



(12) **EUROPEAN PATENT APPLICATION**  
 published in accordance with Art. 153(4) EPC

(43) Date of publication:  
**20.04.2016 Bulletin 2016/16**

(51) Int Cl.:  
**B63H 1/12** (2006.01) **B63H 21/17** (2006.01)  
**B63H 25/42** (2006.01)

(21) Application number: **14811555.3**

(86) International application number:  
**PCT/JP2014/003108**

(22) Date of filing: **11.06.2014**

(87) International publication number:  
**WO 2014/199635 (18.12.2014 Gazette 2014/51)**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**  
 Designated Extension States:  
**BA ME**

(72) Inventors:  
 • **DAIDO, Yoshinori**  
 Hyogo 650-8670 (JP)  
 • **NAKAGAWA, Kentaro**  
 Hyogo 650-8670 (JP)

(30) Priority: **11.06.2013 JP 2013122922**

(74) Representative: **Piésold, Alexander James**  
**Dehns**  
**St Bride's House**  
**10 Salisbury Square**  
**London EC4Y 8JD (GB)**

(71) Applicant: **Kawasaki Jukogyo Kabushiki Kaisha**  
**Kobe-shi, Hyogo 650-8670 (JP)**

(54) **PROPULSIVE FORCE GENERATION DEVICE**

(57) A thrust generator (1) includes: a cylindrical housing (10), which is open at both sides in its axial direction; a thruster body (20) disposed inside the cylindrical housing (10); and a pair of fairing ducts (40, 41) removably mounted to respective side surfaces of the thruster body (20). The thruster body (20) includes an annular stator (25), an annular rotor (30) disposed inside

the stator (25), and a propeller blade (33) provided on an inner peripheral surface of the rotor (30). The cylindrical housing (10) includes a fixing flange (12) protruding radially inward, and the thruster body (20) is removably mounted to the fixing flange (12) by a fastening member (24).

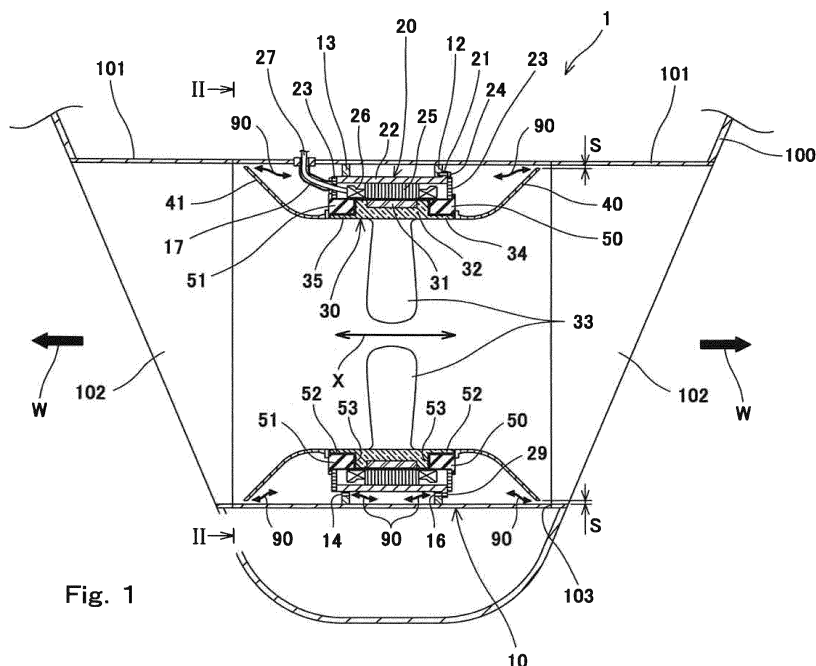


Fig. 1

**Description**

PTL 2: Japanese Laid-Open Patent Application Publication No. 2011-005927

**Technical Field**

[0001] The present invention relates to a thrust generator for generating thrust force of a ship or the like.

**Background Art**

[0002] In recent years, in the field of ships and vessels, there has been an increasing demand for the reduction of noise and vibration from a thruster aiming to, for example, improve the efficiency of the thruster, solve oil leakage problems of the thruster, and improve the cruising comfort for ship crews. However, in reality, for a thruster using a diesel engine, which is conventionally widely used, it is difficult to find ways to improve efficiency, solve oil leakage problems, and reduce noise and vibration.

[0003] Under such circumstances, a thruster in which a propeller is disposed on the inner periphery of the rotor of a ring-shaped electric motor and thereby the electric motor and the propeller are integrated together is drawing attention (hereinafter, such a thruster may be referred to as a "rim drive thruster"). Since the propeller is disposed on the inner periphery of the rotor of the electric motor, the rim drive thruster can suppress the occurrence of cavitation from the blade tips of the propeller. This makes it possible to improve efficiency and reduce noise and vibration due to cavitation. Further, in the case of adopting sea-water lubricated bearings as bearings for supporting the blades of the propeller, even if the thruster becomes damaged, no oil leakage will occur, which makes it possible to contribute to reduction of the burden on the environment in the field of ships and vessels.

[0004] As this type of prior art, there are thrust generators in which the rotor of a ring-shaped electric motor is provided with propeller blades protruding radially inward. These thrust generators utilize the rotation of the propeller blades, which are driven by the electric motor, to squirt a flow of water in the axial direction to generate thrust force (see Patent Literatures 1 and 2, for example). Such type of thrust generator is provided, for example, in an arrangement hole (a tunnel) formed in the fore or the aft of a hull, the arrangement hole extending through the hull in its transverse direction, and components such as the propeller blades can be disassembled. All the propeller blades are connected to a propeller boss disposed at the center of the rotor.

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

[0005]

PTL 1: Japanese Laid-Open Patent Application Publication No. 2011-005926

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

[0006] However, in the case of the thrust generators disclosed in Patent Literatures 1 and 2, at the time of maintenance of components such as propeller blades, it is necessary to disassemble and assemble the boss, propeller blades, rotor body, etc., under water. However, the disassembling and assembling of the components under water is extremely difficult. Therefore, usually, the ship is docked in a dock and the maintenance is performed in the dock. This requires a lot of time and labor.

[0007] On the other hand, for example, in the case of pulling such a thrust generator as described above into an interior space of the ship and perform the maintenance in the interior space, it is necessary to form a large space above the thrust generator so that the thrust generator can be pulled into the interior of the ship, and also, it is necessary to install facilities, such as a crane, for hoisting the thrust generator. This requires a large amount of equipment and cost.

[0008] In view of the above, an object of the present invention is to provide a thrust generator with high maintainability whose components including propeller blades can be integrally removed as a thruster body from a ship.

**Solution to Problem**

[0009] In order to achieve the above-described object, a thrust generator according to the present invention, which is disposed in a liquid and which squirts the liquid to generate thrust force, includes: a cylindrical housing, which is open at both sides in its axial direction; a thruster body disposed inside the cylindrical housing, the thruster body including an annular stator, an annular rotor disposed inside the stator, and a propeller blade provided on an inner peripheral surface of the rotor; and a pair of fairing ducts removably mounted to respective side surfaces of the thruster body and formed such that a diameter of each fairing duct expands from a position corresponding to the inner peripheral surface of the rotor toward the cylindrical housing. The cylindrical housing includes a fixing flange protruding radially inward, and the thruster body is removably mounted to the fixing flange by a fastening member.

[0010] According to this configuration, the thruster body can be separated from the cylindrical housing by removing the fastening member after removing the fairing ducts from the respective side surfaces of the thruster body. Accordingly, the thruster body can be pulled out of the cylindrical housing in the axial direction for maintenance, and thus maintainability can be improved. Therefore, at the maintenance and inspection of the propeller blade and the like, components including the propeller

blade can be integrally removed as the thruster body and readily checked.

**[0011]** The thruster body may include a connecting portion, which overlaps the fixing flange in the axial direction of the cylindrical housing, and the fastening member may be a bolt penetrating the connecting portion or the fixing flange. According to this configuration, when the fairing ducts are removed from the thruster body, the bolt can be unscrewed.

**[0012]** The cylindrical housing may include a support flange, which supports the thruster body at a position that is away from the fixing flange in the axial direction. According to this configuration, the orientation of the thruster body can be kept by the support flange. This makes it possible to stably hold the thruster body inside the cylindrical housing.

**[0013]** The fixing flange may include a liquid passing portion, which allows a cooling liquid to flow into an outer peripheral portion of the thruster body in a state where the thruster body is mounted to the fixing flange. According to this configuration, since the cooling liquid flows into the outer peripheral portion of the thruster body through the liquid passing portion of the fixing flange, the thruster body can be cooled down efficiently. Therefore, an electric motor for rotating the propeller blade can be suitably cooled down, which makes it possible to improve the efficiency of the thruster.

**[0014]** The fixing flange may be continuous in a circumferential direction. The thruster body may include a ring-shaped connecting portion, which overlaps the fixing flange in the axial direction of the cylindrical housing. The fixing flange may include a plurality of flow holes serving as the liquid passing portion, the flow holes being provided in an area where the fixing flange and the connecting portion overlap each other. The connecting portion may include a plurality of flow holes at positions coinciding with positions of the flow holes of the fixing flange. According to this configuration, the cooling liquid can be caused to flow into the outer peripheral portion of the thruster body, or the cooling liquid can be caused to flow out of the outer peripheral portion of the thruster body, in a manner to flow through the connecting portion and the fixing flange of the thruster body.

**[0015]** For example, the cylindrical housing may include a support flange, which supports the thruster body at a position that is away from the fixing flange in the axial direction, and the support flange may include a liquid passing portion, which allows the cooling liquid to flow into the outer peripheral portion of the thruster body.

**[0016]** The thrust generator may further include: a cooling flow passage formed between the cylindrical housing and the thruster body, the cooling flow passage allowing the cooling liquid that has flowed through the liquid passing portion of the fixing flange or the support flange into the outer peripheral portion of the thruster body to flow in a circumferential direction in the outer peripheral portion of the thruster body. This configuration allows the cooling liquid that has flowed through the liquid passing

portion of the fixing flange or the support flange into the outer peripheral portion of the thruster body to flow in the circumferential direction of the thruster body, and thereby the outer peripheral portion of the thruster body can be cooled down efficiently.

**[0017]** The liquid passing portion of the fixing flange may be disposed within a part of the fixing flange in the circumferential direction. The liquid passing portion of the support flange may be disposed within a part of the support flange in the circumferential direction. The cylindrical housing may include a flow passage forming member between the fixing flange and the support flange. The flow passage forming member may include an opening positioned at an opposite side to the liquid passing portion of at least one of the fixing flange and the support flange with respect to a central axis of the cylindrical housing. According to this configuration, the cooling liquid that has flowed through the liquid passing portion of one of the fixing flange and the support flange into the outer peripheral portion of the thruster body flows in the circumferential direction of the thruster body through the flow passage formed by the flow passage forming member, and the cooling liquid flows out of the outer peripheral portion of the thruster body through the liquid passing portion of the other one of the fixing flange and the support flange. Thus, a long cooling flow passage is formed in the outer peripheral portion of the thruster body, and thereby the cooling can be performed more efficiently. In addition, the cooling efficiency can be improved also by setting the cross-sectional area of the flow passage such that the flow velocity of the cooling liquid increases.

**[0018]** The above thrust generator may further include: an electric cable extending from the cylindrical housing and connected to the stator; and a waterproof tube, which is provided between the cylindrical housing and the thruster body and through which the electric cable is inserted. According to this configuration, the electric cable can be kept in a waterproofed state by the waterproof tube while the thrust generator is in operation, and at the time of removing the thruster body, the electric cable can be removed by removing the waterproof tube.

**[0019]** The above thrust generator may further include: an electric cable extending from the cylindrical housing and connected to the stator. The electric cable may include an underwater connector provided between the cylindrical housing and the thruster body, the underwater connector being watertight and removable underwater. According to this configuration, at the time of removing the thruster body, the electric cable can be readily disconnected at the underwater connector.

### Advantageous Effects of Invention

**[0020]** The present invention makes it possible to provide the thrust generator with high maintainability, which is mounted to a ship or the like. At the time of, for example, maintenance of the propeller blade, the thruster body can be integrally removed, and the maintenance of the pro-

PELLER BLADE CAN BE READILY PERFORMED.

### Brief Description of Drawings

#### [0021]

Fig. 1 is a longitudinal sectional view showing a thrust generator according to Embodiment 1 of the present invention.

Fig. 2 is a front view taken along a line II-II of Fig. 1 as viewed in the direction of arrows of the line II-II.

Fig. 3 is a front view of a support flange shown in Fig. 1.

Fig. 4 is a front view of a fixing flange shown in Fig. 1.

Fig. 5 is a schematic diagram illustrating flows of water at flange portions of the thrust generator shown in Fig. 1.

Fig. 6 is a longitudinal sectional view when the thrust generator shown in Fig. 1 is disassembled.

Fig. 7 is a longitudinal sectional view showing a thrust generator according to Embodiment 2 of the present invention.

Fig. 8 is a sectional view taken along a line VIII-VIII of Fig. 7 as viewed in the direction of arrows of the line VIII-VIII.

Fig. 9 is a sectional view taken along a line IX-IX of Fig. 7 as viewed in the direction of arrows of the line IX-IX.

Fig. 10 is a longitudinal sectional view showing a thrust generator according to Embodiment 3 of the present invention.

Fig. 11 is a longitudinal sectional view showing a thrust generator according to Embodiment 4 of the present invention.

Fig. 12 is a front view of a support flange shown in Fig. 11.

Fig. 13 is a front view of a fixing flange shown in Fig. 11.

Fig. 14 is a front view of a flow passage forming flange taken along a line XIV-XIV of Fig. 11 as viewed in the direction of arrows of the line XIV-XIV.

Fig. 15 is a front view of a flow passage forming flange taken along a line XV-XV of Fig. 11 as viewed in the direction of arrows of the line XV-XV.

Fig. 16 is a schematic diagram illustrating flows of water at flange portions of the thrust generator shown in Fig. 11.

Fig. 17 is a longitudinal sectional view showing a part of a thrust generator according to a first variation.

Fig. 18 is a longitudinal sectional view showing a part of a thrust generator according to a second variation.

Fig. 19 is a longitudinal sectional view showing a part of a thrust generator according to a third variation.

Fig. 20 is a longitudinal sectional view showing a part of a thrust generator according to a fourth variation.

### Description of Embodiments

[0022] Hereinafter, embodiments of the present invention are described with reference to the drawings. In the embodiments below, a description is given taking, as an example, a thrust generator that is used, for example, as a side thruster of a ship. The thrust generator is provided on a cylindrical wall (a tunnel) extending through the hull in the hull transverse direction, and the cylindrical wall is provided in the fore or the aft of the hull. That is, the thrust generator is disposed under water.

(Embodiment 1)

[0023] As shown in Fig. 1, a thrust generator 1 according to Embodiment 1 is provided between cylindrical walls 101 provided in a hull 100. The thrust generator 1 squirts water W in the horizontal direction from openings 102 of the respective cylindrical walls 101 to generate thrust force. A central portion between the cylindrical walls 101 serves as an arrangement portion 103. A cylindrical housing 10, which is open at both sides in its axial direction, is fixed to the arrangement portion 103. In the present embodiment, the cylindrical walls 101 are formed as a pair of divided short tubes spaced apart from each other in the hull transverse direction, and a gap between the short tubes forms the arrangement portion 103. The cylindrical housing 10 is formed to have the same internal diameter as that of the cylindrical walls 101. The cylindrical housing 10 is fixed to the cylindrical walls 101 by welding or the like. Hereinafter, for the sake of convenience of the description, the axial direction of the cylindrical housing 10 may be referred to as a left-right direction (and a surface facing in the left-right direction may be referred to as a side surface).

[0024] A thruster body 20 is disposed inside the cylindrical housing 10. In the present embodiment, two flanges 12 and 13 protruding radially inward are provided at predetermined positions on the inner peripheral surface of the cylindrical housing 10. The fixing flange 12 for fixing the thruster body 20 is provided on the right side of Fig. 1, and the support flange 13 for supporting the thruster body 20 is provided on the left side of Fig. 1. These flanges 12 and 13 are arranged away from each other in the axial direction X of a plurality of propeller blades 33 (which is the axial direction of the cylindrical housing 10). The flanges 12 and 13 are disposed at their respective positions, which are equally distant from the center of the propeller blades 33 in the axial direction X. The flanges 12 and 13 may be suitably disposed in accordance with, for example, the size of the thruster body 20. For example, a side surface of the fixing flange 12 and a side surface of the support flange 13 that face each other are spaced apart from each other by a distance that is 0.2 times or more as great as the diameter of a propeller formed by the propeller blades 33.

[0025] In the present embodiment, both the fixing flange 12 and the support flange 13 are continuous in

the circumferential direction. Although the present embodiment shows an example in which the two flanges 12 and 13 are provided, the cylindrical housing 10 is required to include at least one flange (at least the fixing flange 12). The total number of fixing and support flanges 12 and 13 may be three or more. Assume that the cylindrical housing 10 includes only one of these flanges, i.e., the fixing flange 12. In this case, for example, a protrusion functioning as the support flange 13 may be formed on the thruster body 20. In this case, for example, a structure as shown in Fig. 19 is adopted so that the thruster body 20 can be pulled out of the cylindrical housing 10 to the left side. In the present embodiment, the thruster body 20 is pulled out of the cylindrical housing 10 to the right side.

**[0026]** Returning to Fig. 1 (or referring to Fig. 5 as necessary), the thruster body 20 includes: an outer peripheral casing 22 disposed inside the cylindrical housing 10; an annular stator 25 disposed inside the outer peripheral casing 22; and a pair of annular side casings 23 fixed to respective side surfaces of the outer peripheral casing 22. The stator 25 is disposed in an annular groove that is opened radially inward and that is formed by the outer peripheral casing 22 and the side casings 23. The outer peripheral casing 22 is a cylindrical body, which is longer than a distance between a side surface of the fixing flange 12 and a side surface of the support flange 13 that face opposite to each other.

**[0027]** On one end (right end) of the outer peripheral casing 22, a connecting portion 21 overlapping the fixing flange 12 in the axial direction X is provided in a manner to protrude radially outward. In the present embodiment, the connecting portion 21 is ring-shaped and continuous in the circumferential direction. The connecting portion 21 is fixed to the fixing flange 12 by fixing bolts 24 (one example of a fastening member of the present invention) in a state where the connecting portion 21 is in contact with the right side surface of the fixing flange 12 (i.e., in contact with the side surface facing the opposite side to the support flange 13). That is, the thruster body 20 is removably mounted to the fixing flange 12 by the fixing bolts 24, which penetrate the connecting portion 21. On another end (left end) of the outer peripheral casing 22, the outer peripheral surface of the outer peripheral casing 22 is supported by the inner peripheral surface of the support flange 13.

**[0028]** An electric cable 27 extends through the side casing 23 provided at the opposite side to the connecting portion 21 (i.e., the side casing 23 at the left side). The electric cable 27 extends from the cylindrical housing 10 and is connected to armature coils 26 of the stator 25. The stator 25 is provided with a plurality of armature coils 26, which are formed in an annular manner. The electric cable 27 is inserted through a waterproof tube 17, which is provided between the cylindrical housing 10 and the side casing 23. The waterproof tube 17 is fixed to the cylindrical housing 10, and an end of the waterproof tube 17 is mounted to the side casing 23 by a bolt or the like.

**[0029]** An annular rotor 30 is disposed inside the stator 25. The rotor 30 includes: an annular rotor core 31, to which a plurality of magnets are attached; and an annular rotor body 32 fitted to the outside of the rotor core 31. When electric power is fed to the armature coils 26 of the stator 25, the rotor core 31 rotates, and thereby the rotor 30 rotates. By changing the manner of feeding electric power to the armature coils 26, the rotation speed, rotation direction, and the like of the rotor core 31 can be changed.

**[0030]** Heat from the stator 25 is transferred to the outer peripheral casing 22 by thermal conduction. The stator 25 and the rotor 30 form an electric motor. In the present embodiment, the stator 25 is cooled down by convection cooling at the outside of the outer peripheral casing 22 (i.e., at the outer periphery of the thruster body 20).

**[0031]** The propeller blades 33 are provided on the inner peripheral surface of the rotor body 32. Each of the propeller blades 33 is formed to have such a shape that each propeller blade 33 can generate thrust force whether the propeller blade 33 rotates in a normal direction or a reverse direction. The base of each propeller blade 33 is mounted to the rotor body 32. This makes it possible to suppress the cavitation from the propeller blades 33. Therefore, noise and vibration due to the cavitation can be reduced. The tip of each propeller blade 33 is positioned near the center of the rotor 30, and a central opening at the center of the rotor 30 is defined by all of the propeller tips (see Fig. 2). In the present embodiment, the propeller blades 33 (in this example, four propeller blades 33 as described below) are arranged at equally-spaced intervals in the circumferential direction.

**[0032]** The rotor 30 is supported by water-lubricated bearings 50 and 51 provided at the inner periphery of the side casings 23. The rotor body 32 is provided with collar portions 34 and 35 extending to respective sides in the axial direction X from the central part of the rotor body 32 where the rotor core 31 is provided. The water-lubricated bearings 50 and 51 form water films between inner peripheral surfaces 52 of the respective water-lubricated bearings 50 and 51 and outer peripheral surfaces of the respective collar portions 34 and 35, thereby supporting a radial load exerted in the radial direction of the rotor body 32.

**[0033]** The water-lubricated bearings 50 and 51 include facing surfaces 53, respectively. The facing surfaces 53 face respective side surfaces of the rotor body 32 in the axial direction X (i.e., annular surfaces extending radially outward from the bases of the collar portions 34 and 35). The water-lubricated bearings 50 and 51 form water films between the side surfaces of the rotor body 32 in the axial direction X and the facing surfaces 53, thereby supporting a thrust load exerted in the axial direction of the rotor body 32. Thus, the inner peripheral surfaces 52 of the water-lubricated bearings 50 and 51 serve as radial bearing surfaces, and the facing surfaces 53 of the water-lubricated bearings 50 and 51 serve as thrust bearing surfaces. As described above, the water-

lubricated bearings 50 and 51 are provided in a manner to sandwich the rotor body 32 in the axial direction X, and the radial load and the thrust load exerted on the rotor 30 are supported by these water-lubricated bearings 50 and 51. The water-lubricated bearings 50 and 51 serve as plain bearings. In addition, water W flows from the facing surfaces 53 into a gap between the rotor core 31 and the stator 25. Thanks to the water-lubricated bearings 50 and 51, oil leakage problems are eliminated.

**[0034]** A pair of fairing ducts 40 and 41, whose inner peripheral surfaces are continuous with the collar portions 34 and 35, is provided. The fairing ducts 40 and 41 are provided on the respective sides of the rotor 30 in the axial direction X. These fairing ducts 40 and 41 extend such that the more the distance from the rotor 30, the greater the diameter of each fairing duct. To be more specific, the fairing ducts 40 and 41 are formed such that the diameter of each fairing duct increases from a position corresponding to the inner peripheral surface of the rotor 30 (in the present embodiment, a position where the fairing duct forms a continuous surface together with the inner peripheral surface of the rotor 30) toward the cylindrical housing 10, and an end portion of the fairing duct is positioned adjacent to the inner periphery of the cylindrical housing 10. Further, the fairing ducts 40 and 41 are formed to extend from the positions of the water-lubricated bearings 50 and 51 to end portions of the cylindrical housing 10 in the axial direction (specifically, to the vicinity of the borders of the arrangement portion 103). These fairing ducts 40 and 41 are removably mounted by bolts (not shown) to the water-lubricated bearings 50 and 51, which form the respective side surfaces of the thruster body 20.

**[0035]** As shown in Fig. 2, when the thrust generator 1 is seen in the axial direction X, the fairing duct 41 is provided such that a predetermined gap S is formed between the cylindrical housing 10 and the fairing duct 41 (the same is true of the fairing duct 40). The propeller blades 33 are positioned at the center of the fairing duct 41 (40). In this example, there are four propeller blades 33, and a space is formed at the center among the propeller blades 33.

**[0036]** As shown in Fig. 3, the support flange 13 is provided with a plurality of flow holes (liquid passing portions) 14, which are arranged in the circumferential direction. The plurality of flow holes 14 allow the water W to flow through the support flange 13. As shown in Fig. 4, the fixing flange 12 is provided with a plurality of fixing holes (screw holes serving as female screws) 15 and a plurality of flow holes (liquid passing portions) 16. The fixing holes 15 and the flow holes 16 are arranged alternately and fully circumferentially. The fixing holes 15 are arranged at equal pitches in the circumferential direction, and the flow holes 16 are arranged at equal pitches between the fixing holes 15. The fixing bolts 24 are screwed into the fixing holes 15. That is, the flow holes 16 are provided in an area where the fixing flange 12 and the connecting portion 21 overlap each other. The plurality of flow holes

16 allow the water W to flow through the fixing flange 12. In the present embodiment, the number of flow holes 14 formed in the support flange 13 is the same as the number of flow holes 16 formed in the fixing flange 12. The flow holes 14 and 16 are provided for allowing the water W to flow into an outer peripheral portion of the thruster body 20 in a state where the thruster body 20 is mounted to the fixing flange 12.

**[0037]** Fig. 5 shows a state where the thruster body 20 is mounted to the fixing flange 12. Of the outer peripheral casing 22 of the thruster body 20, a portion in contact with the fixing flange 12 and a portion in contact with the support flange 13 are formed as larger-diameter portions 45, whose widths correspond to the thicknesses of the flanges 12 and 13. The other portions of the outer peripheral casing 22 are formed as smaller-diameter portions 46. The larger-diameter portions 45 are connected to the smaller-diameter portions 46 via tapered surfaces. In this manner, gaps (clearances) between the outer peripheral casing 22 and the fixing and support flanges 12 and 13 when the thruster body 20 is moved in the axial direction X are increased, which allows the thruster body 20 to be readily moved in the axial direction X.

**[0038]** In the thruster body 20, as shown in Fig. 5, the connecting portion 21 of the thruster body 20 is brought into contact with the right side surface of the fixing flange 12. Then, the fixing bolts 24 are inserted in bolt insertion holes 28 formed in the connecting portion 21, and the fixing bolts 24 are further screwed into the fixing holes 15 (screw holes serving as female screws) formed in the fixing flange 12. As a result, the thruster body 20 is fixed to the fixing flange 12. The fixing of the thruster body 20 is realized by the surface pressure between the contact surface of the connecting portion 21 and the contact surface of the fixing flange 12, the surface pressure occurring when the connecting portion 21 is fastened to the fixing flange 12 by the fixing bolts 24. Fig. 5 shows only one of the fixing bolts 24, which are arranged in the circumferential direction. In the present embodiment, the connecting portion 21 of the thruster body 20 is fixed to the right side surface of the fixing flange 12 as shown in Fig. 5. Accordingly, in the case of removing the thruster body 20, the connecting portion 21 is pulled out to the right side of the drawing (see Fig. 6).

**[0039]** As described above, portions of the outer peripheral casing 22, other than the portion whose width corresponds to the thickness of the support flange 13 and the portion whose width corresponds to the thickness of the fixing flange 12, are formed as the smaller-diameter portions 46. Therefore, at the time of removing or mounting the thruster body 20, the thruster body 20 can be readily moved in the axial direction X thanks to the large gaps except at the position where the thruster body 20 is fixed.

**[0040]** The fixing flange 12 and the support flange 13 are provided with the flow holes 16 and the flow holes 14. The connecting portion 21 is provided with a plurality of flow holes (liquid passing portions) 29 at positions co-

inciding with the positions of the flow holes 16 in the fixing flange 12. Therefore, as shown in Fig. 5, the flow holes 16 and 29 are in communication with each other in a state where the connecting portion 21 is fixed to the fixing flange 12.

**[0041]** These flow holes 16 and 29 form a cooling flow passage 90 for water-cooling the outer peripheral casing 22 between the fixing flange 12 and the support flange 13 and between the outer peripheral casing 22 and the cylindrical housing 10.

**[0042]** Specifically, as indicated by arrows 91 and 92 in Fig. 5, when the propeller blades 33 are rotated and a water flow is generated, water W (cooling liquid) flows in toward the thruster body 20 through the gap S (Fig. 1) formed between the cylindrical housing 10 and one of the fairing ducts 40 and 41, and the water W flows through the cooling flow passage 90. For example, in a case where the thruster body 20 squirts water W to the left side, water W flows into between the outer peripheral casing 22 and the cylindrical housing 10 through the flow holes 29 and 16 formed in the connecting portion 21 and the fixing flange 12, and after flowing between the outer peripheral casing 22 and the cylindrical housing 10, the water W flows out through the flow holes 14 formed in the support flange 13. The flow of water W along the cooling flow passage 90 is generated by the flow of water W that squirts out to one side through one of the openings 102 of the cylindrical wall 101 when the propeller blades 33 are rotated. The flow of water W is generated either to the right or left in accordance with the rotation direction of the propeller blades 33.

**[0043]** By thus generating the flow of water W between the outer peripheral casing 22 and the cylindrical housing 10, heat transfer of the outer peripheral casing 22 is facilitated, and thereby heat from the stator 25 (indicated by dotted lines H) can be released to the outside of the stator 25 efficiently. This makes it possible to improve the drive efficiency of the electric motor.

**[0044]** Fig. 6 shows a state where the thrust generator 1 according to Embodiment 1 is disassembled. First, the fairing ducts 40 and 41 fixed to the water-lubricated bearings 50 and 51 by bolts (not shown) are removed. By removing the bolts, the fairing ducts 40 and 41 can be removed in the axial direction X through the openings 102 of the cylindrical wall 101.

**[0045]** Then, the fixing bolts 24 fixing the connecting portion 21 of the thruster body 20 to the fixing flange 12 are removed. Also, the electric cable 27 is removed at a hull-side connection (not shown), and the waterproof tube 17 through which the electric cable 27 is inserted is removed from the side casing 23. Thereafter, components including the propeller blades 33 are integrally pulled out as the thruster body 20 to the right side. The pull-out of the thruster body 20 can be readily performed, for example, by laying rails on the inner bottom surfaces of the cylindrical housing 10 and the cylindrical wall 101 and moving the thruster body 20 along the rails in the horizontal direction.

**[0046]** In addition, the work of removing and mounting components including the rotor 30 and the propeller blades 33 integrally as the thruster body 20 can be entirely performed outside the ship. Accordingly, between the hull 100 and the thrust generator 1, components other than the electric cable 27 need not be waterproofed, and thus the number of components that require waterproofing can be minimized.

**[0047]** Therefore, according to the above-described thrust generator 1 mounted to a ship or the like, at the time of, for example, maintenance of the propeller blades 33, components including the propeller blades 33 can be integrally removed as the thruster body 20, and the maintenance can be readily performed on the sea or in a factory.

(Embodiment 2)

**[0048]** Fig. 7 is a longitudinal sectional view of a thrust generator 2 according to Embodiment 2. In Embodiment 2, water-lubricated bearings 60 and 61 are static pressure bearings, which forcibly feed water W. It should be noted that the same components as those of the thrust generator 1 of Embodiment 1 are denoted by the same reference signs as those used in Embodiment 1, and a detailed description of such components is omitted.

**[0049]** As shown in Fig. 7, in the thrust generator 2 according to Embodiment 2, buffer spaces 62 are provided at the outer periphery of the water-lubricated bearings 60 and 61. Water W is forcibly fed to the buffer spaces 62 through pipes 63. The pipes 63 are connected to a pump (not shown) provided inside the ship via connection joints 64 provided on the cylindrical housing 10.

**[0050]** As shown in a cross-sectional view of Fig. 8 taken along a line VIII-VIII, the waterproof tube 17, through which the electric cable 27 is inserted, is provided on the upper part of the side casing 23, and the pipe 63 is provided on the lower part of the water-lubricated bearing 60. This cross-sectional view shows a state where the support flange 13 is seen around the side casing 23, and also, the flow holes 14 formed in the support flange 13 are seen.

**[0051]** As shown in a cross-sectional view of Fig. 9 taken along a line IX-IX, the pipe 63 is provided also on the lower part of the water-lubricated bearing 61 provided at the opposite side of the outer peripheral casing 22. This cross-sectional view shows a state where the connecting portion 21 of the outer peripheral casing 22 is seen around the side casing 23, and also, the flow holes 29 of the connecting portion 21 are seen. The flow holes 29 are in communication with the flow holes 16 formed in the fixing flange 12.

**[0052]** By thus adopting the static pressure bearing system in which the water W is forcibly fed to the bearing surfaces of the water-lubricated bearings 60 and 61, even if the rotor 30 is not rotating, water films can always be formed between the rotor 30 and the water-lubricated bearings 60 and 61.

**[0053]** Thus, according to the thrust generator 2, stable water films can always be formed between the rotor 30 and the bearing surfaces of the water-lubricated bearings 60 and 61. Therefore, the rotor 30 can be supported in a stable manner even under the condition that the thrust generator 2 is used for a long period of time with low speed rotation, for example, in a ship staying at a fixed point.

**[0054]** Also in the present embodiment, the connecting portion 21, the fixing flange 12, and the support flange 13 are provided with the flow holes 29, 16, and 14, respectively (see Fig. 5). Accordingly, when the propeller blades 33 are rotated and a water flow is generated, water W (cooling liquid) flows in toward the thruster body 20 through the gap S formed between the cylindrical housing 10 and one of the fairing ducts 40 and 41, and the water W flows through the cooling flow passage 90. In this manner, the outer surface of the outer peripheral casing 22 can be cooled down efficiently (Fig. 5).

**[0055]** In addition, the electric cable 27, the waterproof tube 17, and the connection joints 64 may be removed after removing the fairing ducts 40 and 41, and similar to Fig. 6, the fixing bolts 24 fixing the connecting portion 21 of the thruster body 20 to the fixing flange 12 may be removed. Consequently, components including the propeller blades 33 can be integrally removed as the thruster body 20 in the axial direction X through the opening 102 of the cylindrical wall 101. Therefore, the maintenance of the components including the propeller blades 33 can be readily performed.

(Embodiment 3)

**[0056]** Fig. 10 is a longitudinal sectional view showing a thrust generator 3 according to Embodiment 3. Embodiment 3 shows an example where instead of adopting the direct connection using the electric cable 27 as in the thrust generator 1 of Embodiment 1, an underwater connector 71 is provided on an electric cable 70. The electric cable 70 extends from the cylindrical housing 10 and is connected to the stator 25. It should be noted that the same components as those of the thrust generator 1 of Embodiment 1 are denoted by the same reference signs as those used in Embodiment 1, and a detailed description of such components is omitted.

**[0057]** As shown in Fig. 10, one of the side casings 23 is provided with an output cable 73, which is provided with a socket 72 of the underwater connector 71. The cylindrical wall 101 is provided with an input cable 75, whose distal end is provided with a plug 74 of the underwater connector 71. The underwater connector 71 shown in Fig. 10 is in a state where the plug 74 and the socket 72 are connected.

**[0058]** According to the thrust generator 3 with the above-described configuration, similar to the thrust generator 1 of Embodiment 1, components including the propeller blades 33 can be integrally removed in the axial direction X as the thruster body 20, by removing the fair-

ing ducts 40 and 41, pulling the plug 74 of the underwater connector 71 out of the socket 72, and removing the fixing bolts 24, which fix the connecting portion 21 of the thruster body 20 to the fixing flange 12.

**[0059]** This makes it possible to greatly improve the maintainability of the thrust generator 3. Further, also in the present embodiment, the connecting portion 21, the fixing flange 12, and the support flange 13 are provided with the flow holes 29, 16, and 14, respectively (see Fig. 5). Accordingly, when the propeller blades 33 are rotated and a water flow is generated, water W (cooling liquid) flows in toward the thruster body 20 through the gap S formed between the cylindrical housing 10 and one of the fairing ducts 40 and 41, and the water W flows through the cooling flow passage 90. In this manner, the outer surface of the outer peripheral casing 22 can be cooled down efficiently (Fig. 5).

(Embodiment 4)

**[0060]** Fig. 11 is a longitudinal sectional view of a thrust generator 4 according to Embodiment 4. Embodiment 4 shows an example where instead of the fixing flange 12 and the support flange 13 of the thrust generator 1 of Embodiment 1, a fixing flange 80, a support flange 81, and flow passage forming members are provided, expecting further improvement in the cooling effect. It should be noted that the same components as those of the thrust generator 1 of Embodiment 1 are denoted by the same reference signs as those used in Embodiment 1, and a detailed description of such components is omitted.

**[0061]** As shown in Fig. 11, in the thrust generator 4 according to the present embodiment, the fixing flange 80 and the support flange 81, both of which protrude radially inward, are provided on the inner peripheral surface of the cylindrical housing 10, and flow passage forming flanges 82 and 83, which serve as the flow passage forming members, are provided between the fixing flange 80 and the support flange 81. The internal diameters of the respective flow passage forming flanges 82 and 83 are slightly greater than those of the fixing flange 80 and the support flange 81, and thereby interference at the time of removing or mounting the thruster body 20 in the axial direction X is prevented.

**[0062]** As shown in Fig. 12, flow holes (liquid passing portions) 84 are formed only in the lower part of the support flange 81 below the central part of the support flange 81. That is, the flow holes 84 are disposed within a part of the support flange 81 in the circumferential direction. The flow holes 84 are arranged at equal pitches. The plurality of flow holes 84 allow the water W to flow through the support flange 81. As shown in Fig. 13, the fixing flange 80 is provided with the plurality of fixing holes 15, which are arranged fully circumferentially, and flow holes (liquid passing portions) 85 are formed only in the upper part of the fixing flange 80 above the central part of the fixing flange 80. That is, the flow holes 85 are disposed

within a part of the fixing flange 80 in the circumferential direction. The plurality of flow holes 85 allow the water W to flow through the fixing flange 80. The fixing holes 15 are arranged at equal pitches in the circumferential direction, and the flow holes 85 are arranged at equal pitches between the upper fixing holes 15. In the present embodiment, the number of flow holes 84 formed in the support flange 81 is the same as the number of flow holes 85 formed in the fixing flange 80.

**[0063]** As shown in Fig. 14, the right-side flow passage forming flange 82, which faces the fixing flange 80, includes an opening 86. The opening 86 is formed by cutting away a predetermined portion of the lower part of the flow passage forming flange 82. Specifically, the opening 86 is positioned at the opposite side to the flow holes 85 of the fixing flange 80 with respect to the central axis of the cylindrical housing 10. In this example, the opening 86 is formed by cutting away a 30° portion of the lower part of the flow passage forming flange 82. As shown in Fig. 15, the left-side flow passage forming flange 83, which faces the support flange 81, includes an opening 87. The opening 87 is formed by cutting away a predetermined portion of the upper part of the flow passage forming flange 83. Specifically, the opening 87 is positioned at the opposite side to the flow holes 84 of the support flange 81 with respect to the central axis of the cylindrical housing 10. In this example, the opening 87 is formed by cutting away a 30° portion of the upper part of the flow passage forming flange 83.

**[0064]** Fig. 16 shows a state where the thruster body 20 is mounted to the fixing flange 80. Of the outer peripheral casing 22 of the thruster body 20, a portion in contact with the fixing flange 80 and a portion in contact with the support flange 81 are formed as larger-diameter portions 45, whose widths correspond to the thicknesses of the flanges 80 and 81. The other portions of the outer peripheral casing 22 are formed as smaller-diameter portions 46. In this manner, gaps (clearances) between the outer peripheral casing 22 and the fixing and support flanges 80 and 81 when the thruster body 20 is moved in the axial direction X are increased, which allows the thruster body 20 to be readily moved in the axial direction X. In addition, since the internal diameters of the respective flow passage forming flanges 82 and 83 are greater than those of the fixing flange 80 and the support flange 81, gaps between the outer peripheral casing 22 and the flow passage forming flanges 82 and 83 are large, and thereby the thruster body 20 can be readily moved in the axial direction X.

**[0065]** In the thruster body 20, as shown in Fig. 16, the connecting portion 21 of the thruster body 20 is brought into contact with the right side surface of the fixing flange 80. Then, the fixing bolts 24 are inserted in the bolt insertion holes 28 formed in the connecting portion 21, and the fixing bolts 24 are further screwed into the fixing holes 15 (screw holes serving as female screws) formed in the fixing flange 80. As a result, the thruster body 20 is fixed to the fixing flange 80. The fixing of the thruster body 20

is realized by the surface pressure between the contact surface of the connecting portion 21 and the contact surface of the fixing flange 80, the surface pressure occurring when the connecting portion 21 is fastened to the fixing flange 80 by the fixing bolts 24. Fig. 16 shows only one of the fixing bolts 24, which are arranged in the circumferential direction. Also in the present embodiment, the connecting portion 21 of the thruster body 20 is fixed to the right side surface of the fixing flange 80 as shown in Fig. 16. Accordingly, in the case of removing the thruster body 20, the connecting portion 21 is pulled out to the right side of the drawing (same as Fig. 6).

**[0066]** As described above, portions of the outer peripheral casing 22, other than the portion whose width corresponds to the thickness of the support flange 81 and the portion whose width corresponds to the thickness of the fixing flange 80, are formed as the smaller-diameter portions 46. Therefore, at the time of removing or mounting the thruster body 20, the thruster body 20 can be readily moved in the axial direction X thanks to the large gaps except at the position where the thruster body 20 is fixed.

**[0067]** The upper part of the connecting portion 21 and the upper part of the fixing flange 80 are provided with the flow holes 29 and 85, respectively. The lower part of the support flange 81 is provided with the flow holes 84. The lower part of the right-side flow passage forming flange 82 is provided with the opening 86. The upper part of the left-side flow passage forming flange 83 is provided with the opening 87.

**[0068]** Accordingly, these holes and openings form a cooling flow passage 90 for water-cooling the outer peripheral casing 22 between the fixing flange 80 and the support flange 81 and between the outer peripheral casing 22 and the cylindrical housing 10. The cooling flow passage 90 allows the water W (cooling liquid) to flow in the circumferential direction. Specifically, as indicated by arrows 91 to 94 in Fig. 16, when the propeller blades 33 are rotated and a water flow is generated, water W flows in toward the thruster body 20 through the gap S (Fig. 11) formed between the cylindrical housing 10 and one of the fairing ducts 40 and 41, and the water W flows through the cooling flow passage 90. For example, when the water W from the right side of Fig. 16 has flowed into between the outer peripheral casing 22 and the cylindrical housing 10 through the flow holes 29 and 85 formed in the connecting portion 21 and the fixing flange 80, the water W flows between the flow passage forming flange 82 and the fixing flange 12 downward. After passing through the opening 86 of the flow passage forming flange 82, the water W flows between the flow passage forming flanges 82 and 83 upward. After passing through the opening 87 of the flow passage forming flange 83, the water W flows between the support flange 81 and the flow passage forming flange 83 downward, and flows out of the flow holes 84 of the support flange 81. It should be noted that the arrows 91 to 94 are double-headed arrows, intending to include a case where the water W is fed from

the flow holes 84 of the support flange 81.

**[0069]** The cross-sectional area of the cooling flow passage 90 of Embodiment 4 is less than that of each cooling flow passage of the thrust generators 1 to 3 of Embodiments 1 to 3 (i.e., less than the area of the cooling flow passage between the fixing flange 12 and the support flange 13 in the circumferential direction). As a result, the flow velocity of the cooling water flowing along the outer surface of the outer peripheral casing 22 increases, which makes it possible to further improve the cooling efficiency.

**[0070]** Therefore, according to the thrust generator 4 of the present embodiment, by removing the connecting portion 21 of the thruster body 20 from the fixing flange 80, the thruster body 20 can be readily removed from the hull or the like for maintenance. In addition, when the propeller blades 33 are rotated to generate thrust force, a water flow from the fixing flange 80 side or the support flange 81 side is generated and passes through the cooling flow passage 90 formed around the outer peripheral casing 22. As a result, the stator 25 can be cooled down efficiently via the outer peripheral casing 22. This makes it possible to improve the efficiency of the electric motor.

(Summary)

**[0071]** As described above, according to the thrust generators 1, 2, 3, and 4, the thruster body 20 including the propeller blades 33 can be integrally removed as a unit from the cylindrical housing 10, which is fixed to the hull or the like. This makes it possible to greatly improve the maintainability of the thrust generators 1 to 4, which are rim drive thrusters.

**[0072]** Since the outer peripheral casing 22 can be efficiently cooled down between the fixing flange (12 or 80) fixing the thruster body 20 to the cylindrical housing 10 and the support flange (13 or 81) supporting the thruster body 20, the efficiency in cooling down the electric motor of each of the thrust generators 1 to 4 can be improved, and thereby the efficiency as the thruster can be improved.

**[0073]** In the above-described embodiments, the flow holes 14 and 84 form the liquid passing portions. However, the manner of allowing the cooling liquid to pass through is not limited to the above-described embodiments. Alternatively, for example, groove-shaped liquid passing portions may be adopted to allow the cooling liquid to pass through.

**[0074]** The above-described embodiments give examples, in which the thrust generators 1 to 4 are each provided on the cylindrical wall 101 of the hull 100 as a side thruster of a ship. However, the thrust generators 1 to 4 may be alternatively used in other structures, and the use thereof is not limited to a thrust generator of a ship. That is, the liquid squirted by each thrust generator is not limited to water, but may be a different liquid.

**[0075]** The above-described embodiments give non-limiting examples, and various modifications can be

made to the embodiments without departing from the spirit of the present invention. Thus, the present invention is not limited to the above-described embodiments.

**[0076]** For example, it is not essential for the fixing flange (12 or 80) to be continuous in the circumferential direction. A plurality of pieces scattered in the circumferential direction may serve as the fixing flange. In this case, gaps between the pieces may serve as the liquid passing portions of the fixing flange. Similarly, it is not essential for the support flange (13 or 81) to be continuous in the circumferential direction. A plurality of pieces scattered in the circumferential direction may serve as the support flange. In this case, gaps between the pieces may serve as the liquid passing portions of the fixing flange.

**[0077]** Also, it is not essential for the connecting portion 21 to be ring-shaped and continuous in the circumferential direction. A plurality of pieces scattered in the circumferential direction may serve as the connecting portion 21.

**[0078]** Further, as shown in Fig. 17, the flow holes (16 or 85) formed in the fixing flange (12 or 80) may be arranged at positions that are radially outward from the connecting portion 21, and the connecting portion 21 need not be provided with the flow holes 29.

**[0079]** Still further, as shown in Fig. 17, a spacer 201 may be interposed between the fixing flange (12 or 80) and the connecting portion 21. Annular members with various cross-sectional shapes are each usable as the spacer 201. Alternatively, a plurality of pieces scattered in the circumferential direction may serve as the spacer 201.

**[0080]** It is not essential for the connecting portion 21 to be integrally formed on the outer peripheral casing 22. For example, as shown in Fig. 18, a check plate 202 may be fixed to a side surface of the outer peripheral casing 22 by bolts 203, and the peripheral portion of the check plate 202 may serve as the connecting portion 21. Alternatively, the peripheral portion of one of the side casings 23 may protrude from the outer peripheral casing 22, and the protruding portion of the side casing 23 may serve as the connecting portion 21.

**[0081]** The connecting portion 21, which overlaps the fixing flange (12 or 80) in the axial direction of the cylindrical housing 10, may be in contact with the left side surface of the fixing flange (the side surface at the support flange 13 side) as shown in Fig. 19. In this case, by increasing the wall thickness of the entire outer peripheral casing 22, the outer portion of the outer peripheral casing 22 can form the connecting portion 21. In the example shown in Fig. 19, the fixing bolts 24 penetrate the fixing flange (12 or 80), and are screwed into screw holes 204 formed in the connecting portion 21.

**[0082]** It is not necessary for the thruster body 20 to include the connecting portion 21 overlapping the fixing flange (12 or 80) in the axial direction of the cylindrical housing 10. For example, as shown in Fig. 20, the outer peripheral surface of the outer peripheral casing 22 may

be provided with screw holes 205, and the fixing bolts 24 penetrating the cylindrical housing 10 and the fixing flange in the radial direction of the cylindrical housing 10 may be screwed into the screw holes 205. In this case, however, it is necessary to remove the fixing bolts 24 from the inside of the hull. On the other hand, in the case of adopting a structure where the fixing bolts 24 penetrate the fixing flange (12 or 80) or the connecting portion 21 in the axial direction of the cylindrical housing 10 as shown in Fig. 1 to Fig. 19, the removal or mounting of the thruster body 20 can be performed only through work outside the ship.

### Industrial Applicability

**[0083]** The thrust generator according to the present invention is useful as a thruster of a ship or the like.

### Reference Signs List

#### [0084]

1 to 4	thrust generator
10	cylindrical housing
12	fixing flange
13	support flange
14	flow hole (liquid passing portion)
15	fixing hole (screw hole)
16	flow hole (liquid passing portion)
17	waterproof tube
20	thruster body
21	connecting portion
22	outer peripheral casing
23	side casing
24	fixing bolt (fastening member)
25	stator
26	armature coil
27	electric cable
28	bolt insertion hole
29	flow hole (liquid passing portion)
30	rotor
33	propeller blade
40, 41	fairing duct
45	larger-diameter portion
46	smaller-diameter portion
50, 51	water-lubricated bearing
52	inner peripheral surface
53	facing surface
60,61	water-lubricated bearing
62	buffer space
63	pipe
70	electric cable
71	underwater connector
80	fixing flange
81	support flange
82, 83	flow passage forming flange (flow passage forming member)
84, 85	flow hole (liquid passing portion)

86, 87	opening
90	cooling flow passage
91 to 94	arrow
100	hull
5 101	cylindrical wall
102	opening
103	arrangement portion
W	water
X	axial direction
10 S	gap
H	heat

### Claims

15

**1.** A thrust generator disposed in a liquid and squirting the liquid to generate thrust force, the thrust generator comprising:

20

a cylindrical housing, which is open at both sides in its axial direction;

a thruster body disposed inside the cylindrical housing, the thruster body including an annular stator, an annular rotor disposed inside the stator, and a propeller blade provided on an inner peripheral surface of the rotor; and

25

a pair of fairing ducts removably mounted to respective side surfaces of the thruster body and formed such that a diameter of each fairing duct expands from a position corresponding to the inner peripheral surface of the rotor toward the cylindrical housing, wherein the cylindrical housing includes a fixing flange protruding radially inward, and the thruster body is removably mounted to the fixing flange by a fastening member.

30

35

**2.** The thrust generator according to claim 1, wherein the thruster body includes a connecting portion, which overlaps the fixing flange in the axial direction of the cylindrical housing, and the fastening member is a bolt penetrating the connecting portion or the fixing flange.

40

45

**3.** The thrust generator according to claim 1 or 2, wherein the cylindrical housing includes a support flange, which supports the thruster body at a position that is away from the fixing flange in the axial direction.

50

**4.** The thrust generator according to any one of claims 1 to 3, wherein the fixing flange includes a liquid passing portion, which allows a cooling liquid to flow into an outer peripheral portion of the thruster body in a state where the thruster body is mounted to the fixing flange.

55

5. The thrust generator according to claim 4, wherein the fixing flange is continuous in a circumferential direction,  
 the thruster body includes a ring-shaped connecting portion, which overlaps the fixing flange in the axial direction of the cylindrical housing,  
 the fixing flange includes a plurality of flow holes serving as the liquid passing portion, the flow holes being provided in an area where the fixing flange and the connecting portion overlap each other, and  
 the connecting portion includes a plurality of flow holes at positions coinciding with positions of the flow holes of the fixing flange.

6. The thrust generator according to claim 4 or 5, wherein  
 the cylindrical housing includes a support flange, which supports the thruster body at a position that is away from the fixing flange in the axial direction, and  
 the support flange includes a liquid passing portion, which allows the cooling liquid to flow into the outer peripheral portion of the thruster body.

7. The thrust generator according to claim 6, further comprising:  
 a cooling flow passage formed between the cylindrical housing and the thruster body, the cooling flow passage allowing the cooling liquid that has flowed through the liquid passing portion of the fixing flange or the support flange into the outer peripheral portion of the thruster body to flow in a circumferential direction in the outer peripheral portion of the thruster body.

8. The thrust generator according to claim 7, wherein the liquid passing portion of the fixing flange is disposed within a part of the fixing flange in the circumferential direction,  
 the liquid passing portion of the support flange is disposed within a part of the support flange in the circumferential direction,  
 the cylindrical housing includes a flow passage forming member between the fixing flange and the support flange, and  
 the flow passage forming member includes an opening positioned at an opposite side to the liquid passing portion of at least one of the fixing flange and the support flange with respect to a central axis of the cylindrical housing.

9. The thrust generator according to any one of claims 1 to 8, further comprising:  
 an electric cable extending from the cylindrical housing and connected to the stator;  
 and

a waterproof tube, which is provided between the cylindrical housing and the thruster body and through which the electric cable is inserted.

10. The thrust generator according to any one of claims 1 to 8, further comprising:  
 an electric cable extending from the cylindrical housing and connected to the stator,  
 wherein  
 the electric cable includes an underwater connector provided between the cylindrical housing and the thruster body, the underwater connector being watertight and removable underwater.

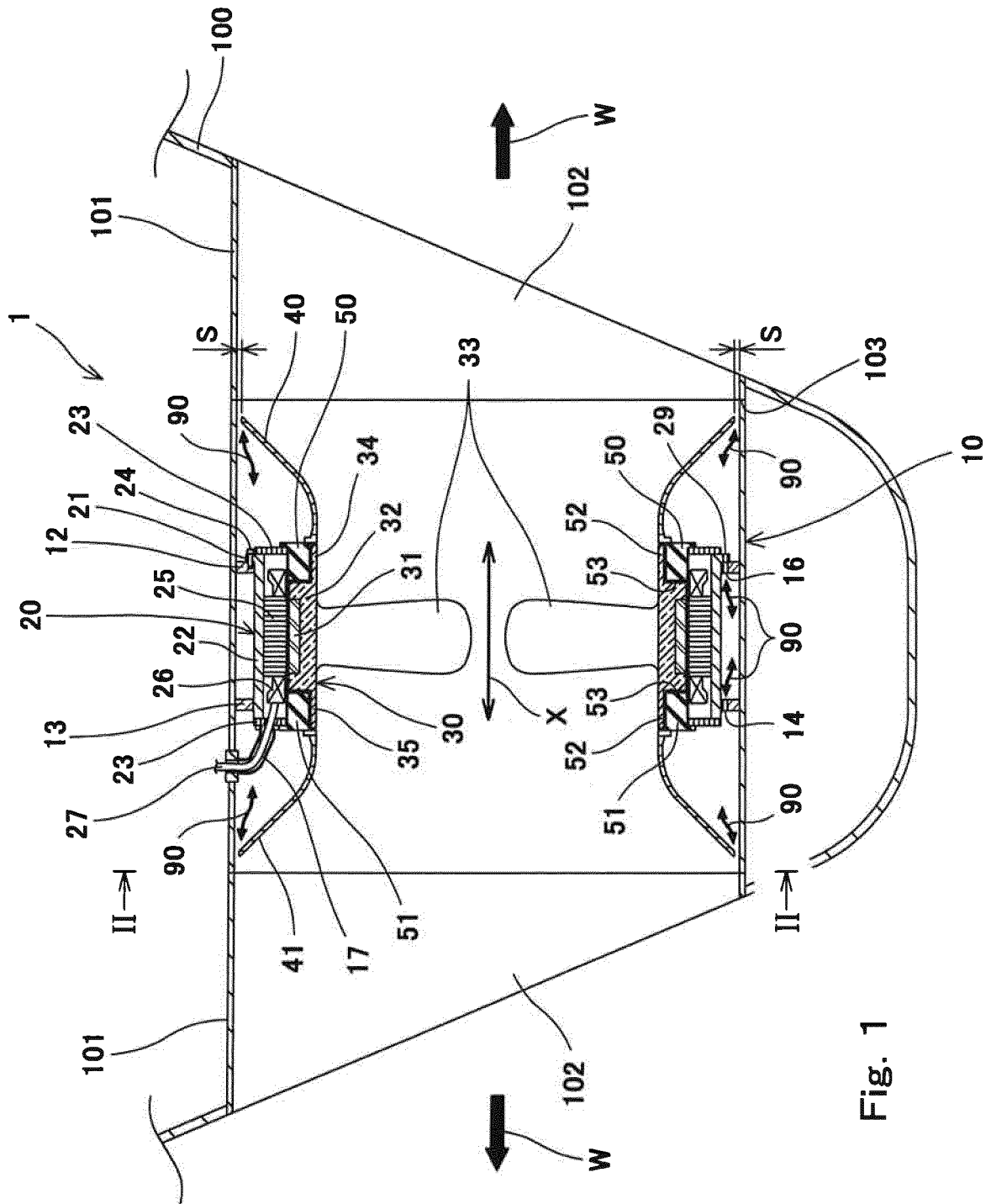


Fig. 1

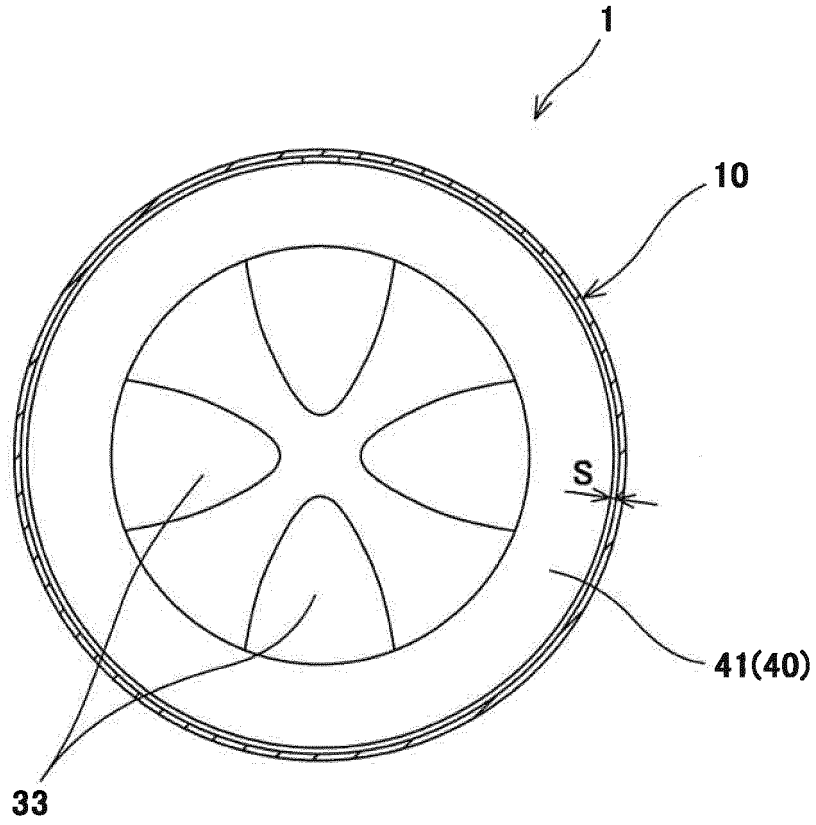


Fig. 2

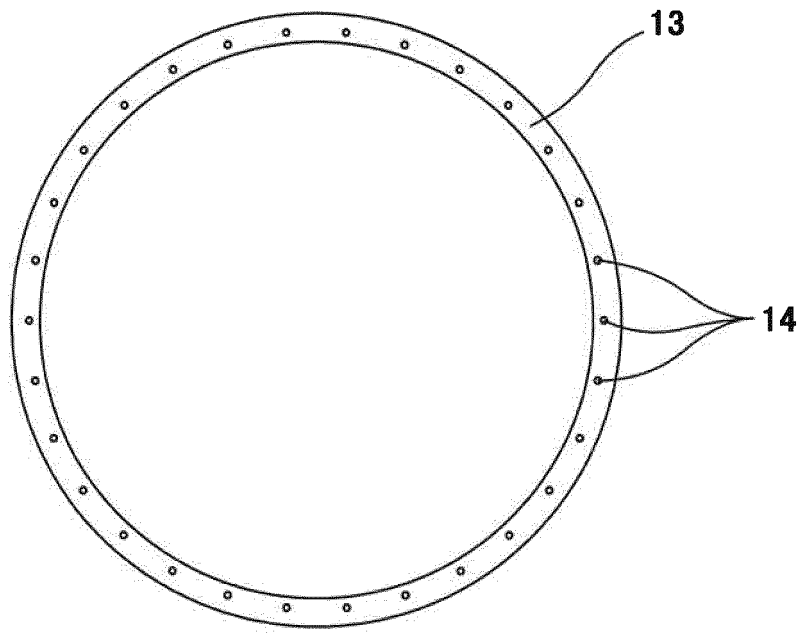


Fig. 3

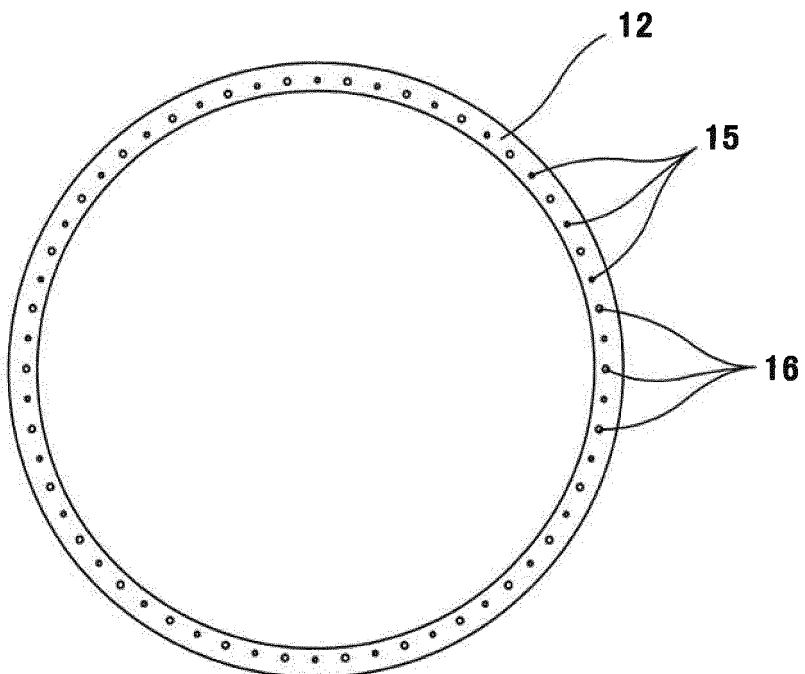


Fig. 4

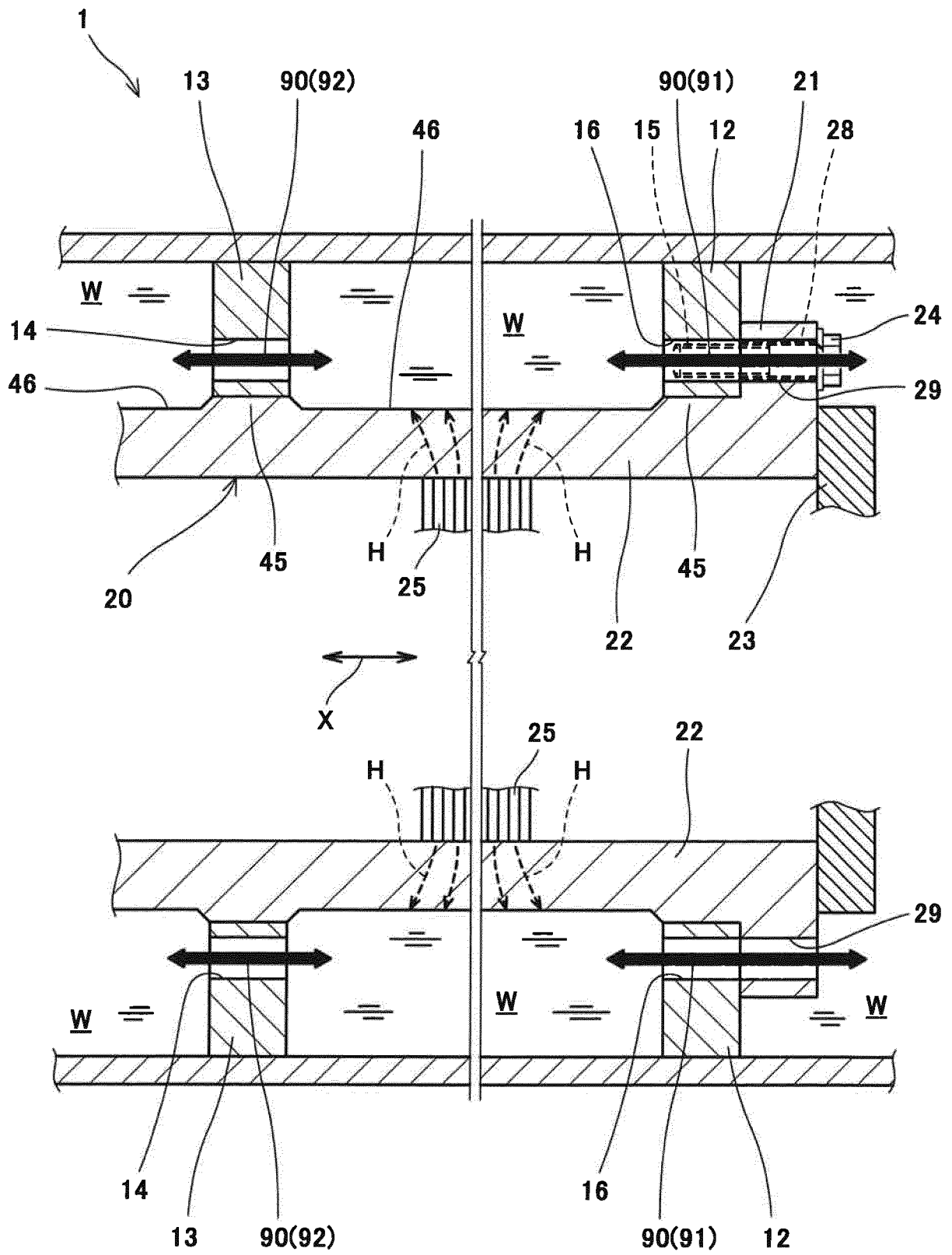


Fig. 5

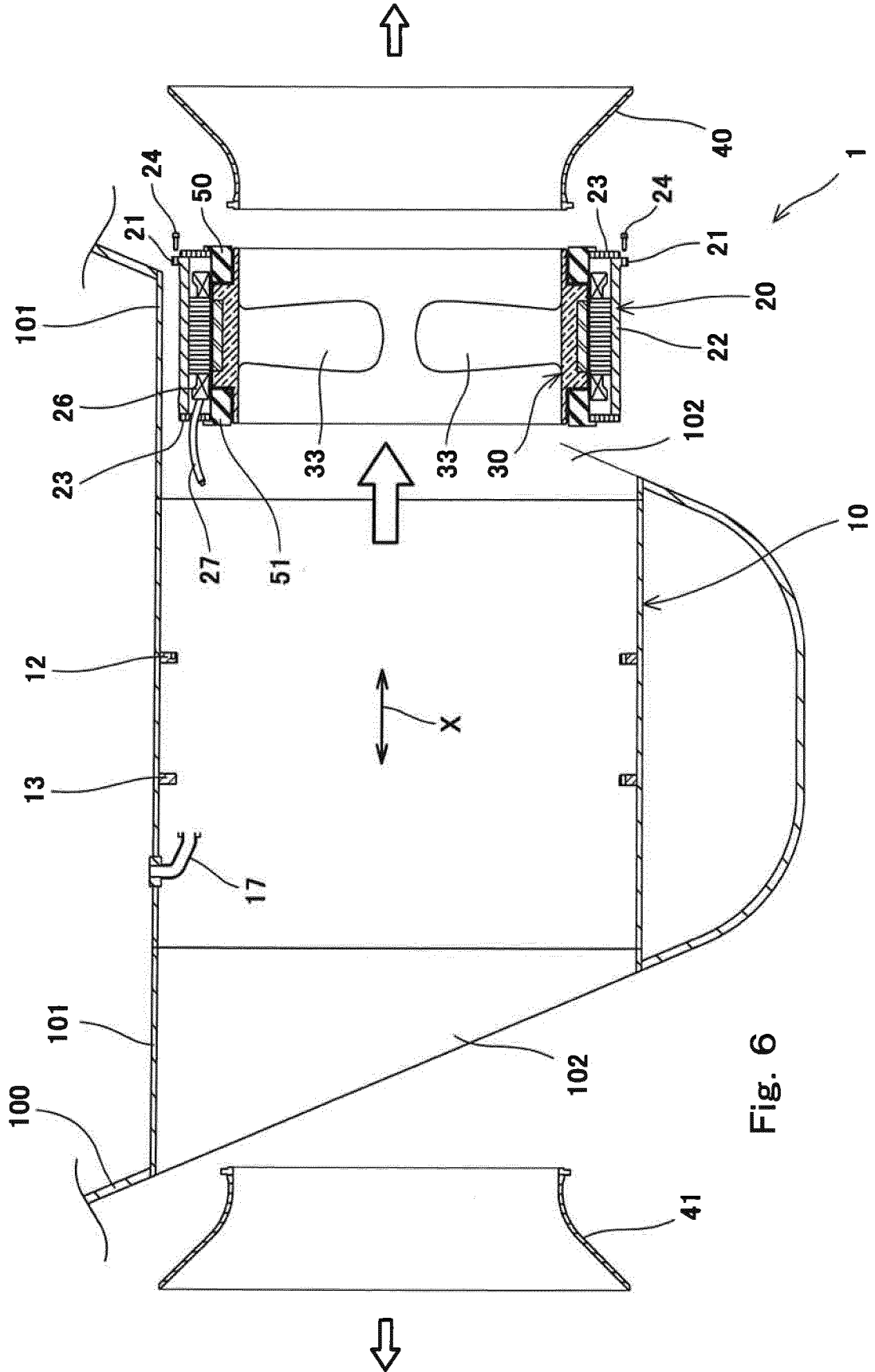
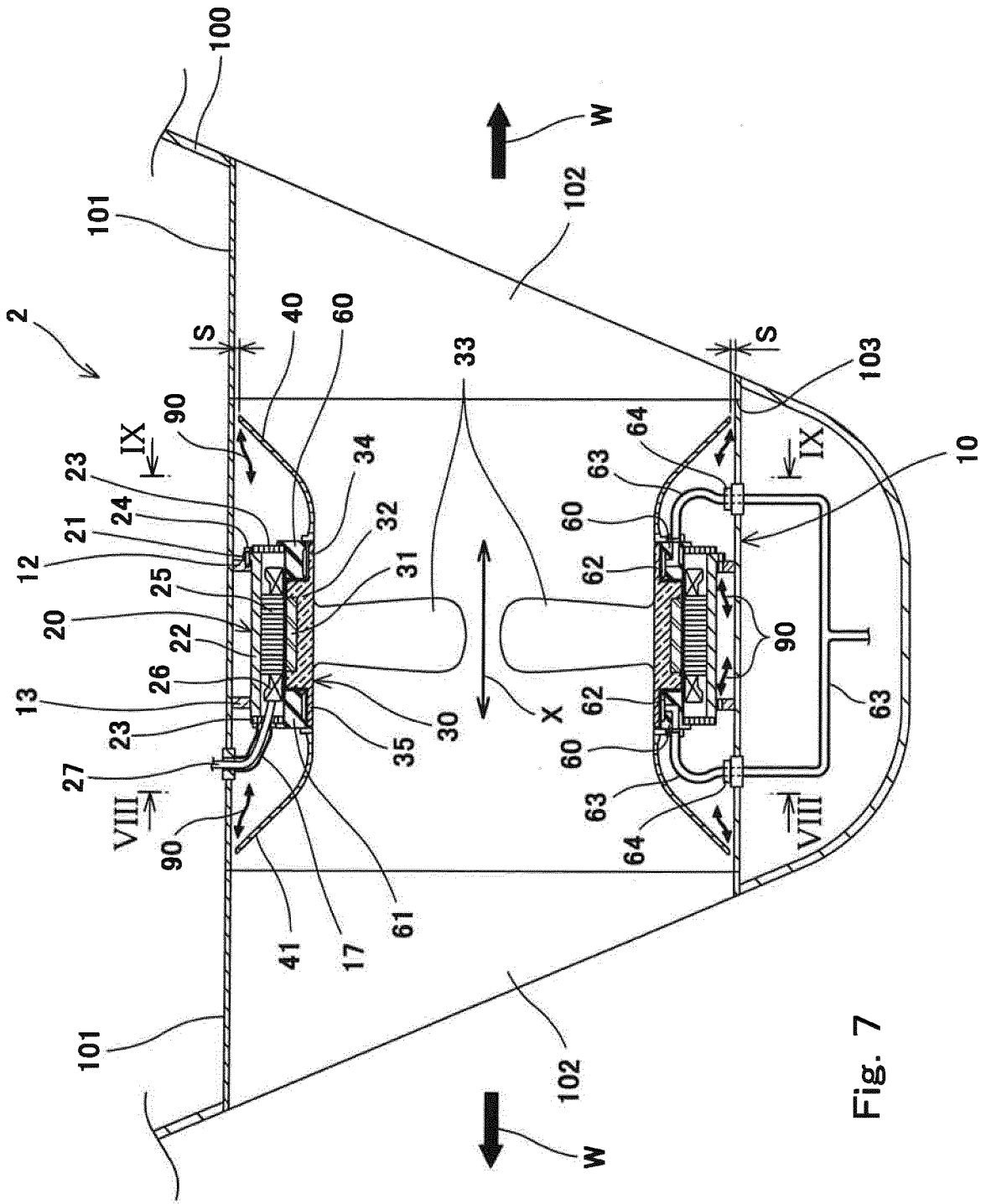


Fig. 6



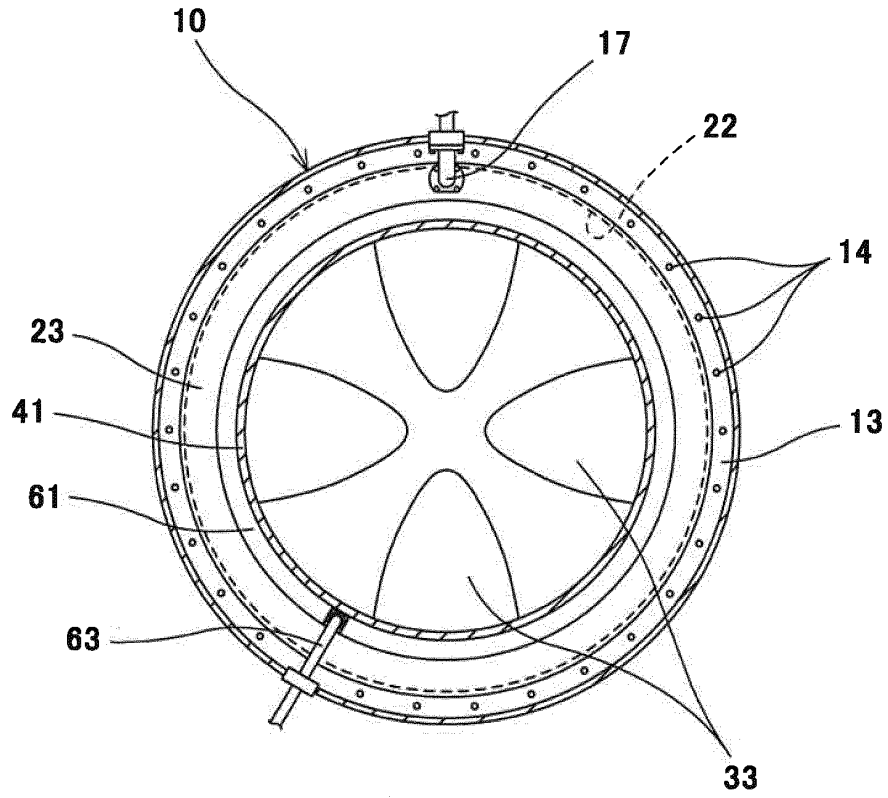


Fig. 8

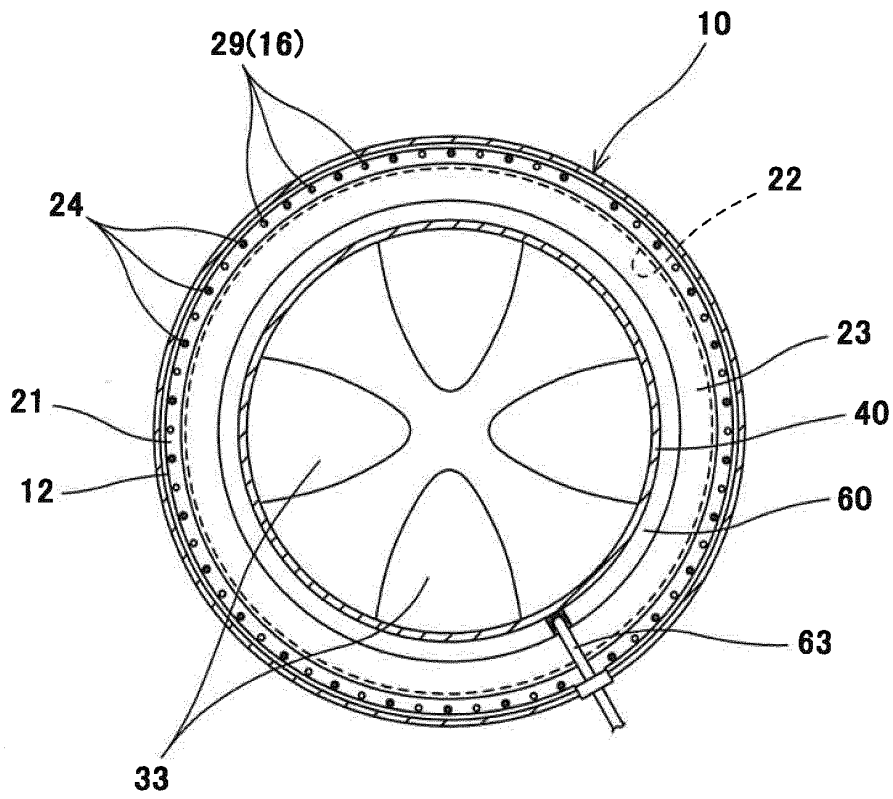


Fig. 9



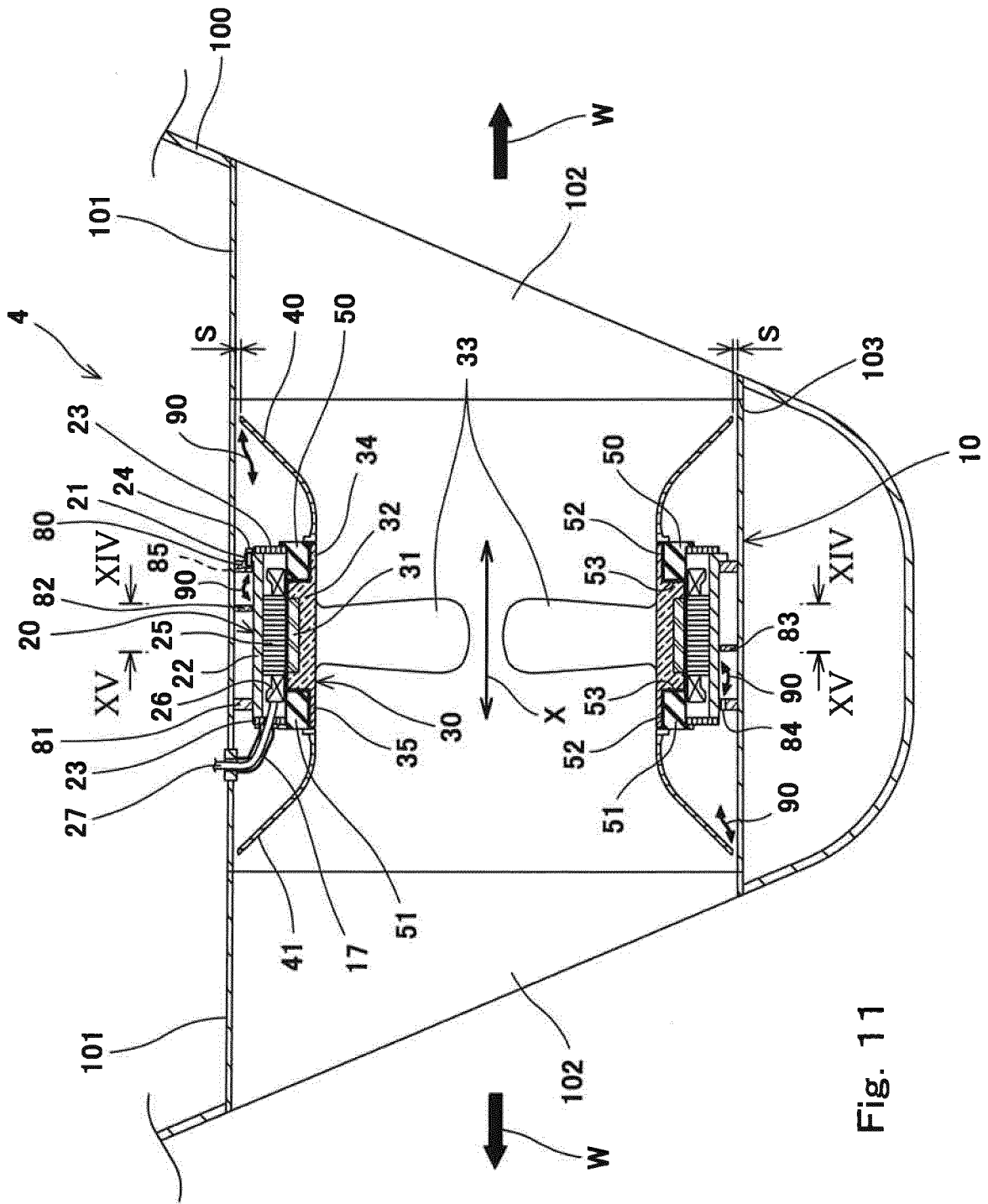


Fig. 11

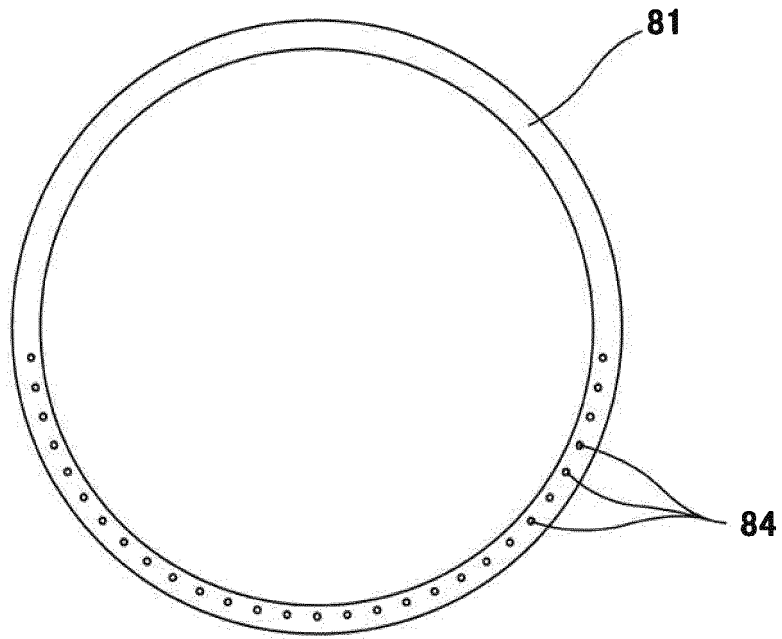


Fig. 12

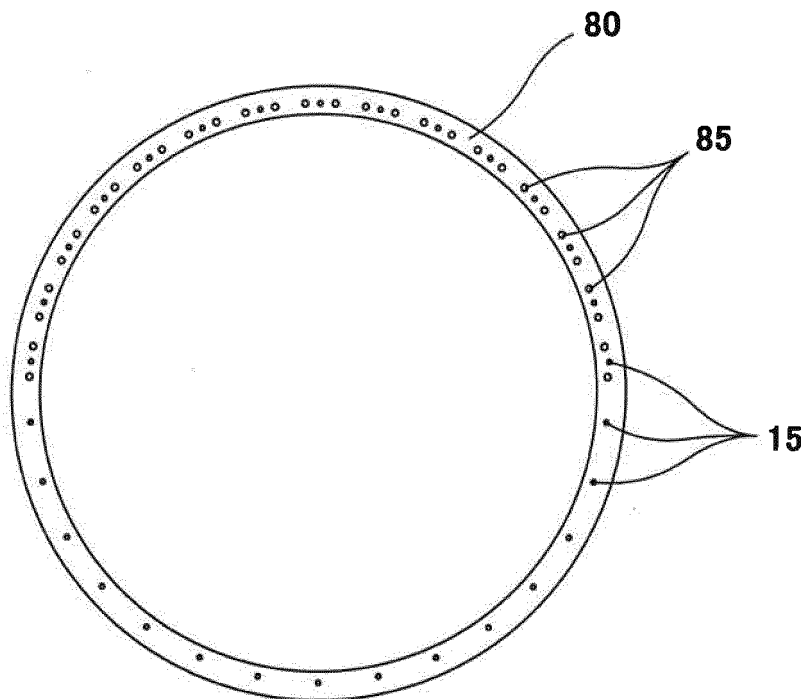


Fig. 13

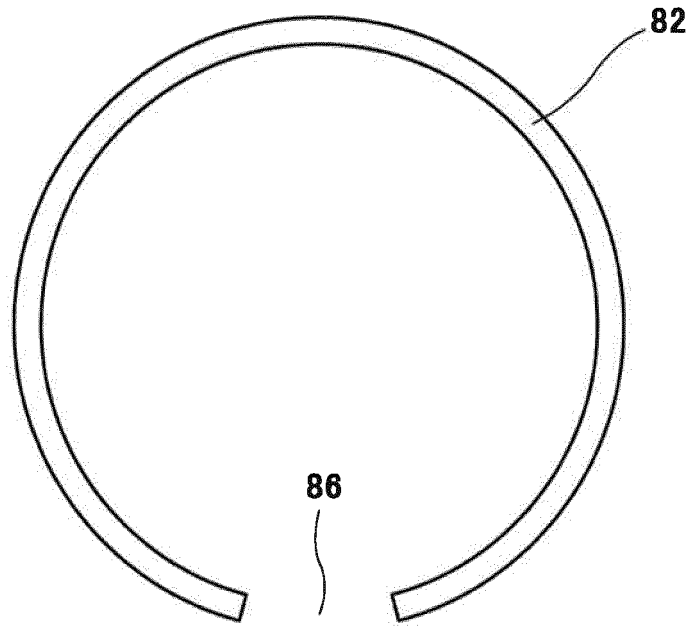


Fig. 14

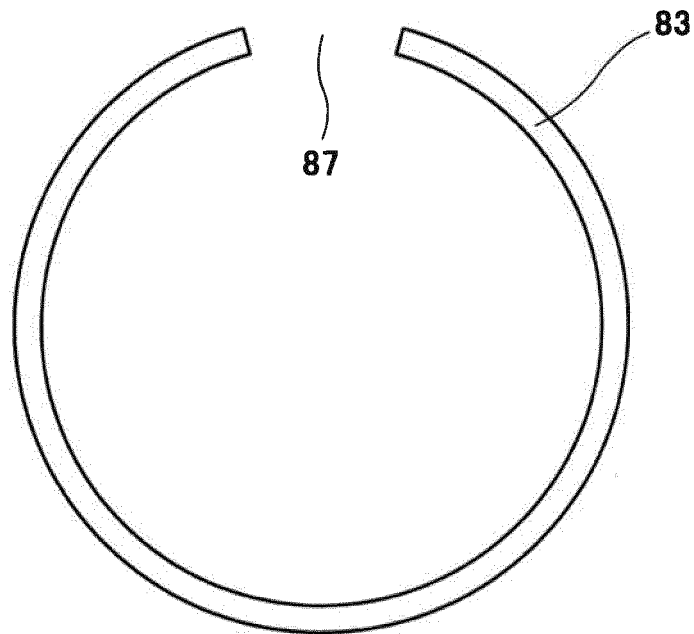


Fig. 15

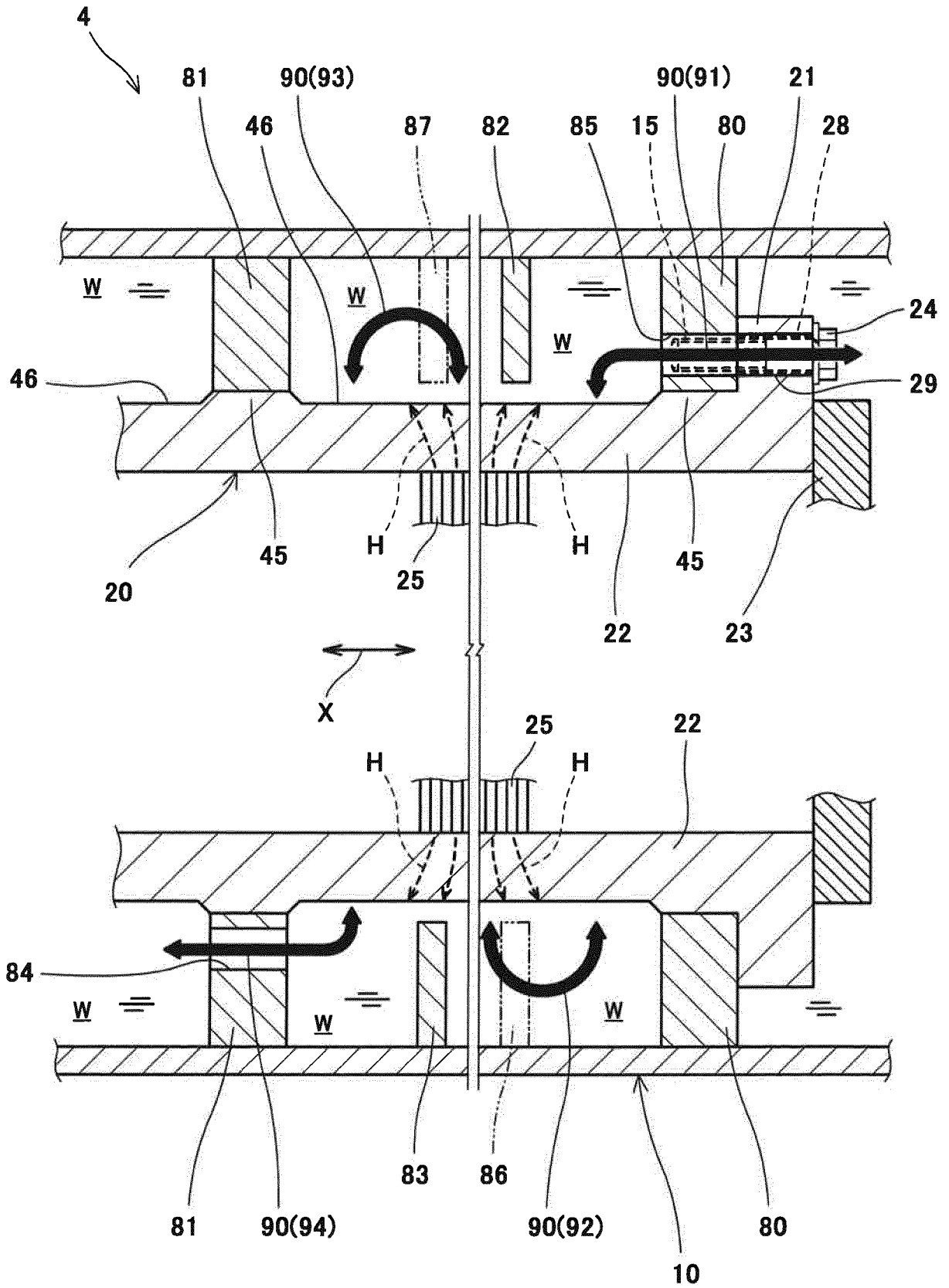


Fig. 16

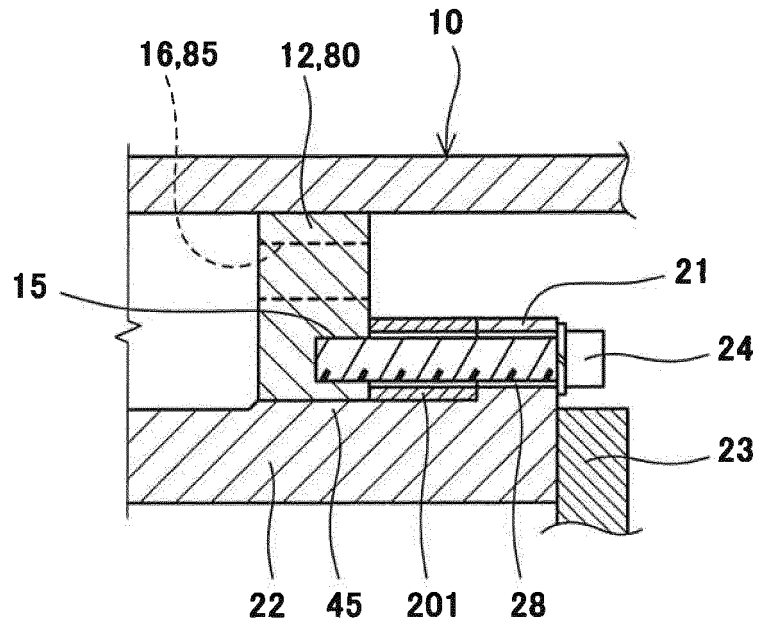


Fig. 17

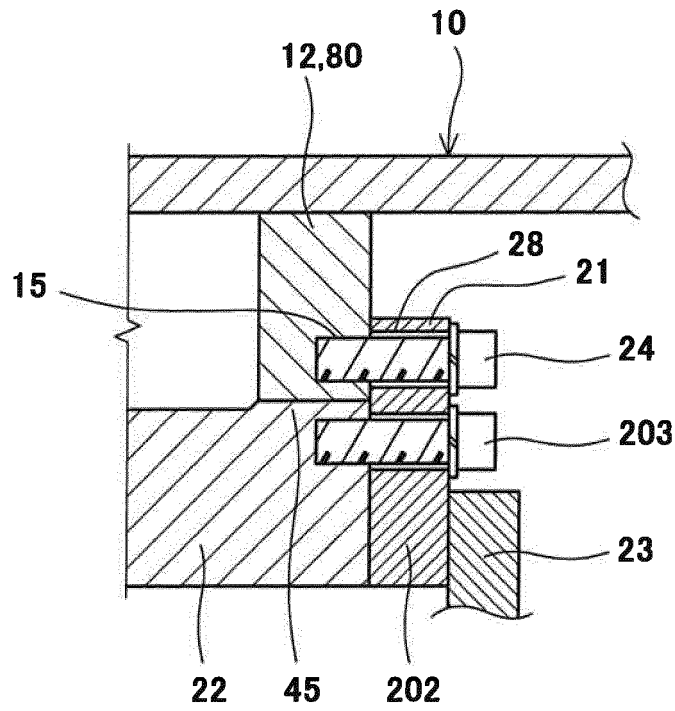


Fig. 18

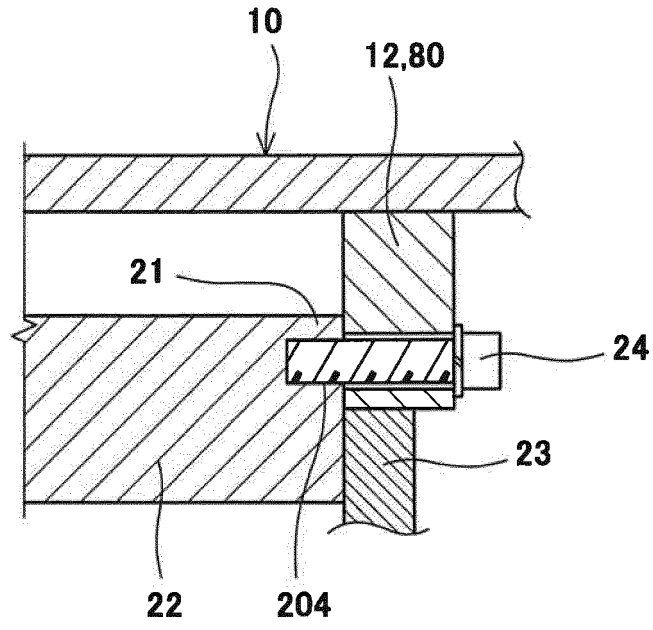


Fig. 19

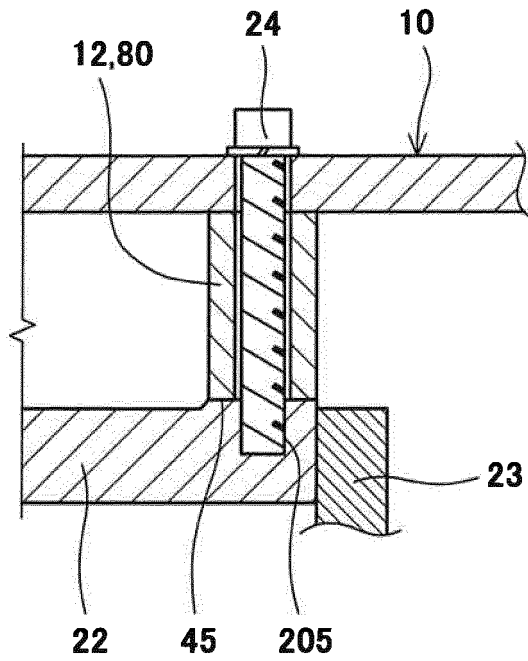


Fig. 20

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/003108

## A. CLASSIFICATION OF SUBJECT MATTER

B63H1/12(2006.01)i, B63H21/17(2006.01)i, B63H25/42(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)

B63H1/12, B63H21/17, B63H25/42

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2014
Kokai Jitsuyo Shinan Koho	1971-2014	Toroku Jitsuyo Shinan Koho	1994-2014

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 2009-161003 A (Kawasaki Heavy Industries, Ltd.), 23 July 2009 (23.07.2009), paragraphs [0042] to [0044]; fig. 1 to 5 & US 2010/0279559 A1 & EP 2239194 A1 & WO 2009/084168 A1 & KR 10-2010-0035714 A & CN 101888948 A & KR 10-2012-0104448 A	1-2 9-10 3-8
Y	JP 2011-5927 A (Kawasaki Heavy Industries, Ltd.), 13 January 2011 (13.01.2011), paragraphs [0021] to [0023]; fig. 1 to 3 & US 2012/0156070 A1 & EP 2447148 A1 & WO 2010/150499 A1 & KR 10-2012-0011074 A & SG 176992 A & CN 102803063 A	9-10

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

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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

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

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

Date of the actual completion of the international search  
13 August, 2014 (13.08.14)Date of mailing of the international search report  
26 August, 2014 (26.08.14)Name and mailing address of the ISA/  
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

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

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/003108

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2011-5926 A (Kawasaki Heavy Industries, Ltd.), 13 January 2011 (13.01.2011), entire text; all drawings & US 2012/0201703 A1 & EP 2447147 A1 & WO 2010/150498 A1 & KR 10-2012-0011073 A & SG 176993 A & CN 102803064 A	3-8
A	US 2003/0186601 A1 (SHEPPARD Mullin Richter & Hampton LLP), 02 October 2003 (02.10.2003), entire text; all drawings & WO 2003/082669 A1	3-8
A	WO 2009/153124 A2 (SIEMENS AG), 23 December 2009 (23.12.2009), entire text; all drawings & EP 2279113 A	3-8

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

**REFERENCES CITED IN THE DESCRIPTION**

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

**Patent documents cited in the description**

- JP 2011005926 A [0005]
- JP 2011005927 A [0005]