindrical portion 12 and an end spherical portion 13. The cylindrical portion 12 extends in a horizontal direction as a longitudinal direction Dx. In the present embodiment, the cylindrical portion 12 is formed in a cylindrical shape in which a cross-sectional shape orthogonal to the longitudinal direction Dx (in other words, a cross-sectional shape cut along a vertical plane extending in a ship width direction) forms a constant circular shape in the longitudinal direction Dx. In the present embodiment, the longitudinal direction Dx of the tank 10 (cylindrical portion 12) coincides with the bow-stern direction Da. The end spherical portions 13 are respectively disposed at both end portions of the cylindrical portion 12 in the longitudinal direction Dx. The end spherical portions 13 have a hemispherical shape, respectively. In other words, the end spherical portions 13 are formed to gradually decrease in diameter toward an outside in the longitudinal direction Dx in a cross-sectional view orthogonal to the longitudinal direction Dx. The end spherical portions 13 close openings in both ends of the cylindrical portion 12 in the bow-stern direction Da, respectively.

(Configuration of Swash Bulkhead)

[0017] The swash bulkhead 20 is disposed, for example, at an intermediate portion of the cylindrical portion 12 in the longitudinal direction Dx.

[0018] In Fig. 2, a case where only one swash bulkhead 20 is provided is exemplified. However, a plurality of the swash bulkheads 20 may be disposed in the cylindrical portion 12 at intervals in the longitudinal direction Dx.

[0019] As illustrated in Figs. 3 to 5, the swash bulkhead 20 includes a pair of annular members 21 and 22, a cylindrical member 23, a bulkhead 25, a plurality of ribs 27, and an outer peripheral member 29.

[0020] The pair of annular members 21 and 22 are disposed inside the cylindrical portion 12 described above in a radial direction Dr. The pair of annular members 21 and 22 are disposed at an interval in the longitudinal direction Dx. The pair of annular members 21 and 22 are continuous in a circumferential direction Dc along an inner wall surface 12w of the cylindrical portion 12, respectively. The pair of annular members 21 and 22 have an annular shape when viewed from the longitudinal direction Dx, respectively. The pair of annular members 21 and 22 are formed in a plate shape having front and back surfaces orthogonal to (intersecting) the longitudinal direction Dx. The pair of annular members 21 and 22 are respectively fixed to the inner wall surface 12w of the cylindrical portion 12 by welding. The annular members 21 and 22 in the present embodiment are exemplified as having the same shape. However, the present disclosure is not limited thereto.

[0021] The cylindrical member 23 is disposed inside the pair of annular members 21 and 22 in a radial direction Dr. The cylindrical member 23 has a cylindrical shape extending in the longitudinal direction Dx. The cylindrical member 23 connects inner peripheral edge portions 21a and 22a of the pair of annular members 21 and 22 to each other (refer to Fig. 4). In the present embodiment, the cylindrical member 23 slightly protrudes to both sides in the longitudinal direction Dx with respect to the pair of annular members 21 and 22.

[0022] The bulkhead 25 suppresses the movement of the liquefied gas L accommodated in the tank body 11 in the longitudinal direction Dx. The bulkhead 25 is disposed inside the cylindrical member 23 in the radial direction Dr. The outer edge of the bulkhead 25 is joined to the cylindrical member 23 by welding. The bulkhead 25 closes at least a part of the space inside the cylindrical

member 23 in the radial direction Dr. Here, the bulkhead 25 may close the entire inside of the cylindrical member 23 in the radial direction Dr. In this case, the bulkhead 25 has a disk shape when viewed from the longitudinal direction Dx to close the entire circular space inside the cylindrical member 23 in the radial direction Dr. In the bulkhead 25 in the present embodiment, an opening or a slit (not illustrated) communicating with both sides in the longitudinal direction Dx is formed to allow the liquefied gas L to come and go on both sides with the bulkhead 25 interposed therebetween.

[0023] The bulkhead 25 is disposed at a position overlapping the annular member 22 disposed on the other side in the longitudinal direction Dx of the pair of annular members 21 and 22 in the longitudinal direction Dx. In other words, the bulkhead 25 is disposed on the same vertical plane as the annular member 22. The thickness of the bulkhead 25 in the longitudinal direction Dx in the present embodiment is equal to or slightly smaller than the thickness of the annular members 21 and 22 in the longitudinal direction Dx.

[0024] The plurality of ribs 27 reinforce the bulkhead 25 and suppress the bulkhead 25 from being bent and deformed by the pressure in the longitudinal direction Dx that acts from the liquefied gas L when the liquefied gas L shakes in the longitudinal direction Dx in the tank body 11. The plurality of ribs 27 extend along a bulkhead surface 25f of the bulkhead 25 facing one side in the longitudinal direction Dx. The plurality of ribs 27 are fixed to the bulkhead surface 25f by welding, respectively. Further, both end portions of the plurality of ribs 27 are fixed to the inner peripheral surface of the cylindrical member 23 by welding, respectively.

[0025] The plurality of ribs 27 in the present embodiment extend in the up-down direction Dz. The plurality of ribs 27 are disposed at intervals in the tank width direction Dy along the bulkhead surface 25f. In the present embodiment, in each rib 27, the cross-sectional shape orthogonal to the extending direction of each rib 27 (up-down direction Dz) is a T-shape.

[0026] Each rib 27 integrally has a web 27a and a flange 27b. The web 27a has a plate shape orthogonal to the bulkhead surface 25f, and continuously extends in the up-down direction Dz. The web 27a is joined to the bulkhead surface 25f of the bulkhead 25 by welding. The dimension of the web 27a in the longitudinal direction Dx of the present embodiment is equal to the distance between the annular member 21 and the annular member 22 in the longitudinal direction Dx.

[0027] The flange 27b is formed at an edge portion of the web 27a on the side opposite to the bulkhead surface 25f in the longitudinal direction Dx. The flange 27b has a plate shape parallel to the bulkhead surface 25f, and continuously extends in the up-down direction Dz. Here, the thickness of the flange 27b in the longitudinal direction Dx of the present embodiment is equal to the thickness of the annular members 21 and 22. In the present embodiment, a case where the web 27a is formed in a band shape with a constant width is exemplified. However, the web 27a is not limited to the constant width.

[0028] The rib 27 and the annular member 21 disposed on the one side in the longitudinal direction Dx of the pair of annular members 21 and 22 are disposed at positions overlapping in the longitudinal direction Dx. In the present embodiment, a case where the flange 27b of the rib 27 is disposed in the same plane as the annular member 21 is exemplified.

[0029] The outer peripheral member 29 is disposed on the outside in the radial direction Dr with the cylindrical member 23 interposed between the outer peripheral member 29 and the rib 27. The outer peripheral member 29 is disposed on both sides of the cylindrical member 23 in the up-down direction Dz. The outer peripheral member 29 has a plate shape along a plane orthogonal to the tank width direction Dy (refer to Fig. 5) . For example, the thickness of the outer peripheral member 29 can be made the same as the thickness of the web 27a of the rib 27.

[0030] The outer peripheral member 29 is joined to the cylindrical member 23 and the pair of annular members 21 and 22 by welding, respectively. An end portion 29r (refer to Fig. 4) of the outer peripheral member 29 on one side in the longitudinal direction Dx is disposed at the same position as the outer peripheral end 21s of the annular member 21 in the radial direction Dr. Similarly, an end portion 29s of the outer peripheral member 29 on the other side in the longitudinal direction Dx is disposed at the same position as the outer peripheral end 22s of the annular member 22 in the radial direction Dr.

[0031] In the outer peripheral member 29, the recessed portion 29p is formed. The recessed portion 29p is formed in a curved shape recessed to the inside in the radial direction Dr with respect to the end portions 29r and 29s. Accordingly, in the outer peripheral member 29, the cross-sectional area in the cross section intersecting the radial direction Dr is gradually reduced from the inside to the outside in the radial direction Dr in the portion where the recessed portion 29p is formed. The outer end portions 29r and 29s of the outer peripheral member 29 in the radial direction Dr are not joined to the inner wall surface 12w of the tank body 11.

[0032] As illustrated in Fig. 6, in the swash bulkhead 20, for example, if the bulkhead 25 and the plurality of ribs 27 are bent and deformed by the pressure P1 (indicated by an arrow in Fig. 6) that is directed from the other side toward one side in the longitudinal direction Dx, a force (couple of force) F11 (indicated by an arrow in Fig. 6) in a direction of pulling the annular member 21 in the up-down direction Dz acts on the annular member 21 located on one side in the longitudinal direction Dx of the pair of annular members 21 and 22. Due to the force F11, the annular member 21 located on one side in the longitudinal direction Dx is elastically deformed to spread in the up-down direction Dz.

[0033] Meanwhile, a force (couple of force) F12 (indicated by an arrow in Fig. 6) in a direction of compressing

the annular member 22 in the up-down direction Dz acts on the annular member 22 located on the other side in the longitudinal direction Dx. Due to the force F12, the annular member 22 located on the other side in the longitudinal direction Dx is elastically deformed to collapse in the up-down direction Dz.

[0034] In addition, for example, as illustrated in Fig. 7, if the bulkhead 25 and the plurality of ribs 27 are bent and deformed by the pressure P2 (indicated by an arrow in Fig. 7) that is directed from one side to the other side in the longitudinal direction Dx, a force (couple of force) F21 (indicated by an arrow in Fig. 7) in a direction of compressing the annular member 21 in the up-down direction Dz acts on the annular member 21 located on the one side in the longitudinal direction Dx. Due to the force F21, the annular member 21 located on one side in the longitudinal direction Dx is elastically deformed to collapse in the up-down direction Dz.

[0035] In addition, a force (couple of force) F22 (indicated by an arrow in Fig. 7) in a direction of pulling the annular member 22 in the up-down direction Dz acts on the annular member 22 located on the other side in the longitudinal direction Dx. Due to the force F22, the annular member 22 located on the other side in the longitudinal direction Dx is elastically deformed to spread in the up-down direction Dz.

(Effects of Action)

[0036] The tank 10 of the present embodiment includes the pair of annular members 21 and 22 and the cylindrical member 23 between the bulkhead 25 and the plurality of ribs 27 and the inner wall surface 12w of the cylindrical portion 12 of the tank body 11.

[0037] According to the above embodiment, if the fluid in the tank 10 shakes in the longitudinal direction Dx, the pressures P1 and P2 in the longitudinal direction Dx act on the bulkhead 25. The bulkhead 25 and the plurality of ribs 27 are deformed by the pressures P1 and P2 in the longitudinal direction Dx. As a result of the deformation of the bulkhead 25 and the plurality of ribs 27, the annular members 21 and 22 are elastically deformed to spread or collapse in the up-down direction Dz via the cylindrical member 23. In other words, the bending moments of the end portions of the bulkhead 25 and the plurality of ribs 27 are transmitted as a couple of force of the annular members 21 and 22, and the annular members 21 and 22 are elastically deformed in the up-down direction Dz (radial direction Dr).

[0038] Therefore, the stress caused by the elastic deformation of the annular members 21 and 22 in the up-down direction acts on the tank body 11, and as a result, it is possible to suppress the occurrence of the local stress in the vicinity of the fixing portion as in a case where the bulkhead 25 and the plurality of ribs 27 are directly fixed to the tank body 11.

[0039] Therefore, even in a case where an excessive pressure acts on a bulkhead 25, it is possible to suppress an influence on a joint portion between the swash bulkhead 20 and the tank 10 or on the tank 10 itself.

[0040] In the above embodiment, further, the outer peripheral member 29 is provided, which is disposed outside in the radial direction Dr with the cylindrical member 23 interposed between the outer peripheral member 29 and the rib 27 and is joined to the cylindrical member 23 and the pair of annular members 21 and 22.

[0041] Accordingly, when the bulkhead 25 and the plurality of ribs 27 are deformed by the pressures P1 and P2 in the longitudinal direction Dx that act on the bulkhead 25, a part of the couple of force generated in the annular members 21 and 22 can be received by the outer peripheral member 29. Therefore, deformation of the cylindrical member 23 or the annular members 21 and 22 can be suppressed. In addition, the outer peripheral member 29 can suppress the deformation of the annular members 21 and 22 in the direction in which the annular members 21 and 22 are separated from and approach each other. Therefore, the stress generated in the connecting portion between the annular members 21 and 22 and the cylindrical member 23 can be reduced.

[0042] In the above embodiment, further, the outer peripheral member 29 is not joined to the inner wall surface 12w of the tank body 11.

[0043] Accordingly, in a case where the bulkhead 25 and the plurality of ribs 27 are deformed by the pressures P1 and P2 in the longitudinal direction Dx that act on the bulkhead 25, even if the external force acts on the outer peripheral member 29 from each rib 27 via the cylindrical member 23, the outer peripheral member 29 is not joined to the inner wall surface 12w of the tank body 11. Therefore, it is possible to suppress the occurrence of stress between the outer peripheral member 29 and the tank body 11.

[0044] In addition, in general, the tank body 11 of the tank 10 is subjected to a stress in the circumferential direction Dc by the internal pressure. For example, in a case where the outer peripheral member 29 is joined to the inner wall surface 12w, the joint portion becomes a stress concentration portion that increases a stress in the circumferential direction Dc, which acts on the tank body 11. However, the outer peripheral member 29 is not joined to the inner wall surface 12w of the tank body 11, so that an increase in the stress can be suppressed.

[0045] In the above embodiment, further, in the outer peripheral member 29, the cross-sectional area in the cross section intersecting the radial direction Dr is gradually reduced from the inside to the outside in the radial direction Dr.

[0046] Accordingly, when the bulkhead 25 and the plurality of ribs 27 are deformed by the pressure in the longitudinal direction Dx that acts on the bulkhead 25, it is possible to suppress the occurrence of stress concentration by outer peripheral member 29 coming into contact with the tank body 11. Further, when the bulkhead 25 and the plurality of ribs 27 are deformed by the pressures P1 and P2 in the longitudinal direction Dx that act

on the bulkhead 25, it is possible to suppress the outer peripheral member 29 from hindering elastic deformation of the annular members 21 and 22 in the up-down direction Dz (radial direction Dr). In addition, since the cross-sectional area of the outer peripheral member 29 is gradually reduced, the rigidity of the outer peripheral member 29 can be gradually reduced. Therefore, it is possible to avoid stress concentration due to a rapid reduction in rigidity.

[0047] In the above embodiment, further, the bulkhead 25 is disposed at a position overlapping the annular member 22 in the longitudinal direction Dx.

[0048] Accordingly, when the bulkhead 25 is deformed by the pressures P1 and P2 in the longitudinal direction Dx, the bending moment of the bulkhead 25 can be more efficiently transmitted as the couple of force of the annular member 22 disposed on the other side in the longitudinal direction Dx.

[0049] In the above embodiment, further, the rib 27 is disposed at a position overlapping the annular member 21 in the longitudinal direction Dx. In addition, in the above embodiment, the flange 27b of the rib 27 is disposed at a position overlapping the annular member 21 in the longitudinal direction Dx.

[0050] Accordingly, when the bulkhead 25 and the plurality of ribs 27 are deformed by the pressures P1 and P2 in the longitudinal direction Dx, the bending moments of the plurality of ribs 27 can be more efficiently transmitted as the couple of force of the annular member 21 disposed on the one side in the longitudinal direction Dx. In addition, since the flange 27b of the rib 27 is disposed at a position overlapping the annular member 21 in the longitudinal direction Dx, the bending moments of the plurality of ribs 27 can be even more efficiently transmitted as the couple of force of the annular member 21 disposed on one side in the longitudinal direction Dx.

[0051] In the above embodiment, further, the annular members 21 and 22 have a plate shape intersecting the longitudinal direction Dx.

[0052] Accordingly, when the bulkhead 25 and the plurality of ribs 27 are deformed by the pressures P1 and P2 in the longitudinal direction Dx that act on the bulkhead 25, the annular members 21 and 22 can be elastically deformed in the radial direction Dr in a favorable manner.

[0053] The ship 1 according to the above embodiment includes the tank 10 as described above.

[0054] Therefore, even in a case where an excessive pressures P1 and P2 act on a bulkhead 25, it is possible to suppress an influence on a joint portion between the bulkhead 25 and the tank 10 or on the tank 10 itself.

(Other Embodiments)

[0055] Although the embodiments of the present disclosure have been described in detail with reference to the drawings hereinbefore, a specific configuration is not limited to the embodiments, and design changes or the like are also included without departing from the gist of the present disclosure. For example, in the above embodiment, the plurality of ribs 27 are configured to extend in the up-down direction Dz. However, the present disclosure is not limited thereto. For example, each rib 27 may extend in the tank width direction Dy. Further, the rib 27 may extend in an oblique direction along the bulkhead surface 25f. In addition, the rib 27 in the above embodiment has been exemplified as being linear when viewed from the longitudinal direction Dx of the tank 10. However, the rib 27 may be slightly curved when viewed from the longitudinal direction Dx. In addition, although a case where the plurality of ribs 27 extend parallel to each other has been exemplified, the present disclosure is not limited thereto.

[0056] In addition, the cross-sectional shape of each rib 27 is not limited to a T-shape having the web 27a and the flange 27b. The cross-sectional shape of each rib 27 may be, for example, an L-shape, an I-shape, an H-shape, or the like.

[0057] In addition, in the above embodiment, the tank 10 is provided with only one tank body 11. However, the present disclosure is not limited thereto. The tank 10 may have a configuration in which the tank 10 is a multi-lobe type such as a so-called bi-lobe type or a tri-lobe type and includes a combination of a plurality of tank bodies 11 that extend in the longitudinal direction Dx. In such a case, the cross-sectional shape of the tank body 11 is not limited to a circular shape, and may be another shape. In this case, the contour of the swash bulkhead 20 may have a shape corresponding to the cross-sectional shape of the tank body 11 of the tank 10, such as a bi-lobe type or a tri-lobe type.

[0058] Further, in the above embodiment, the tank 10 is disposed such that the longitudinal direction Dx of the cylindrical portion 12 extends along the bow-stern direction Da. However, the present disclosure is not limited thereto. The tank 10 may be disposed such that the longitudinal direction Dx of the cylindrical portion 12 extends along the ship width direction.

[0059] In addition, in the above embodiment, a case where the tank 10 includes the end spherical portion 13 has been exemplified. However, the shape of the end portion of the tank 10 in the longitudinal direction is not limited to a hemispherical shape. Further, the number and the disposition of the tanks 10 included in the ship 1 are not limited to those described above.

[0060] In addition, in the above embodiment, the tank 10 is configured to accommodate the liquefied gas L. However, the present disclosure is not limited thereto. For example, the tank 10 may accommodate various liquids such as fuel and water.

[0061] In the above-described embodiment, the tank 10 is provided in the ship 1. However, the present disclosure is not limited thereto. The application of the tank 10 is not limited to a ship application as long as the application is an application in which the liquid to be accommodated shakes. For example, the tank 10 can be appropriately used for other applications such as marine

structures.

<Additional Notes>

[0062] The tank 10 and the ship 1 described in the embodiment are understood as follows, for example.

[0063]

(1) A tank 10 according to a first aspect includes a tank body 11 having a cylindrical portion 12 extending in a longitudinal direction Dx as a horizontal direction, a pair of annular members 21 and 22 that are disposed inside the cylindrical portion 12 in a radial direction Dr at an interval in the longitudinal direction Dx, are continuous in a circumferential direction Dc along an inner wall surface 12w of the cylindrical portion 12, respectively, and are fixed to the inner wall surface 12w, a cylindrical member 23 that is disposed inside the pair of annular members 21 and 22 in the radial direction Dr, has a cylindrical shape extending in the longitudinal direction Dx, and connects inner peripheral edge portions 21a and 22a of the pair of annular members 21 and 22 to each other, a bulkhead 25 that is disposed inside the cylindrical member 23 in the radial direction Dr, closes at least a part of the inside of the cylindrical member 23 in the radial direction Dr, and has an outer peripheral portion joined to the cylindrical member 23, and a plurality of ribs 27 that extend along a bulkhead surface 25f of the bulkhead 25 facing one side in the longitudinal direction Dx and are fixed to the bulkhead surface 25f.

According to the tank 10, when the bulkhead 25 and the plurality of ribs 27 are deformed by the pressures P1 and P2 in the longitudinal direction Dx that act on the bulkhead 25, the bending moment of the rib 27 is transmitted as the couple of force of the annular members 21 and 22, and the annular members 21 and 22 are elastically deformed in the radial direction Dr. Therefore, the stress caused by the elastic deformation of the annular members 21 and 22 in the radial direction Dr acts on the tank body 11, and thus, the occurrence of excessive stress in the joint portion between the annular members 21 and 22 and the inner wall surface 12w of the tank body 11 can be suppressed. Therefore, even in a case where an excessive pressures P1 and P2 act on a bulkhead 25, it is possible to suppress an influence on a joint portion between the bulkhead 25 and the tank 10 or on the tank 10 itself.

(2) A tank 10 according to a second aspect is the tank 10 of (1), and further includes an outer peripheral member 29 that is disposed on an outside in the radial direction Dr with the cylindrical member 23 interposed between the outer peripheral member 29 and the rib 27 and is joined to the cylindrical member 23 and the pair of annular members 21 and 22.

Accordingly, when the bulkhead 25 and the plurality of ribs 27 are deformed by the pressures P1 and P2 in the longitudinal direction Dx that act on the bulkhead 25, a part of the couple of force generated in the annular members 21 and 22 can be received by the outer peripheral member 29. Therefore, deformation of the cylindrical member 23 or the annular members 21 and 22 can be suppressed.

(3) A tank 10 according to a third aspect is the tank 10 of (1), in which the outer peripheral member 29 is not joined to the inner wall surface 12w of the tank body 11.

[0064] Accordingly, in a case where the bulkhead 25 and the plurality of ribs 27 are deformed by the pressures P1 and P2 in the longitudinal direction Dx that act on the bulkhead 25, even if the external force acts on the outer peripheral member 29 from each rib 27 via the cylindrical member 23, the outer peripheral member 29 is not joined to the inner wall surface 12w of the tank body 11. Therefore, it is possible to suppress the occurrence of stress between the outer peripheral member 29 and the tank body 11.

[0065] In addition, in general, the tank body 11 of the tank 10 is subjected to a stress in the circumferential direction Dc by the internal pressure. For example, in a case where the outer peripheral member 29 is joined to the inner wall surface 12w, the joint portion becomes a stress concentration portion that increases a stress in the circumferential direction Dc, which acts on the tank body 11. However, the outer peripheral member 29 is not joined to the inner wall surface 12w of the tank body 11, so that an increase in the stress can be suppressed.

[0066] (4) A tank 10 according to a fourth aspect is the tank 10 of (3), in which the outer peripheral member 29 has a cross-sectional area in a cross section intersecting the radial direction Dr, which is gradually reduced from the inside toward an outside in the radial direction Dr.

[0067] Accordingly, when the bulkhead 25 and the plurality of ribs 27 are deformed by the pressures P1 and P2 in the longitudinal direction Dx that act on the bulkhead 25, it is possible to suppress the outer peripheral member 29 from hindering elastic deformation of the annular members 21 and 22 in the radial direction Dr.

[0068] In addition, since the cross-sectional area of the outer peripheral member 29 is gradually reduced, the rigidity of the outer peripheral member 29 can be gradually reduced. Therefore, it is possible to avoid stress concentration due to a rapid reduction in rigidity.

[0069] (5) A tank 10 according to a fifth aspect is the tank 10 according to any one of (1) to (4), in which the bulkhead 25 is disposed at a position overlapping an annular member 22 disposed on the other side in the longitudinal direction Dx of the pair of annular members 21 and 22 in the longitudinal direction Dx.

[0070] Accordingly, when the bulkhead 25 is deformed by the pressures P1 and P2 in the longitudinal direction Dx that act on the bulkhead 25, the bending moment of the bulkhead 25 can be more efficiently transmitted as

the couple of force of the annular member 22 disposed on the other side in the longitudinal direction Dx.

[0071] (6) A tank 10 according to a sixth aspect is the tank 10 according to any one of (1) to (5), in which the rib 27 is disposed at a position overlapping an annular member 21 disposed on the one side in the longitudinal direction Dx of the pair of annular members 21 and 22 in the longitudinal direction Dx.

[0072] Accordingly, when the bulkhead 25 and the plurality of ribs 27 are deformed by the pressures P1 and P2 in the longitudinal direction Dx that act on the bulkhead 25, the bending moment of the plurality of ribs 27 can be more efficiently transmitted as the couple of force of the annular member 21 disposed on the one side in the longitudinal direction Dx.

[0073] (7) A tank 10 according to a seventh aspect is the tank 10 according to any one of (1) to (6), in which the annular member 21, 22 has a plate shape intersecting the longitudinal direction Dx.

[0074] Accordingly, when the bulkhead 25 and the plurality of ribs 27 are deformed by the pressures P1 and P2 in the longitudinal direction Dx that act on the bulkhead 25, the annular members 21 and 22 can be elastically deformed in the radial direction Dr in a favorable manner.

[0075] (8) A ship 1 according to an eighth aspect includes the tank 10 according to any one of (1) to (7).

[0076] Therefore, even in a case where an excessive pressures P1 and P2 act on a bulkhead 25, it is possible to suppress an influence on a joint portion between the bulkhead 25 and the tank 10 or on the tank 10 itself. Therefore, it is possible to suppress the damage to the tank 10 provided in the ship 1 and to reduce the burden on the maintenance of the ship 1.

Industrial Applicability

[0077] According to a tank and a ship of the present disclosure, even in a case where an excessive pressure acts on a bulkhead, it is possible to suppress an influence on a joint portion between the bulkhead and the tank or on the tank itself.

Reference Signs List

[0078]

1: ship
2: hull
2a: bow
2b: stern
3A, 3B: broadside
4: bottom
5: upper deck
7: superstructure
8: tank storage compartment
10: tank
11: tank body
12: cylindrical portion
12w: inner wall surface
13: end spherical portion
20: swash bulkhead
21, 22: annular member
21a, 22a: inner peripheral edge portion
21s, 22s: outer peripheral end
23: cylindrical member
25: bulkhead
25f: bulkhead surface
27: rib
27a: web
27b flange
29: outer peripheral member
29p: recessed portion
29r, 29s: end portion
L: liquefied gas

Claims

1. A tank comprising:

   a tank body having a cylindrical portion extending in a longitudinal direction as a horizontal direction;
   a pair of annular members that are disposed inside the cylindrical portion in a radial direction at an interval in the longitudinal direction, are continuous in a circumferential direction along an inner wall surface of the cylindrical portion, respectively, and are fixed to the inner wall surface;
   a cylindrical member that is disposed inside the pair of annular members in the radial direction, has a cylindrical shape extending in the longitudinal direction, and connects inner peripheral edge portions of the pair of annular members to each other;
   a bulkhead that is disposed inside the cylindrical member in the radial direction, closes at least a part of the inside of the cylindrical member in the radial direction, and has an outer peripheral portion joined to the cylindrical member; and
   a plurality of ribs that extend along a bulkhead surface of the bulkhead facing one side in the longitudinal direction and are fixed to the bulkhead surface.

2. The tank according to Claim 1, further comprising:
   an outer peripheral member that is disposed on an outside in the radial direction with the cylindrical member interposed between the outer peripheral member and the rib and is joined to the cylindrical member and the pair of annular members.

3. The tank according to Claim 2,
   wherein the outer peripheral member is not joined to the inner wall surface of the tank body.

4. The tank according to Claim 3, wherein the outer peripheral member has a cross-sectional area in a cross section intersecting the radial direction, which is gradually reduced from the inside toward an outside in the radial direction.

5. The tank according to any one of Claims 1 to 4, wherein the bulkhead is disposed at a position overlapping an annular member disposed on the other side in the longitudinal direction of the pair of annular members in the longitudinal direction.

6. The tank according to any one of Claims 1 to 5, wherein the rib is disposed at a position overlapping an annular member disposed on the one side in the longitudinal direction of the pair of annular members in the longitudinal direction.

7. The tank according to any one of Claims 1 to 6, wherein the annular member has a plate shape intersecting the longitudinal direction.

8. A ship comprising:
the tank according to any one of Claims 1 to 7.

FIG. 1

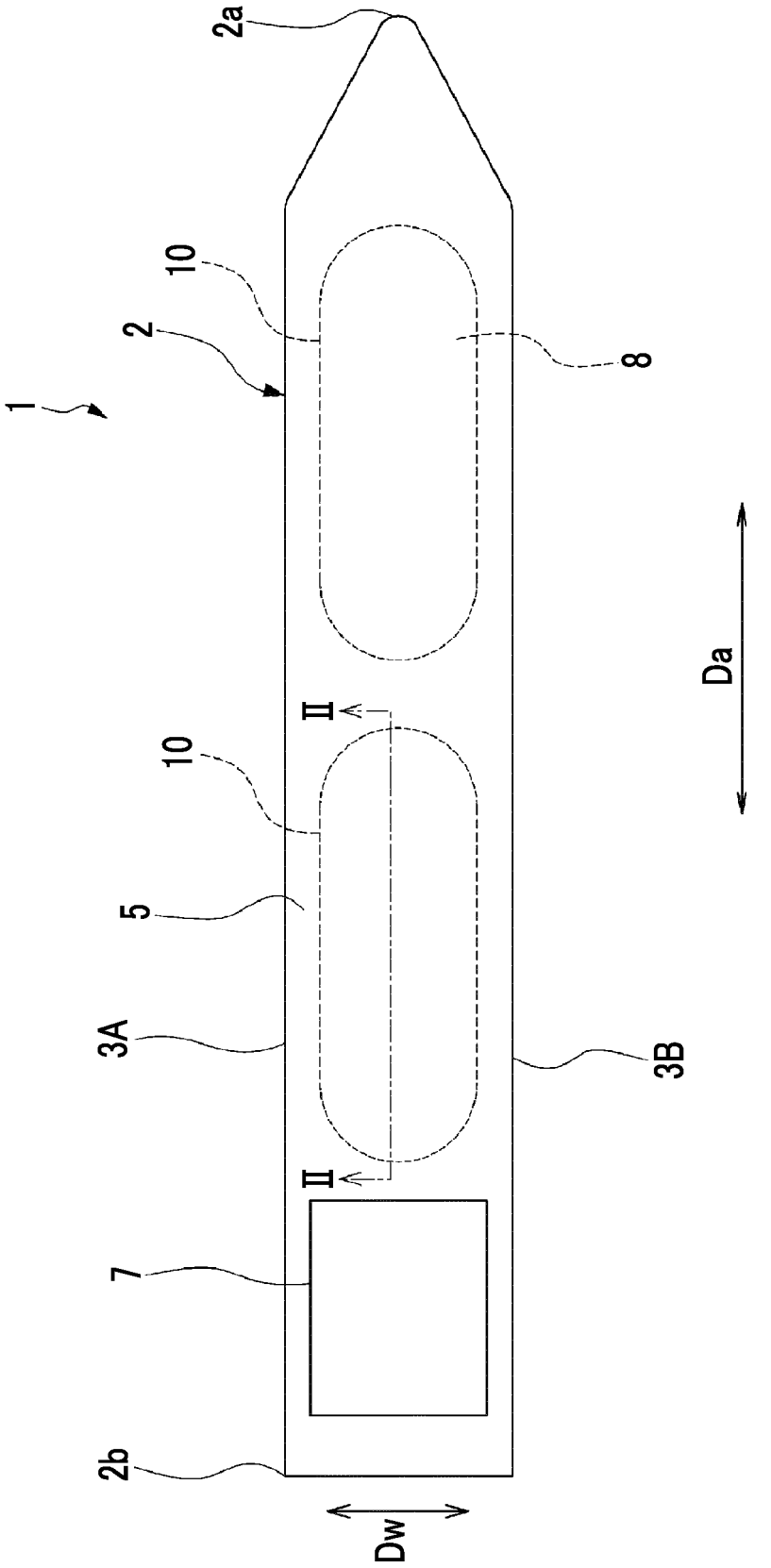


FIG. 2

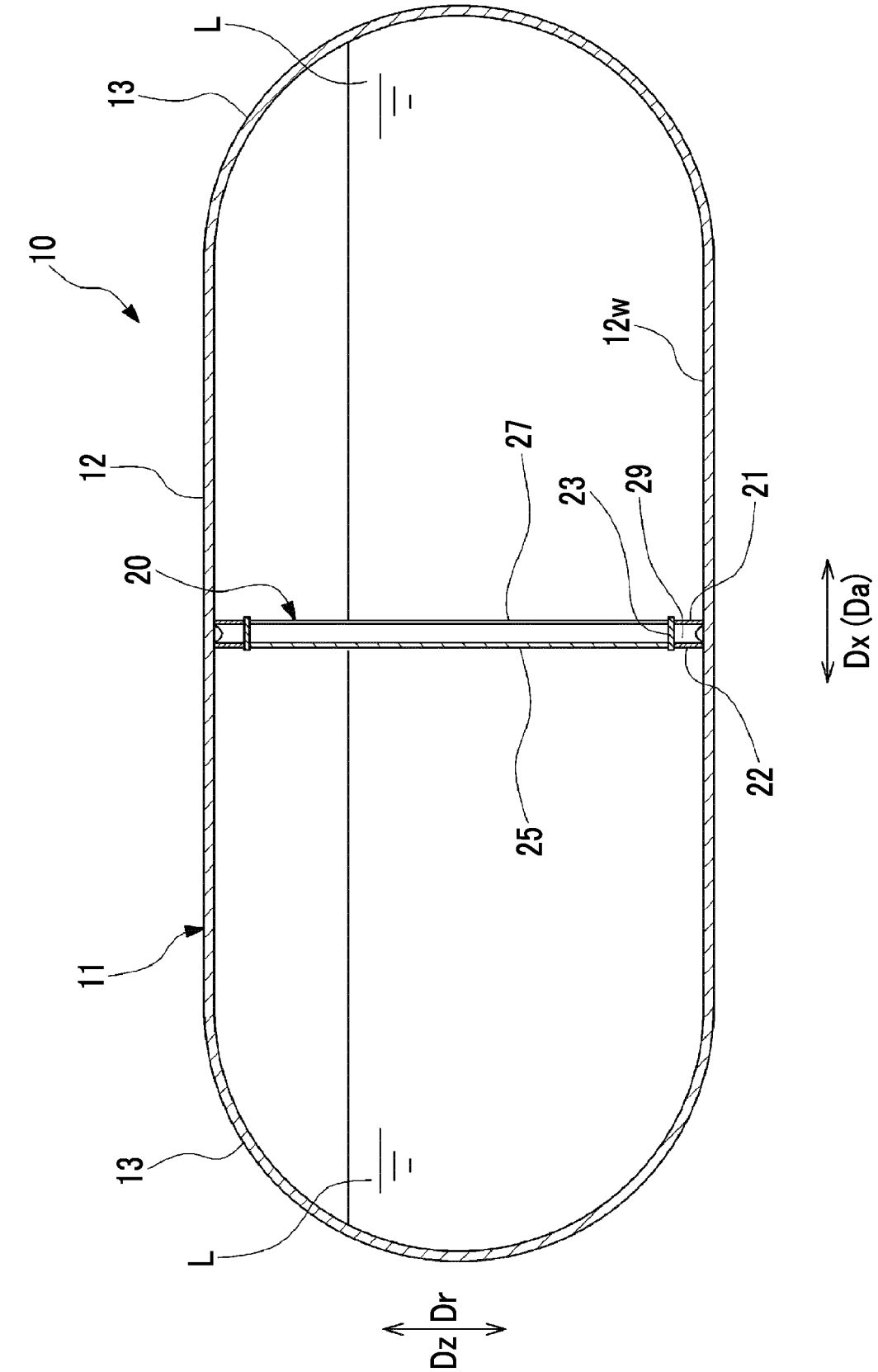


FIG. 3

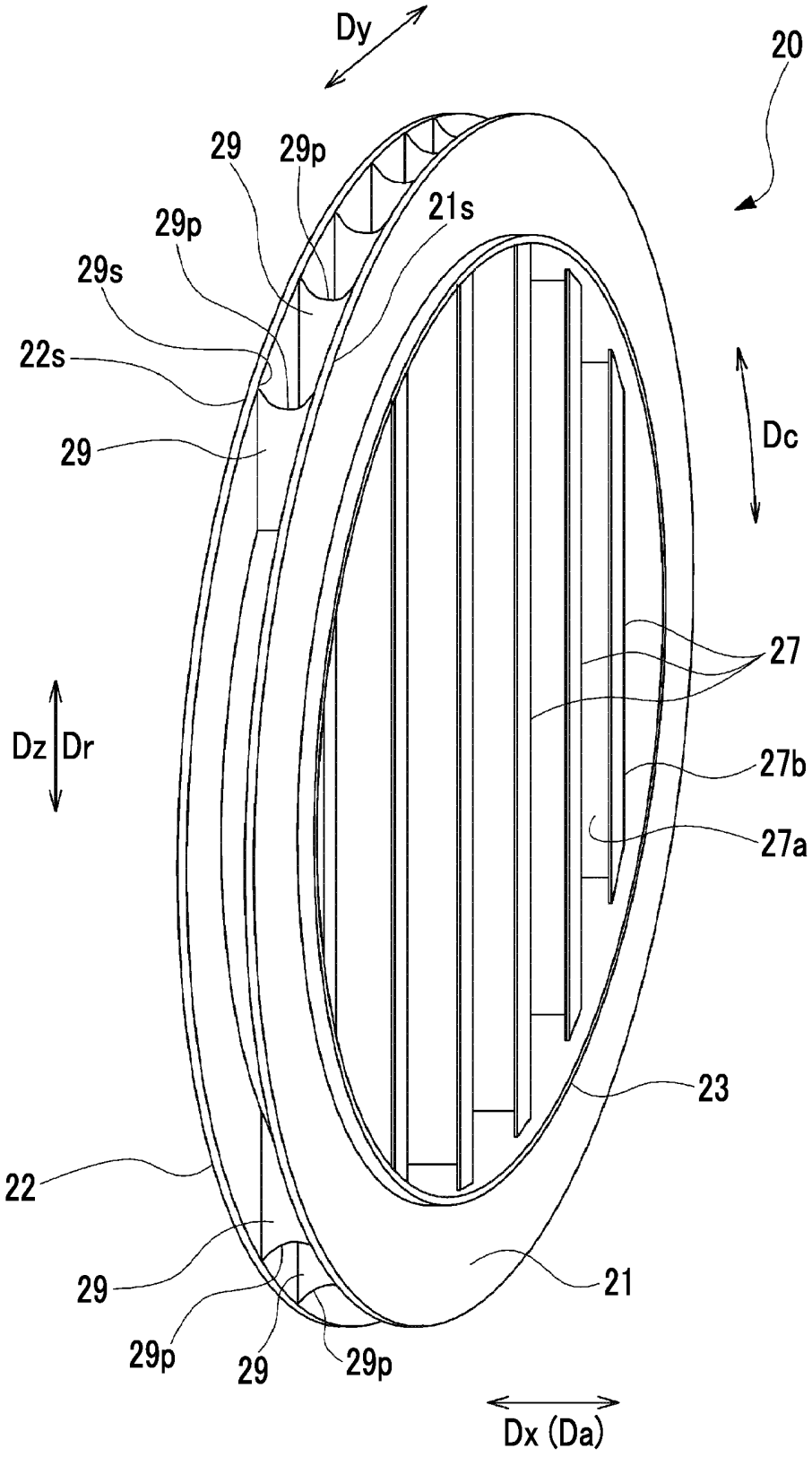

Dy
20
29
29p
21s
29p
29s
22s
29
Dc
27
Dz
Dr
27b
27a
23
22
29
21
29p
29
29p
Dx (Da)

FIG. 4

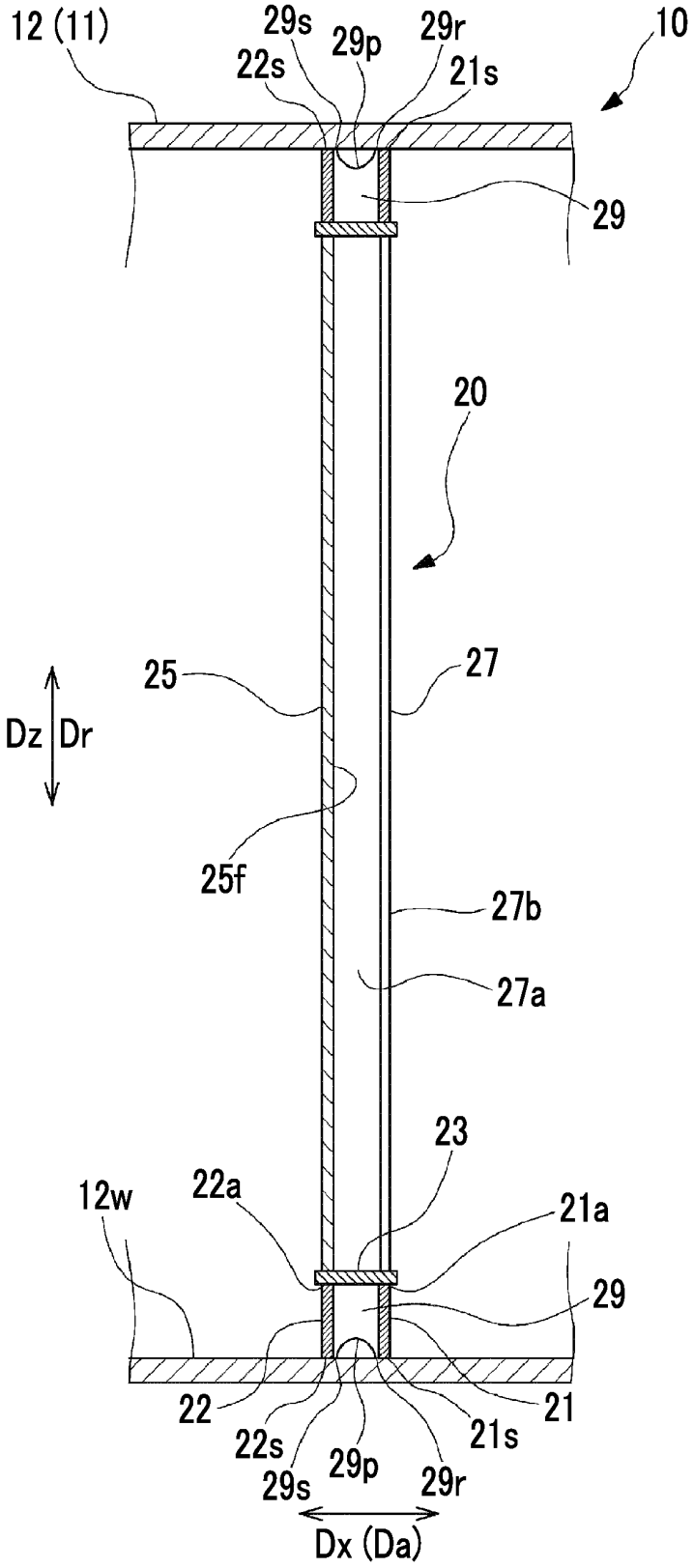

12 (11)
29s
29p
29r
10
22s
21s
29
20
25
27
Dz
Dr
25f
27b
27a
23
12w
22a
21a
29
22
21
22s
21s
29p
29s
29r
Dx (Da)

FIG. 5

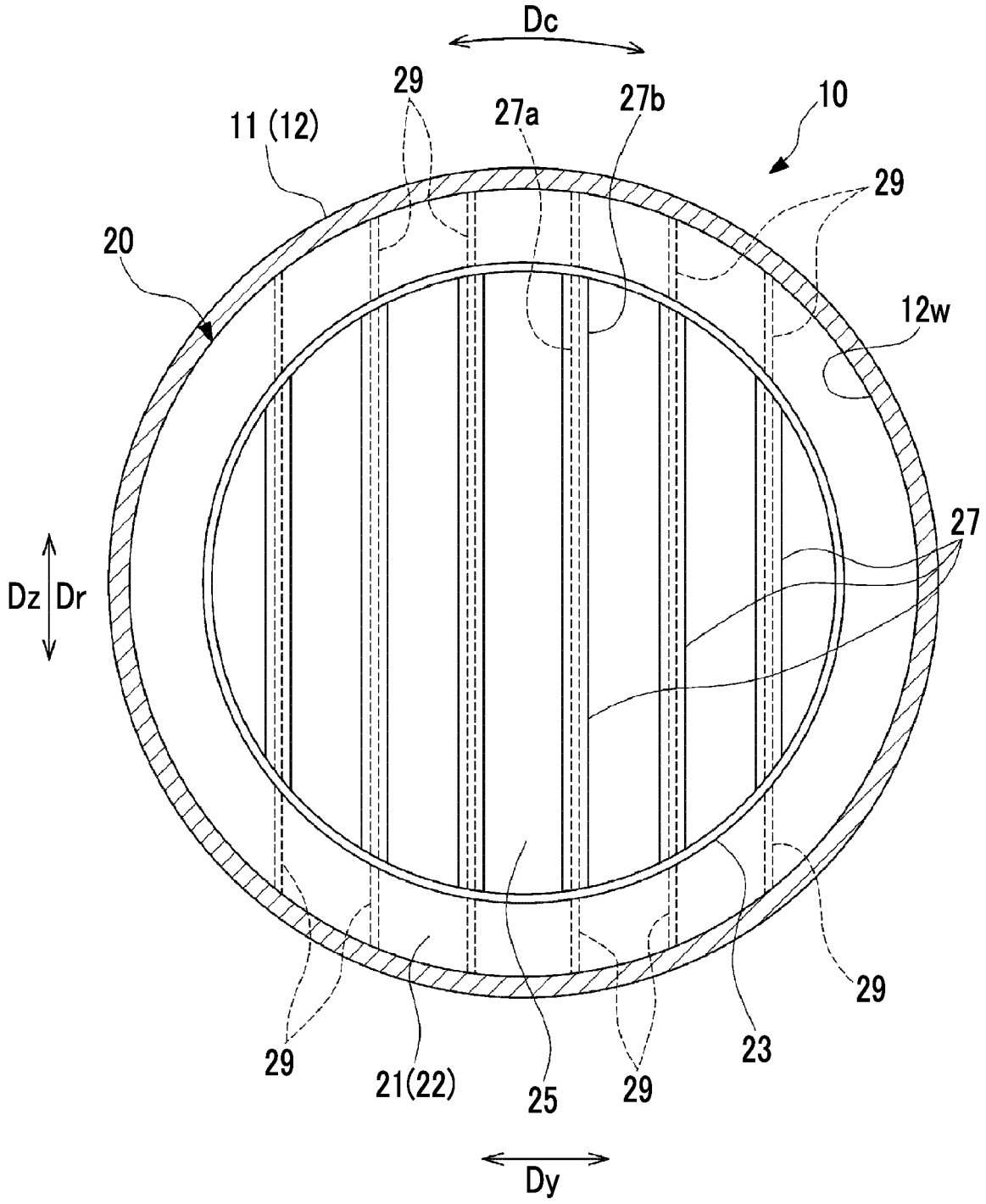


FIG. 6

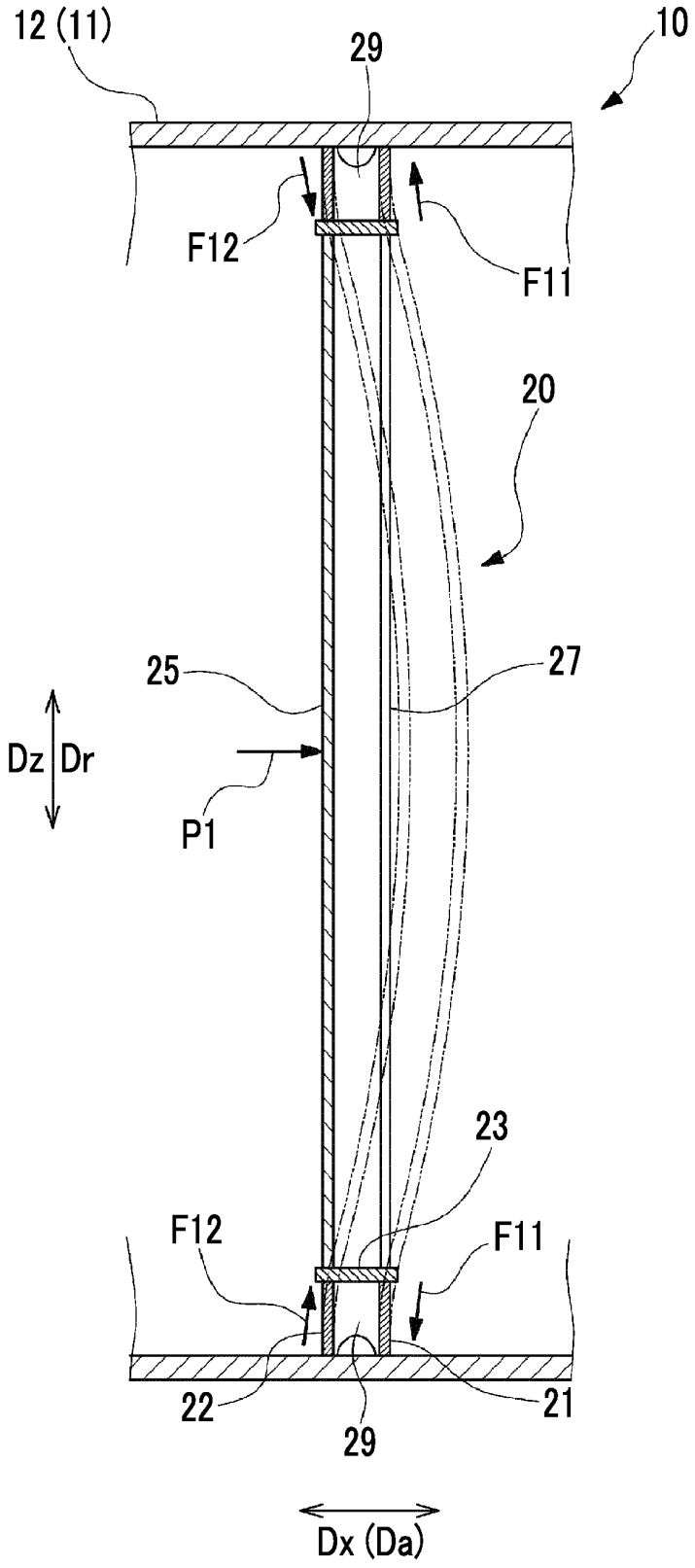
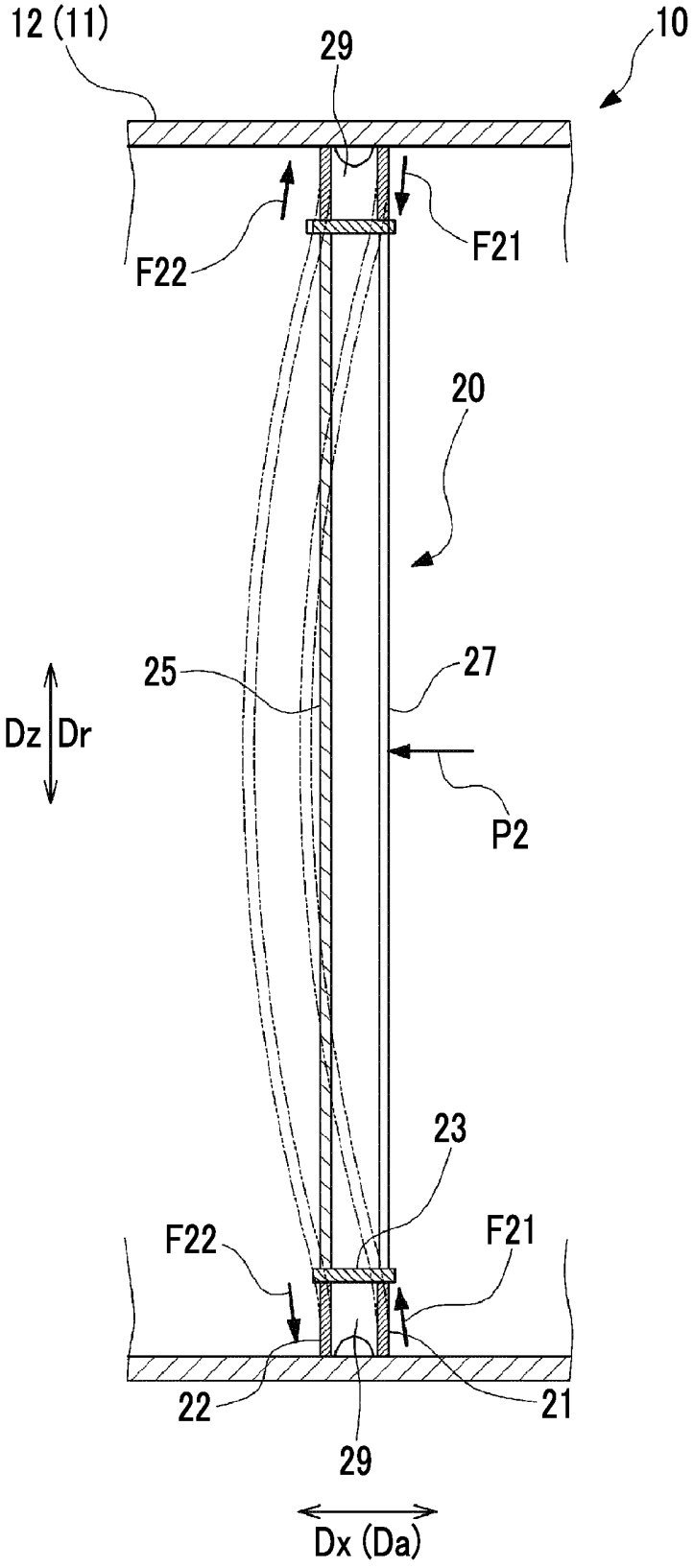


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/040635

A. CLASSIFICATION OF SUBJECT MATTER

B63B 25/08(2006.01)i; ***B65D 88/06***(2006.01)i; ***B65D 90/52***(2006.01)i
FI: B63B25/08 J; B65D90/52; B65D88/06 Z

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)

B63B25/08; B65D88/06; B65D90/52

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

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	KR 10-2018-0060238 A (NK CO., LTD.) 07 June 2018 (2018-06-07) entire text, all drawings	1-8
A	KR 10-2017-0059295 A (NK CO., LTD.) 30 May 2017 (2017-05-30) entire text, all drawings	1-8
A	KR 10-2015-0116195 A (SAMSUNG HEAVY IND. CO., LTD.) 15 October 2015 (2015-10-15) entire text, all drawings	1-8
A	JP 2014-151922 A (IZUMI STEEL WORKS LTD) 25 August 2014 (2014-08-25) entire text, all drawings	1-8
A	SAKAI, Hidemitsu. UEMICHI, Akane. TAKAI, Akihiro. YAMASAKI, Yudai. KANEKO, Shigehiko. Sloshing in a Horizontal Cylindrical Tank Subjected to Pitching Excitation and Damping Effects by Perforated Plates. Journal of Pressure Vessel Technology. August 2017, vol. 139, issue 4, DOI: 10.1115/1.4036429, ISSN 1528-8978(online), 0094-9930(print) entire text, all charts	1-8

☑ 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
13 January 2022	**25 January 2022**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/040635

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	HAN, Yueyang. ZHU, Xiang. LI, Tianyun. GUO, Wenjie. PAN, Luyan. A semi-analytical study of the three-dimensional liquid sloshing in a horizontal cylindrical tank with an arbitrary liquid depth. Ocean Engineering. 27 August 2021, Vol. 238, DOI: 10.1016/j.oceaneng.2021.109722, ISSN 0029-8018 entire text, all charts	1-8

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/040635

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
KR 10-2018-0060238 A	07 June 2018	(Family: none)	
KR 10-2017-0059295 A	30 May 2017	CN 106969261 A	
KR 10-2015-0116195 A	15 October 2015	(Family: none)	
JP 2014-151922 A	25 August 2014	(Family: none)	

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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