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(54) PLATE, BOAT PROPULSOR WITH A PLATE AND BOAT WITH BOAT PROPULSOR

(57) The reduction in maneuverability of a hull caused by a sink vortex generated in the vicinity of a duct is suppressed. A boat propulsor includes a duct, a propeller disposed in the duct and rotatable around a rotation axis along the axial direction of the duct, and a rotation mechanism to rotate the propeller. The upper portion of the duct is provided with a plate extending from the duct in the axial direction and having a plurality of holes formed therein. In this boat propulsor, the plate is provided to extend from the upper portion of the duct, and the plate is provided with a plurality of holes formed therein. Multiple water streams coming around along the duct are attenuated as they pass through the holes in the plate.

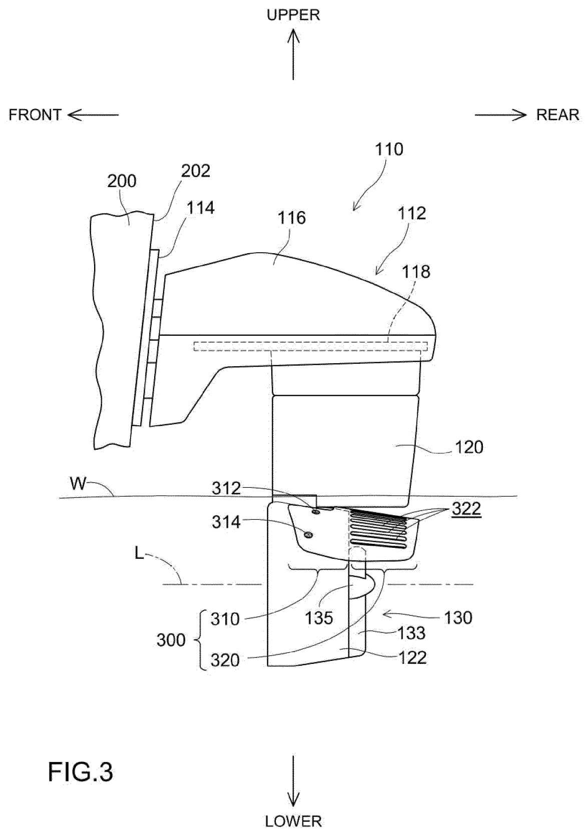

FIG.3

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Description

[0001] The present invention relates to a plate configured to be provided at a duct of a boat propulsor, a boat propulsor with a plate and a boat with a boat propulsor.

[0002] Duct-type boat propulsors are known. A duct-type boat propulsor has a duct, a propeller disposed in the duct and rotatable around a rotation axis along the axial direction of the duct, and a rotation mechanism to rotate the propeller (see, e.g., JP Utility Model Application Publication No.JP 2016-068610A, JP 2013-100013A, JP 2013-100014A, JP 2022-018645A).

[0003] In the known duct-type boat propulsor, the generation of a large vortex engulfing the air entering the duct (hereinafter referred to as "sink vortex") can affect the maneuverability of the hull such as making it impossible to move laterally. Specifically, when a propeller is rotated in water, multiple water streams that flow around along the duct merge and grow into a large vortex ("sink vortex") that engulfs the air near the water surface. As a result, the sink vortex can affect the maneuverability of the hull, causing the hull to move diagonally sideways despite the maneuvering command to move the hull laterally.

[0004] It is the object of the present invention to provide a plate configured to be provided at a duct of a boat propulsor, a boat propulsor with a plate and a boat with a boat propulsor which allows proper maneuvering of a boat.

[0005] According to the present invention said object is solved by a plate configured to be provided at a duct of a boat propulsor having the features of independent claim 1, a boat propulsor with a plate according to claim 7 and a boat with a boat propulsor according to claim 14. Preferred embodiments are laid down in the dependent claims.

[0006] The technology disclosed herein can be implemented in the following aspects.

[0007] A boat propulsor disclosed herein includes a duct, a propeller disposed in the duct and rotatable around a rotation axis along the axial direction of the duct, and a rotation mechanism to rotate the propeller. The upper portion of the duct is provided with a plate extending from the duct in the axial direction and having a plurality of holes formed therein. In this boat propulsor, the plate is provided to extend from the upper portion of the duct, and the plate is provided with a plurality of holes formed therein. Multiple water streams coming around along the duct are attenuated as they pass through the holes in the plate. Thus, the present boat propulsor can suppress the reduction in maneuverability of the hull caused by the sink vortex generated in the vicinity of the duct.

[0008] In the above boat propulsor, the lowest end of the plate may be configured to be located above the rotation axis. Thus, compared to a configuration in which the plate extends from the entire circumference of the duct, this boat propulsor can reduce the weight of the boat propulsor while suppressing the reduction in maneuverability of the hull caused by the sink vortex.

[0009] In the above boat propulsor, the plate may be configured to be symmetrical with respect to the rotation axis when viewed in the upper-lower direction. According to this boat propulsor, compared to a configuration in which the plate is asymmetrically shaped, it is possible to suppress the boat propulsor from being subjected to unequal left-right forces due to left-right flow variations in the vicinity of the duct.

[0010] In the above boat propulsor, the plate may be configured to be curved along the circumferential direction of the duct. According to this boat propulsor, compared to a configuration in which the plate is flat, the plate does not disturb the wing-like connection of the duct and also has excellent attachability to the duct, as well as suppressing the reduction in maneuverability of the hull caused by the sink vortex.

[0011] In the above boat propulsor, the plurality of holes may be configured to include a plurality of slits extending along the axial direction of the duct. According to this boat propulsor, compared to a configuration in which the holes are slits extending in a direction that intersects the axial direction of the duct, it is possible to suppress the existence of the holes from becoming a resistance element to the maneuverability of the hull.

[0012] In the above-mentioned boat propulsor, the plurality of holes may be configured to be arranged symmetrically with respect to the rotation axis when viewed in the upper-lower direction. According to this boat propulsor, it is possible to suppress the boat propulsor from being subjected to unequal left-right forces due to variations in the arrangement of the plurality of holes.

[0013] In the above boat propulsor, the separation distance between two mutually adjacent holes may be configured to be wider than the opening width of each hole in the alignment direction of the two holes. According to this boat propulsor, vortices dispersed by two adjacent holes can merge again after passing through each hole to form a large vortex, thereby suppressing the reduction in maneuverability of the hull.

[0014] In the above boat propulsor, the plate may be configured to be a part separate from the duct, and the plate may be configured to be fixed to the outer surface of the duct at a first fixing position and a second fixing position that is displaced from the first fixing position in both the axial and circumferential directions of the duct. Thus, compared to a configuration in which all fixing positions are disposed on the same circle, this boat propulsor can improve the strength of the plate against the downward force due to the sink vortex.

[0015] A boat disclosed herein may be configured to include a hull and a boat propulsor according to any one of (1) to (8) above. This boat can suppress the reduction in maneuverability of the hull caused by the sink vortex generated in the vicinity of the duct.

[0016] A plate disclosed herein is provided so as to extend axially from an upper portion of a duct of a boat propulsor wherein a propeller is disposed in the duct and rotatable about a rotation axis along the axial direction of the duct. The plate is provided with a plurality of holes formed therein. This plate can suppress the reduction in maneuverability of the hull caused by the sink vortex generated in the vicinity of the duct.

[0017] The above plate may be configured to be symmetrical in shape when viewed in the upper-lower direction. According to this plate, for example, compared to a configuration in which the plate is asymmetrically shaped, it is possible to suppress the boat propulsor from being subjected to unequal left-right forces due to left-right flow variations in the vicinity of the duct.

[0018] The above plate may be configured to be curved. According to this plate, compared to a configuration in which the plate is flat, the plate does not disturb the wing-like connection of the duct and also has excellent attachability to the duct, as well as suppressing the reduction in maneuverability of the hull caused by the sink vortex.

[0019] In the above plate, the plurality of holes may be configured to include a plurality of slits extending along a predetermined direction. According to this plate, for example, compared to a configuration in which a plurality of slits extend in different directions from each other, it is possible to suppress the existence of the holes from becoming a resistance element to the maneuverability of the hull.

[0020] In the above plate, the plurality of holes may be configured to be arranged symmetrically when viewed in the upper-lower direction. This plate can suppress the boat propulsor from being subjected to unequal left-right forces due to variations in the arrangement of the plurality of holes.

[0021] In the above plate, the separation distance between two mutually adjacent holes may be configured to be wider than the opening width of each hole in the alignment direction of the two holes. With this plate, vortices dispersed by two adjacent holes can merge again after passing through each hole to form a large vortex, thereby suppressing the reduction in maneuverability of the hull.

[0022] The technology disclosed herein can be implemented in various forms, such as in the form of a boat, a boat propulsor provided on the boat, a plate provided on the boat propulsor, and a method for suppressing a sink vortex toward a duct.

[0023] The boat propulsor disclosed herein can suppress the reduction in maneuverability of the hull caused by the sink vortex generated in the vicinity of the duct.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

FIG. 1 is a simplified top view illustrating a configuration of a boat in an embodiment.

FIG. 2 is a simplified side view illustrating a configuration of the leading edge of the boat.

FIG. 3 is a simplified side view illustrating a configuration of an electric propulsor.

FIG. 4 is a schematic view illustrating a configuration of a drive unit.

FIG. 5 is a top view illustrating a configuration of a first plate.

FIG. 6 is a top view illustrating the first plate in a state attached to a duct.

FIG. 7 is a front view illustrating a configuration of a second plate.

FIG. 8 is an explanatory view schematically illustrating the water streams near the duct without the first plate.

FIG. 9 is an explanatory view schematically illustrating the water streams near the duct with the first plate.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] FIG. 1 is a simplified top view illustrating a configuration of a boat 10 in an embodiment, and FIG. 2 is a simplified side view illustrating a configuration of the leading edge of the boat 10. FIGS. 1 and 2, as well as other drawings described below, show arrows representing each direction with respect to the position of the boat 10. More specifically, each drawing shows arrows representing the front direction (FRONT), rear direction (REAR), left direction (LEFT), right direction (RIGHT), upper direction (UPPER), and lower direction (LOWER), respectively. The front-rear direction, left-right direction, and upper-lower (vertical) direction are orthogonal to each other.

[0026] As shown in FIGS. 1 and 2, the boat 10 includes a hull 200, a boat propulsion system (hereinafter referred to as the "propulsion system") 100 mounted on the hull 200, a first plate 300 (see, e.g., FIG. 3 below) and a second plate 350 (see FIG. 7 below).

[0027] The hull 200 is a part of the boat 10 for occupants to ride. The hull 200 includes, e.g., a hull main body having a living space, a pilot seat (not shown) installed in the living space, and an operating device (not shown) installed near the pilot seat.

[0028] The propulsion system 100 includes a plurality of electric propulsors 110, a bow thruster 150 provided separately from the electric propulsors 110, and a boat control device (not shown) that controls them. The electric propulsor 110 is an example of the boat propulsor in the claims. FIG. 1 shows a duct 122, a stator fin 133, and a bearing 135 of the electric propulsor 110, and a propeller 154 of the bow thruster 150, all of which will be described later.

[0029] The electric propulsor 110 is a device that generates thrust to propel the boat 10. Each electric propulsor 110 is provided at the stern 202 of the hull 200 and is designed to exert propulsion force on the hull 200 behind the instantaneous turning center P of the hull 200. In this embodiment, the plurality of electric propulsors

110 include the left-side electric propulsor 110 (the electric propulsor 110 on the left side in FIG. 1) and the right-side electric propulsor 110 (the electric propulsor 110 on the right side in FIG. 1). The left-side electric propulsor 110 and the right-side electric propulsor 110 are arranged symmetrically with respect to the center line C of the hull 200.

[0030] FIG. 3 is a simplified side view illustrating a configuration of the electric propulsor 110. As shown in FIG. 3, each electric propulsor 110 includes a propulsor body 112 and a bracket 114. The propulsor body 112 is attached to the stern 202 of the hull 200 via the bracket 114.

[0031] The propulsor body 112 includes a cover 116, a base 118, a housing 120, a duct 122, and a drive unit 130.

[0032] The base 118 is connected to the bracket 114. The cover 116 covers the upper portion of the bracket 114. The housing 120 is disposed below the base 118. The housing 120 extends downward from the base 118. The duct 122 is disposed below the housing 120. The duct 122 is tubular in shape. The duct 122 is disposed at a position below the water surface W (see FIG. 3). The drive unit 130 is disposed in the duct 122.

[0033] FIG. 4 is a schematic view illustrating a configuration of the drive unit 130. The drive unit 130 generates thrust that propels the boat 10. As shown in FIG. 4, the drive unit 130 includes a propeller 132 and an electric motor 134. The electric motor 134 is an example of the rotation mechanism in the claims.

[0034] The propeller 132 is a rotating body having a plurality of blades and generates thrust by rotating. The propeller 132 is provided inside the duct 122 and is rotatable around a horizontal propeller rotation axis L (see FIG. 4). The propeller rotation axis L is parallel to the central axis of the duct 122. The duct 122 covers the entire circumference of the propeller 132, and the ducting effect of the duct 122 increases the velocity of water flowing into the duct 122. The duct 122 is an example of the duct in the claims.

[0035] The electric motor 134 rotates the propeller 132. The electric motor 134 includes a rotor 136 and a stator 138. The rotor 136 and the stator 138 each have a tubular shape. The rotor 136 is disposed radially inward of the stator 138. The rotor 136 and the stator 138 are disposed on the same axis. The rotor 136 is rotatably supported against the duct 122. The rotor 136 rotates about the propeller rotation axis L with respect to the stator 138. The propeller 132 is disposed radially inward of the rotor 136. The propeller 132 is fixed to the rotor 136 and rotates together with the rotor 136. The rotor 136 includes a plurality of permanent magnets 140. The plurality of permanent magnets 140 are disposed along the circumferential direction of the rotor 136. In FIG. 4, only one of the plurality of permanent magnets 140 is labeled with the reference character "140", and the reference characters of the other permanent magnets 140 are omitted.

[0036] The stator 138 is fixed to the duct 122. The stator 138 includes a plurality of coils 142. The plurality of coils 142 are disposed along the circumferential direction of the stator 138. When the plurality of coils 142 are energized, an electromagnetic force is generated to rotate the rotor 136. In FIG. 4, only one of the plurality of coils 142 is labeled with the reference character "142", and the reference characters of the other coils 142 are omitted. With the above configuration, the propeller 132 generates forward propulsion force when the electric motor 134 rotates in the forward direction and backward propulsion force when the electric motor 134 rotates in the reverse direction.

[0037] In each electric propulsor 110, the housing 120 is rotatably mounted with respect to the base 118 around a steering axis (an axis along the vertical direction in each figure) as a vertical rotation axis. As the housing 120 rotates, the drive unit 130 also rotates around the steering axis. The stator fin 133 and the bearing 135 are provided on the radial inner side of the duct 122. The bearing 135 supports the propeller 132 rotatably about the propeller rotation axis L. The stator fin 133 has a plurality of fins (e.g., three fins). The plurality of fins are arranged radially around the bearing 135 and equally spaced around the propeller rotation axis L and are fixed to the duct 122. The plurality of fins are provided behind the propeller 132, projecting backward from the duct 122 (see FIGS. 1 and 3).

[0038] As shown in FIG. 2, the bow thruster 150 is disposed at a position in the hull 200 in the vicinity of the bow 204 and lower than the water surface W. The bow thruster 150 is a propulsor that provides lateral propulsion force to the hull 200. The bow thruster 150 includes a duct 152, a propeller 154, and an electric motor (not shown).

[0039] The duct 152 is a tubular body that penetrates in the left-right direction and is attached to the hull 200 via a bracket 156. The propeller 154 is a rotating body having a plurality of blades and generates thrust by rotating. The propeller 154 is provided inside the duct 152 in the radial direction and is rotatable around the propeller rotation axis M in the left-right direction. The electric motor has the same configuration as the electric motor 134 described above and is disposed in the duct 152. The propeller 154 is rotated by the power generated by the electric motor. Specifically, the propeller 154 generates propulsion force to the right when the electric motor rotates in the forward direction and to the left when the electric motor rotates in the reverse direction.

[0040] FIG. 5 is a top view illustrating a configuration of a first plate 300, and FIG. 6 is a top view illustrating the first plate 300 in a state attached to the duct 122. The first plate 300 is attached to the duct 122 of the electric propulsor 110 (see, e.g., FIG. 3) and serves to attenuate the vorticity of the sink vortex generated by the multiple water flows that occur near the duct 122. In this embodiment, the first plate 300 is a part separate from the duct 122.

[0041] As shown in FIGS. 3 and 6, the first plate 300 is provided in the upper portion of the duct 122 and extends from the duct 122 in a direction along the propeller rotation axis L. The first plate 300 is provided with a plurality of holes 322 formed therein.

[0042] Specifically, as shown in FIG. 5, the first plate 300 is, as a whole, a substantially rectangular flat plate. The first plate 300 is formed of a metal such as an aluminum alloy. The entire first plate 300 has a uniform thickness. The first plate 300 is curved along the circumferential direction of the duct 122 (see FIGS. 3, 5, and 6). The first plate 300 is curved around the propeller rotation axis L. When the duct 122 is positioned lower than the water surface W and the propeller rotation axis L is aligned with the horizontal line (see FIG. 3), the first plate 300 projects from the upper portion of the duct 122 along the propeller rotation axis L.

[0043] The lowest end of the first plate 300 is located above the propeller rotation axis L (see FIG. 3). Specifically, the total circumferential length of the first plate 300 (protruding portion 320 described below) is a length corresponding to 120 degrees (1/3) with respect to the total circumference of the duct 122. The overall length of the first plate 300 is preferably no less than a length corresponding to 90 degrees (1/4) and no more than a length corresponding to 180 degrees (1/2) with respect to the entire circumference of the duct 122. The first plate 300 is symmetrical with respect to the propeller rotation axis L when viewed in the upper-lower direction (see FIGS. 5 and 6). Specifically, the first plate 300 has the fixing portion 310 and the protruding portion 320. The protruding end of the protruding portion 320 is preferably located behind the rear end of the housing 120 (see FIG. 3). If the diameter of the propeller 132 is supposed to be "N" (e.g., 280 mm), the length of the first plate 300 protruding from the rear end of the duct 122 (length of the protruding portion 320) may be 0.25N or more, or 0.4N or more. The length of the protruding portion 320 may be 0.75D or less, or 0.6N or less.

[0044] The fixing portion 310 is the portion of the first plate 300 that is fixed to the duct 122. The fixing portion 310 is the front portion including the front end in the first plate 300 and is fixed to the outer circumference of the duct 122. Specifically, the fixing portion 310 is curved in shape corresponding to the outer circumferential surface of the duct 122. Therefore, the inner surface of the fixing portion 310 is in surface contact with the outer circumferential surface of the duct 122 over the entire circumferential length of the fixing portion 310.

[0045] The fixing portion 310 is fixed to the outer circumferential surface of the duct 122 at first fixing positions 312 and second fixing positions 314 (see FIGS. 5 and 6). The first fixing position 312 and the second fixing position 314 are displaced from each other in the direction along the propeller rotation axis L of the duct 122 as well as in the circumferential direction of the duct 122. Specifically, the first fixing positions 312 are respectively arranged symmetrically with respect to L when viewed in the upper-lower direction. The second fixing positions 314 are respectively arranged symmetrically with respect to L when viewed in the upper-lower direction. Each first fixing position 312 is positioned closer to the propeller rotation axis L than the second fixing position 314 when viewed in the upper-lower direction. Each first fixing position 312 is positioned on a first virtual circle R1 centered on the propeller rotation axis L. Each second fixing position 314 is located on a second virtual circle R2 centered on the propeller rotation axis L. The second virtual circle R2 is located closer to the front end of the first plate 300 (fixing portion 310) than the first virtual circle R1. At each fixing position, the first plate 300 is fixed to the duct 122 by a fastening member (such as bolts) not shown.

[0046] The protruding portion 320 is a portion of the first plate 300 that protrudes from the duct 122 in a direction along the propeller rotation axis L (rear side of the duct 122). The protruding portion 320 is provided with a plurality of holes 322 formed therein. All holes 322 are slits extending along the propeller rotation axis L. The opening width D1 of the slits (see FIG. 5) is substantially identical over the entire length of the slits. The slit can be a closed hole that is closed all the way around, as shown in, e.g., FIG. 5, or it can be an open hole that is partially open (e.g., at the rear end side of the first plate 300). In this embodiment, all holes 322 are of the same shape and size as each other and are arranged at equal intervals (see separation distance D2 in FIG. 3) in the circumferential direction of the duct 122. The separation distance D2 is substantially identical over the entire length of the slit.

[0047] All holes 322 are arranged symmetrically with respect to the propeller rotation axis L when viewed in the upper-lower direction (see FIGS. 5 and 6). In this embodiment, a plurality (equal number) of holes 322 are formed on the right side and the left side, respectively, with respect to the propeller rotation axis L. The separation distance D2 between two holes 322 (slits) adjacent to each other is wider than the opening width D1 of each hole in the alignment direction of the two holes 322 (circumferential direction of the duct 122) (see FIG. 5).

[0048] In this embodiment, all holes 322 satisfy all of the following conditions (1) to (5).

(1) In the direction along the propeller rotation axis L, the lengths of all holes 322 are substantially identical to each other. The length of the holes 322 may be 1/2 or more, 2/3 or more, or 4/5 or more of the protruding length of the protruding portion 320 of the first plate 300.

(2) The positions of the front ends of all holes 322 are located on the same virtual line perpendicular to the propeller rotation axis L when viewed in the upper-lower direction.

(3) The rear ends of all the holes 322 are positioned on the same imaginary line perpendicular to the propeller rotation axis L when viewed in the upper-lower direction.

(4) The opening width D1 of each hole 322 is substantially identical over the entire length.

(5) The corners of the hole shape of the holes 322 are arcuate.

[0049] FIG. 7 is a front view illustrating a configuration of a second plate 350. The second plate 350 is attached to the duct 152 of the bow thruster 150 and serves to attenuate the vorticity of the sink vortex generated by the multiple water streams near the duct 152. In this embodiment, the second plate 350 is a part separate from the duct 152.

[0050] As shown in FIG. 7, the second plate 350 is provided in the upper portion of the duct 152 and extends from the duct 152 in a direction along the propeller rotation axis M. The second plate 350 is provided with a plurality of holes 352 formed therein.

[0051] Specifically, the second plate 350 is, as a whole, a substantially rectangular flat plate. The second plate 350 is formed of a metal such as an aluminum alloy. The entire second plate 350 has a uniform thickness. The second plate 350 is curved along the circumferential direction of the duct 152. The second plate 350 is curved around the propeller rotation axis M. When the duct 152 is positioned lower than the water surface W and the propeller rotation axis M is aligned with the horizontal line (see FIG. 7), the second plate 350 protrudes from the upper portion of the duct 152 along the propeller rotation axis M.

[0052] Specifically, the second plate 350 has a fixing portion 360 and a pair of protruding portions 370. The fixing portion 360 is the portion of the second plate 350 that is fixed to the duct 152. The pair of protruding portions 370 are portions of the second plate 350 respectively protruding from the duct 152 in the direction along the propeller rotation axis M (on either side of the duct 152). Each protruding portion 370 is provided with a plurality of holes 352 formed therein. All holes 352 are slits extending along the propeller rotation axis M. All holes 352 are equally spaced in the circumferential direction of the duct 152.

[0053] The boat 10 can move not only forward and backward but also laterally. The lateral movement is a translational movement in which the hull 200 is moved in a direction that includes a left-right component (e.g., to the right or to the right-diagonally backward) while maintaining the longitudinal orientation without turning the hull 200. In this embodiment, the boat 10 is moved laterally by using the propulsion force of the bow thruster 150 in addition to the electric propulsor 110. The boat 10 may be configured to move laterally without using the propulsion force of the bow thruster 150.

[0054] FIG. 1 illustrates the boat 10 moving laterally in the right direction. As shown in FIG. 1, the left propulsion force FL from the left-side electric propulsor 110 and the right-directional propulsion force FR from the right-side electric propulsor 110 generate a right-directional propulsion force F1. At this time, the orientation of each electric propulsor 110 is adjusted so that the left action line DL of the left propulsion force FL and the right action line DR of the right-directional propulsion force FR cross each other on the front side of the electric propulsor 110. In other words, each action line DL, DR is inclined with respect to the center line C of the hull 200. The left-side electric propulsor 110 and the right-side electric propulsor 110 rotate the propellers 132 in opposite directions. As a result, the combined force of the left propulsion force FL and the right-directional propulsion force FR is generated at the intersection position X of the left action line DL and the right action line DR as the right-directional propulsion force F1. Furthermore, the right-directional propulsion force F2 is generated by the bow thruster 150 in this configuration. Therefore, a propulsion force F3, which is the combined force of the right-directional propulsion force F1 and the right-directional propulsion force F2, is generated in the hull 200, causing the hull 200 to move laterally.

[0055] The magnitudes of the propulsion force F1 and F2 are set so that the yawing moment about the turning center P due to the propulsion force F1 (hereinafter referred to as "moment") cancels the moment about the turning center P due to the propulsion force F2. The output of the electric propulsor 110 and bow thruster 150 is controlled according to the amount of operation at the operation device. Specifically, the boat control device sets the target value of the propulsion force F3, the hull target value, according to the amount of operation at the operation device.

[0056] FIG. 8 is an explanatory view schematically illustrating the water streams near the duct 122 without the first plate 300, and FIG. 9 is an explanatory view schematically illustrating the water streams near the duct 122 with the first plate 300.

[0057] First, as shown in FIG. 8, when the first plate 300 is not attached to the duct 122, a large vortex (hereinafter referred to as a "sink vortex S1") may be generated that engulfs the air S3 toward the duct 122. Specifically, when the propeller 132 is rotated in the water, multiple water streams S2 that flow around along the duct 122 merge and grow into a large vortex (the "sink vortex S1") that engulfs the air S3 near the water surface W. As a result, an air cavity is formed in the vicinity of the propeller 132, and the propulsion force of the electric propulsor 110 (see arrow FRa) is considered to fluctuate due to the fluctuating thrust of the propeller 132.

[0058] In lateral movement, the fluctuation of the propulsion force of the electric propulsor 110 (see arrow FRa) caused by the sink vortex S1 is particularly pronounced. The sink vortex S1 tends to occur especially on the upstream side of the duct 122 in the right-side electric propulsor 110 (upstream side of the water stream flowing through the duct 122 due to the rotation of the propeller 132, or behind the duct 122 on the right side in FIG. 1). In contrast, the sink vortex S1 is comparatively less likely to occur on the upstream side of the duct 122 in the left-side electric propulsor 110 (in front of the left-side duct 122 in FIG. 1). This is because the hull 200 exists in front of the left-side duct 122 so that multiple water streams S2 that come around along the duct 122 are dispersed due to interference with the hull 200. If the right-directional propulsion force FRa by the right-side electric propulsor 110 is reduced due to the generation of the sink vortex S1 behind the right-side duct 122, the combined force of the left propulsion force FL and the right-directional propulsion force FRa becomes the right-diagonal forward propulsion force Fa (see FIG. 1). As a result, the combined force of the right-diagonal forward propulsion force Fa generated by the electric propulsor 110 and the right-directional propulsion force F2 generated by the bow thruster 150 becomes the right-diagonal forward propulsion force Fb, making it impossible to move the boat 10 laterally with good accuracy.

[0059] In contrast, the boat 10 of the present embodiment can attenuate the vorticity of the sink vortex S1 generated on the rear side of the duct 122 of the right-side electric propulsor 110 because the first plate 300 is attached to the duct 122 of the right-side electric propulsor 110. That is, the first plate 300 is provided on the upper portion of the duct 122 and extends from the duct 122 in a direction along the propeller rotation axis L. The first plate 300 is provided with a plurality of holes 322 formed therein. As shown in FIG. 9, the multiple water streams S2 flowing around along the duct 122 reduce their vorticity (strength) as they pass through the holes 322 formed in the first plate 300. As a result, the vorticity of the sink vortex S1 generated by the multiple water streams S2 can be attenuated. As a result, the combined force of the left propulsion force FL and the right-directional propulsion force FR becomes the right-directional propulsion force F1 (see FIG. 1). As a result, the combined force of the right-directional propulsion force F1 generated by the electric propulsor 110 and the right-directional propulsion force F2 generated by the bow thruster 150 becomes the right-directional propulsion force F3, allowing the boat 10 to move laterally with high accuracy.

[0060] Similarly, when the boat 10 moves laterally in the left direction, since the first plate 300 is also attached to the left-side electric propulsor 110, the vorticity of the sink vortex S1 generated on the rear side of the duct 122 of the left-side electric propulsor 110 can be attenuated. Not only when the boat 10 moves laterally but also when the boat 10 moves forward or backward, a sink vortex can occur near the duct 122 of the electric propulsor 110. However, this embodiment can suppress the reduction in maneuverability of the hull 200 caused by the sink vortex because the first plate 300 is attached to the duct 122.

[0061] In addition, since the second plate 350 is attached to the duct 152 of the bow thruster 150 of the boat 10, the vorticity of the sink vortex S1 generated on the right and left sides of the duct 152 can be attenuated. As a result, it is possible to suppress the reduction in maneuverability of the hull 200 during lateral movement that would occur when the propulsion force F2 generated by the bow thruster 150 is reduced due to the generation of the sink vortex S1 near the duct 152.

[0062] In this embodiment, the lowest end of the first plate 300 is located above the propeller rotation axis L (see FIG. 3). Thus, for example, compared to a configuration in which the first plate 300 extends from the entire circumference of the duct 122, this embodiment can reduce the weight of the electric propulsor 110 while suppressing the reduction in maneuverability of the hull 200 caused by the sink vortex.

[0063] In this embodiment, the first plate 300 is symmetrical with respect to the propeller rotation axis L when viewed in the upper-lower direction (see FIGS. 5 and 6). Thus, for example, compared to a configuration in which the first plate 300 is asymmetrically shaped, the electric propulsor 110 can be suppressed from being subjected to unequal left-right forces due to left-right flow variations in the vicinity of the duct 122.

[0064] In this embodiment, the first plate 300 is curved along the circumferential direction of the duct 122 (see FIGS. 3, 5, and 6). Thus, for example, compared to a configuration in which the first plate 300 is flat, the first plate 300 does not disturb the wing-like connection of the duct 122 and also has excellent attachability to the duct 122, and the strength of the first plate 300 can be improved while suppressing the reduction in maneuverability of the hull 200 caused by the sink vortex. In addition, for example, compared to a configuration in which the first plate 300 is flat, the first plate 300 is less likely to obstruct the flow of water along the duct 122. Therefore, it is possible to suppress the reduction in maneuverability of the hull 200 due to the presence of the first plate 300.

[0065] In this embodiment, the plurality of holes 322 formed in the first plate 300 are slits that extend along the propeller rotation axis L. Therefore, for example, compared to a configuration in which the holes 322 are slits extending in a direction that intersects the propeller rotation axis L, the holes 322 are less likely to obstruct the flow of water along the duct 122. Therefore, it is possible to suppress the reduction in maneuverability of the hull 200 due to the presence of the holes 322. In addition, compared to a plate in which, instead of the slit, a plurality of small holes are formed side by side in an area corresponding to the entire length of the slit, the number of steps required for the manufacturing process of the plate can be reduced because fewer steps are required to open the holes.

[0066] In this embodiment, the plurality of holes 322 are arranged symmetrically with respect to the propeller rotation axis L when viewed in the upper-lower direction (see FIGS. 5 and 6). This can suppress the electric propulsor 110 from being subjected to uneven left-right forces, e.g., due to variations in the arrangement of the plurality of holes 322.

[0067] In this embodiment, the separation distance D2 between two holes 322 (slits) adjacent to each other is wider than the opening width D1 of each hole in the alignment direction of the two holes 322 (circumferential direction of the duct 122) (see FIG. 5). Therefore, the vortices dispersed by the 1/2 holes 322 adjacent to each other can merge again after the passage of each hole 322 to form a large vortex, and as a result, the reduction in maneuverability of the hull 200 during lateral movement can be suppressed.

[0068] In this embodiment, the fixing portion 310 is fixed to the outer surface of the duct 122 at a first fixing position 312 and a second fixing position 314 (see FIGS. 5 and 6). The first fixing position 312 and the second fixing position 314 are displaced from each other in the direction along the propeller rotation axis L of the duct 122 as well as in the circumferential direction of the duct 122. Thus, for example, compared to a configuration in which all fixing positions are located on the same circle, the strength of the first plate 300 against the downward force due to the sink vortex can be improved.

[0069] The embodiments described above can be modified into various forms. In particular, it is referred to the following modifications.

[0070] The configuration of the boat 10, the boat propulsion system 100, and the plates 300, 350 in the above embodiment is only an example and can be modified in various ways. For example, in the above embodiment, the boat propulsion system 100 is provided with a plurality of electric propulsors 110 and the bow thruster 150, but it may be configured with one or three or more electric propulsors 110 or without the bow thruster 150.

[0071] In the above embodiment, the electric propulsor 110 is illustrated as the boat propulsor, but the boat propulsor may be an outboard motor, an inboard motor, an inboard/outboard motor, or a jet propulsor. The drive source for these outboard motors or the like may be an electric motor or an internal combustion engine. The electric propulsor 110 may also be configured without the stator fin 133. In the above embodiment, the bow thruster 150 located near the bow 204 of the hull 200 is illustrated as the boat propulsor, but the boat propulsor may be a side thruster located at a position other than the bow 204 (e.g., near the stern 202).

[0072] In the above embodiment, a rim-drive type configuration with the electric motor 134 built into the duct 122 is illustrated as the rotation mechanism. Alternatively, the rotation mechanism may include a drive source provided outside the duct 122 and a transmission mechanism that transmits the power of the drive source to the propeller 132.

[0073] In the above embodiment, the first plate 300 is a part separate from the duct 122. Alternatively, the first plate 300 may be configured as an integral part of the duct 122. Similarly, the second plate 350 may be in a configuration integrally formed with the duct 152.

[0074] Although the first plate 300 (protruding portion 320) is configured to be located at a position corresponding to the upper portion of the duct 122, the first plate 300 may also be configured to be located over the entire circumference of the duct 122. In other words, the first plate 300 (protruding portion 320) need only be disposed at a position corresponding at least to the upper portion of the duct 122. Preferably, the upper portion of the duct 122 is provided in the counterclockwise direction from 45 degrees or 60 degrees to 90 degrees with respect to a reference line (not shown) extending upwardly from the propeller rotation axis L of the duct 122 and in the clockwise direction from 45 degrees or 60 degrees to 90 degrees with respect to the reference line, for example.

[0075] The holes 322 formed in the first plate 300 and the holes 352 formed in the second plate 350 as slits extending along the propeller rotation axis L. Alternatively, the holes can be slits intersecting (e.g., orthogonally intersecting) the propeller rotation axis L, triangular slits having an opening width wider toward the protruding end of the plate, or round holes or rectangular holes, among others. The plurality of holes 322, 352 formed in each plate 300, 350 may be of the same shape and size as each other but may also include a plurality of holes that differ from each other in at least one of shape and size, or may be arranged in an uneven pattern. The minimum opening width in each of the holes 322, 352 (opening width D1 described above) is preferably narrower than the separation distance from the nearest other hole (separation distance D2 described above) but may be equal to or wider than the separation distance. The minimum opening width in each hole 322, 352 (opening width D1 above) is preferably wider than the thickness of each plate 300, 350 but may be narrower than the thickness of each plate 300, 350. Furthermore, in the above embodiment, at least some of the plurality of holes 322 formed in the first plate 300 may not satisfy at least some of the conditions in (1) to (5) described above.

[0076] The first plate 300 is formed to have a curved shape. Alternatively, the plate may be formed flat as a whole. The right portion and left portion of the first plate 300 may be asymmetrical in shape relative to the propeller rotation axis L when viewed in the upper-lower direction.

[0077] The fixing portion 310 of the first plate 300 may be fixed to the duct 122 by a fixing method (e.g., welding) other than the fastening member mentioned above. The fixing portion 310 may be fixed to the inner surface side of the duct 122. The protruding portion 320 of the first plate 300 may be provided to protrude not only to the rear side of the duct 122 but also to the front side of the duct 122.

[0078] Although the second plate 350 (protruding portion 370) is configured to be located at a position corresponding to the upper portion of the duct 152, the second plate 350 may also be configured to be located over the entire circumference of the duct 152. In other words, the second plate 350 (protruding portion 370) need only be disposed at a position corresponding at least to the upper portion of the duct 152. Preferably, the upper portion of the duct 152 is provided in the counterclockwise direction from 60 degrees to 90 degrees with respect to a reference line (not shown) extending upwardly from the propeller rotation axis M of the duct 152 and in the clockwise direction from 60 degrees to 90 degrees with respect to the reference line, for example.

[0079] The second plate 350 is formed to have a curved shape. Alternatively, the plate may be formed flat as a whole. The front portion and rear portion of the second plate 350 may be asymmetrical in shape relative to the propeller rotation axis M when viewed in the upper-lower direction.

Claims

1. A plate (300, 350) configured to be provided at a duct (122, 152) of a boat propulsor (110) wherein the plate (300, 350) is provided with a plurality of holes (322, 352) formed therein, and configured to extend in an axially direction from the duct (122, 152) having a propeller (132, 154) is disposed in the duct (122, 152) and rotatable about a rotation axis (L) along the axial direction.

2. The plate (300, 350) according to claim 1, wherein the plate (300, 350) is symmetrical in shape with regard to the axial direction.

3. The plate (300, 350) according to claim 1 or 2, wherein the plate (300, 350) is curved.

4. The plate (300, 350) according to any one of claims 1 to 3, wherein the plurality of holes (322, 352) includes a plurality of slits extending along a predetermined direction.

5. The plate (300, 350) according to any one of claims 1 to 4, wherein the plurality of holes (322, 352) are arranged symmetrically with regard to the axial direction.

6. The plate (300, 350) according to any one of claims 1 to 5, wherein the separation distance (D2) between the two holes (322, 352) adjacent to each other is wider than the opening width (D1) of each hole in the alignment direction of the two holes (322, 352).

7. A boat propulsor (110), comprising:

    a duct (122, 152);
    a propeller (132, 154) disposed in the duct (122, 152) and rotatable around a rotation axis (L) along the axial direction of the duct (122, 152); and
    a rotation mechanism (134) to rotate the propeller (132, 154), wherein
    the upper portion of the duct (122, 152) is provided with a plate (300, 350) according to at least one of the claims 1 to 6 extending from the duct (122, 152) in the axial direction and having the plurality of holes (322, 352) formed therein.

8. The boat propulsor (110) according to claim 7, wherein the plate (300, 350) is entirely located at one side with regard to the rotation axis (L).

9. The boat propulsor (110) according to claim 2, wherein the plate (300, 350) is symmetrical with respect to the rotation axis (L).

10. The boat propulsor (110) according to any one of claims 7 to 9, wherein the plate (300, 350) is curved along the circumferential direction of the duct (122, 152).

11. The boat propulsor (110) according to any one of claims 7 to 10, wherein the plurality of holes (322, 352) includes a plurality of slits extending along the axial direction of the duct (122, 152).

12. The boat propulsor (110) according to any one of claims 7 to 11, wherein the plurality of holes (322, 352) are arranged symmetrically with respect to the rotation axis (L).

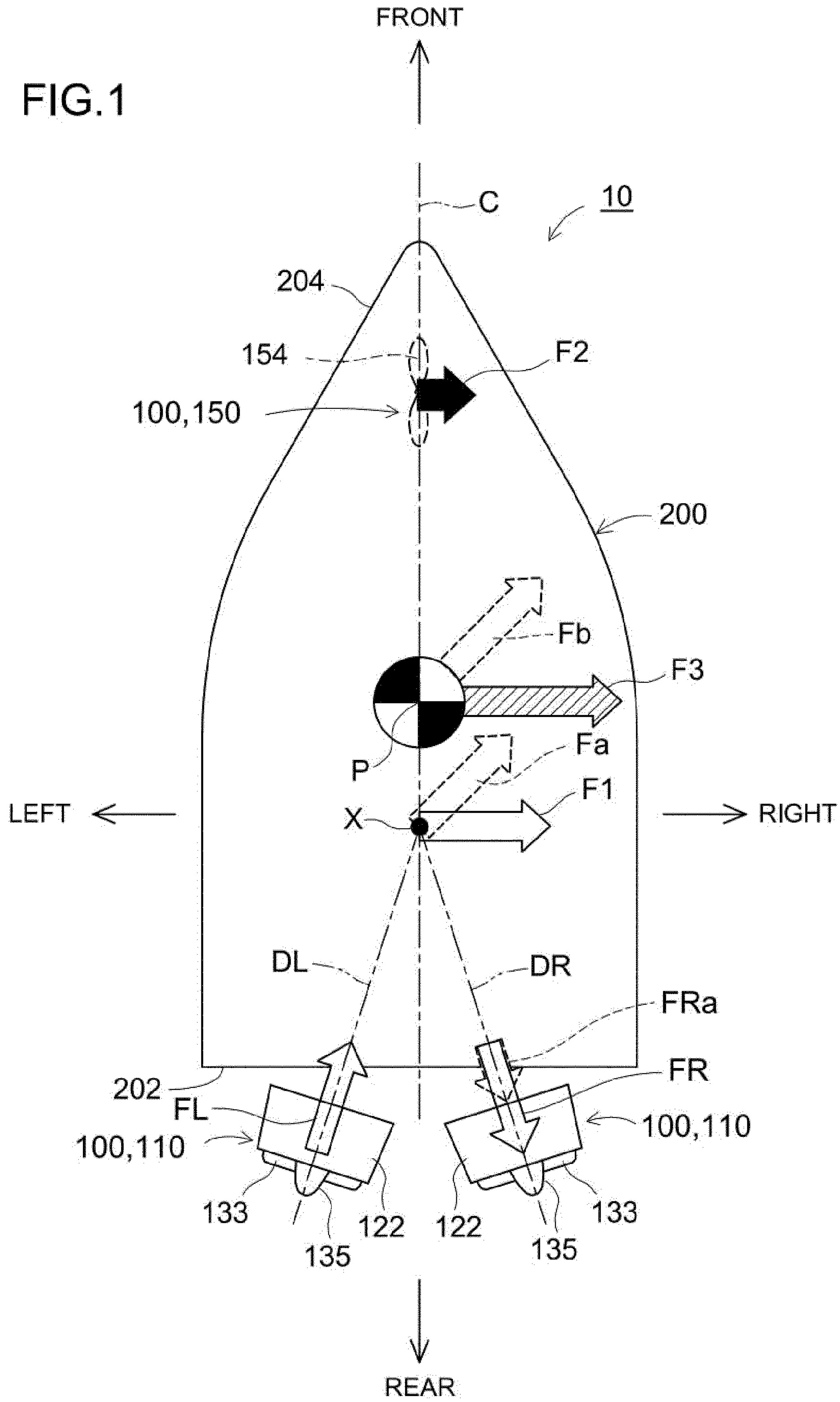
13. The boat propulsor (110) according to any one of claims 7 to 12, wherein the plate (300, 350) is a separate part from the duct (122, 152), and
    the plate (300, 350) is fixed to the outer surface of the duct (122, 152) at a first fixing position (312) and a second fixing position (314) that is displaced from the first fixing position (312) in both the axial and circumferential directions of the duct (122, 152).

14. A boat, comprising:

    a hull (200); and
    a boat propulsor (110) according to any one of claims 7 to 13.

15. The boat according to claim 15, wherein an upper portion of the duct (122, 152) is provided with the plate (300, 350) according to at least one of the claims 1 to 6.

FIG.1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135
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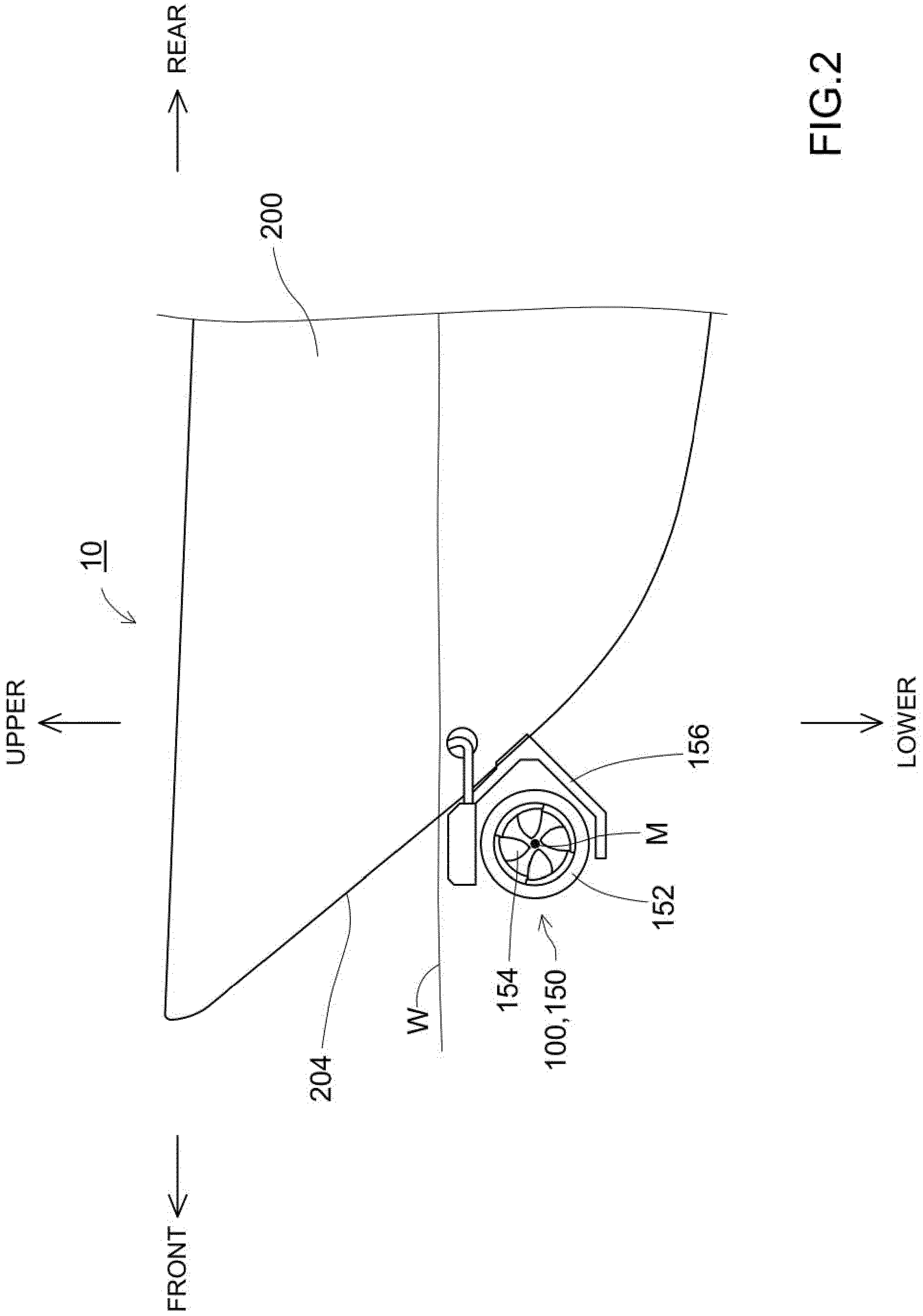
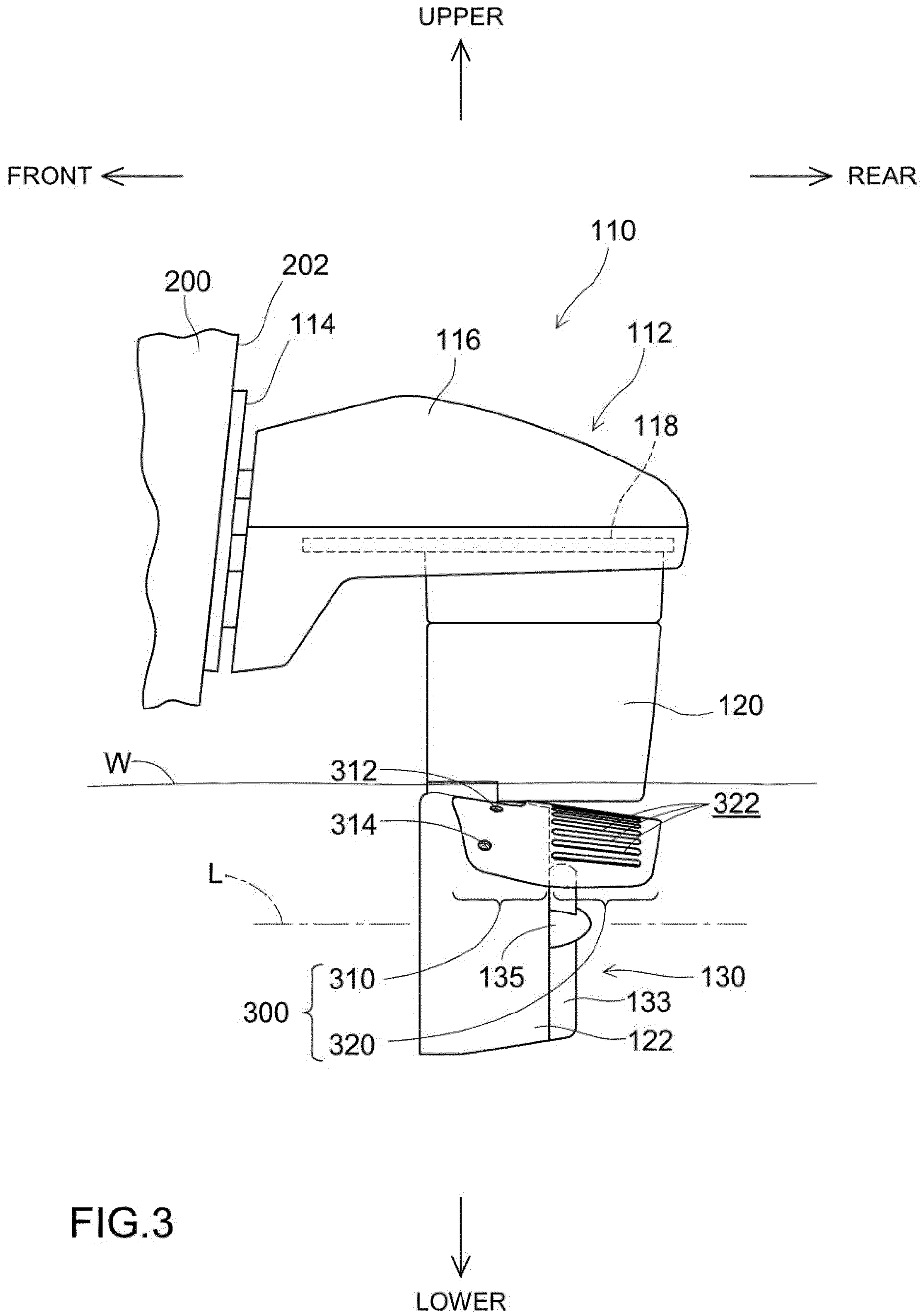


FIG.2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122
LOWER

FIG.3

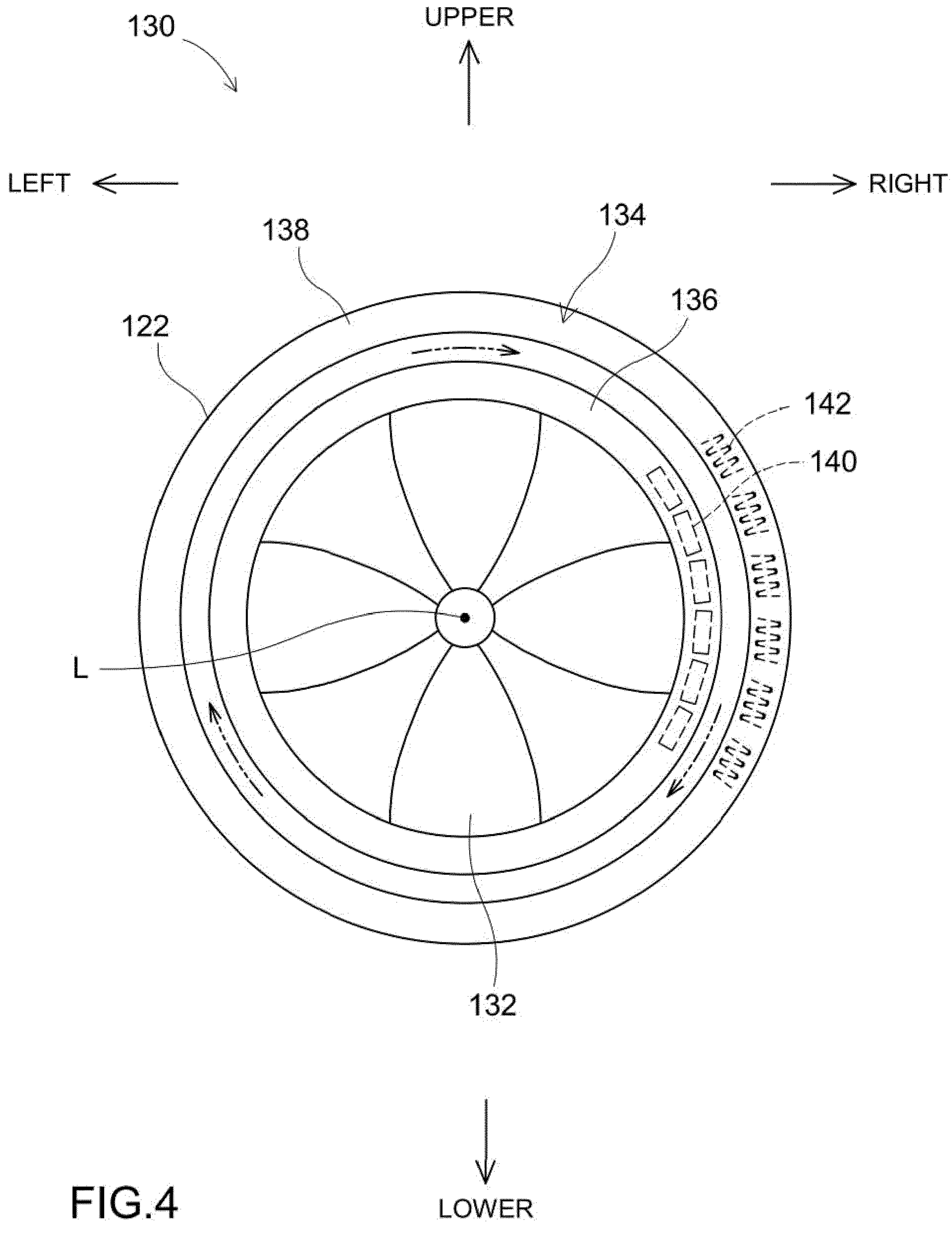
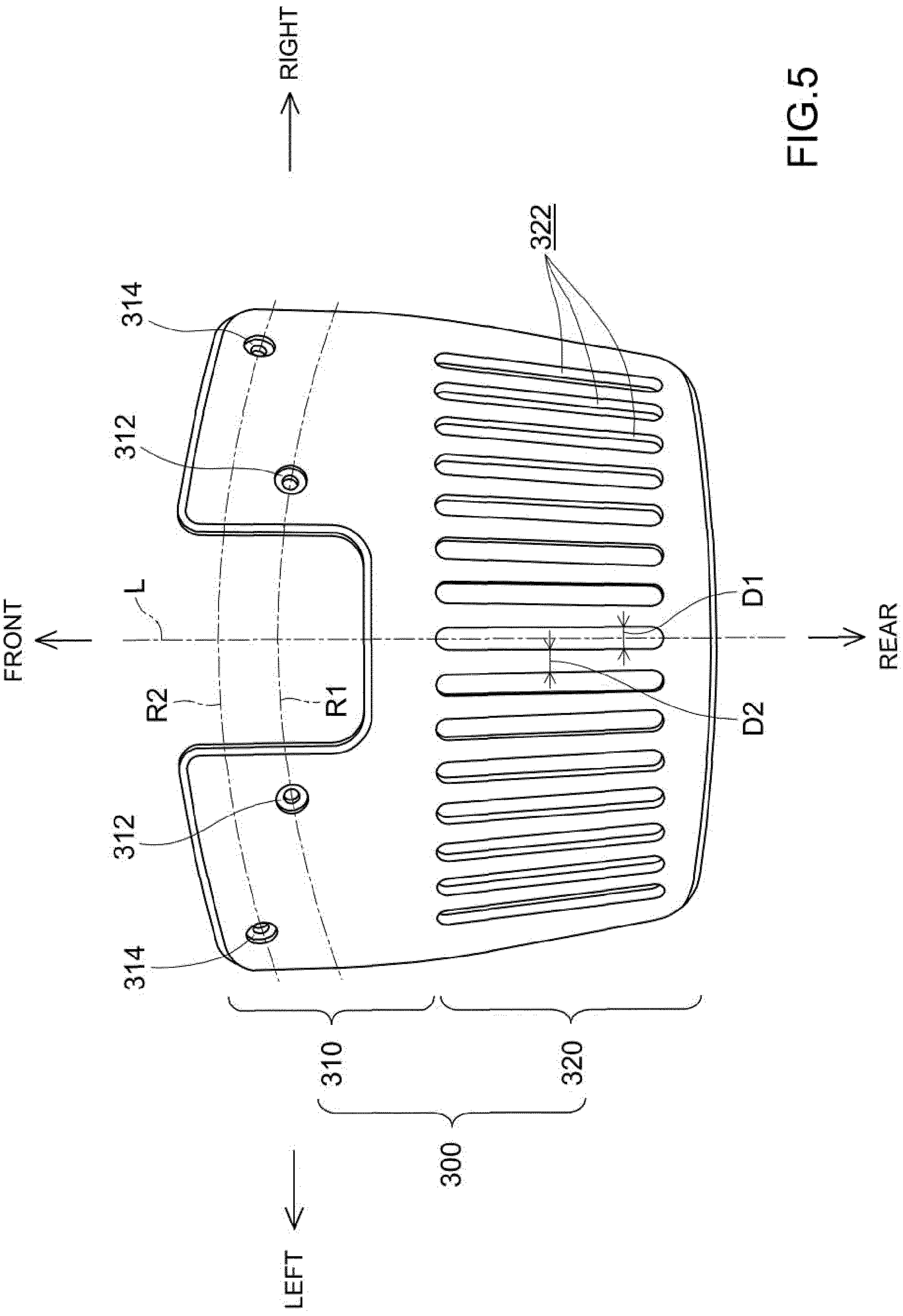


FIG.4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R1
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D1
D2
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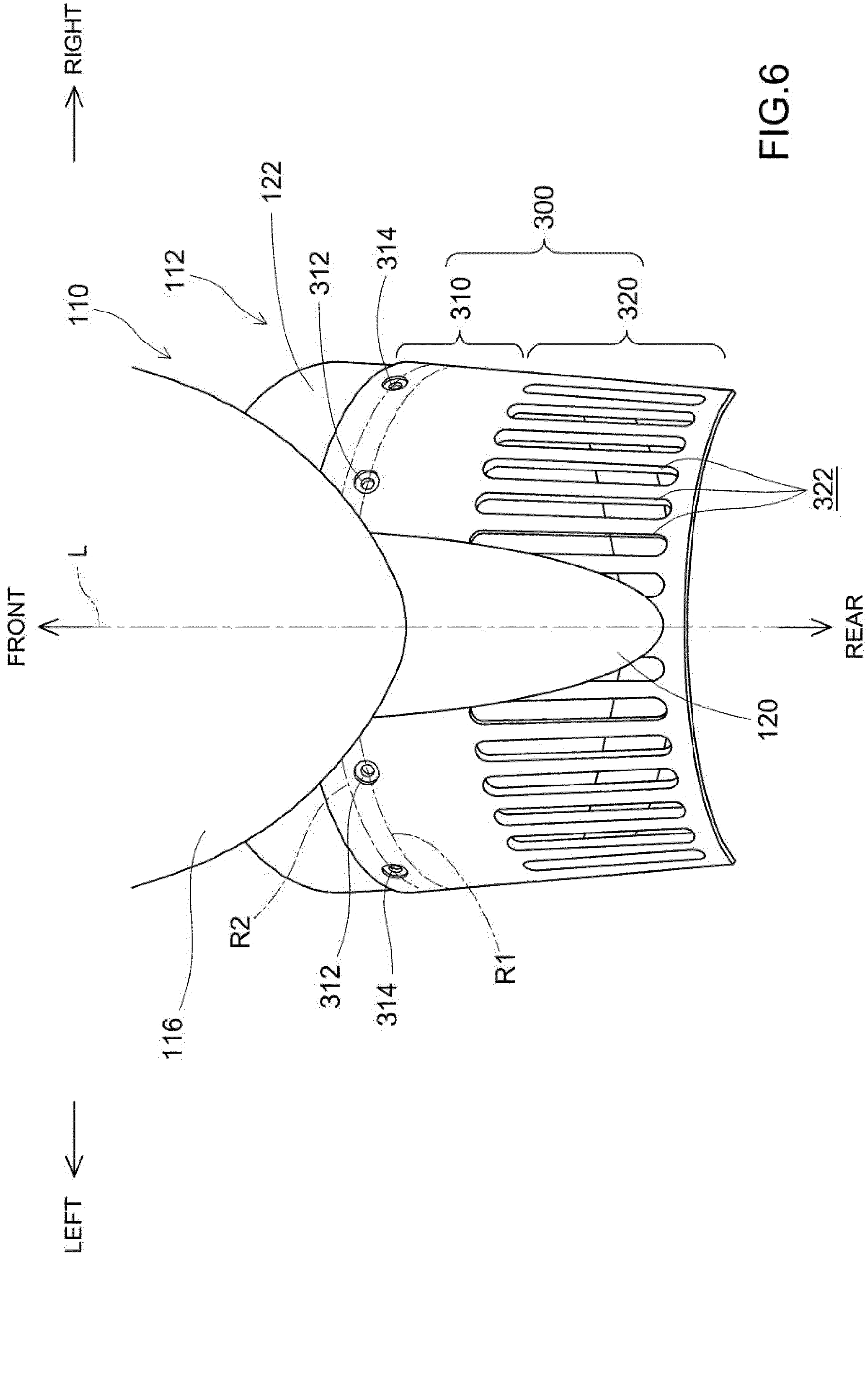
300

FIG.5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R1

FIG.6

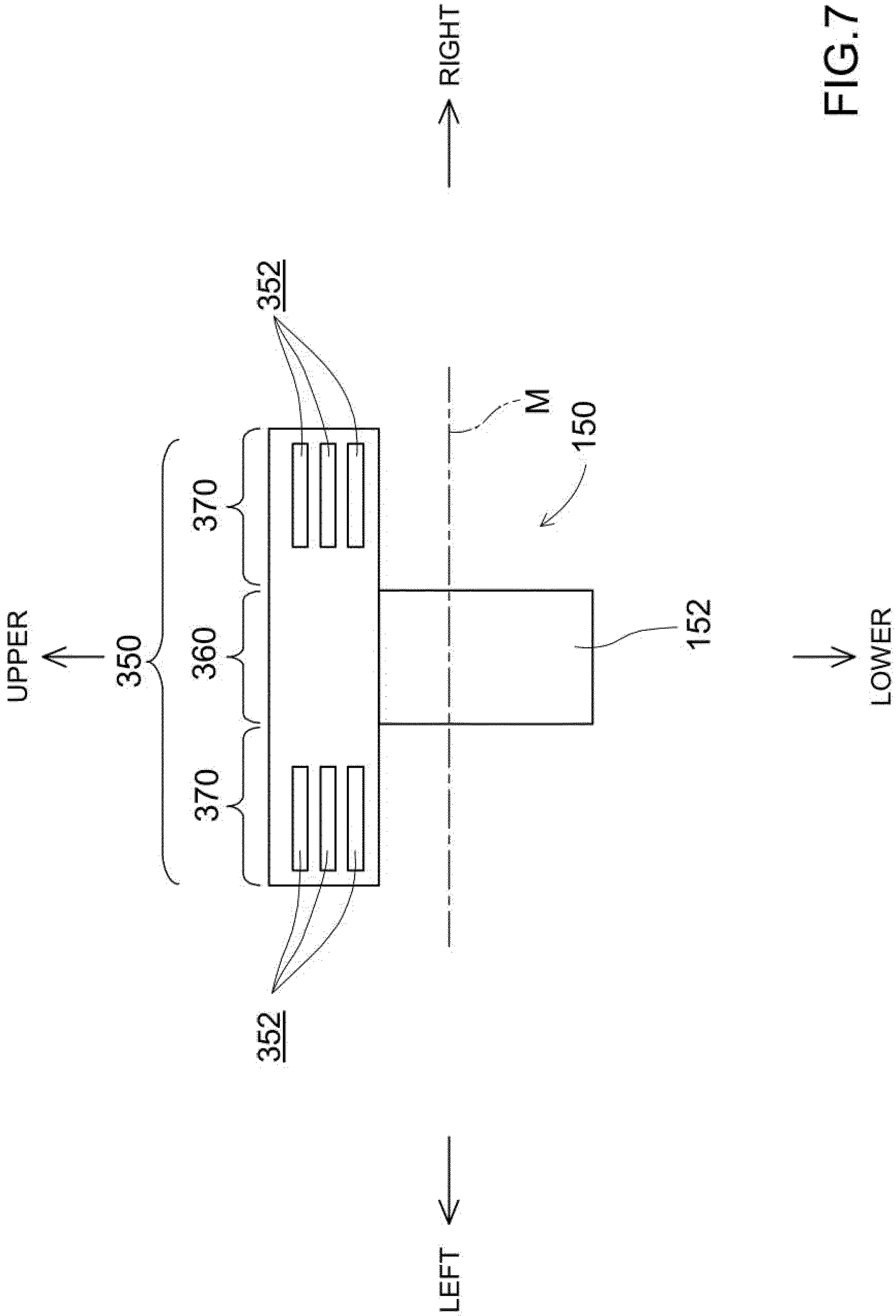

FIG.7

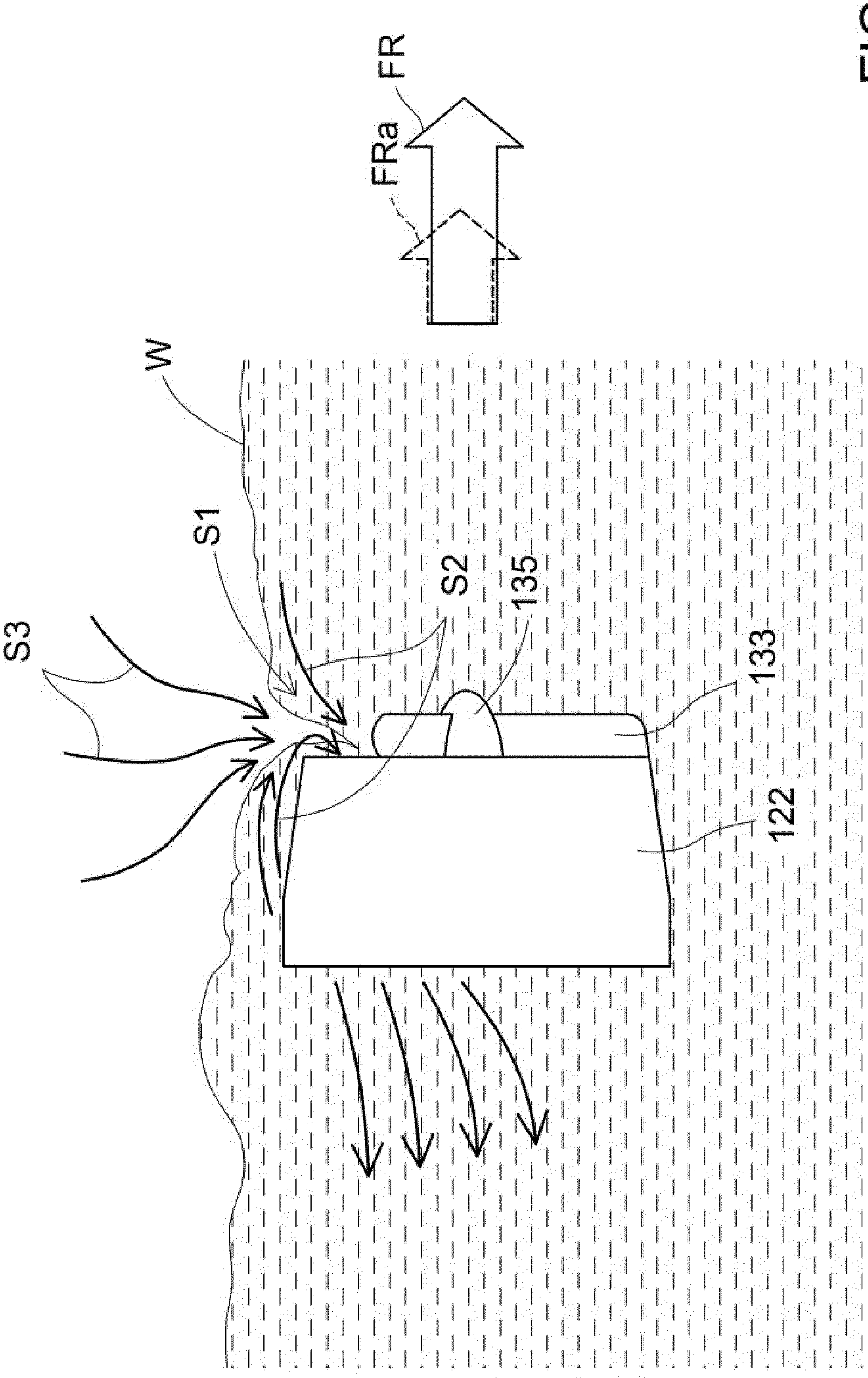

FIG.8

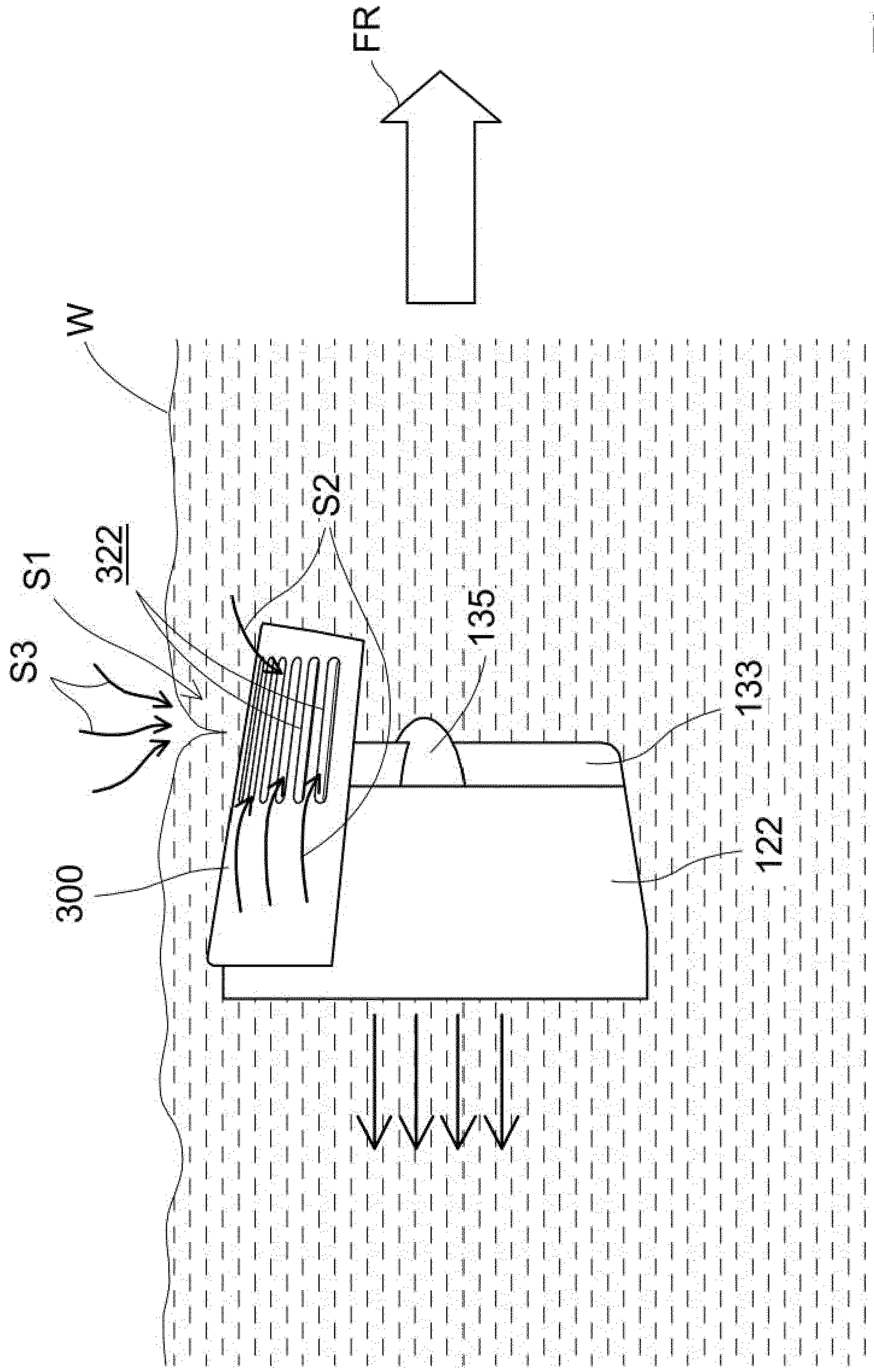

FIG.9

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EUROPEAN SEARCH REPORT

Application Number
EP 23 20 6050

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2020/010163 A1 (TAYLOR GUY [US]) 9 January 2020 (2020-01-09) * paragraph [0055] * * paragraph [0059] - paragraph [0062] * * figures *	1-7,9-12	INV. B63H20/34 B63H5/14 B63H5/07
X	US 8 911 272 B1 (GILK ARLON J [US] ET AL) 16 December 2014 (2014-12-16) * abstract; figures 2-4 *	1-4,6	
X	US 5 848 922 A (ITIMA ROMEO [US] ET AL) 15 December 1998 (1998-12-15) * abstract; figures 2-7 *	1,7-9, 11-15	
A	US 2015/158568 A1 (VAN DER LAAN MARKUS [NL] ET AL) 11 June 2015 (2015-06-11) * paragraph [0027]; figures *	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

B63H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	25 April 2024	Barré, Vincent

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25-04-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2020010163 A1	09-01-2020	NONE	
US 8911272 B1	16-12-2014	US 8911272 B1	16-12-2014
		US 9475558 B1	25-10-2016
		US 10710686 B1	14-07-2020
		US 2017043852 A1	16-02-2017
US 5848922 A	15-12-1998	NONE	
US 2015158568 A1	11-06-2015	EP 2870064 A1	13-05-2015
		NL 2009156 C2	13-01-2014
		US 2015158568 A1	11-06-2015
		WO 2014011036 A1	16-01-2014

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Patent documents cited in the description

- JP 2016068610 A **[0002]**
- JP 2013100013 A **[0002]**
- JP 2013100014 A **[0002]**
- JP 2022018645 A **[0002]**