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(72) Inventors:
• **Matin, Farhan**
53129 Bonn (DE)
• **Schindler, Henry**
19061 Schwerin (DE)
• **Will, Johannes**
22175 Hamburg (DE)

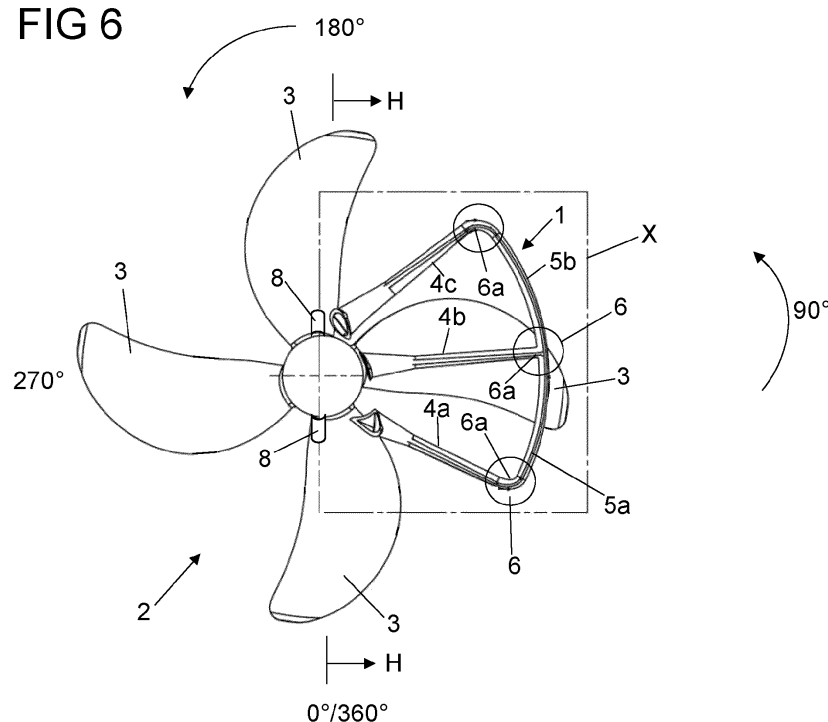
(71) Applicant: **Damen Components Holding B.V.**
3371 XE Hardinxveld-Giessendam (NL)

(74) Representative: **Maikowski & Ninnemann**
Patentanwlte Partnerschaft mbB
Postfach 15 09 20
10671 Berlin (DE)

(54) FLOW-GUIDING SYSTEM FOR A SHIP PROPULSION SYSTEM

(57) The invention relates to a flow-guiding system (10) for a ship propulsion system, the flow-guiding system comprising a flow-guiding device (1) and a propeller (2), the flow-guiding device (1) being positioned upstream of the propeller (2), wherein the flow-guiding device (1) comprises at least one flow-guiding element (4a, 4b, 4c, 5a, 5b) for changing - during

operation - the flow pattern of an upstream water flow (F1) from upstream of the flow-guiding element (1) to the propeller (2) so that it increases the angle of attack of the incoming water flow (F2) of blades (3) of the propeller (2) and / or generates at least one vortex (V1, V2, V3) in the incoming water flow (F2) of the blades (3) of the propeller (2)

FIG 6**EP 4 155 190 A1**

Description

[0001] The invention relates to a flow-guiding system for a ship with the features of claim 1 and the use of a flow-guiding system in a ship.

[0002] Propulsion systems of ships operate in a complex, three-dimensional flow field, in which in particular the flow around the ship hull is accelerated by one or more propellers.

[0003] Several flow-guiding systems are known to improve the performance to the propulsion. Examples for such devices are ducts around the propeller, pre-swirl nozzles for the propeller, and bulbs at a rudder downstream from the propeller or special designs of rudders.

[0004] As the energy efficiency of a ship propulsion system is an important design and performance factor, improved flow-guiding systems are needed.

[0005] The subject matter of claim 1 addresses this issue.

[0006] The flow-guiding system is positioned upstream from the propeller of the ship. At least one flow-guiding device of the flow-guiding system comprises a flow-guiding element for changing - during operation - the flow pattern of an upstream water flow from upstream of the flow-guiding element to the propeller. This results inter alia in an increase of the angle of attack of the incoming water flow to the blades of the propeller. Alternatively or in addition, the at least one flow guiding element generates at least one vortex in the incoming water flow of the blades of the propeller.

[0007] Therefore, the flow-guiding device deliberately changes the flow towards the propeller to increase the propulsion efficiency.

[0008] In one embodiment, the change in the flow pattern of the upstream water flow is a deflection of the upstream water flow and / or the introduction of a rotational component to the water in the propeller environment. In particular, - in the case of the deflection - the flow-guiding device is changing the main direction of the upstream water flow towards the blades of the propeller. Locally the flow field comprises turbulence, the deflected the main flow direction extends from the flow-guiding device to the propeller and then on to the rudder.

[0009] In one embodiment, the propeller accelerates water in the wake of the propeller and the radial flow component and / or a tangential flow component (being rotate3d in axial direction) of that accelerated water is at least partially counterbalanced by the deflected upstream water flow.

[0010] A propeller acts on different flow patterns in the wake of the ship. Therefore, the flow-guiding device in one embodiment is partially or fully located in the half-space in which the propeller is rotating upwards. In this region, a deflection and / or an introduction of vortices has a large effect on the propulsion efficiency. In one further embodiment, the flow guiding-device is fully located in a the half-space in which the propeller is rotating upwards and covers an angular range of less than 100°

in that half-space, in particular less than 80°. With this arrangement, the flow-guiding device interacts specifically in a region, where it can achieve a large effect on the propulsion efficiency.

[0011] To that effect, an embodiment of the flow-guiding device can comprise at least one vortex generation device. This can e.g. be a vane, a surface section with a rough surface and / or a sharp edge for creation of the vortex at a distance around the rotation axis of the propeller. Vanes, rough surface patches or sharp edges can introduce vortices deliberately. In particular, at least two vortex generation devices are used to generate at least two vortices circumferentially around the rotation axis of the propeller. This means that the propeller will have to rotate through those vortices, which are deliberately created by the vortex generation device in the propeller environment.

[0012] In one embodiment, the flow-guiding device comprises at least two, in particular three radial flow-guiding elements. Those radial flow-guiding elements protrude radially from a hub of axis of rotation outwards. The flow-guiding device can e.g. comprise at least one azimuthal flow-guiding element that is arranged around the rotational axis of the propeller. For mechanical stability, it is beneficial that the azimuthal flow-guiding elements are connected to the at least two radial flow-guiding elements. The radial flow-guiding elements are stabilized by the azimuthal flow guiding elements. In particular, the at least one azimuthal flow-guiding element is connected to the tips of the at least one radial flow-guiding element.

[0013] A good design alternative is a flow-guiding device comprising three radial flow-guiding elements and two azimuthal flow-guiding elements, wherein the two angles between the respective radial flow-guiding elements are not equal. The difference of the two angles can be less than 10°, in particular equal to 5°.

[0014] The generation of vortices can be integrated into such a flow-guiding device if at least one vortex generator device is located at the transition area of the at least one radial flow-guiding element and the at least one azimuthal flow-guiding element. The vortex generators can use e.g. vanes. It is also possible that at least one radial flow-guiding element and at least one azimuthal flow-guiding element have different cross-sections at the transition points thereby forming the at least one vortex generation device. The change in cross-sections is conducive to creating vortices.

[0015] In one embodiment, the flow-guiding device is positioned asymmetrically relative to a horizontal plane in which the rotational axis of the propeller is positioned.

[0016] The embodiments of a flow-guiding system can be used in a ship.

[0017] In the following, embodiments of a flow-guiding system are shown in an exemplary, nonlimiting way.

Fig. 1 shows a schematic side view of an embodiment of a flow-guiding system;

Fig. 2 shows a representation of the nominal wake of a ship in a plane of a propeller;

Fig. 3 shows view from aft onto a propeller;

Fig. 4 shows propulsion efficiencies with and without an embodiment of a flow-guiding system;

Fig. 5 shows a perspective view of an embodiment of a flow-guiding system deflecting a flow to a propeller;

Fig. 6 shows a view towards the rear of an embodiment similar to the one shown in Fig. 5;

Fig. 7 shows a detail X of the flow-guiding device shown in Fig. 6;

Fig. 8 show a schematic view of an embodiment of the flow-guiding device;

Fig. 9 shows a simulation result of flow using an embodiment of a flow-guiding device.

Fig. 10 shows a further embodiment of a flow-guiding device with three radial flow-guiding elements of different lengths;

Fig. 11 shows a further embodiment of a flow-guiding device with three radial flow-guiding elements connected through two azimuthal flow-guiding elements;

Fig. 12A shows isotach lines in the axial wake without a flow-guiding device;

Fig. 12B shows isotach lines in the axial wake with a flow-guiding device creating vortices.

[0018] In Fig. 1, a side view of an aft section of a ship 100 is shown. In this case, a single propeller 2 is used to provide thrust to the ship 100 by rotating around a rotational axis R. The situation shown in Fig. 1 is just an example, as e.g. the shape of the ship 100 and the number of propellers 2 can vary in different embodiments.

[0019] A flow-guiding element 1 is located upstream from the propeller 2. As will be explained below, the flow-guiding element 1 is designed to make the propulsion of the ship 100 more efficient, by minimizing in particular rotational energy losses and thereby reducing the fuel consumption of the ship 100.

[0020] The flow-guiding device 1 comprises at least one flow-guiding element 4, 5 (see Fig. 5 to 8) for changing - during operation the propeller 2 - the flow pattern of an upstream water flow F1 from upstream of the flow-guiding element 1 to the propeller 2 so that it increases the angle of attack of the incoming water flow F2 of blades

3 of the propeller 2 and / or generates at least one vortex V1 in the incoming water flow F2 of the blades 3 of the propeller 2 (see Fig. 9).

[0021] Before showing embodiments of the flow-guiding device, the flow-field will briefly be explained.

[0022] In Fig. 2, the nominal wake, i.e. the velocity field in the propeller plane P undisturbed by the rotation of the propeller 2 is shown. The grey-scale on the left hand side indicates the water velocity in the longitudinal direction; the vectors indicate the combined radial and tangential water velocity.

[0023] The highest longitudinal velocities are towards the rim of the lower half, the lowest velocities are directly above the axis R of the propeller.

[0024] The velocity in radial and tangential direction is symmetrical to a vertical line through the axis R. The water flow in the left hand half-plane having a clockwise direction, the water flow in the right hand half-plane having a counter-clockwise direction. In both half-planes, the general direction of the combined radial and tangential water flow is upwards. This flow pattern is a typical consequence of the aft-hull shape of the ship 100.

[0025] This is a representation of the three-dimensional flow field, the propeller 2 is operating in; it is a non-uniform flow field.

[0026] In Fig. 3, a schematic view of a propeller 2 is shown as seen from abaft toward the front. The propeller 2 is rotating in a clockwise direction. Considering the flow field shown in Fig. 2, the blades 3 of the propeller 2 are upward sweeping in the left-half plane, i.e. from 0° to 180° (0° being on the vertical axis pointing downwards). The blades 3 of the propeller 2 are sweeping downwards in the right-half plane, i.e. from 180° to 360°.

[0027] Hence, the downward rotating blades 3 of the propeller 2 "see" an upward water flow (see Fig. 2), in the right-hand plane. The blades 3 of the propeller 2 on the upward rotation in the left half-plane "see" an upward water flow (see Fig. 2).

[0028] The propeller 2 accelerates water in the wake of the propeller 2 and the radial flow component and / or a tangential flow component of that accelerated water is at least partially counterbalanced by the deflected upstream water flow.

[0029] This means for an individual blade 3 that the angle of attack is higher on the downward-sweep (right-hand half plane) compared to the upward-sweep (left-hand side plane).

[0030] A consequence is that the blade 3 generates more thrust in the right-hand half plane (180° to 360°) than in the left-hand half plane (0° to 180°). This is shown in Fig. 4, in which the propulsion efficiencies (ratios of thrust / torque) are shown over one full rotation angle (0° to 360°).

[0031] The curve C1 represents the unaided propulsion efficiency without an embodiment of a flow-guiding system 10.

[0032] The curve C2 represents the improvement that can be achieved by using an embodiment of a flow-guid-

ing system 10, as e.g. shown in Fig. 5. Not only the overall propulsion efficiency is higher, but also the peak of the maximum efficiency is broader, i.e. covering an angular range of ca. 90° to 220°.

[0033] It is one aim of the flow-guiding device 1 to change the flow pattern of the water flow so that the upward sweeping movement of the blades 3 (i.e. in the left-hand half plane, 0° to 180°) encounters higher angles of attack, thereby generating more thrust.

[0034] It should be noted that the flow-field shown in Fig. 3 refers to nominal wake conditions. The rotation of the propeller 2 interacts with this flow-field, altering the velocity distribution and resulting in an "effective wake" condition.

[0035] One further embodiment of a flow-guiding system 10 is depicted in Fig. 5 in a perspective view. This is essentially the same view as in schematic Fig. 1. The view is here towards the rudder from the port side. The propeller is turning over the top to starboard (which is in line with all previous figures).

[0036] Here, the flow pattern of an upstream water flow F1 - as seen from a flow-guiding element 1 - is changed towards the propeller 2. The deflection increases the angle of attack of the incoming flow F2 of blade 3 of the propeller 2. This has the effect that is shown in curve C2 in Fig. 4. A rudder 7 is located downstream from the propeller 2. It should be noted that Fig. 5 shows the main directions of the upstream water flow F1 and the incoming water flow F2. The propeller environment is highly turbulent, so the individual streamlines will be more complex than the ones shown in Fig. 5.

[0037] The embodiment of the flow-guiding system 10 comprises a flow-guiding device 1 with three radial flow-guiding elements 4 and two azimuthal flow-guiding elements 5 that are arranged around the rotational axis R of the propeller 2. The azimuthal flow-guiding elements 5 are connected to the radial flow-guiding elements 4 at transition points 6a.

[0038] An embodiment of the flow-guiding system 10 similar to the one depicted in Fig. 5 is shown in a view towards the rear in Fig. 6. The view is here from the bow towards the aft of the ship 100.

[0039] Here, the propeller 2, having four blades 3, is rotating in a counter-clockwise direction in this view (indicated by arrows). It should be noted that this is the same rotation direction as shown in Fig. 3, only the direction of the view is different.

[0040] The upward-sweep of the blades 3 (0° to 180°) is in the right-hand half space H in this view. The downward-sweep of the blades 3 (180° to 360°) is in left-hand half space.

[0041] The flow-guiding device 1 is located in the right-hand half space H. The flow-guiding device 1 comprises three radial flow-guiding elements 4a, 4b, 4c protruding from the center of rotation (hub) outwards, almost towards the tip of the blades 3. The detail X of the flow-guiding device 1 is shown in Fig. 7.

[0042] As can also be seen in Fig. 7, the angular loca-

tion of the radial flow-guiding elements 4 is slightly asymmetric, i.e. the middle radial flow-guiding element 4b has an angle of about 5° with the horizontal line going through the rotational axis R. The angle A1 between the upper radial flow-guiding element 4c and the middle radial flow-guiding element 4b is about 30°, the angle A2 between the lower flow-guiding element 4a and the middle flow-guiding element 4b is about 25°. This means that the total angular sweep of the flow-guiding device 1 is about 60°, slightly tilted upwards.

[0043] This means that this embodiment of the flow-guiding device 1 is fully located in the half-space H in which the propeller 2 is rotating upwards. In other embodiments, the angular range of the flow-guiding device is less than 100° in that half-space H. The angles A1, A2 can vary in other embodiments.

[0044] At the distal ends of the radial flow-guiding elements 4a, 4b, 4c, two azimuthal flow-guiding elements 5a, 5b are arranged around the rotational axis R of the propeller 2. The two azimuthal flow-guiding elements 5a, 5b are connected to the tips of the three radial flow-guiding elements 4a, 4b, 4c at transition points 6a.

[0045] In the embodiment shown here, the radial flow-guiding elements 4a, 4b, 4c have the same radial lengths. In other embodiments, the lengths can differ.

[0046] The cross-sections of the radial flow-guiding elements 4a, 4b, 4c and 5a, 5b have an airfoil profile, as it is e.g. known from the NACA airfoils. The shape of the radial flow-guiding elements 4a, 4b, 4c is chiefly responsible for creating the deflection of the upstream water flow F1 to the incoming water flow F2 to the blades 3 of the propeller 2.

[0047] In one embodiment, the cross-sections of the radial flow-guiding elements 4a, 4b, 4c and 5a, 5b are different (e.g. having different geometries, in particular curvatures). This change in cross-sections creates transition elements 6 at the transition points 6a causing a defined creation of vortices V1, V2, V3, as will be shown below.

[0048] Therefore, the embodiment of the flow-guiding device 1 shown here changes the flow pattern, e.g. deflects the upstream water flow F1 to create a higher angle of attack for the blades 3 and creates vortices V1, V2, V3 the same time. So, this embodiment does a deflection and introduction of a rotational component to the water at the same time.

[0049] The vortices V1, V2, V3 change the flow vector components locally so that they improve the (local) flow situation (in particular due to an improved angular of attack) of the propeller 2. The vortices V1, V2, V3 are most effective when they meet the higher loaded sections of the propeller 2. That might be in most cases around 0.7 R (i.e. the radius of the propeller 2).

[0050] In the same way they reduce the angular of attack on their other side, therefore reducing the angular of attack, and unloading the outer radii of the propeller, reducing tip vortex losses.

[0051] The deflection of the flow introduced by the flow-

guiding device 1 is changed in the main direction of the upstream water flow F1 towards the blades 3 of the propeller 2. As mentioned above, this main flow direction is superimposed on turbulent flow in the propeller environment.

[0052] Other embodiments only change the flow pattern, e.g. deflect the water flow or only create vortices V1, V2, V3.

[0053] In this embodiment (see Fig. 6), hub flow-guiding elements 8 are located at the 0° and 180° position of the hub of the propeller 2. Those hub flow-guiding elements 8 are not connected to each other. The hub flow-guiding element 8 align the flow and improve the flow field by reducing rotational flow components.

[0054] Fig. 8 shows a schematic view toward the front of the ship 100, with the flow-guiding device 1 on the left-hand side. The vortex generators 6 at the transition points 6a are indicated by arrows. The radial flow-guiding elements deflect the flow.

[0055] In Fig. 9, a simulation result using an embodiment of the flow-guiding device 1 shown in Fig. 6 and 7 is shown. The Figure shows the flow field in the propeller plane P, as seen from aft towards the bow of the ship 100 (as in Fig. 8). In the view of Fig. 9, the flow-guiding device 1 is located in the left-hand space H. The change in the flow pattern can e.g. be seen as three vortices V1, V2, V3 are created by the transition elements 6. The three vortices V1, V2, V3 are introduced in the flow and are located circumferentially (as the transition elements 6) around the rotation axis R of the propeller 2. A comparison of Fig. 8 and 9 shows that the three vortex generators are causing the three vortices V1, V2, V3 visible in the flow field simulation.

[0056] In Fig. 10 a further embodiment of the flow-guiding device 1 is shown. The functionality is essentially the same as in the embodiments described above so that reference can be made to the description above. Here the radial flow-guiding elements 4a, 4b, 4c have different radial lengths. The azimuthal flow-guiding elements 5a, 5b are curve sections rather than circle sections. At the transition points 6a, transition elements form the vortex generators 6.

[0057] In Fig. 11 another variation of the flow-guiding device 1 is shown. Here the radial flow-guiding elements 4a, 4b, 4c are of the same length. The azimuthal flow-guiding elements 5a, 5b are connecting those radial element not at the tips but approximately at the half radial lengths. The vortex generators 6 are formed by the tips.

[0058] In Fig. 12A, 12B isotachs of the axial component in the wake are shown. The view is abhacht with portside on the left and starboard on the right. The dashed circular line represents the outer radius of the propeller 2 (not shown here).

[0059] Fig. 12A show the isotachs without a flow-guiding system, Fig. 12B shows the flow field with a flow-guiding system with vortices recognizable on the port side.

Reference numbers

[0060]

5	1	flow-guiding device
	2	propeller
	3	blade of propeller
	4a-c	radial flow-guiding elements
	5a-b	azimuthal flow-guiding elements
10	6	vortex generator device
	6a	transition point
	7	rudder
	8	hub flow-guiding elements
15	10	flow-guiding system
	100	ship
	A1	first angle between two radial flow-guiding elements
20	A2	second angle between two radial flow-guiding elements
	F1	upstream water flow (as seen from flow-guiding element)
25	F2	incoming water flow to a blade of a propeller
	H	half space in which the propeller is rotation upwards
	P	propeller plane
	R	rotation axis of propeller
30	V1	first vortex
	V2	second vortex
	V3	third vortex
	X	detail

Claims

1. Flow-guiding system (10) for a ship propulsion system, the flow-guiding system comprising a flow-guiding device (1) and a propeller (2),

the flow-guiding device (1) being positioned upstream of the propeller (2), wherein the flow-guiding device (1) comprises at least one flow-guiding element (4a, 4b, 4c, 5a, 5b) for changing - during operation - the flow pattern of an upstream water flow (F1) from upstream of the flow-guiding element (1) to the propeller (2) so that it increases the angle of attack of the incoming water flow (F2) of blades (3) of the propeller (2) and / or generates at least one vortex (V1, V2, V3) in the incoming water flow (F2) of the blades (3) of the propeller (2).

2. Flow-guiding system, according to claim 1, wherein the change in the flow pattern of the upstream water

flow (F1) is a deflection of the upstream water flow (F1) and / or the introduction of a rotational component to the water in the propeller environment.

3. Flow-guiding system of claim 2, wherein the flow-guiding device (1) is changing the main direction of the upstream water flow (F1) towards the blades (3) of the propeller (2).
4. Flow-guiding system of at least one of the preceding claims, wherein the propeller (2) accelerates water in the wake of the propeller (2) and the radial flow component and / or a tangential flow component of that accelerated water is at least partially counter-balanced by the deflected upstream water flow (F1).
5. Flow-guiding system of at least one of the preceding claims, wherein the flow-guiding device (1) is partially or fully located in the half-space (H) in which the propeller (2) is rotating upwards.
6. Flow-guiding system of at least one of the preceding claims, wherein the flow-guiding device (1) is fully located in a the half-space (H) in which the propeller (2) is rotating upwards and covers an angular range of less than 100° in that half-space, in particular less than 80°.
7. Flow-guiding system of at least one of the preceding claims, wherein the flow-guiding device (1) comprises at least one vortex generation device (6).
8. Flow-guiding system of claim 7, wherein the vortex generation means (6) comprises a vane, a surface section with a rough surface and / or a sharp edge for creation of at least one vortex (V1, V2, V3) at a distance around the rotation axis (R) of the propeller (2).
9. Flow-guiding system of claim 7 or 8, wherein at least two vortex generation devices (6) are used to generate at least two vortices (V1, V2, V3) circumferential around the rotation axis (R) of the propeller (2).
10. Flow-guiding system of at least one of the preceding claims, wherein the flow-guiding device (1) comprises at least two, in particular three radial flow-guiding elements (4a, 4b, 4c).
11. Flow-guiding system of claim 10, wherein the flow-guiding device (1) comprises at least one azimuthal flow-guiding element (5a, 5b) that is arranged around the rotational axis (R) of the propeller (2), the azimuthal flow-guiding elements (5a, 5b) being connected to the at least two radial flow-guiding elements (4a, 4b, 4c).
12. Flow-guiding system of claim 11, wherein the at least one azimuthal flow-guiding element (5) is connected to the tips of the at least one radial flow-guiding element (4a, 4b, 4c).
13. Flow-guiding system of at least one of the claims 10 to 12, wherein the flow-guiding device (1) comprises three radial flow-guiding elements (4a, 4b, 4c) and two azimuthal flow-guiding elements (5a, 5a), wherein the two angles (A1, A2) between the respective radial flow-guiding elements (4) are not equal.
14. Flow-guiding system of claim 13, wherein the difference of the two angles (A1, A2) is less than 10°, in particular equal to 5°.
15. Flow-guiding system of at least one of the claims 7 to 14, wherein at least one vortex generator device (6) is located at the transition of the at least one radial flow-guiding element (4a, 4b, 4c) and the at least one azimuthal flow-guiding element (5a, 5b).
16. Flow-guiding system of claim 15, wherein at least one radial flow-guiding element (4a, 4b, 4c) and at least one azimuthal flow-guiding element (5a, 5b) have different cross-sections at the transitions points (6a) thereby forming the at least one vortex generation device (6).
17. Flow-guiding system of at least one of the preceding claims, wherein the flow-guiding device (1) is positioned asymmetrically relative to a horizontal plane in which the rotational axis (R) of the propeller (2) is located.
18. Ship (100) with a flow-guiding system according to one of the claims 1 to 17.

FIG 1

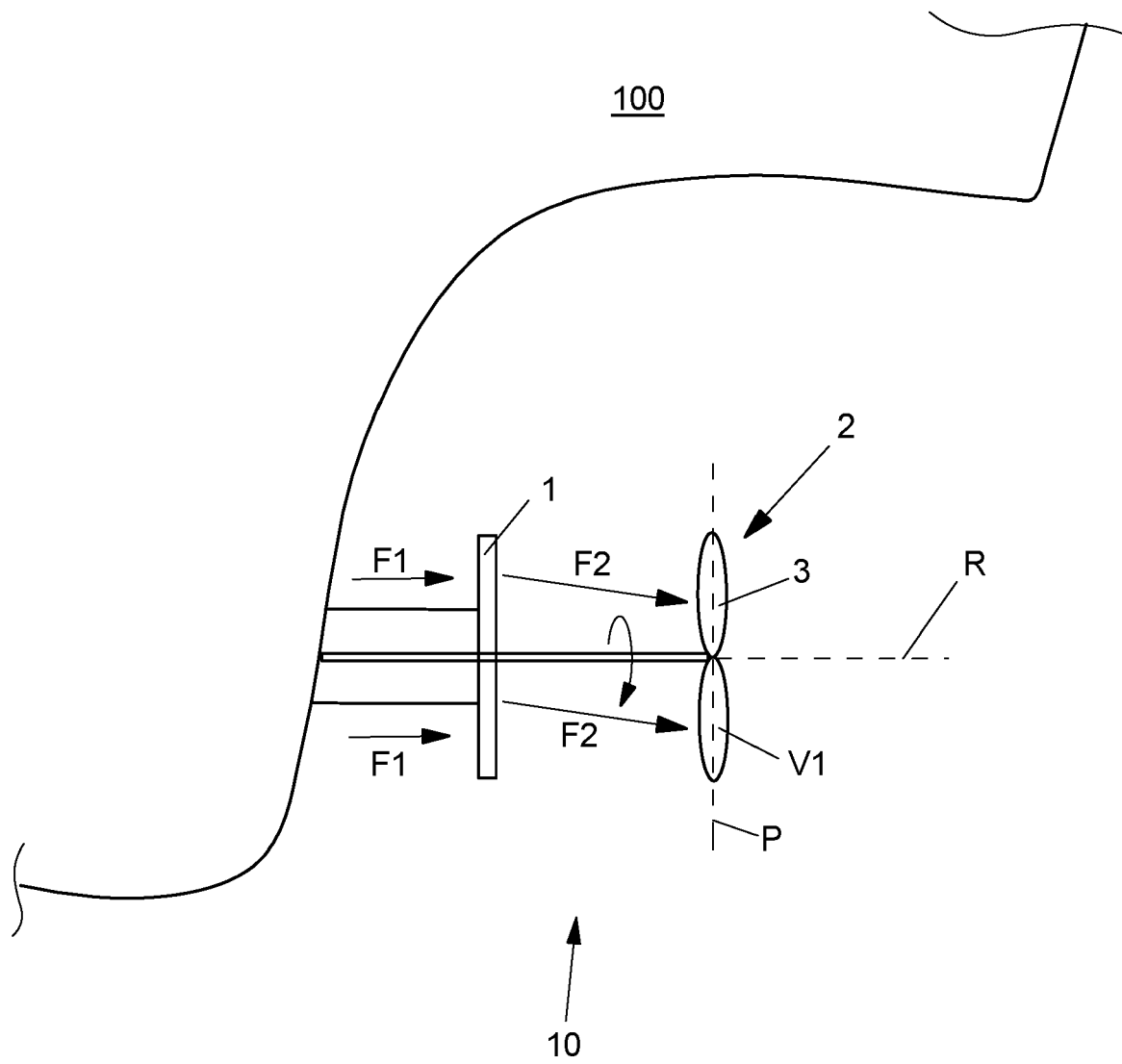


FIG 2

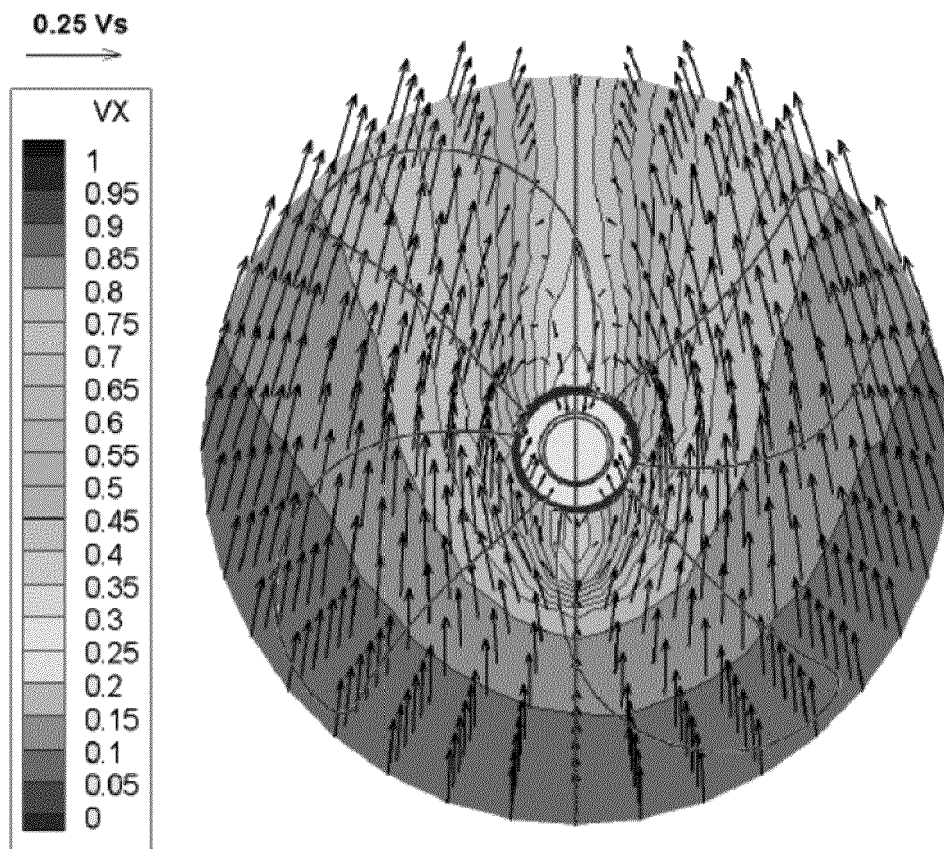


FIG 3

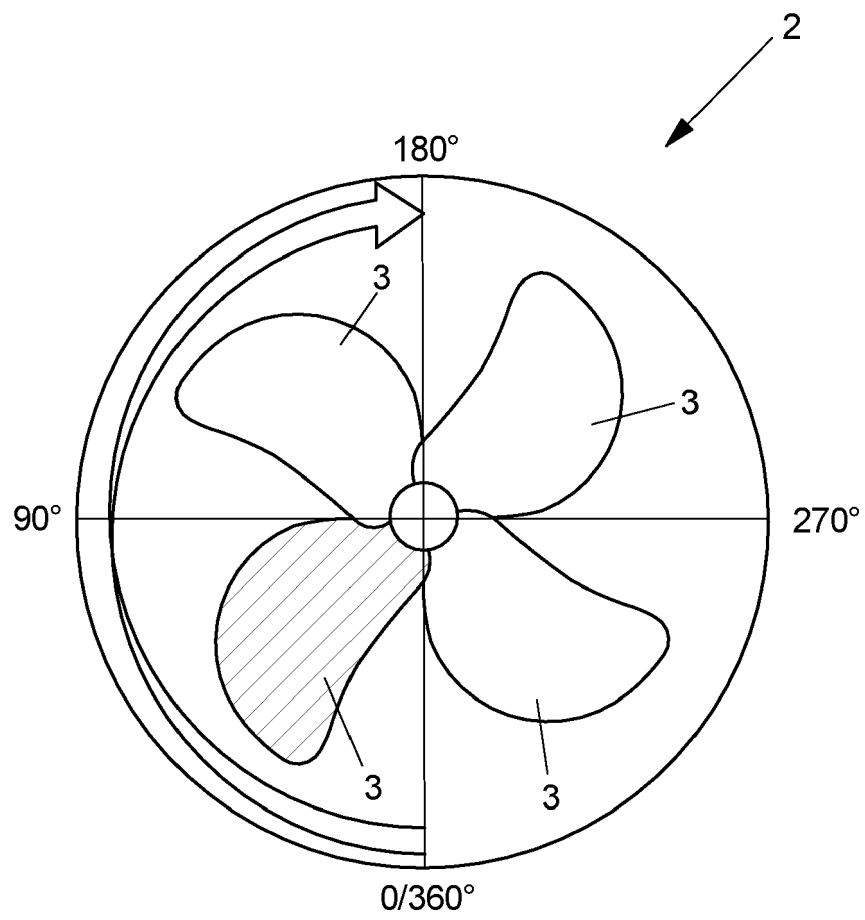


FIG 4

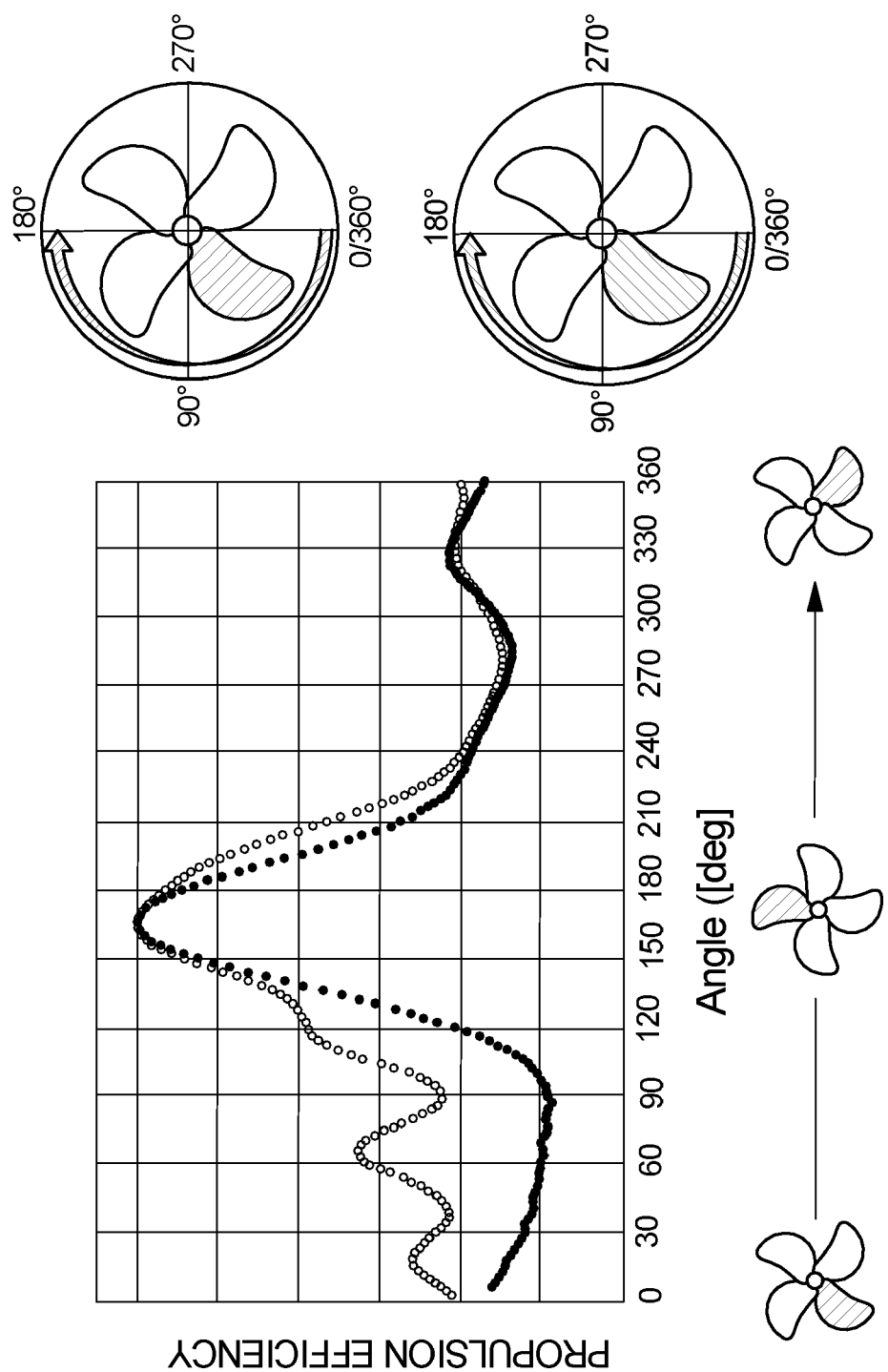


FIG 5

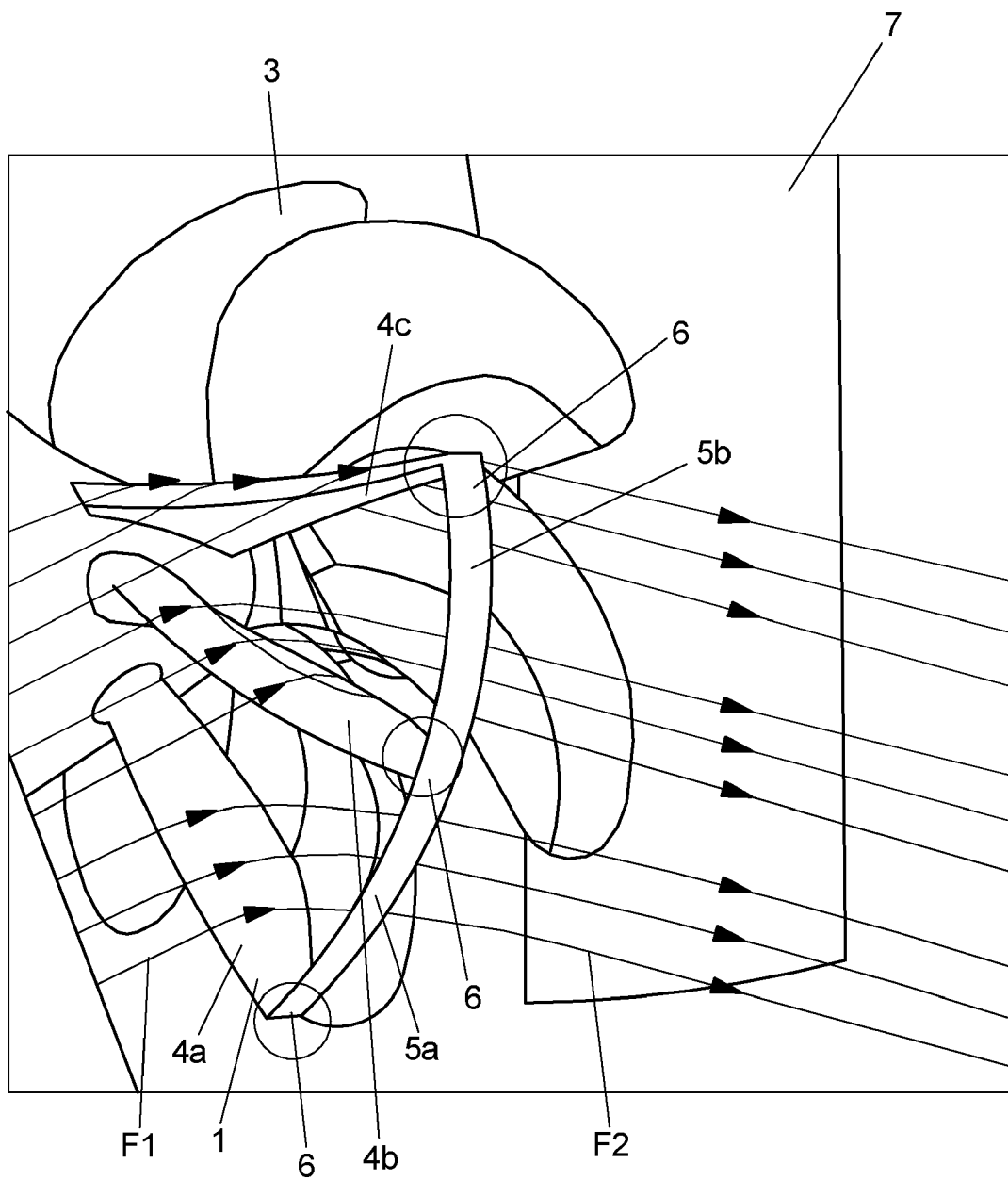


FIG 6

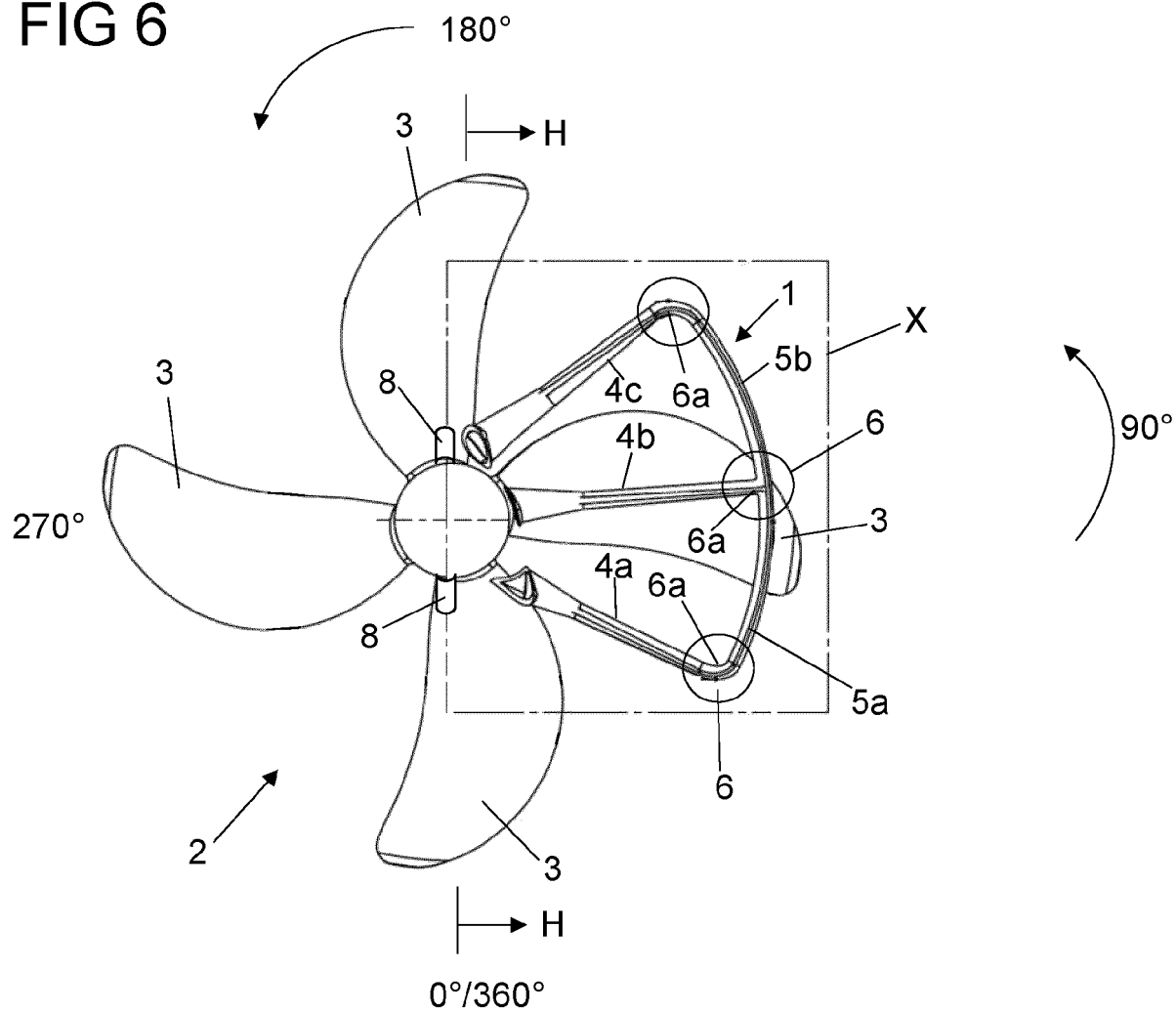


FIG 7

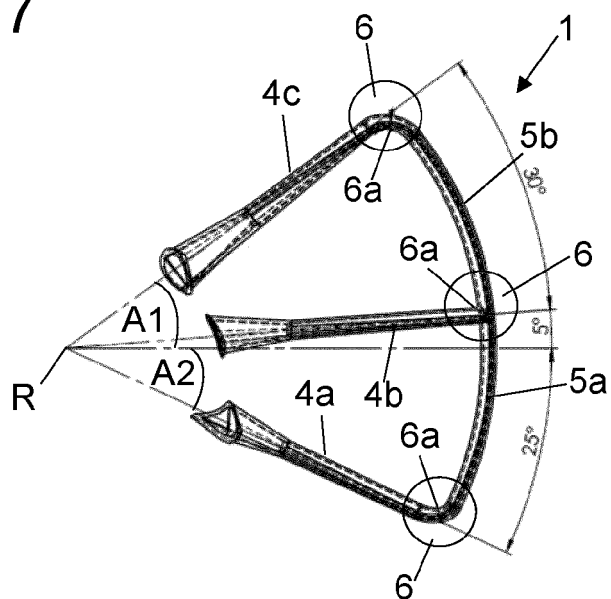


FIG 8

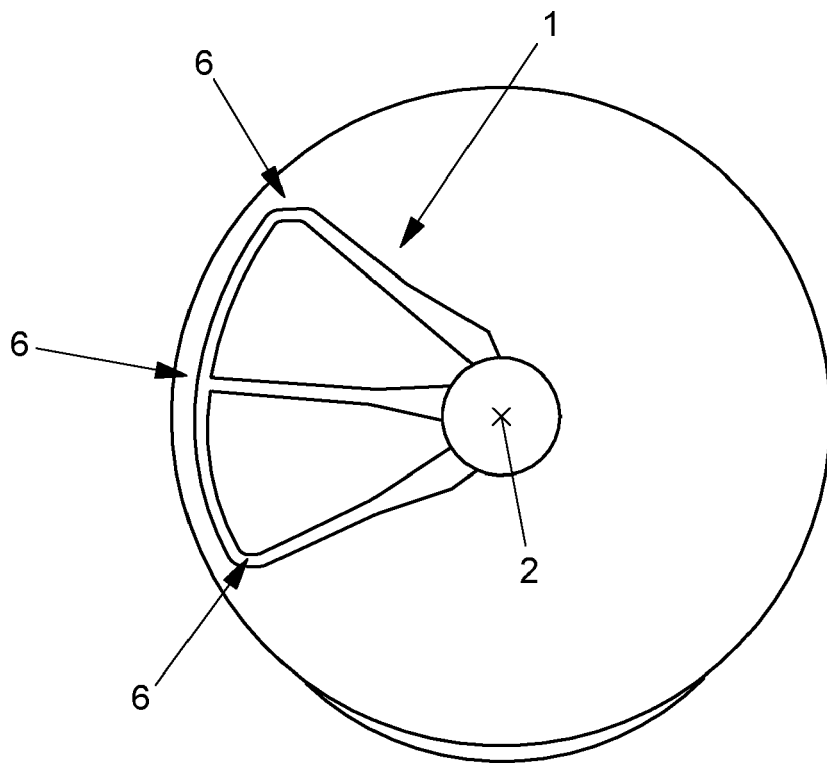


FIG 9

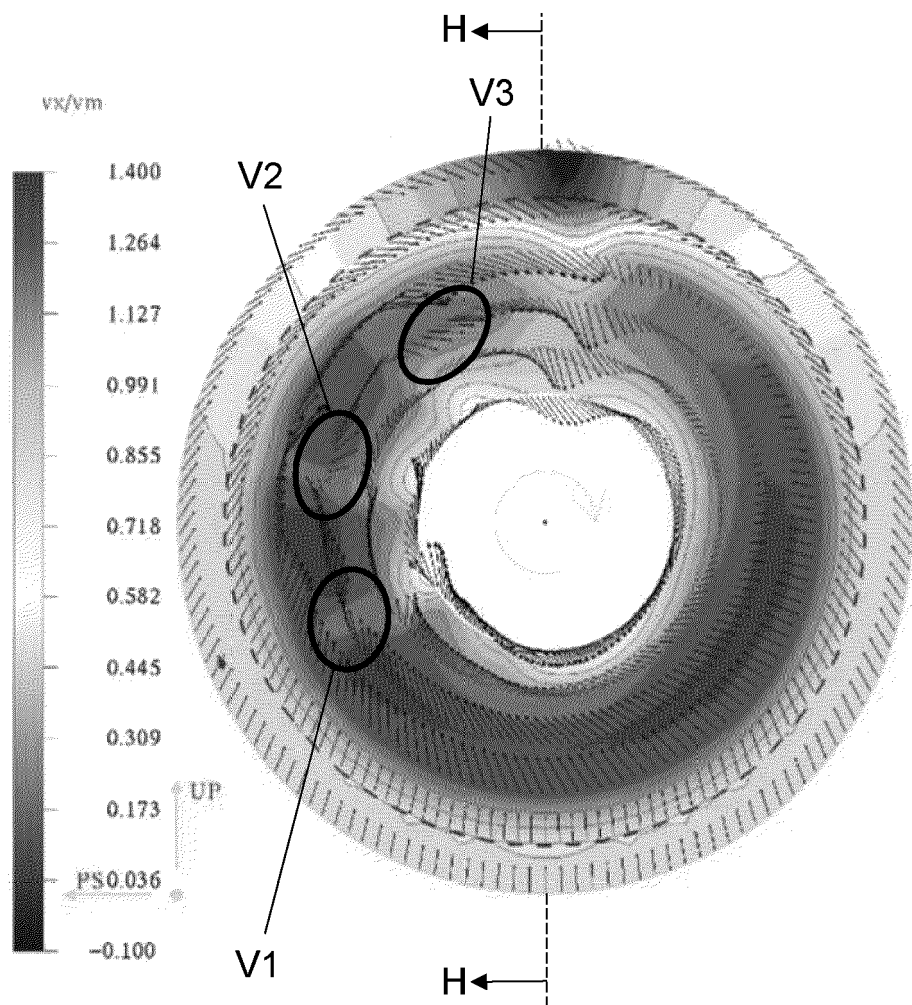


FIG 10

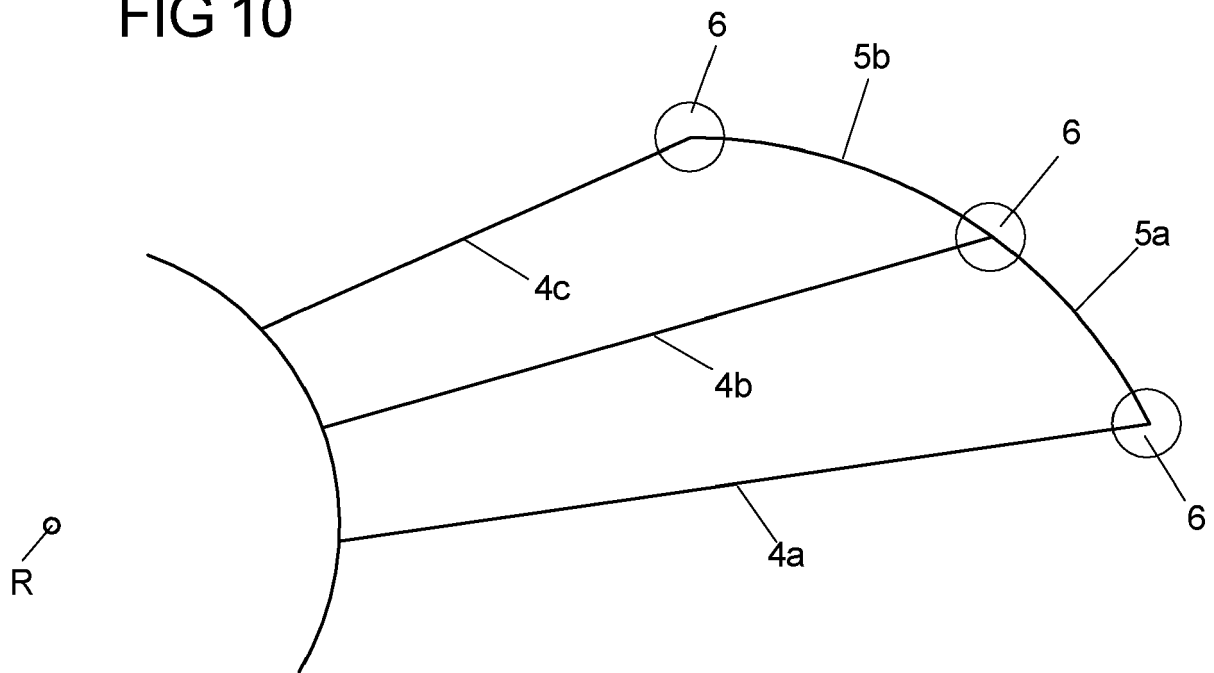


FIG 11

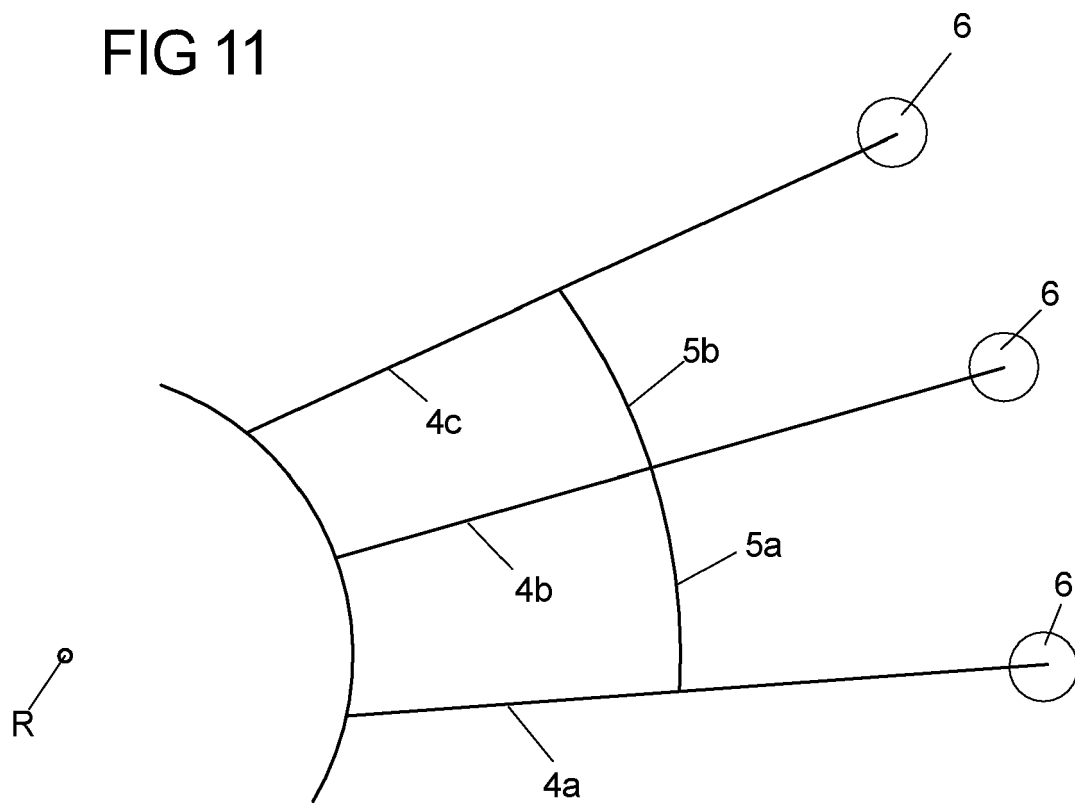


FIG 12A

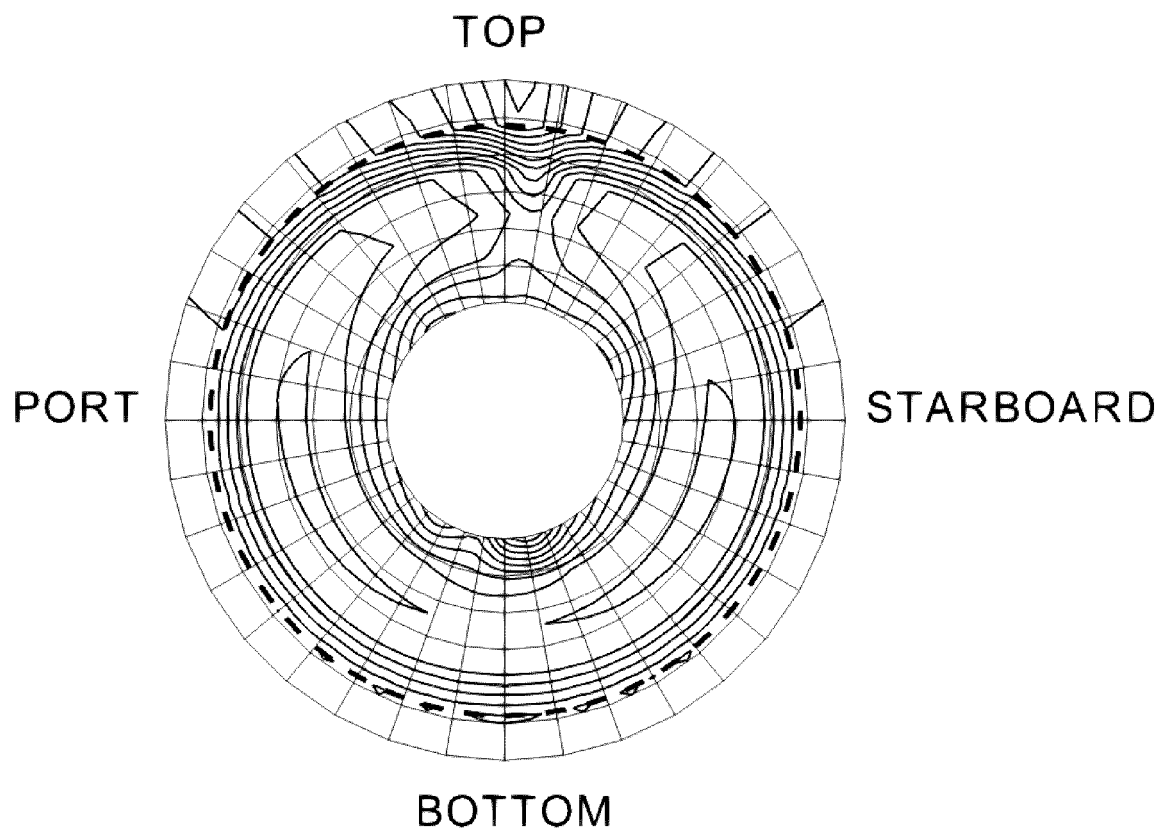
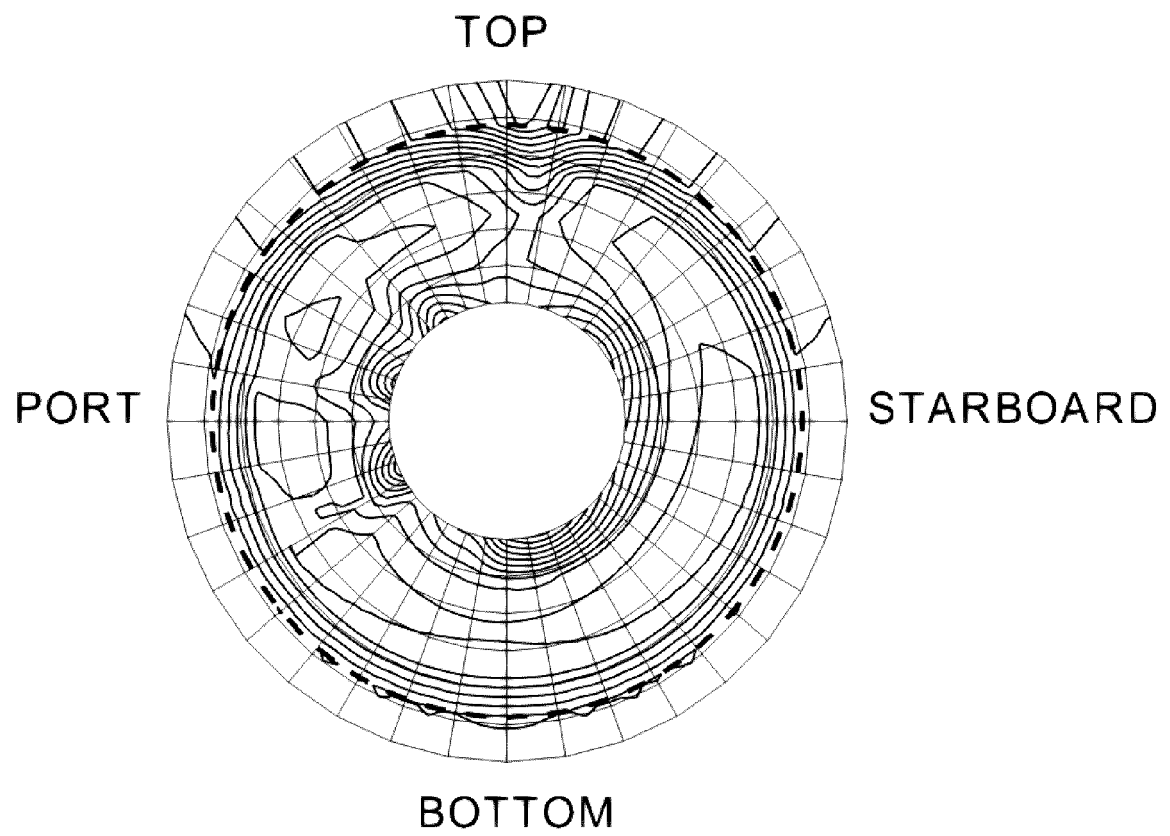


FIG 12B





EUROPEAN SEARCH REPORT

Application Number

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