(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 705 392 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
05.03.2025 Bulletin 2025/10

(21) Application number: **18872708.5**

(22) Date of filing: **31.10.2018**

(51) International Patent Classification (IPC):
B63H 5/16 *(2006.01)* ***B63H 1/28*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B63H 1/28; B63H 5/16

(86) International application number:
PCT/KR2018/013108

(87) International publication number:
WO 2019/088696 (09.05.2019 Gazette 2019/19)

(54) **APPARATUS FOR ENHANCING PROPULSION EFFICIENCY**

VORRICHTUNG ZUR STEIGERUNG DER ANTRIEBSLEISTUNG

APPAREIL POUR AMÉLIORER L'EFFICACITÉ DE PROPULSION

(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

(30) Priority:
31.10.2017 KR 20170143239
31.10.2017 KR 20170143315
31.10.2017 KR 20170143359
31.10.2017 KR 20170143470

(43) Date of publication of application:
09.09.2020 Bulletin 2020/37

(73) Proprietor: **Samsung Heavy Ind. Co., Ltd.**
Seongnam-si, Gyeonggi-do 13486 (KR)

(72) Inventors:
- **LEE, Hee Dong**
  Geoje-si
  Gyeongsangnam-do 53261 (KR)
- **KIM, Hee Taek**
  Geoje-si
  Gyeongsangnam-do 53261 (KR)
- **PARK, Hyoung Gil**
  Geoje-si
  Gyeongsangnam-do 53261 (KR)
- **AN, Dae Young**
  Geoje-si
  Gyeongsangnam-do 53261 (KR)
- **LEE, Sang Hwan**
  Geoje-si
  Gyeongsangnam-do 53261 (KR)
- **LEE, Tae Goo**
  Geoje-si
  Gyeongsangnam-do 53261 (KR)
- **LEE, Ho Jae**
  Geoje-si
  Gyeongsangnam-do 53261 (KR)
- **KIM, Dong Uk**
  Geoje-si
  Gyeongsangnam-do 53261 (KR)
- **CHO, Kyung Hyun**
  Geoje-si
  Gyeongsangnam-do 53261 (KR)

(74) Representative: **Taruttis, Tilman**
Keenway Patentanwälte Neumann
Heine Taruttis PartG mbB
Postfach 103363
40024 Düsseldorf (DE)

(56) References cited:

JP-A- 2008 239 060	**JP-A- 2008 239 060**
KR-A- 20100 103 982	**KR-A- 20100 103 982**
KR-A- 20120 094 763	**KR-A- 20120 094 763**
KR-A- 20120 126 910	**KR-A- 20120 126 910**
KR-A- 20160 032 475	**KR-A- 20160 032 475**
KR-A- 20160 058 370	**KR-A- 20160 058 370**

- **No further relevant documents disclosed**

EP 3 705 392 B1

Description

BACKGROUND

1. Technical Field

[0001] The present invention relates to an apparatus for improving propulsion efficiency.

2. Description of the Related Art

[0002] Recently, various technologies have been developed to reduce energy consumed in the operation of ships.

[0003] One example of energy saving technology is a duct disposed in front of a propeller.

[0004] The duct generates additional thrust as it passes through a flow moving backwards along a surface of a hull. In this case, the duct may be a factor to increase the propulsion efficiency.

[0005] However, because the duct acts as a resistance on the other side, it is also a factor to reduce the propulsion efficiency.

[0006] Document KR 2016 0058370 A discloses the preamble of claim 1.

SUMMARY

[0007] The present invention is intended to provide an apparatus for improving propulsion efficiency.

[0008] Aspects of the present invention provide an apparatus for improving propulsion efficiency, including: a duct disposed in front of a propeller, having an arc shape, and generating thrust; and a plurality of pre-swirl stators for supporting the duct to a stern boss, the plurality of pre-swirl stators generating a swirl flow in a direction opposite to a rotation direction of the propeller.

[0009] The duct has a camber having a convex shape in a direction toward the stern boss, and the plurality of pre-swirl stators have a camber having a convex shape in the rotation direction of the propeller.

[0010] The apparatus for improving the propulsion efficiency may further include a first connector for interconnecting a first end of the duct in the rotation direction of the propeller and a first outer stator positioned last in the rotation direction of the propeller among the plurality of pre-swirl stators; and a second connector for interconnecting a second end of the duct in the direction opposite to the rotation direction of the propeller and a second outer pre-swirl stator positioned last in the direction opposite to the rotation direction of the propeller among the plurality of pre-swirl stators, in which the first connector may have a shape in which the first end of the duct and the first outer pre-swirl stator, which have different camber shapes, are continuously connected, and in which the second connector may have a shape in which the second end of the duct and the second outer pre-swirl stator, which have the same camber shape, are continuously connected.

[0011] The duct may have an arc shape extending from a lower left area to an upper right area with respect to a centerline of an arc formed by the duct, and the plurality of pre-swirl stators may be disposed to be spaced apart from each other from the lower left area to the upper right area with respect to the centerline of the arc formed by the duct.

[0012] The propeller may rotate clockwise when viewed from the rear, and the number of the pre-swirl stators positioned in a port of a hull among the plurality of pre-swirl stators may be greater than the number of the pre-swirl stators positioned in a starboard.

[0013] The centerline of the arc formed by the duct may be positioned above a rotation axis of the propeller.

[0014] A distance between the centerline of the arc formed by the duct and the rotation axis of the propeller may be 0.1 times or more and 0.4 times or less of a radius of the propeller.

[0015] The duct may be positioned within a rotation area of the propeller.

[0016] Aspects of the present invention also provide an apparatus for improving propulsion efficiency, including: a plurality of pre-swirl stators supported to a stern boss in front of a propeller and generating a swirl flow in a direction opposite to a rotation direction of the propeller; a duct supported to ends of the plurality of pre-swirl stators, having an arc shape, and generating thrust; and a connector for interconnecting the duct and the pre-swirl stators.

[0017] The duct has a camber having a convex shape in a direction toward the stern boss, and the plurality of pre-swirl stators have a camber having a convex shape in the rotation direction of the propeller.

[0018] The connector may further include a first connector for interconnecting a first end of the duct in the rotation direction of the propeller and a first outer stator positioned last in the rotation direction of the propeller among the plurality of pre-swirl stators; and a second connector for interconnecting a second end of the duct in the direction opposite to the rotation direction of the propeller and a second outer pre-swirl stator positioned last in the direction opposite to the rotation direction of the propeller among the plurality of pre-swirl stators, in which the first connector may have a shape in which the first end of the duct and the first outer pre-swirl stator, which have different camber shapes, are continuously connected, and in which the second connector may have a shape in which the second end of the duct and the second outer pre-swirl stator, which have the same camber shape, are continuously connected.

[0019] The first connector and the second connector may be separately manufactured from the duct, the first outer pre-swirl stator, and the second outer pre-swirl stator, respectively, and be coupled to.

[0020] Aspects of the present invention also provide an apparatus for improving propulsion efficiency, including: a duct disposed in front of a propeller, having an arc shape, and generating thrust; and a plurality of pre-swirl stators for supporting the duct to a stern boss, the plurality of pre-swirl stators generating a swirl flow in a direction opposite to a rotation direction of the propeller, in which the duct may have a shape in which a length of cord changes from a first end in the rotation direction of the propeller to a second end in the direction opposite to the rotation direction of the propeller.

[0021] A first outer pre-swirl stator, which is positioned last in the rotation direction of the propeller among the plurality of pre-swirl stators, may have a shape in which a length of cord decreases from a root to a tip, the duct may have a shape in which the length of the cord increases and decreases from the first end in the rotation direction of the propeller to the second end in the direction opposite to the rotation direction of the propeller, and a second outer pre-swirl stator, which is positioned last in the direction opposite to the rotation direction of the propeller among the plurality of pre-swirl stators, may have a shape in which a length of cord decreases from a root to a tip.

[0022] It may further include: a first connector interposed between a first end of the duct in the rotation direction of the propeller and a first outer stator positioned last in the rotation direction of the propeller among the plurality of pre-swirl stators; and a second connector interposed between a second end of the duct in the direction opposite to the rotation direction of the propeller and a second outer pre-swirl stator positioned last in the direction opposite to the rotation direction of the propeller among the plurality of pre-swirl stators, in which the first connector may have a shape in which a length of cord decreases and increases from a tip of the first outer stator to the first end of the duct, and in which the second connector may have a shape in which a length of cord decreases and increases from a tip of the second outer stator to the second end of the duct.

[0023] In an exploded view of one surface facing outward of the duct, a curve formed by a leading edge of the duct may have a single curvature.

[0024] Aspects of the present invention also provide an apparatus for improving propulsion efficiency, including: a duct disposed in front of a propeller, having an arc shape, and generating thrust; and a plurality of pre-swirl stators for supporting the duct to a stern boss, the plurality of pre-swirl stators generating a swirl flow in a direction opposite to a rotation direction of the propeller, in which the plurality of pre-swirl stators are positioned at different positions in a longitudinal direction of a hull.

[0025] An inner pre-swirl stator positioned between a first outer pre-swirl stator positioned last in the rotation direction of the propeller and a second outer pre-swirl stator positioned last in the direction opposite to the rotation direction of the propeller, among the plurality of pre-swirl stators, is positioned in front of the first outer pre-swirl stator and the second outer pre-swirl stator.

[0026] The number of the inner pre-swirl stator may be one or more, in which a front end of a tip of the inner pre-swirl stator fixed to an inner side of the duct may be positioned behind a leading edge of the duct, and a rear end thereof may be positioned in front of a trailing edge of the duct.

[0027] The inner pre-swirl stator, the first outer pre-swirl stator, and the second outer pre-swirl stator may all have the same length of cord at a root and a tip, and a front-and-rear distance of the inner pre-swirl stator, the first outer pre-swirl stator, and the second outer pre-swirl stator may be 0.05 times or more and 0.15 times or less of a length of cord of a root of the inner pre-swirl stator.

[0028] However, aspects of the present invention are not restricted to those set forth herein. The above and other aspects of the present invention will become more apparent to one of ordinary skill in the art to which the present invention pertains by referencing the appended claims, which define the invention.

[0029] According to aspects of the present invention, a pre-swirl stator which generates a swirl flow in a direction opposite to a rotation direction of the propeller is used as a support for supporting a duct, thereby increasing a propeller thrust and improving the propulsion efficiency unlike the conventional method for supporting a duct using a general support structure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The above and other aspects and features of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings, in which:

FIG. 1 is a perspective view of a not claimed apparatus for improving propulsion efficiency, which is viewed from the left rear;

FIG. 2 is a perspective view of a propeller removed in FIG. 1;

FIG. 3 is a view of the apparatus for improving the propulsion efficiency, which is viewed from the rear;

FIG. 4 is a view of the apparatus for improving the propulsion efficiency, which is viewed from the left side;

FIG. 5 is a perspective view of the apparatus for improving the propulsion efficiency, which is viewed from the left rear, in which a cross-sectional shape is added to a duct and a pre-swirl stator;

FIG. 6 is a view the left side, in which the duct is omitted;

FIG. 7 is a view showing an exploded view of an outer surface of a combination of the duct, a first outer pre-swirl stator, and a second outer pre-swirl stator;

FIG. 8 is a perspective view of another apparatus for improving the propulsion efficiency, which is viewed from the left rear;

FIG. 9 is a perspective view of a propeller removed in FIG. 8;

FIG. 10 is a view of the another apparatus for improving the propulsion efficiency, which is viewed from the rear;

FIG. 11 is a view of the another apparatus for improving the propulsion efficiency, which is viewed from the left side;

FIG. 12 is a perspective view of the another apparatus for improving the propulsion efficiency, which is viewed from the left rear, in which a cross-sectional shape is added to a duct and a pre-swirl stator;

FIG. 13 is a view showing an exploded view of an outer surface of a combination of the duct, a first outer pre-swirl stator, and a second outer pre-swirl stator of the another apparatus for improving the propulsion efficiency;

FIG. 14 is a view of the apparatus for improving the propulsion efficiency according to the present invention, which is viewed from the left side;

FIG. 15 is a view of a duct removed in FIG. 14;

FIG. 16 is a perspective view of the apparatus for improving the propulsion efficiency according to the present invention, which is viewed from the left rear;

FIG. 17 is a perspective view of the apparatus for improving the propulsion efficiency according to the present invention, which is viewed from the rear, and FIG. 18 is a view of a propeller removed in FIG. 17; and

FIGS. 19 to 24 are views for explaining the effect of the apparatus for improving the propulsion efficiency.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0031] The present invention may add various transformations and may have various embodiments. Therefore, specific embodiments will be illustrated in the drawings and described in detail in the detailed description. However, this is not intended to limit the invention to specific embodiments. In describing the present invention, when it is determined that the detailed description of the related known technology may obscure the subject matter of the present invention, the detailed description thereof will be omitted.

[0032] Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings. In the description with reference to the accompanying drawings, the same or corresponding components will be given the same reference numerals, and redundant description thereof will be omitted.

[0033] FIG. 1 is a perspective view of an apparatus for improving propulsion efficiency, which is viewed from the left rear. FIG. 2 is a perspective view of a propeller removed in FIG. 1. FIG. 3 is a view of the apparatus for improving the propulsion efficiency, which is viewed from the rear. FIG. 4 is a view of the apparatus for improving the propulsion efficiency, which is viewed from the left side. It is noted that, in FIGS. 1 to 4, +X means the front, and +Y means the left direction.

[0034] Referring to FIGS. 1 to 4, the apparatus 100 for improving the propulsion efficiency includes a duct 110 and pre-swirl stators 131, 132, 133, and 134.

[0035] The duct 110 is disposed in front of a propeller 30. The propeller 30 is disposed behind a stern boss 20. The propeller 30 rotates to generate thrust. In this apparatus, the propeller 30 rotates clockwise as seen in FIGS. 1 to 3. In other words, the propeller 30 rotates clockwise when viewed from the rear.

[0036] The duct 110 has an arc shape.

[0037] For example, the duct 110 may have an arc shape extending from a lower left area to an upper right area with respect to a centerline A_D of an arc formed by the duct 110 as shown in FIGS. 1 to 3.

[0038] As another example, although not shown, the duct may have an arc shape extending from an upper left area to an upper right area with respect to the centerline of the arc formed by the duct.

[0039] An arc angle of the arc formed by the duct 110 is preferably less than 180 degrees.

[0040] The duct 110 has a structure that partially surrounds the stern boss 20.

[0041] The centerline A_D of the arc formed by the duct 110 may be positioned above a rotation axis A_P of the propeller 30 as shown in FIG. 4.

[0042] Here, a distance H between the centerline A_D of the arc formed by the duct 110 and the rotation axis A_P of the propeller 30 may be equal to or more than 0.4 times of a radius of the propeller 30. When the distance H between the centerline A_D of the arc formed by the duct 110 and the rotation axis A_P of the propeller 30 exceeds 0.4 times of the propeller 30, the range in which the pre-swirl stator may be installed may be significantly limited.

[0043] Further, the distance H between the centerline A_D of the arc formed by the duct 110 and the rotation axis A_P of the propeller 30 may be 0.1 times or more and 0.4 times or less of the radius of the propeller 30.

[0044] The duct 110 is positioned within a rotational area of the propeller 30. Here, a flow that passes through the duct 110 may flow into the propeller 30 in an aligned form, and the propulsion efficiency of the propeller 30 may be improved.

[0045] Here, a radius of the duct 110 is less than or equal to the radius of the propeller minus the distance between the centerline A_D of the arc of the duct 110 and the rotation axis A_P of the propeller 30.

[0046] The duct 110 generates thrust. For example, the duct 110 has an airfoil cross section and has a camber having a convex shape in a direction toward the stern boss 20. This will be described later.

[0047] A lifting force is generated in the cross section of the duct 110 while a flow moving backward along a hull 10 passes through the duct 110. A component parallel to a longitudinal direction of the hull 10 (e.g., X-axis direction) of the lifting force acts as thrust for pushing the hull 10.

[0048] The duct 110 may be supported by a stern of the hull 10 by a separate support member (not shown).

[0049] The pre-swirl stators 131, 132, 133, and 134 support the duct 110 with respect to the stern boss 20.

[0050] A plurality of pre-swirl stators 131, 132, 133, and 134 are provided.

[0051] For example, the number of the pre-swirl stators 131, 132, 133, and 134 may be four as shown in FIGS. 1 to 3.

[0052] As another example, the number of the pre-swirl stators may be three or five, although not shown.

[0053] The plurality of pre-swirl stators 131, 132, 133, and 134 are disposed to be spaced apart in the rotation direction of the propeller 30 as shown in FIGS. 1 to 3. In other words, the plurality of pre-swirl stators 131, 132, 133, and 134 may be spaced apart in an arc direction about the centerline A_D of the arc formed by the duct 110 as shown in FIGS. 2 and 3.

[0054] For example, the plurality of pre-swirl stators 131, 132, 133, and 134 may be disposed to be spaced apart from each other from the lower left area to the upper right area with respect to the centerline A_D of the arc formed by the duct 110 as shown in FIGS. 2 and 3.

[0055] As another example, although not illustrated, the plurality of pre-swirl stators may be disposed to be spaced apart from each other from the upper left area to the upper right area with respect to the centerline of the arc formed by the duct.

[0056] The plurality of pre-swirl stators 131, 132, 133, and 134 generate a swirl flow in a direction opposite to the rotation direction of the propeller 30.

[0057] The swirl flow by the pre-swirl stators 131, 132, 133, and 134 flows into the propeller 30 to improve the propulsion efficiency by reducing the swirl flow in the rotation direction of the propeller 30. In other words, when the swirl flow in the direction opposite to the rotation direction of the propeller 30 is generated by the pre-swirl stators 131, 132, 133, and 134, an angle of attack of a flow flowing into the propeller 30 is increased to increase the thrust generated in the propeller 30, thereby improving the propulsion efficiency.

[0058] FIG. 5 is a perspective view of the apparatus for improving the propulsion efficiency, which is viewed from the left rear, in which a cross-sectional shape is added to a duct and a pre-swirl stator.

[0059] Referring to FIG. 5, in the apparatus, the propeller (not shown) rotates clockwise when viewed from the rear. Here, in order to generate the swirl flow in the direction opposite to the rotation direction of the propeller (not shown), the plurality of pre-swirl stators 131, 132, 133, and 134 have the camber having a convex shape in the rotation direction of the propeller (not shown) as shown in FIG. 5.

[0060] The apparatus 100 for improving the propulsion efficiency as described above uses the pre-swirl stators 131, 132, 133, and 134 for generating the swirl flow in the direction opposite to the rotation direction of the propeller 30 as a support that supports the duct 110 for generating the thrust with respect to the stern boss 20.

[0061] In this regard, unlike the pre-swirl stators 131, 132, 133, and 134 according to this apparatus, a simple shaped support member is typically used to support the duct that is disposed in front of the propeller to generate the thrust. This simple shaped support member acts as a resistance, which is a factor in increasing the resistance of a ship.

[0062] However, the apparatus 100 for improving the propulsion uses the pre-swirl stators 131, 132, 133, and 134 to generate the swirl flow in the direction opposite to the rotation direction of the propeller 30 as the support for supporting the duct 110. Therefore, unlike the convention, it increases the thrust of the propeller 30 and improves the propulsion efficiency.

[0063] In this apparatus, the number of pre-swirl stators 132, 133, and 134 positioned at a port of the hull 10 among the plurality of pre-swirl stators 131, 132, 133, and 134 is larger than the number of the pre-swirl stators 131 positioned in a starboard.

[0064] More specifically, typically, looking into the distribution of wake into the propeller in a barehull state without the pre-swirl stator, in the port, the wake occurs in the same direction as the rotation direction of the propeller, and in the starboard, the wake occurs in the direction opposite to the rotation direction of the propeller.

[0065] In the port where the wake in the same direction as the rotation direction of the propeller 30 is generated, the pre-swirl stators 132, 133, and 134 may change an inflow flowing into the pre-swirl stators 132, 133, and 134 at a small pitch angle (attachment angle) in the direction opposite to the rotation direction of the propeller 30. However, in the starboard where the wake in the direction opposite to the rotation direction of the propeller 30 is generated, the inflow flowing into the pre-swirl stator 131 may be changed in the direction opposite to the rotation direction of the propeller 30 only when the pre-swirl stator 131 is installed at a larger pitch angle (attachment angle) than that of the port.

[0066] In this case, the increase in resistance due to the attachment of the pre-swirl stators 132, 133, 134 is small in the port that may generate the swirl flow in the direction opposite to the rotation direction of the propeller 30 at the small pitch angle. However, the increase in resistance due to the attachment of the pre-swirl stator 131 becomes excessive in the starboard that may generate the swirl flow in the direction opposite to the rotation direction of the propeller 30 only at the large pitch angle. Therefore, it is desirable to place more pre-swirl stators in the port than the starboard for high propulsion efficiency.

[0067] In this apparatus, a first outer end of the duct 110 in the rotation direction of the propeller 30 and a first outer pre-swirl stator 131 positioned last in the rotation direction of the propeller 30 among the plurality of pre-swirl stators 131, 132, 133, and 134 are connected to each other. As shown in FIG. 3, the first outer pre-swirl stator 131 may be positioned in the right upper area with respect to the centerline A_D of the arc formed by the duct 110.

[0068] A second outer end of the duct 110 in the rotation direction of the propeller 30 and a second outer pre-swirl stator 132 positioned last in the direction opposite to the rotation direction of the propeller 30 among the plurality of pre-swirl stators 131, 132, 133, and 134 are connected to each other. As shown in FIG. 3, the second outer pre-swirl stator 132 may be positioned in the lower left area with respect to the centerline A_D of the arc formed by the duct 110.

[0069] In this apparatus, the duct 110 and the first outer pre-swirl stator 131 are different in camber shape.

[0070] More specifically, the duct 110 has a camber having a convex shape toward the stern boss 20 as shown in FIG. 5, and the first outer pre-swirl stator 131 has a camber having a convex shape in the rotation direction of the propeller 30.

[0071] In other words, the duct 110 has the camber having the convex shape toward an inside of a space surrounded by the duct 110, the first outer pre-swirl stator 131, and the second outer pre-swirl stator 132. The first outer pre-swirl stator 131 has the camber having the convex shape toward an outside of a space surrounded by the duct 110, the first outer pre-swirl stator 131, and the second outer pre-swirl stator 132.

[0072] In this apparatus, as described above, the first end of the duct 110 and the first outer pre-swirl stator 131, which have different camber shapes, are continuously connected.

[0073] For example, as shown in FIG. 5, the first end of the duct 110 and the first outer pre-swirl stator 131, which have the cambers having the convex shape in opposite directions, have a shape that the camber gradually disappears toward its boundary.

[0074] In this apparatus, the duct 110 and the second outer pre-swirl stator 132 are identical in camber shape.

[0075] More specifically, the duct 110 has the camber having the convex shape toward the stern boss 20 as shown in FIG. 5, and the second outer pre-swirl stator 132 has the camber having the convex shape in the rotation direction of the propeller 30.

[0076] In other words, Both the duct 110 and the second outer pre-swirl stator 132 have the camber having the convex shape toward the inside of the space surrounded by the duct 110, the first outer pre-swirl stator 131, and the second outer pre-swirl stator 132.

[0077] In this apparatus, as described above, the second end of the duct 110 and the second outer pre-swirl stator 132, which have the same camber shape, are continuously connected.

[0078] FIG. 6 is a view showing a part according to the apparatus, which is viewed from the left side, in which the duct is omitted.

[0079] Referring to FIGS. 5 and 6, the first outer pre-swirl stator 131, the second outer pre-swirl stator 132, and the inner pre-swirl stators 133 and 134 may have a swept-back stator shape. Here, the first outer pre-swirl stator 131, the second outer pre-swirl stator 132, and the inner pre-swirl stator 133 and 134 have a shape in which a leading edge is struck rearward from a root to a tip.

[0080] In this apparatus, the plurality of pre-swirl stators 131, 132, 133, and 134 may each be disposed on the same plane where trailing edges are perpendicular to the centerline A_D of the arc formed by the duct 110. Here, the plurality of pre-swirl stators 131, 132, 133, and 134 may be as close as possible to the propellers (not shown), and the swirl flow in the direction opposite to the rotation direction of the propeller 30 generated by the pre-swirl stators 131, 132, 133, and 134 may flow directly into the propeller 30, thereby improving the propulsion efficiency.

[0081] In this apparatus, the first outer pre-swirl stator 131, the second outer pre-swirl stator 132, and the inner pre-swirl stator 133 and 134 may all have the same length of cord at the root. Further, the first outer pre-swirl stator 131, the second outer pre-swirl stator 132, and the inner pre-swirl stator 133 and 134 may all have the same length of cord at the tip. In addition, the first outer pre-swirl stator 131, the second outer pre-swirl stator 132, and the inner pre-swirl stator 133 and 134 may all have a length of cord at a root greater than a length of cord at a tip.

[0082] Referring to FIG. 5, in this apparatus, the tips of the inner pre-swirl stators 133 and 134 may be fixed to an inner surface of the duct 110.

[0083] Here, front ends of the tips of the inner pre-swirl stators 133 and 134 are positioned behind the leading edge of the duct 110, and rear ends of the tips of the inner pre-swirl stators 133 and 134 are positioned in front of the trailing edge of the duct 110.

[0084] In this case, circular rods constituting leading edges of the inner pre-swirl stators 133 and 134 may not interfere with a circular rod constituting the leading edge of the duct 110, and circular rods constituting trailing edges of the inner pre-swirl stators 133 and 134 may not interfere with a circular rod constituting the trailing edge of the duct 110, thereby improving the workability. It is noted that coupling an end of one rod to a side of another rod is much less workable than coupling an end of one rod to a surface of a plate.

[0085] FIG. 7 is a view showing an exploded view of an outer surface of a combination of the duct, a first outer pre-swirl stator, and a second outer pre-swirl stator according to the apparatus.

[0086] Referring to FIG. 7, in the exploded view, a trailing edge 110b of the duct 110 may have a straight shape, and a leading edge 110a of the duct 110 may have a curved shape that is convex forward.

[0087] In this case, the most convex peak portion in the exploded view of the duct 110 approaches the hull 10, so that the duct 110 is easily fixed to the hull 10.

[0088] More specifically, the duct 110 having the exploded view as shown in FIG. 7 has a structure in which the peak portion protrudes forward as shown in FIG. 4. Here, the peak portion is closer to the hull 10 so that a short support member (not shown) may support the duct 110 with respect to the hull 10. Since the short support member is structurally larger in strength than a long support member, the duct 110 may be stably supported with respect to the hull 10.

[0089] Referring to FIG. 7, in the exploded view, a curve formed by the leading edge 110a of the duct 110 may have a single curvature R. In this case, the duct 110 has a shape in which a length of the cord increases and decreases from a first end 110c to a second end 110d.

[0090] Typically, the duct has a structure in which plates constituting a pressure surface and a suction surface are coupled to a circular rod constituting the leading edge.

[0091] In the exploded view, in order to manufacture the duct 110 such that the curve formed by the leading edge 110a of the duct 110 has the single curvature R, the circular rod is bending processed to have one curvature. In this case, comparing to a case where the circular rod is bending processed to have two or more curvatures, the workability is greatly improved.

[0092] Referring to FIG. 7, the first outer pre-swirl stator 131 has a shape in which the length of the cord decreases from a root 131c to a tip 131d. The second outer pre-swirl stator 132 has a shape in which the length of the cord decreases from a root 132c to a tip 132d.

[0093] FIG. 8 is a perspective view of another apparatus for improving the propulsion efficiency, which is viewed from the left rear. FIG. 9 is a perspective view of a propeller removed in FIG. 8. FIG. 10 is a view of the another apparatus for improving the propulsion efficiency, which is viewed from the rear. FIG. 11 is a view of the another apparatus for improving the propulsion efficiency, which is viewed from the left side. FIG. 12 is a perspective view of the another apparatus for improving the propulsion efficiency, which is viewed from the left rear, in which a cross-sectional shape is added to a duct and a pre-swirl stator. It is noted that, in FIGS. 8 to 12, +X means the front, and +Y means the left direction.

[0094] Referring to FIGS. 8 to 12, the another apparatus 100' for improving propulsion efficiency may include the duct 110, the pre-swirl stators 131, 132, 133, and 134, a first connector 150, and a second connector 160. The another apparatus 100' for improving propulsion efficiency differs from the apparatus 100 for improving the propulsion efficiency as described above in that it further includes the first connector 150 and the second connector 160.

[0095] The first connector 150 interconnects the first outer end of the duct 110 in the rotation direction of the propeller 30 and the first outer pre-swirl stator 131 positioned last in the rotation direction of the propeller 30 among the plurality of pre-swirl stators 131, 132, 133, and 134.

[0096] The first connector 150 may be manufactured separately from the duct 110 and the first outer pre-swirl stator 131, and both ends of the first connector 150 may be coupled to the first outer pre-swirl stator 131 and the first end of the duct 110, respectively.

[0097] The second connector 160 interconnects the second outer end of the duct 110 in the rotation direction of the propeller 30 and the second outer pre-swirl stator 132 positioned last in the direction opposite to the rotation direction of the propeller 30 among the plurality of pre-swirl stators 131, 132, 133, and 134.

[0098] The second connector 160 may be manufactured separately from the duct 110 and the second outer pre-swirl stator 132, and both ends of the second connector 160 may be coupled to the second outer pre-swirl stator 132 and the second end of the duct 110, respectively.

[0099] In this apparatus, the duct 110 and the first outer pre-swirl stator 131 are different in camber shape.

[0100] More specifically, the duct 110 has a camber having a convex shape toward the stern boss 20 as shown in FIG. 5, and the first outer pre-swirl stator 131 has a camber having a convex shape in the rotation direction of the propeller 30.

[0101] In other words, the duct 110 has the camber having the convex shape toward an inside of a space surrounded by the duct 110, the first outer pre-swirl stator 131, and the second outer pre-swirl stator 132. The first outer pre-swirl stator 131 has the camber having the convex shape toward an outside of a space surrounded by the duct 110, the first outer pre-swirl stator 131, and the second outer pre-swirl stator 132.

[0102] The first connector 150 according to this apparatus has a shape in which the first end of the duct 110 and the first outer pre-swirl stator 131, which have different camber shapes as described above, are continuously connected.

[0103] For example, the first connector 150 includes a first area 151 with the camber having the convex shape in the same direction as the camber of the duct 110 as shown FIG. 5, and a second area 152 with the camber having the convex shape in the same direction as the camber of the first outer pre-swirl stator 131. The cambers of the first area 151 and the second area 152 gradually disappear as they approach the boundary between the first area 151 and the second area 152, respectively.

[0104] In this embodiment, the duct 110 and the second outer pre-swirl stator 132 are identical in camber shape.

[0105] More specifically, the duct 110 has the camber having the convex shape toward the stern boss 20 as shown in FIG. 5, and the second outer pre-swirl stator 132 has the camber having the convex shape in the rotation direction of the propeller 30.

[0106] In other words, Both the duct 110 and the second outer pre-swirl stator 132 have the camber having the convex shape toward the inside of the space surrounded by the duct 110, the first outer pre-swirl stator 131, and the second outer pre-swirl stator 132.

[0107] The second connector 160 according to this apparatus has a shape in which the second end of the duct 110 and the second outer pre-swirl stator 132, which have the same camber shape, are continuously connected.

[0108] For example, as shown in FIG. 5, the second connector 160 has a camber having a convex shape toward an inside of the space surrounded by the duct 110, the first outer pre-swirl stator 131, and the second outer pre-swirl stator 160.

[0109] FIG. 13 is a view showing an exploded view of an outer surface of a combination of the duct, a first outer pre-swirl stator, and a second outer pre-swirl stator according to the another apparatus.

[0110] Referring to FIG. 13, in the exploded view, a trailing edge 110b of the duct 110 may have a straight shape, and a leading edge 110a of the duct 110 may have a curved shape that is convex forward.

[0111] In this case, the most convex peak portion in the exploded view of the duct 110 approaches the hull 10, so that the duct 110 is easily fixed to the hull 10.

[0112] Referring to FIG. 13, in the exploded view, a curve formed by the leading edge 110a of the duct 110 may have a single curvature. In this case, the duct 110 has a shape in which a length of the cord increases and decreases from a first end 110c to a second end 110d.

[0113] Referring to FIG. 13, the first outer pre-swirl stator 131 has a shape in which the length of the cord decreases from the root 131c to the tip 131d. The second outer pre-swirl stator 132 has a shape in which the length of the cord decreases from the root 132c to the tip 132d.

[0114] Further, the first connector 150 has a shape in which the length of the cord decreases and increases from the tip 131d of the first outer pre-swirl stator 131 to the first end 110c of the duct 110. In particular, a portion where the length of the cord decreases and increases in the first connector 150 becomes the shortest cord 153 in the first connector 150. The shortest code 153 of the first connector 150 corresponds to the boundary between the first area (151 of FIG. 10) and the second area (152 of FIG. 10). The second connector 160 may have a shape in which a length of cord decreases and increases from a tip 132d of the second outer pre-swirl stator 132 to a second end 110d of the duct 110.

[0115] Reference numerals 131a, 150a, 110a, 160a, and 132a denote leading edges, and reference numerals 131b, 150b, 110b, 160b and 132b denote trailing edges.

[0116] FIG. 14 is a view of the apparatus for improving the propulsion efficiency according to an embodiment of the present invention, which is viewed from the left side. FIG. 15 is a view of a duct removed in FIG. 14. FIG. 16 is a perspective view of the apparatus for improving the propulsion efficiency according to the embodiment of the present invention, which is viewed from the left rear.

[0117] Referring to FIGS. 14 to 16, an apparatus 100" for improving propulsion efficiency according to the embodiment of the present invention includes the duct 110, the plurality of pre-swirl stators 131, 132, 133, and 134, the first connector 150, and the second connector 160.

[0118] The apparatus 100" for improving the propulsion efficiency according to the embodiment of the present invention differs from the apparatus 100 for improving the propulsion efficiency in the front and rear positions of the plurality of pre-swirl stators 131, 132, 133, and 134.

[0119] In this embodiment, the inner pre-swirl stators 133 and 134 are positioned in front of the first outer pre-swirl stator 131 and the second outer pre-swirl stator 132.

[0120] Here, the front ends of the tips of the inner pre-swirl stators 133 and 134 are also positioned behind the leading edge of the duct 110, and the rear ends of the tips of the inner pre-swirl stators 133 and 134 are also positioned in front of the trailing edge of the duct 110.

[0121] In this embodiment, a front-and-rear distance L of the inner pre-swirl stators 133 and 134, the first outer pre-swirl stator 131, and the second outer pre-swirl stator 132 may be 0.05 times or more and 0.15 times or less of a length of cord of a root of the inner pre-swirl stator 133 and 134 or the first outer pre-swirl stator 131 or the second outer pre-swirl stator 132. It is noted that, in this embodiment, lengths of cord of the roots of the inner pre-swirl stators 133 and 134, the first outer pre-swirl stator 131, and the second outer pre-swirl stator 132 are all the same.

[0122] As described above, when the inner pre-swirl stators 133 and 134 are positioned in front of the first outer pre-swirl stator 131 and the second outer pre-swirl stator 132, the resistance acting on the hull 10 is reduced compared to a case where the pre-swirl stators 131, 132, 133, and 134 are all positioned at the same position in a longitudinal direction of the hull 10.

[0123] This is because the inner pre-swirl stators 133 and 134 are positioned to be separated from the first outer pre-swirl stator 131 and the second outer pre-swirl stator 132 by a predetermined distance L, such that the Venturi effect generated among the inner pre-swirl stators 133 and 134, the first outer pre-swirl stator 131, and the second outer pre-swirl stator 132 are weakened, thereby reducing the resistance applied to the hull 10.

[0124] When the front-and-rear distance of the inner pre-swirl stators 133 and 134, the first outer pre-swirl stator 131, and the second outer pre-swirl stator 132 exceed the range, a distance between the inner pre-swirl stators 133 and 134 and the propeller (not shown) is increased so that a flow induced by the inner pre-swirl stators 133 and 134 may not sufficiently flow into the propeller (not shown), thereby decreasing the propulsion efficiency.

[0125] When the front-and-rear distance of the inner pre-swirl stators 133 and 134, and the first outer pre-swirl stator 131, and the second outer pre-swirl stator 132 are smaller than the range, the resistance to the hull 10 may increase due to the Venturi effect generated among the inner pre-swirl stators 133 and 134, the first outer pre-swirl stator 131, and the second outer pre-swirl stator 132.

[0126] FIG. 17 is a perspective view of the apparatus for improving the propulsion efficiency according to the embodiment of the present invention, which is viewed from the rear, and FIG. 18 is a view of a propeller removed in FIG. 17.

[0127] Referring to FIGS. 17 and 18, an apparatus 100a for improving propulsion efficiency according to the embodiment of the present invention includes the duct 110 and the plurality of pre-swirl stators 131, 132, 133, and 134.

[0128] As described using FIG. 7, in an exploded view of the duct 110, the trailing edge 110b of the duct 110 may have a straight shape, and the leading edge 110a of the duct 110 may have a curved shape that is convex forward. The duct 110 has a structure in which a peak portion protrudes forward as shown in FIG. 4. Here, the peak portion is closer to the hull 10 so that a short support member (not shown) may support the duct 110 with respect to the hull 10. Since the short support member is structurally larger in strength than a long support member, the duct 110 may be stably supported with respect to the hull 10. Unlike those described in FIGS. 8 to 16, the separate connectors 150 and 160 may not be included.

[0129] As described in FIGS. 14 to 16, the inner pre-swirl stators 133 and 134 are positioned in front of the first outer pre-swirl stator 131 and the second outer pre-swirl stator 132.

[0130] The front ends of the tips of the inner pre-swirl stators 133 and 134 are also positioned behind the leading edge of the duct 110, and the rear ends of the tips of the inner pre-swirl stators 133 and 134 are positioned in front of the trailing edge of the duct 110.

[0131] As described above, when the inner pre-swirl stators 133 and 134 are positioned in front of the first outer pre-swirl stator 131 and the second outer pre-swirl stator 132, the resistance acting on the hull 10 is reduced compared to a case where the pre-swirl stators 131, 132, 133, and 134 are all positioned at the same position in a longitudinal direction of the hull 10.

[0132] Hereinafter, referring to FIGS. 19 to 22, the fuel saving effect of the apparatuses 100, 100', 100", and 100a for improving the propulsion efficiency will be described in more detail.

[0133] First, FIG. 19 is a case in which only the plurality of pre-swirl stators (see 131, 132, 133, and 134 of FIGS. 1 to 18) is installed in front of the propeller. FIG. 20 is a case in which the plurality of pre-swirl stators and a circular duct (i.e., full duct) are installed in front of the propeller. The circular duct is shaped so as to surround the pre-swirl stator in a circle. FIG. 21 is a case in which the plurality of pre-swirl stators and a partial duct are installed in front of the propeller, such as the apparatuses for improving the propulsion efficiency.

[0134] The case in which only the pre-swirl stators are installed (FIG. 19), the case in which the pre-swirl stators and the circular duct are installed (FIG. 20), and the case in which the pre-swirl stators and the partial duct are installed (FIG. 21) are compared with a case in which only the propeller is installed (i.e., a case to be compared). Then, the fuel savings effect was tested and the results are shown in FIG. 22. In FIG. 22, a stator denotes a pre-swirl stator, a full duct denotes a circular duct, and a partial duct denotes a partial duct.

[0135] Referring to FIG. 22, the case in which only the pre-swirl stators are installed (FIG. 19) had a 2.0% fuel saving effect compared to the case to be compared. The case in which the pre-swirl stators and the circular duct are installed (FIG. 20) had a 1.0% fuel saving effect compared to the case to be compared. The case in which the pre-swirl stators and the partial duct are installed (FIG. 21) had a 3.0% fuel saving effect compared to the case to be compared.

[0136] In order to confirm why the fuel saving effect of the case in which the pre-swirl stators and the circular ducts are installed (FIG. 20) is relatively low compared to other cases, additional tests were made and the results are shown in FIGS. 23 and 24.

[0137] Comparing FIGS. 23 and 24, it may be seen from FIG. 23 that the hull pressure drop occurs between under the stern boss and the circular duct (see D1). On the other hand, in FIG. 24, it may be seen that the hull pressure drop does not occur under the stern boss (see D2). When the hull pressure drop occurs, this causes a negative pressure at a lower part of the hull, which increases the hull resistance. Therefore, the fuel saving effect is lowered.

[0138] Compared to the case in which only the pre-swirl stators are installed (FIG. 19), the reason why the fuel saving effect of the case in which the pre-swirl stator and the partial duct are installed (FIG. 21) is good is as follows.

[0139] In the case using the duct (FIG. 21), all pre-swirl stators are connected to the partial duct in a multipoint support structure (i.e., a multiple support). Therefore, the case using the partial duct (FIG. 21) has a higher structural stability than the case in which only the cantilever type pre-swirl stators are installed (FIG. 19).

[0140] In addition, in the pre-swirl stator which generates the swirl flow, cavitation due to end vortex may occur. Therefore, in the case in which only the pre-swirl stators are installed (FIG. 19), an additional shape such as a winglet should be mounted in order to reduce the cavitation of ends. However, since the case using the partial duct (FIG. 21) has a shape in which all the pre-swirl stators are surrounded by the partial duct, the end vortex is essentially blocked. Therefore, no additional device such as the winglet is needed.

[0141] In the above, an embodiment of the present invention has been described. However, those skilled in the art may variously modify and change the present invention by adding, changing, deleting, or adding components within the scope defined by the claims.

Reference Numeral

[0142]

10: hull
20: stern boss
30: propeller
100: apparatus for improving propulsion efficiency
110: duct
131: first outer pre-swirl stator
132: second outer pre-swirl stator
133, 134: inner pre-swirl stator
150: first connector
160: second connector

Claims

1. An apparatus (100) for improving propulsion efficiency, comprising:

   a duct (110) configured to be disposed in front of a propeller (30), having an arc shape, and generating thrust; and
   a plurality of pre-swirl stators (131-134) for supporting the duct (110) configured to be fixed to a stern boss (20), the plurality of pre-swirl stators (131-134) generating a swirl flow in a direction opposite to a rotation direction of the propeller (30),
   wherein
   the duct (110) has a camber of convex shape toward the stern boss (20), and
   the plurality of pre-swirl stators (131-134) have a camber having a convex shape in the rotation direction of the propeller (30), wherein the first outer pre-swirl stator (131) is positioned last in the rotation direction of the propeller (30) among the plurality of pre-swirl stators (131-134),
   characterized in that the camber of the duct (110) and the camber of the first outer pre-swirl stator (131) gradually disappear towards the boundary of the duct (110) and the first pre-swirl stator (131),
   wherein the duct (110) and the first outer swirl stator (131) are different in camber shape, and wherein when the duct (110) and the plurality of pre-swirl stators (131-134) are viewed from the side, the contact part between inner pre-swirl stators (133-134) and the stern boss (20) is exposed to the outside in front of the duct (110).

2. The apparatus (100) of claim 1, further comprising:

   a first connector (150 for interconnecting a first end (110c) of the duct (110) in the rotation direction of the propeller (30) and a first outer pre-swirl stator (131) positioned last in the rotation direction of the propeller (30) among the plurality of pre-swirl stators (131-134); and
   a second connector (160) for interconnecting a second end (110d) of the duct (110) in the direction opposite to the rotation direction of the propeller (30) and a second outer pre-swirl stator (132) positioned last in the direction opposite to the rotation direction of the propeller (30) among the plurality of pre-swirl stators (131-134),
   wherein the first connector (150) has a shape in which the first end (110c) of the duct (110) and the first outer pre-swirl stator (131), which have different camber shapes, are continuously connected, and
   wherein the second connector (160) has a shape in which the second end (110d) of the duct (110) and the second outer pre-swirl stator (132), which have the same camber shape, are continuously connected.

3. The apparatus (100) of claim 1, wherein the duct (110) has an arc shape extending from a lower left area to an upper right area with respect to a centerline of an arc formed by the duct (110), and
   wherein the plurality of pre-swirl stators (131-134) are disposed to be spaced apart from each other from the lower left area to the upper right area with respect to the centerline of the arc formed by the duct (110).

4. The apparatus (100) of claim 1, wherein the propeller (30) rotates clockwise when viewed from the rear, and
   wherein the number of the pre-swirl stators (131-134) positioned in a port of a hull (10) among the plurality of pre-swirl stators (131-134) is greater than the number of the pre-swirl stators (131-134) positioned in a starboard.

5. The apparatus (100) of claim 1, wherein a centerline of an arc formed by the duct (110) is positioned above a rotation axis of the propeller (30).

6. The apparatus (100) of claim 1, wherein a distance between a centerline of an arc formed by the duct (110) and a rotation axis of the propeller (30) is 0.1 times or more and 0.4 times or less of a radius of the propeller (30).

7. The apparatus (100) of claim 1, wherein the duct (110) is positioned within a rotation area of the propeller (30).

8. The apparatus (100) of claim 1, further comprising:

a connector for interconnecting the duct (110) and the pre-swirl stators (131-134).

9. The apparatus (100) of claim 8, wherein the duct (110) has a camber having a convex shape in a direction toward the stern boss (20), and
wherein the plurality of pre-swirl stators (131-134) have a camber having a convex shape in the rotation direction of the propeller (30).

10. The apparatus (100) of claim 9, wherein the connector further comprises:

a first connector (150) for interconnecting a first end (110c) of the duct (110) in the rotation direction of the propeller (30) and a first outer pre-swirl stator (131) positioned last in the rotation direction of the propeller (30) among the plurality of pre-swirl stators (131-134); and
a second connector (160) for interconnecting a second end (110d) of the duct (110) in the direction opposite to the rotation direction of the propeller (30) and a second outer pre-swirl stator (132) positioned last in the direction opposite to the rotation direction of the propeller (30) among the plurality of pre-swirl stators (131-134),
wherein the first connector (150) has a shape in which the first end (110c) of the duct (110) and the first outer pre-swirl stator (131), which have different camber shapes, are continuously connected, and
wherein the second connector (160) has a shape in which the second end (110d) of the duct (110) and the second outer pre-swirl stator (132), which have the same camber shape, are continuously connected.

11. The apparatus (100) of claim 10, wherein the first connector (150) and the second connector (160) are separately manufactured from the duct (110), the first outer pre-swirl stator (131), and the second outer pre-swirl stator (132), respectively, and are coupled to the duct (110).

12. The apparatus (100) of claim 1, further comprising: wherein the plurality of pre-swirl stators (131-134) are positioned at different positions in a longitudinal direction of a hull (10).

13. The apparatus (100) of claim 12, wherein an inner pre-swirl stator (133-134) positioned between a first outer pre-swirl stator (131) positioned last in the rotation direction of the propeller (30) and a second outer pre-swirl stator (132) positioned last in the direction opposite to the rotation direction of the propeller (30), among the plurality of pre-swirl stators (131-134), is positioned in front of the first outer pre-swirl stator (131) and the second outer pre-swirl stator (132).

14. The apparatus (100) of claim 13, wherein the number of the inner pre-swirl stators (133-134) is one or more, and
wherein a front end of a tip of the inner pre-swirl stator (133-134) fixed to an inner side of the duct (110) is positioned behind a leading edge (110a) of the duct (110), and a rear end thereof is positioned in front of a trailing edge (110b) of the duct (110).

15. The apparatus (100) of claim 13, wherein the inner pre-swirl stator (133-134), the first outer pre-swirl stator (131), and the second outer pre-swirl stator (132) all have the same length of cord at a root and a tip, and
wherein a front-and-rear distance of the inner pre-swirl stator (133-134), the first outer pre-swirl stator (131), and the second outer pre-swirl (132) stator is 0.05 times or more and 0.15 times or less of a length of cord of a root of the inner pre-swirl stator (133-134).

Patentansprüche

1. Einrichtung (100) zur Verbesserung der Antriebseffizienz, umfassend:

eine Führung (110), die so konfiguriert ist, dass sie vor einem Propeller (30) angeordnet ist, eine Bogenform aufweist und Schub erzeugt; und
eine Vielzahl von Vordrallstatoren (131-134) zum Stützen der Führung (110), die so konfiguriert sind, dass sie an einem Heckauge (20) befestigt werden, wobei die Vielzahl von Vordrallstatoren (131-134) eine Wirbelströmung in einer Richtung erzeugen, die der Drehrichtung des Propellers (30) entgegengesetzt ist,
wobei die Führung(110) eine konvexe Wölbung in Richtung des Heckauges (20) aufweist, und die Vielzahl von Vordrallstatoren (131-134) eine Wölbung mit einer konvexen Form in der Drehrichtung des Propellers (30) aufweist, wobei der erste äußere Vordrallstator (131) in der Vielzahl von Vordrallstatoren (131-134) in der Drehrichtung des Propellers (30) zuletzt positioniert ist,
dadurch gekennzeichnet, dass die Wölbung der Führung (110) und die Wölbung des ersten äußeren Vordrallstators (131) allmählich zur Grenze des Kanals (110) und des ersten Vordrallstators (131) hin verschwinden,
wobei die Führung (110) und der erste äußere Vordrallstator (131) eine unterschiedliche Wölbungsform aufweisen, und
wobei, wenn die Führung (110) und die Vielzahl von Vordrallstatoren (131-134) von der Seite

betrachtet werden, der Kontaktteil zwischen inneren Vordrallstatoren (133-134) und dem Heckauge (20) vor der Führung (110) nach außen freiliegt.

2. Einrichtung (100) nach Anspruch 1, ferner umfassend:

einen ersten Verbinder (150) zum Verbinden eines ersten Endes (110c) der Führung (110) in Drehrichtung des Propellers (30) und eines ersten äußeren Vordrallstators (131), der in Drehrichtung des Propellers (30) in der Vielzahl von Vordrallstatoren (131-134) zuletzt positioniert ist; und
einen zweiten Verbinder (160) zum Verbinden eines zweiten Endes (110d) der Führung (110) in der der Drehrichtung des Propellers (30) entgegengesetzten Richtung mit einem zweiten äußeren Vordrallstator (132), der unter den mehreren Vordrallstatoren (131-134) als letzter in der der Drehrichtung des Propellers (30) entgegengesetzten Richtung positioniert ist,
wobei der erste Verbinder (150) eine Form aufweist, bei der das erste Ende (110c) der Führung (110) und der erste äußere Vordrallstator (131), die unterschiedliche Wölbungsformen aufweisen, kontinuierlich verbunden sind, und
wobei der zweite Verbinder (160) eine Form aufweist, bei der das zweite Ende (110d) der Führung (110) und der zweite äußere Vordrallstator (132), die die gleiche Wölbungsform aufweisen, durchgehend verbunden sind.

3. Einrichtung (100) nach Anspruch 1, wobei die Führung (110) eine Bogenform aufweist, die sich von einem unteren linken Bereich zu einem oberen rechten Bereich in Bezug auf eine Mittellinie eines durch die Führung (110) gebildeten Bogens erstreckt, und wobei die Vielzahl von Vordrallstatoren (131-134) so angeordnet sind, dass sie in Bezug auf die Mittellinie des durch die Führung (110) gebildeten Bogens vom unteren linken Bereich bis zum oberen rechten Bereich voneinander beabstandet sind.

4. Einrichtung (100) nach Anspruch 1, wobei sich der Propeller (30) von hinten betrachtet im Uhrzeigersinn dreht, und
wobei die Anzahl der an einer Backbordseite eines Rumpfs (10) positionierten Vordrallstatoren (131-134) unter der Vielzahl von Vordrallstatoren (131-134) größer ist als die Anzahl der an Steuerbord positionierten Vordrallstatoren (131-134).

5. Vorrichtung (100) nach Anspruch 1, wobei eine Mittellinie eines durch die Führung (110) gebildeten Bogens über einer Drehachse des Propellers (30) positioniert ist.

6. Einrichtung (100) nach Anspruch 1, wobei ein Abstand zwischen einer Mittellinie eines durch die Führung (110) gebildeten Bogens und einer Drehachse des Propellers (30) das 0,1-Fache oder mehr und das 0,4-Fache oder weniger eines Radius des Propellers (30) beträgt.

7. Einrichtung (100) nach Anspruch 1, wobei die Führung (110) innerhalb eines Drehbereichs des Propellers (30) positioniert ist.

8. Einrichtung (100) nach Anspruch 1, ferner umfassend:
ein Verbindungsstück zum Verbinden der Führung(110) und der Vordrallstatoren (131-134).

9. Einrichtung (100) nach Anspruch 8, wobei die Führung (110) eine Wölbung mit einer konvexen Form in Richtung des Heckauges (20) aufweist, und
wobei die Vielzahl von Vordrallstatoren (131-134) eine Wölbung mit einer konvexen Form in der Drehrichtung des Propellers (30) aufweisen.

10. Einrichtung (100) nach Anspruch 9, wobei der Verbinder ferner umfasst:

einen ersten Verbinder (150) zum Verbinden eines ersten Endes (110c) der Führung (110) in Drehrichtung des Propellers (30) und eines ersten äußeren Vordrallstators (131), der in Drehrichtung des Propellers (30) in der Vielzahl von Vordrallstatoren (131-134) zuletzt positioniert ist; und
einen zweiten Verbinder (160) zum Verbinden eines zweiten Endes (110d) der Führung (110) in der der Drehrichtung des Propellers (30) entgegengesetzten Richtung mit einem zweiten äußeren Vordrallstator (132), der in der Vielzahl von Vordrallstatoren (131-134) als letzter in der der Drehrichtung des Propellers (30) entgegengesetzten Richtung positioniert ist,
wobei der erste Verbinder (150) eine Form aufweist, bei der das erste Ende (110c) der Führung (110) und der erste äußere Vordrallstator (131), die unterschiedliche Wölbungsformen aufweisen, durchgehend verbunden sind, und
wobei der zweite Verbinder (160) eine Form aufweist, bei der das zweite Ende (110d) der Führung (110) und der zweite äußere Vordrallstator (132), die die gleiche Wölbungsform aufweisen, durchgehend verbunden sind.

11. Einrichtung (100) nach Anspruch 10, wobei der erste Verbinder (150) und der zweite Verbinder (160) jeweils separat von der Führungl (110), dem ersten äußeren Vordrallstator (131) und dem zweiten äußeren Vordrallstator (132) hergestellt und mit der Führung (110) verbunden sind.

12. Einrichtung (100) nach Anspruch 1, ferner umfassend:
wobei die Vielzahl von Vordrallstatoren (131-134) an unterschiedlichen Positionen in einer Längsrichtung eines Rumpfs (10) positioniert ist.

13. Einrichtung (100) nach Anspruch 12, wobei ein innerer Vordrallstator (133-134), der zwischen einem ersten äußeren Vordrallstator (131), der in der Drehrichtung des Propellers (30) zuletzt positioniert ist, und einem zweiten äußeren Vordrallstator (132), der in der entgegengesetzten Richtung zur Drehrichtung des Propellers (30) zuletzt positioniert ist, unter der Vielzahl von Vordrallstatoren (131-134) vor dem ersten äußeren Vordrallstator (131) und dem zweiten äußeren Vordrallstator (132) positioniert ist.

14. Einrichtung (100) nach Anspruch 13, wobei die Anzahl der inneren Vordrallstatoren (133-134) eins oder mehr beträgt, und
wobei ein vorderes Ende einer Spitze des inneren Vordrallstators (133-134), der an einer Innenseite der Führung(110) befestigt ist, hinter einer Vorderkante (110a) des Kanals (110) positioniert ist und ein hinteres Ende davon vor einer Hinterkante (110b) der Führung (110) positioniert ist.

15. Einrichtung (100) nach Anspruch 13, wobei der innere Vordrallstator (133-134), der erste äußere Vordrallstator (131) und der zweite äußere Vordrallstator (132) alle die gleiche Schnurlänge an einer Wurzel und einer Spitze aufweisen, und
wobei ein Vorder- und Hinterabstand des inneren Vordrallstators (133-134), des ersten äußeren Vordrallstators (131) und des zweiten äußeren Vordrallstators (132) das 0,05-Fache oder mehr und das 0,15-Fache oder weniger einer Schnurlänge einer Wurzel des inneren Vordrallstators (133-134) beträgt.

Revendications

1. Appareil (100) destiné à améliorer l'efficacité de propulsion, comprenant :

un conduit (110) conçu pour être disposé devant une hélice (30), ayant une forme d'arc et générant une poussée ; et
une pluralité de stators pré-tourbillonnaires (131-134) pour soutenir le conduit (110) conçu pour être fixé à un bossage de poupe (20), la pluralité de stators pré-tourbillonnaires (131-134) générant un flux tourbillonnaire dans une direction opposée à une direction de rotation de l'hélice (30),
dans lequel le conduit (110) présente une cambrure de forme convexe vers le bossage arrière (20), et
la pluralité de stators pré-tourbillonnaires (131-134) ont une cambrure de forme convexe dans le sens de rotation de l'hélice (30), dans lequel le premier stator pré-tourbillonnaire extérieur (131) est positionné en dernier dans le sens de rotation de l'hélice (30) parmi la pluralité de stators pré-tourbillonnaires (131-134),
caractérisé en ce que la cambrure du conduit (110) et la cambrure du premier stator pré-tourbillonnaire externe (131) disparaissent progressivement vers la limite du conduit (110) et du premier stator pré-tourbillonnaire (131),
dans lequel le conduit (110) et le premier stator pré-tourbillonnaire extérieur (131) ont une forme de cambrure différente, et
lorsque le conduit (110) et la pluralité de stators de pré-tourbillon (131-134) sont vus de côté, la partie de contact entre les stators de pré-tourbillon intérieurs (133-134) et le bossage arrière (20) est exposée à l'extérieur à l'avant du conduit (110).

2. Dispositif (100) selon la revendication 1, comprenant en outre :

un premier connecteur (150) pour interconnecter une première extrémité (110c) du conduit (110) dans le sens de rotation de l'hélice (30) et un premier stator pré-tourbillonnaire extérieur (131) positionné en dernier dans le sens de rotation de l'hélice (30) parmi la pluralité de stators pré-tourbillonnaires (131-134) ; et
un second connecteur (160) pour interconnecter une seconde extrémité (110d) du conduit (110) dans le sens opposé au sens de rotation de l'hélice (30) et un second stator pré-tourbillonnaire extérieur (132) positionné en dernier dans le sens opposé au sens de rotation de l'hélice (30) parmi la pluralité de stators pré-tourbillonnaires (131-134),
dans lequel le premier connecteur (150) a une forme dans laquelle la première extrémité (110c) du conduit (110) et le premier stator pré-tourbillonnaire extérieur (131), qui ont des formes de cambrure différentes, sont reliés de manière continue, et
dans lequel le second connecteur (160) a une forme dans laquelle la seconde extrémité (110d) du conduit (110) et le second stator pré-tourbillonnaire externe (132), qui ont la même forme de cambrure, sont reliés de manière continue.

3. Appareil (100) selon la revendication 1, dans lequel le conduit (110) a une forme d'arc s'étendant d'une zone inférieure gauche à une zone supérieure droite par rapport à une ligne centrale d'un arc formé par le conduit (110), et dans lequel la pluralité de stators pré-tourbillonnaires (131-134) sont disposés de manière à être espacés les uns des autres de la zone inférieure gauche à la zone supérieure droite par rapport à l'axe central de l'arc formé par le conduit (110).

4. Appareil (100) selon la revendication 1, dans lequel l'hélice (30) tourne dans le sens des aiguilles d'une montre lorsqu'elle est vue de l'arrière, et
dans lequel le nombre de stators de pré-tourbillon (131-134) positionnés dans un port d'une coque (10) parmi la pluralité de stators de pré-tourbillon (131-134) est supérieur au nombre de stators de pré-tourbillon (131-134) positionnés dans un tribord.

5. Appareil (100) selon la revendication 1, dans lequel l'axe central d'un arc formé par le conduit (110) est positionné au-dessus d'un axe de rotation de l'hélice (30).

6. Appareil (100) selon la revendication 1, dans lequel une distance entre une ligne centrale d'un arc formé par le conduit (110) et un axe de rotation de l'hélice (30) est 0,1 fois ou plus et 0,4 fois ou moins d'un rayon de l'hélice (30).

7. Appareil (100) selon la revendication 1, dans lequel le conduit (110) est positionné dans une zone de rotation de l'hélice (30).

8. Dispositif (100) selon la revendication 1, comprenant en outre :
un connecteur pour interconnecter le conduit (110) et les stators pré-tourbillonnaires (131-134).

9. Appareil (100) selon la revendication 8, dans lequel le conduit (110) présente une cambrure de forme convexe en direction du bossage arrière (20), et
dans lequel la pluralité de stators pré-tourbillonnaires (131-134) ont une cambrure de forme convexe dans le sens de rotation de l'hélice (30).

10. Appareil (100) selon la revendication 9, dans lequel le connecteur comprend en outre :

un premier connecteur (150) pour interconnecter une première extrémité (110c) du conduit (110) dans le sens de rotation de l'hélice (30) et un premier stator pré-tourbillonnaire extérieur (131) positionné en dernier dans le sens de rotation de l'hélice (30) parmi la pluralité de stators pré-tourbillonnaires (131-134) ; et
un second connecteur (160) pour interconnecter une seconde extrémité (110d) du conduit (110) dans le sens opposé au sens de rotation de l'hélice (30) et un second stator pré-tourbillonnaire extérieur (132) positionné en dernier dans le sens opposé au sens de rotation de l'hélice (30) parmi la pluralité de stators pré-tourbillonnaires (131-134),
dans lequel le premier connecteur (150) a une forme dans laquelle la première extrémité (110c) du conduit (110) et le premier stator pré-tourbillonnaire extérieur (131), qui ont des formes de cambrure différentes, sont reliés de manière continue, et
dans lequel le second connecteur (160) a une forme dans laquelle la seconde extrémité (110d) du conduit (110) et le second stator pré-tourbillonnaire externe (132), qui ont la même forme de cambrure, sont reliés de manière continue.

11. Appareil (100) selon la revendication 10, dans lequel le premier connecteur (150) et le second connecteur (160) sont fabriqués séparément du conduit (110), du premier stator pré-tourbillonnaire extérieur (131) et du second stator pré-tourbillonnaire extérieur (132), respectivement, et sont accouplés au conduit (110).

12. Dispositif (100) selon la revendication 1, comprenant en outre :
dans lequel la pluralité de stators pré-tourbillonnaires (131-134) sont placés à différentes positions dans la direction longitudinale d'une coque (10).

13. Appareil (100) selon la revendication 12, dans lequel un stator pré-tourbillonnaire intérieur (133-134) positionné entre un premier stator pré-tourbillonnaire extérieur (131) positionné en dernier dans le sens de rotation de l'hélice (30) et un second stator pré-tourbillonnaire extérieur (132) positionné en dernier dans le sens opposé au sens de rotation de l'hélice (30), parmi la pluralité de stators pré-tourbillonnaires (131-134), est positionné en avant du premier stator pré-tourbillonnaire extérieur (131) et du second stator pré-tourbillonnaire extérieur (132).

14. Appareil (100) selon la revendication 13, dans lequel le nombre de stators internes de pré-tourbillon (133-134) est d'un ou plusieurs, et
dans lequel l'extrémité avant d'une pointe du stator interne de pré-tourbillon (133-134) fixée sur un côté intérieur du conduit (110) est positionnée derrière un bord d'attaque (110a) du conduit (110), et son extrémité arrière est positionnée devant un bord de fuite (110b) du conduit (110).

15. Appareil (100) selon la revendication 13, dans lequel le stator pré-tourbillonnaire intérieur (133-134), le premier stator pré-tourbillonnaire extérieur (131) et le second stator pré-tourbillonnaire extérieur (132) ont tous la même longueur de cordon à une racine et à une extrémité, et
dans lequel une distance avant-arrière du stator pré-tourbillon intérieur (133-134), du premier stator pré-

tourbillon extérieur (131) et du second stator pré-tourbillon extérieur (132) est égale ou supérieure à 0,05 fois et inférieure ou égale à 0,15 fois la longueur du cordon d'une racine du stator pré-tourbillon intérieur (133-134).

Fig. 1

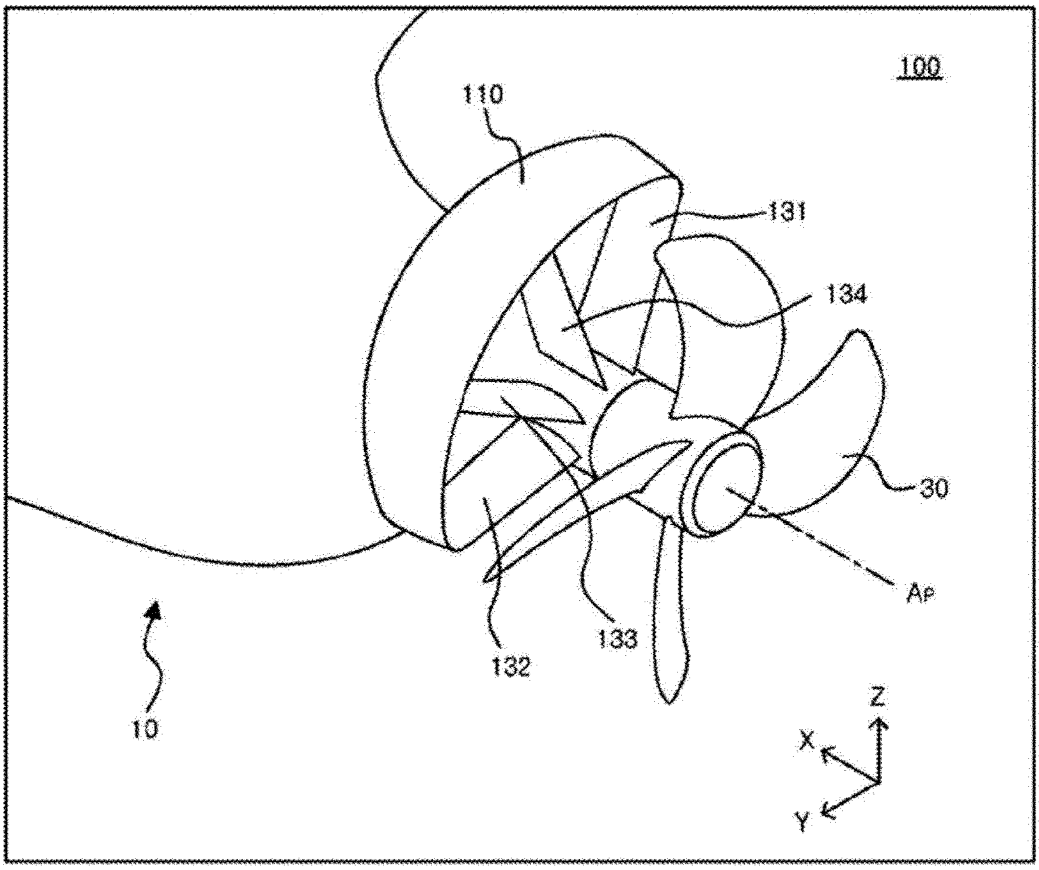


Fig. 2

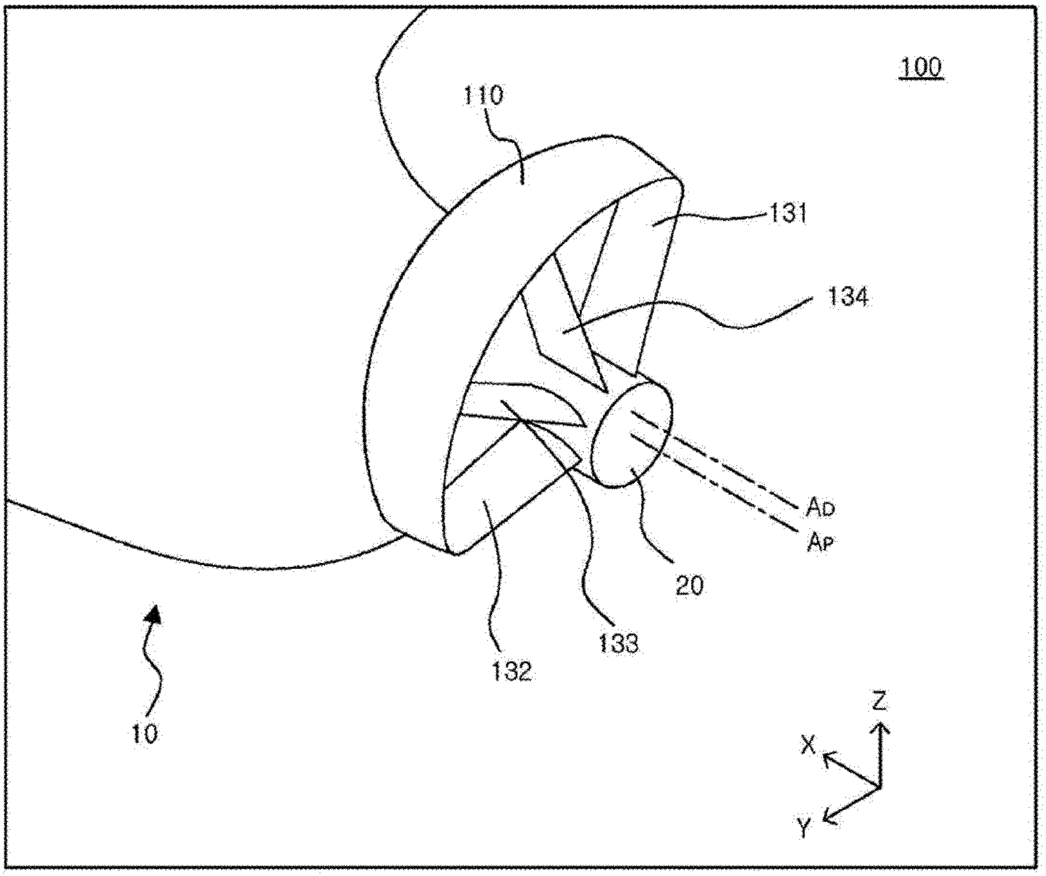


Fig. 3

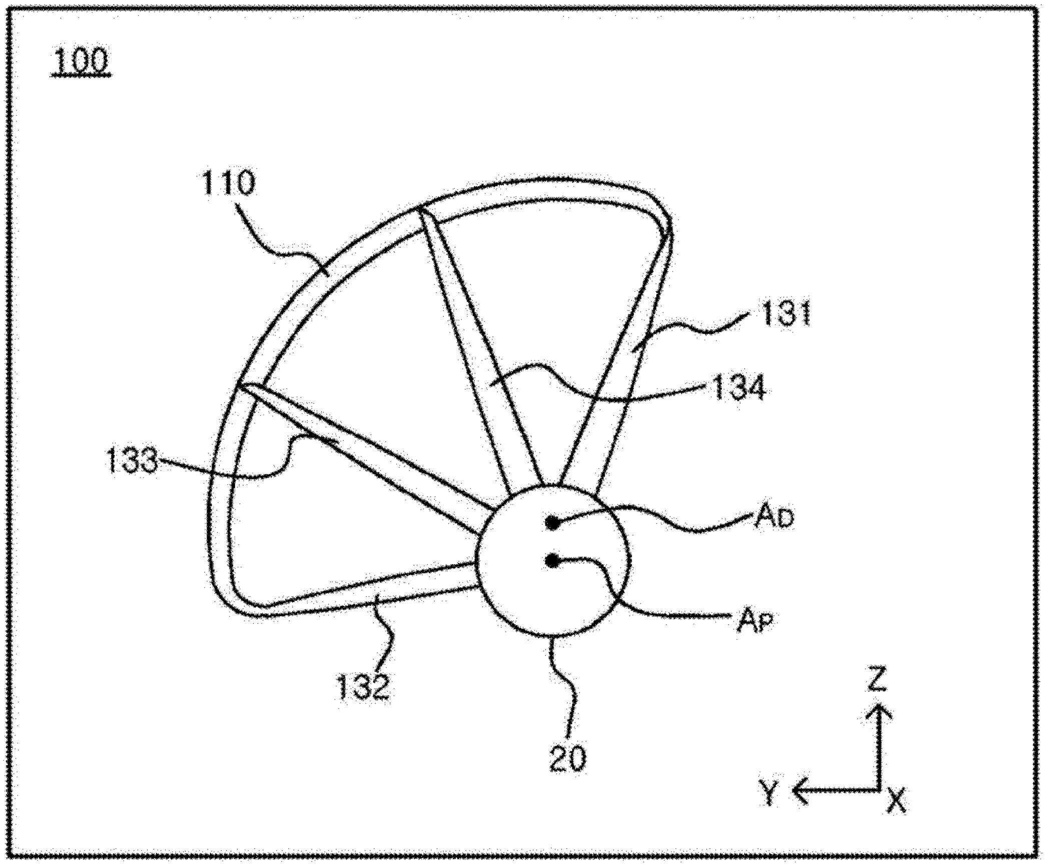


Fig. 4

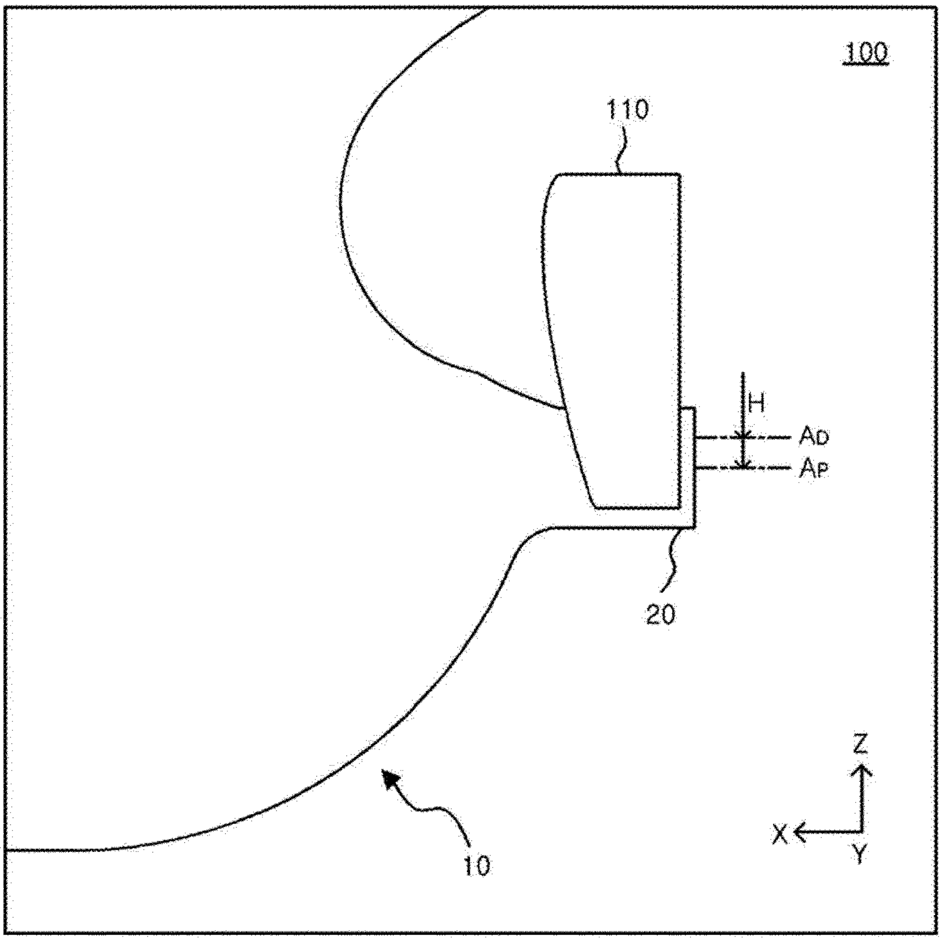


Fig. 5

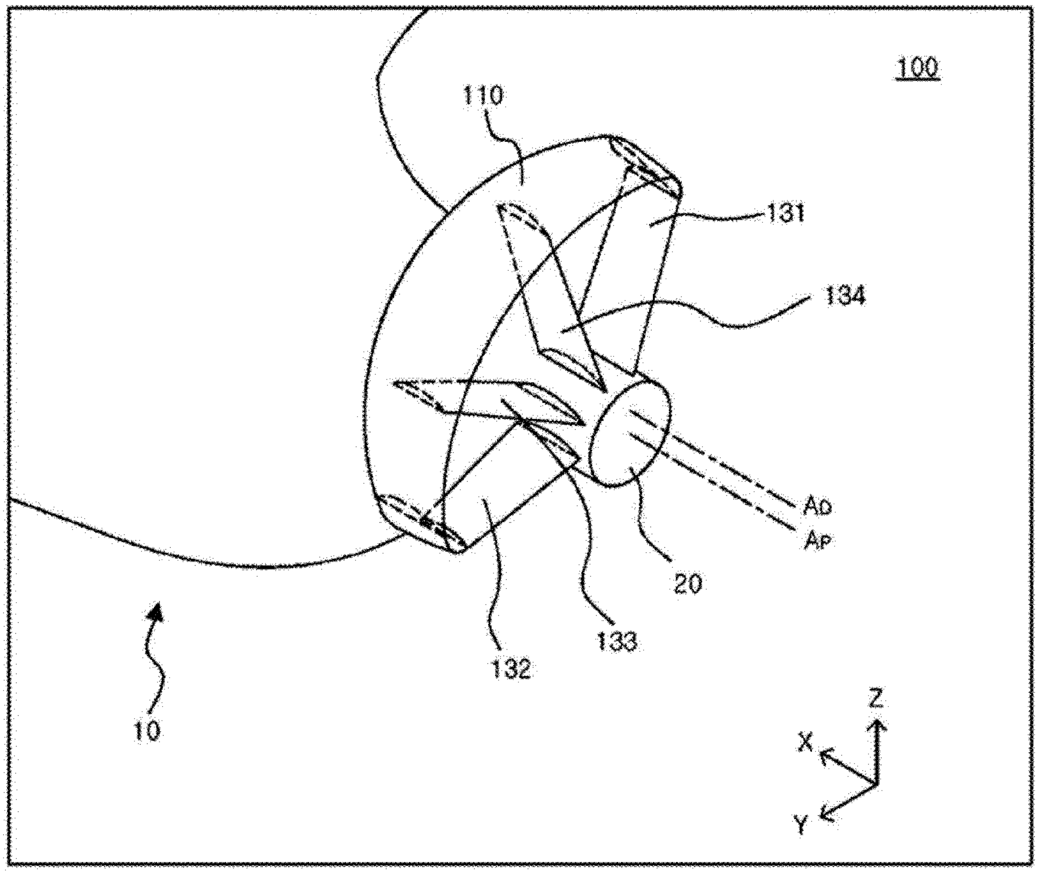


Fig. 6

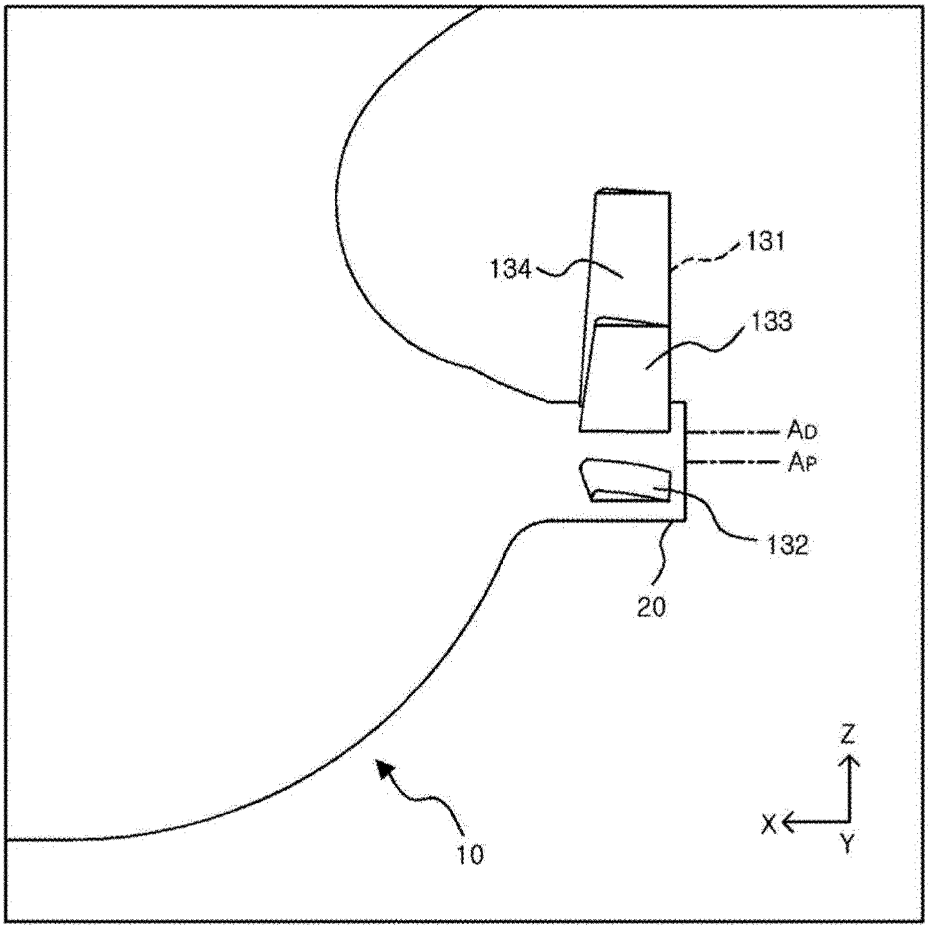


Fig. 7

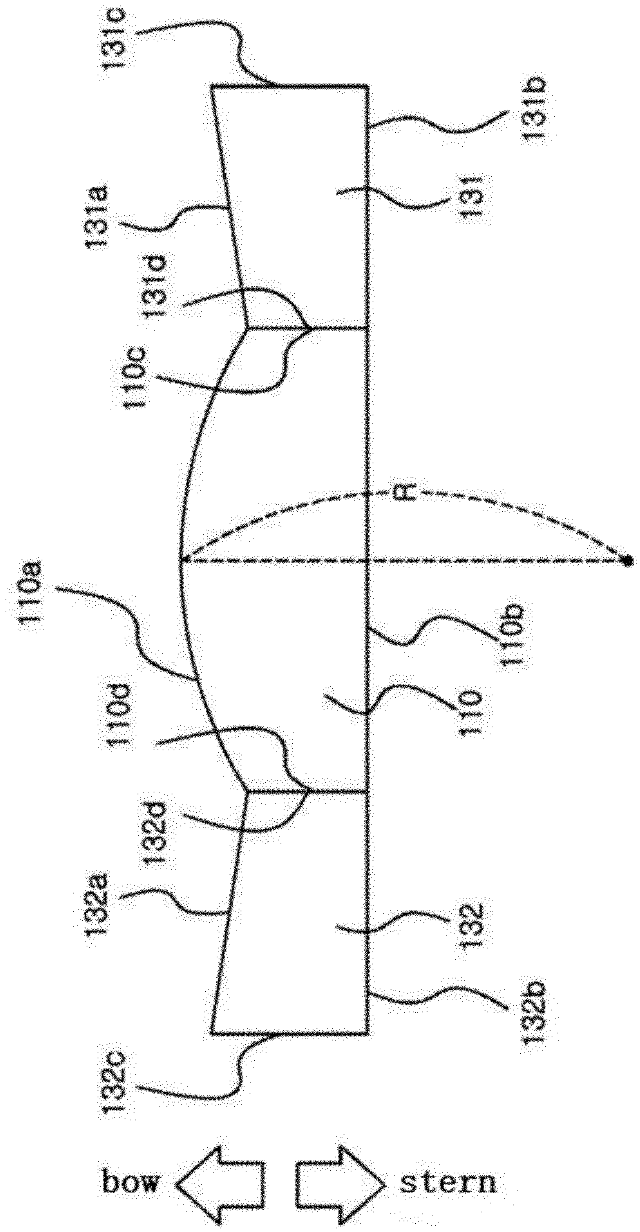

131c
131b
131
131a
131d
110c
R
110a
110b
110
110d
132d
132a
132
132b
132c
bow
stern

Fig. 8

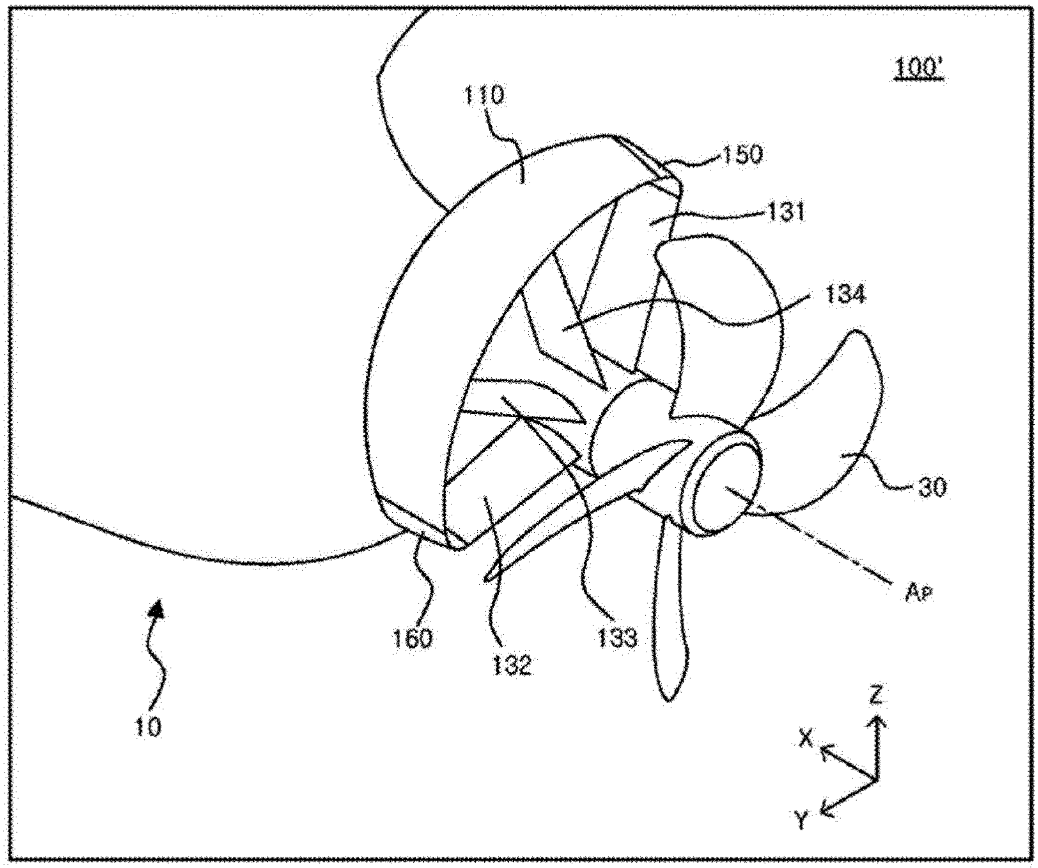


Fig. 9

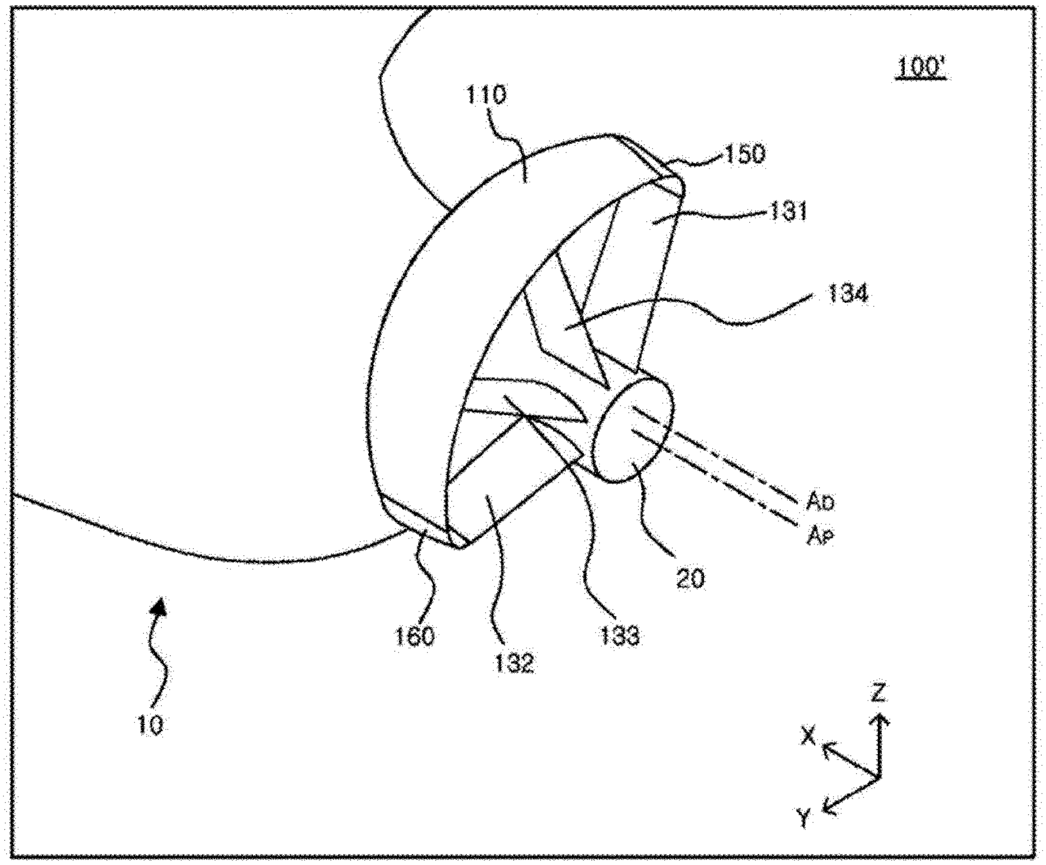


Fig. 10

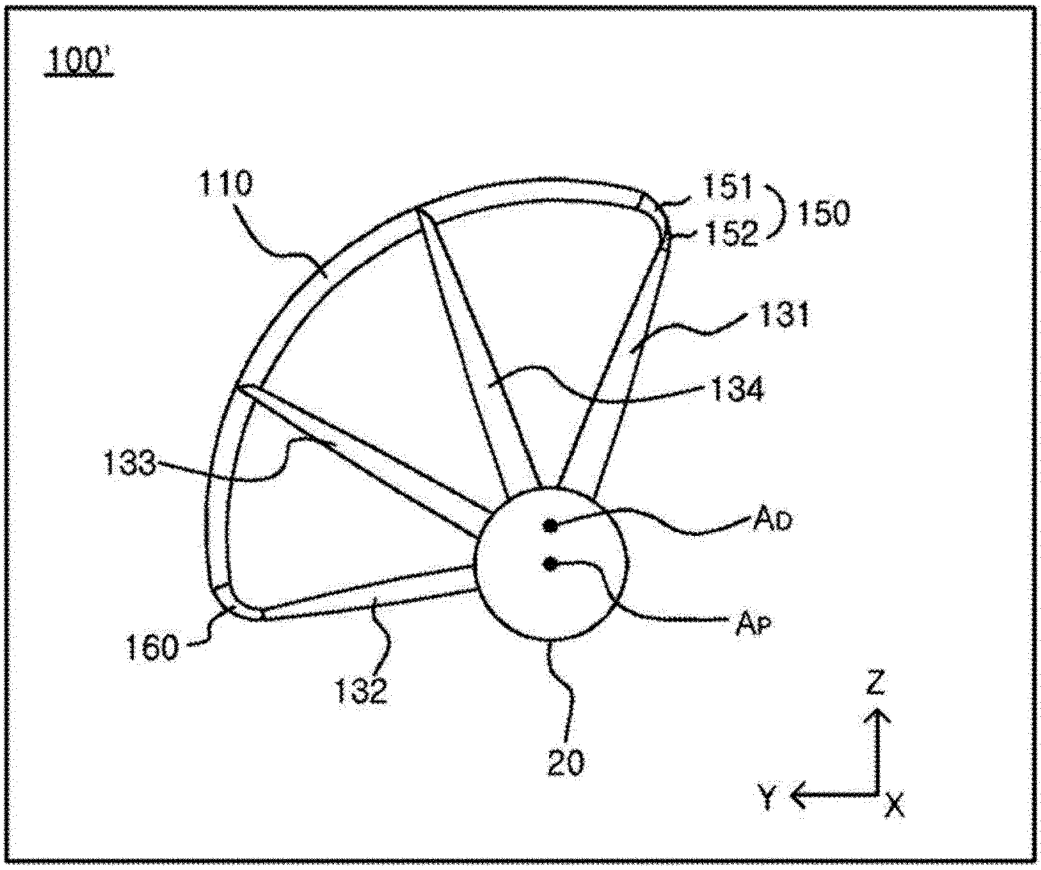


Fig. 11

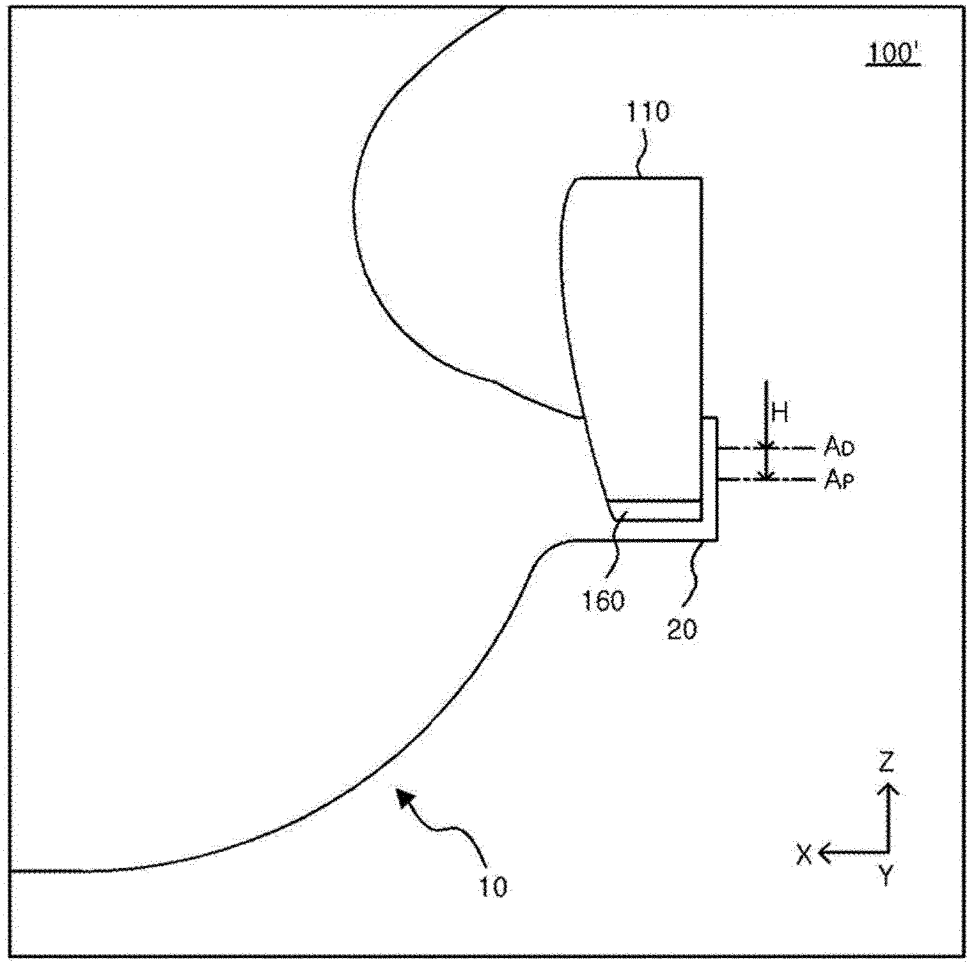


Fig. 12

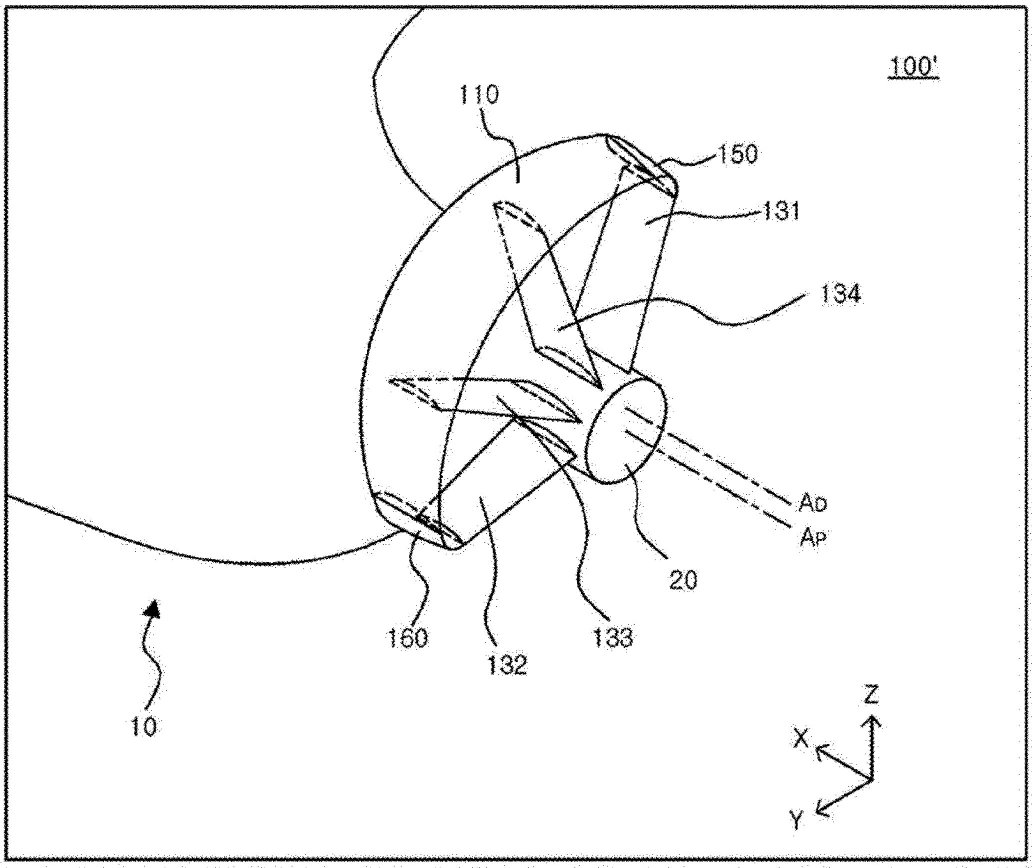


Fig. 13

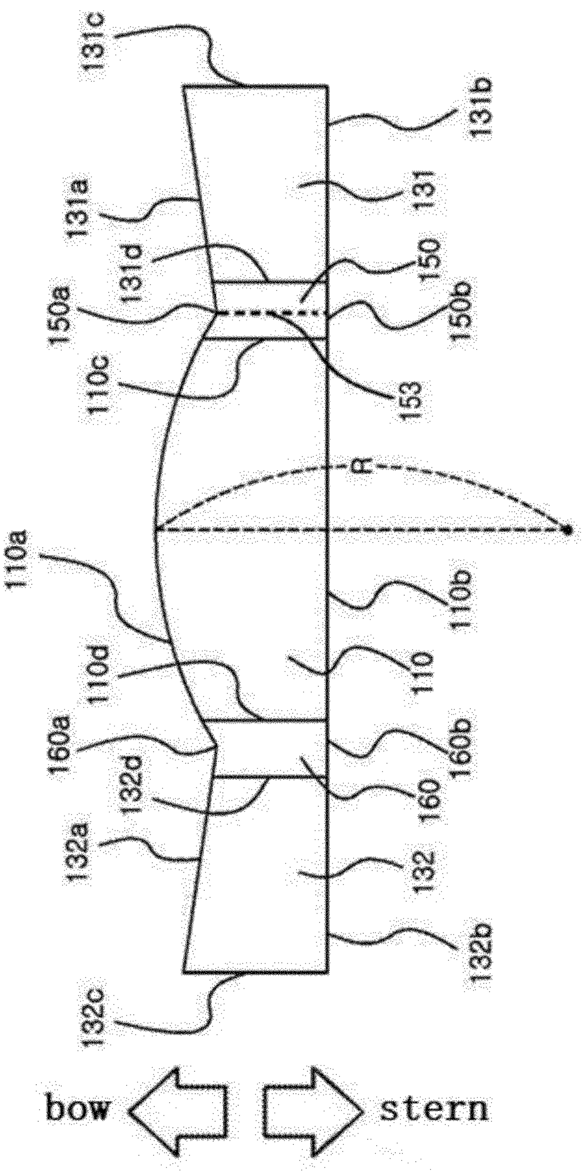

131c
131b
131a
131
131d
150
150a
150b
110c
153
R
110a
110b
110d
110
160a
160b
132d
160
132a
132
132b
132c
bow
stern

Fig. 14

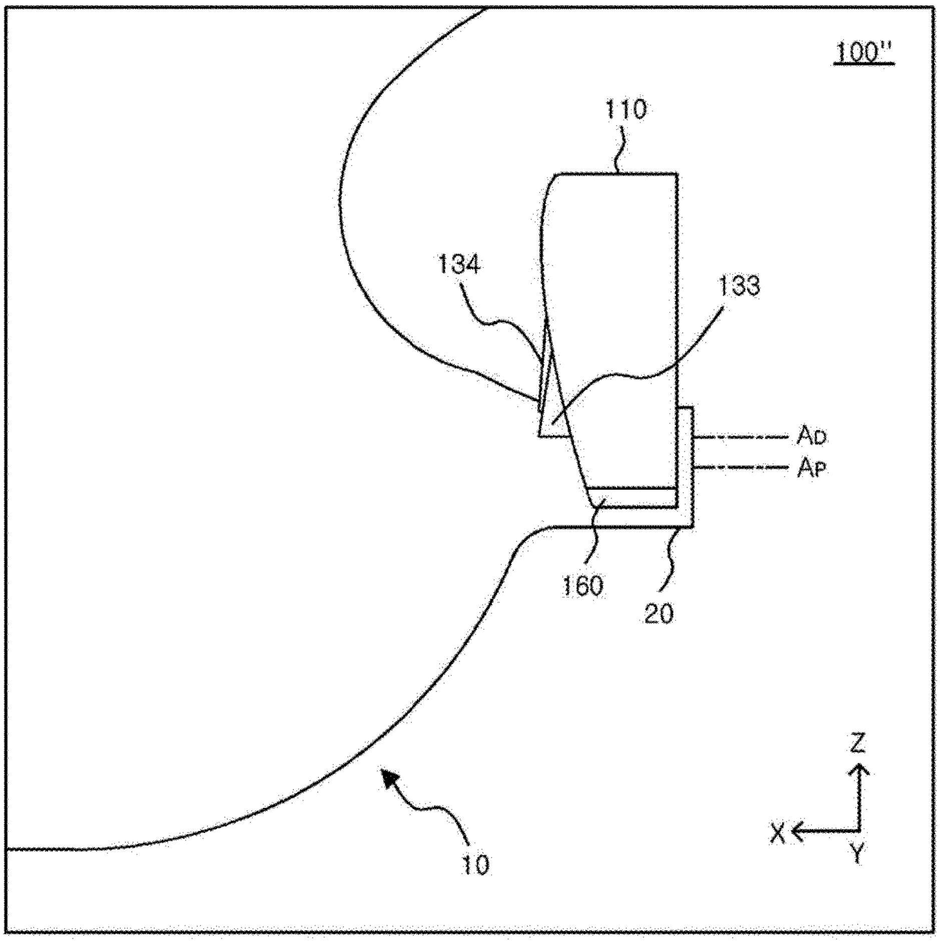


Fig. 15

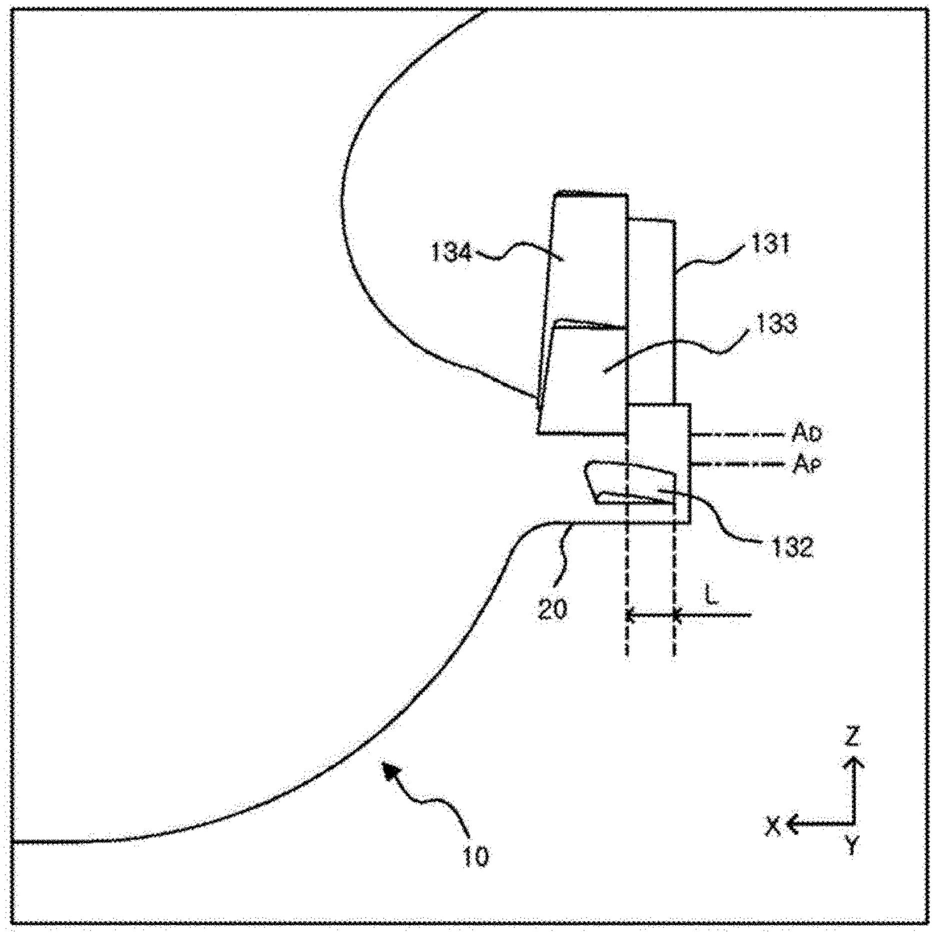


Fig. 16

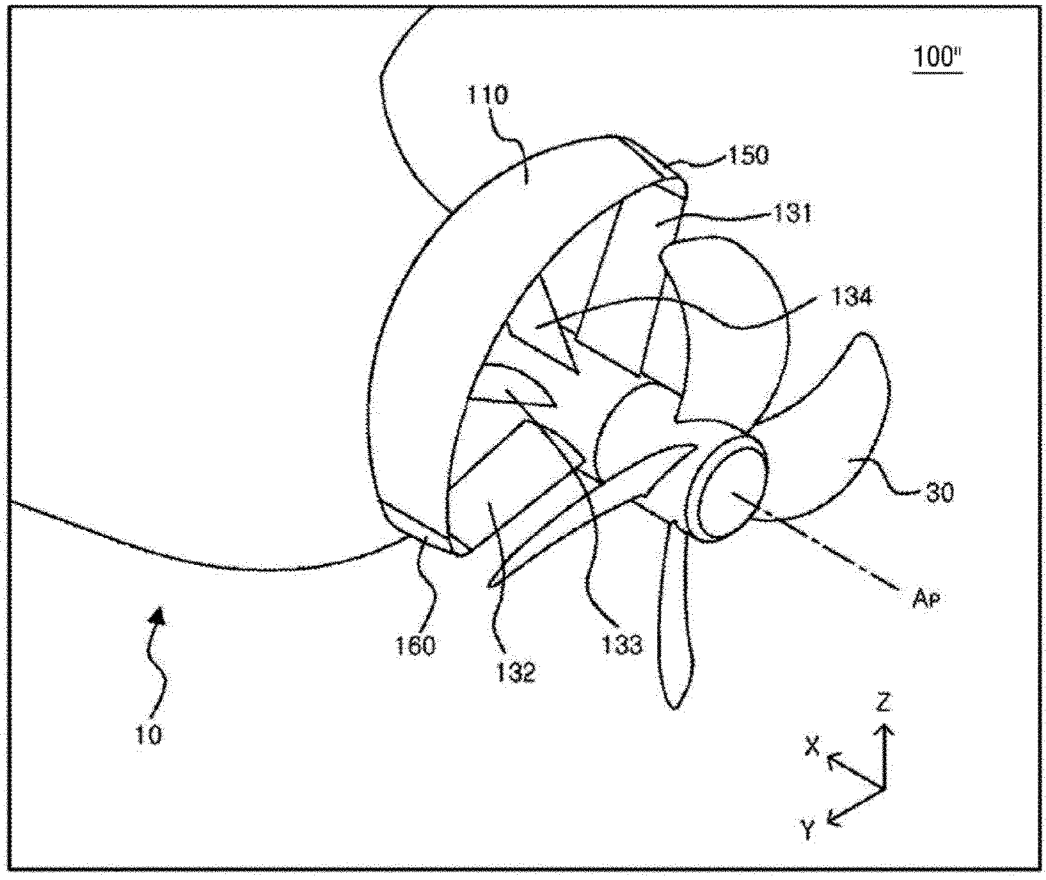


Fig. 17

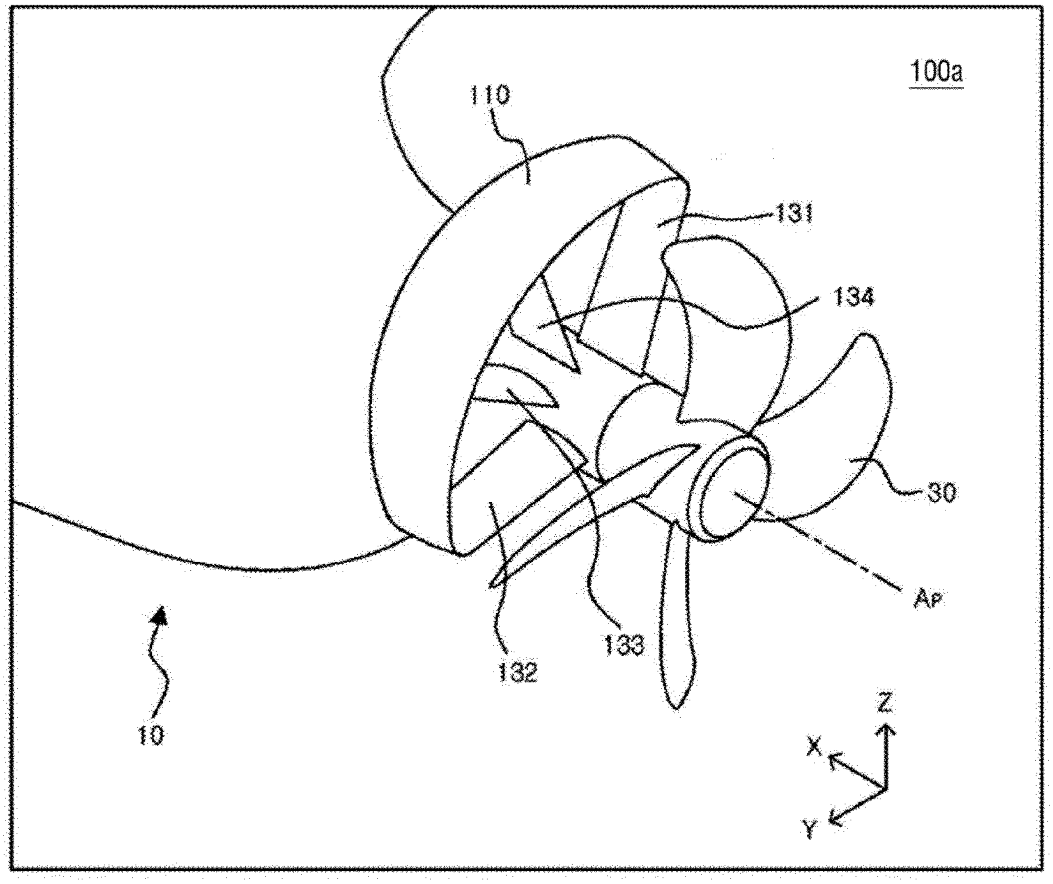


Fig. 18

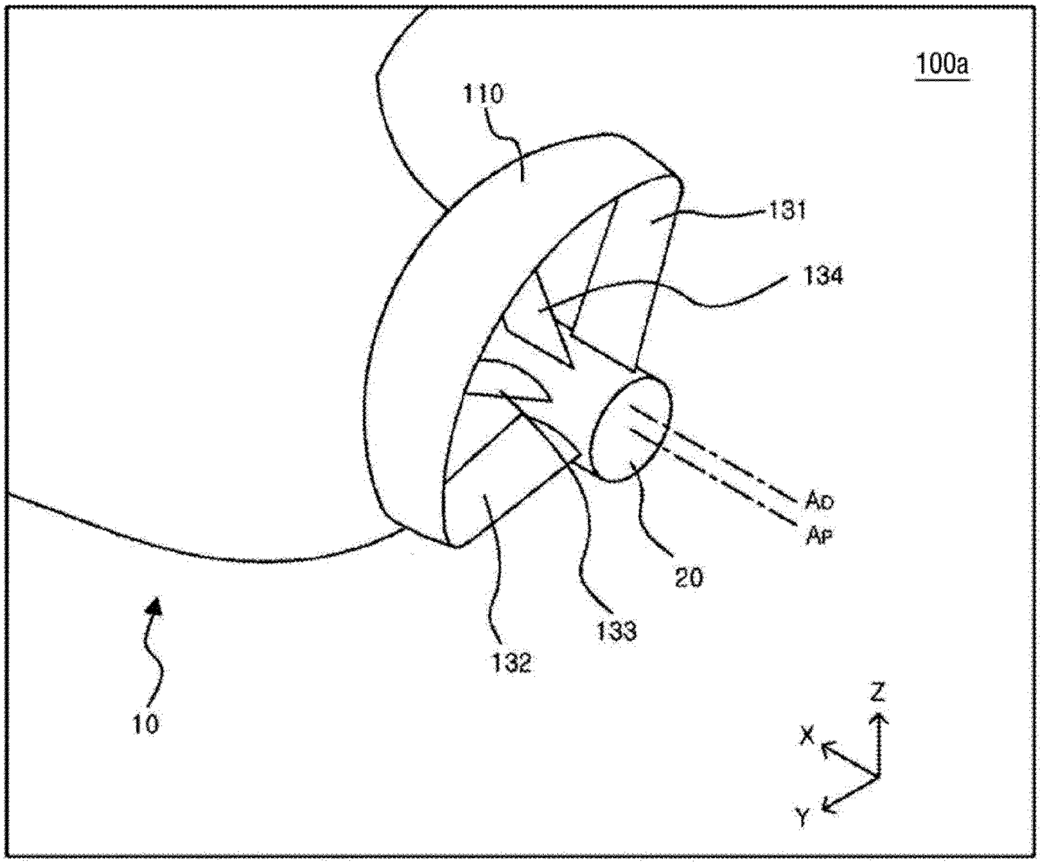


Fig. 19

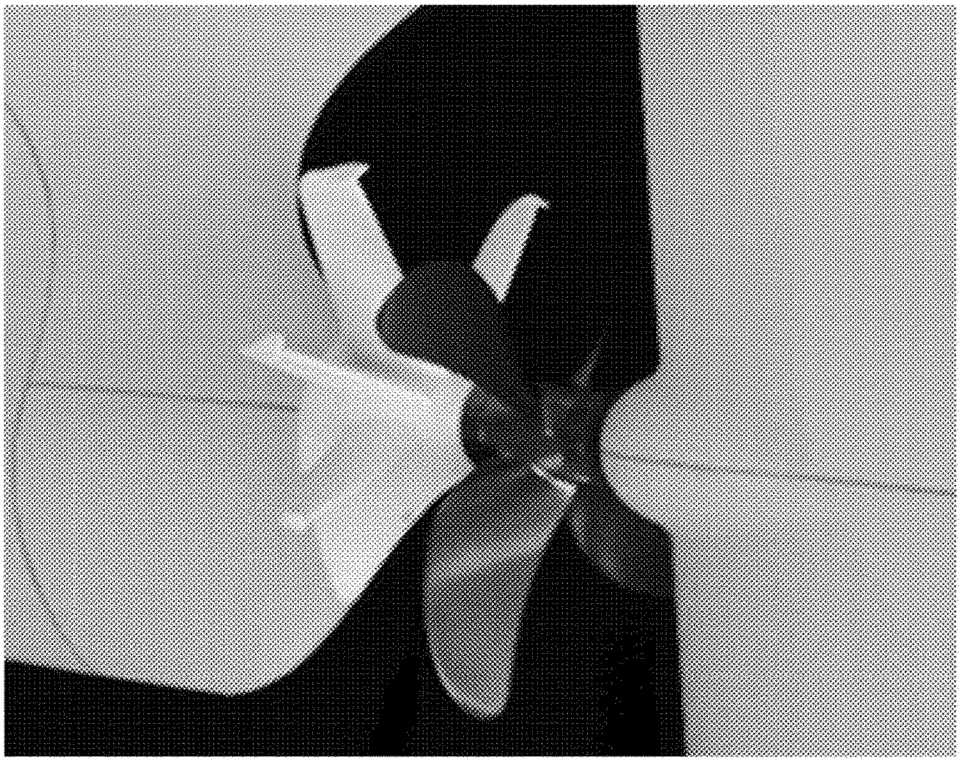


Fig. 20

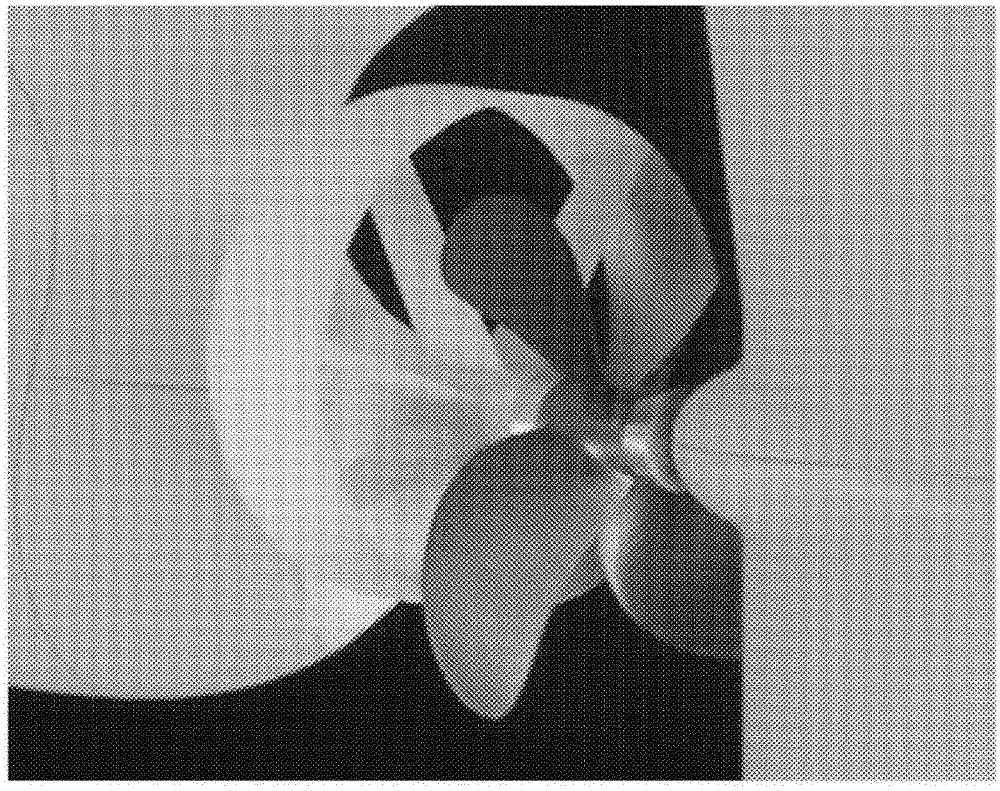


Fig. 21

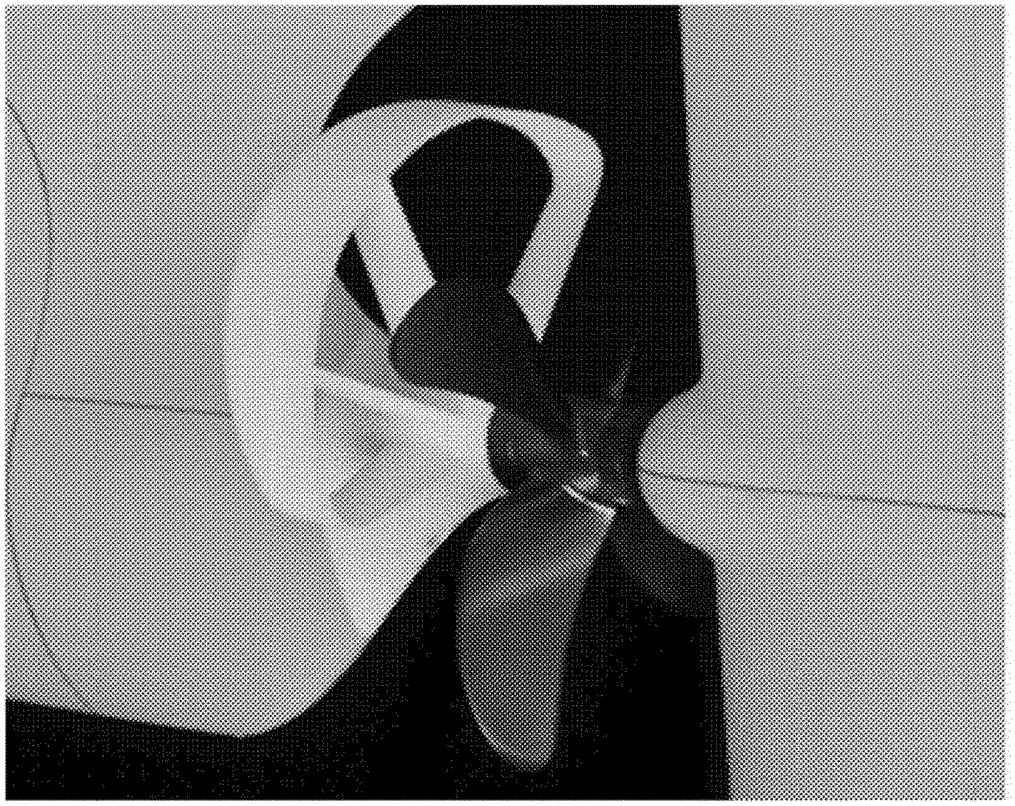


Fig. 22

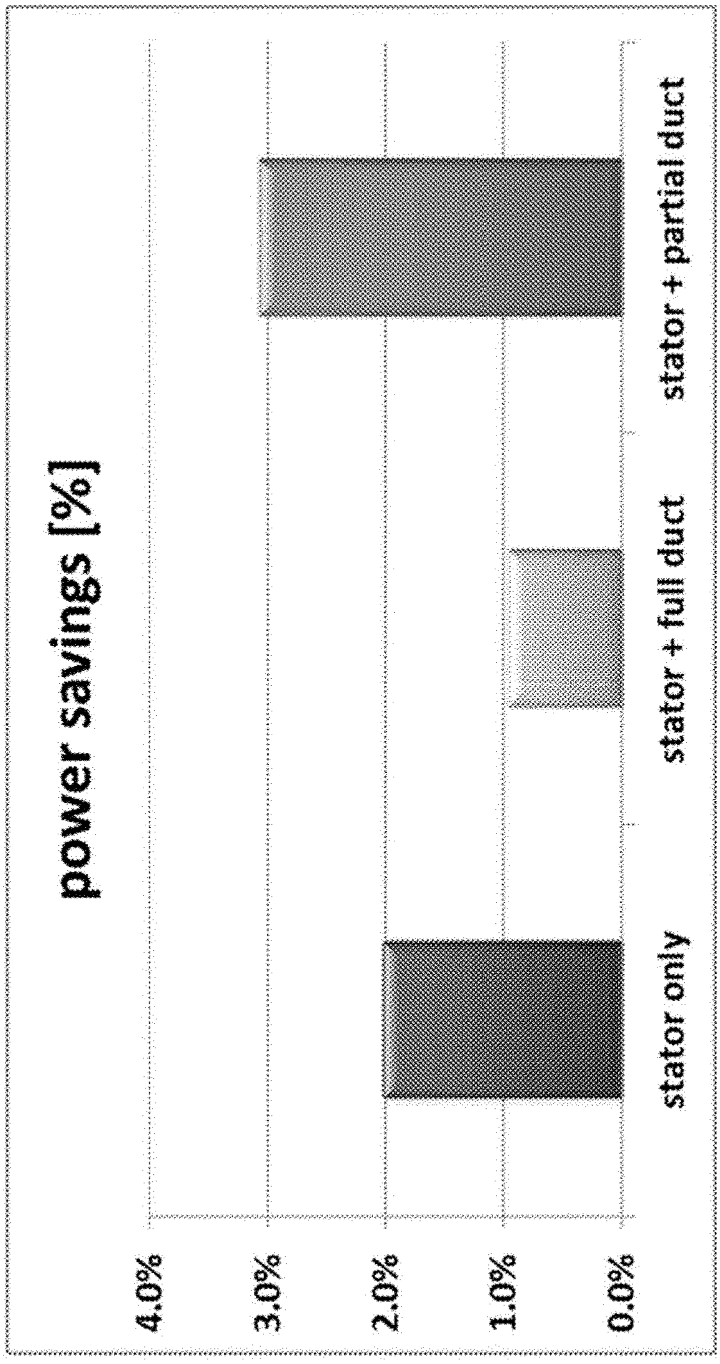

power savings [%]
4.0%
3.0%
2.0%
1.0%
0.0%
stator only
stator + full duct
stator + partial duct

Fig. 23

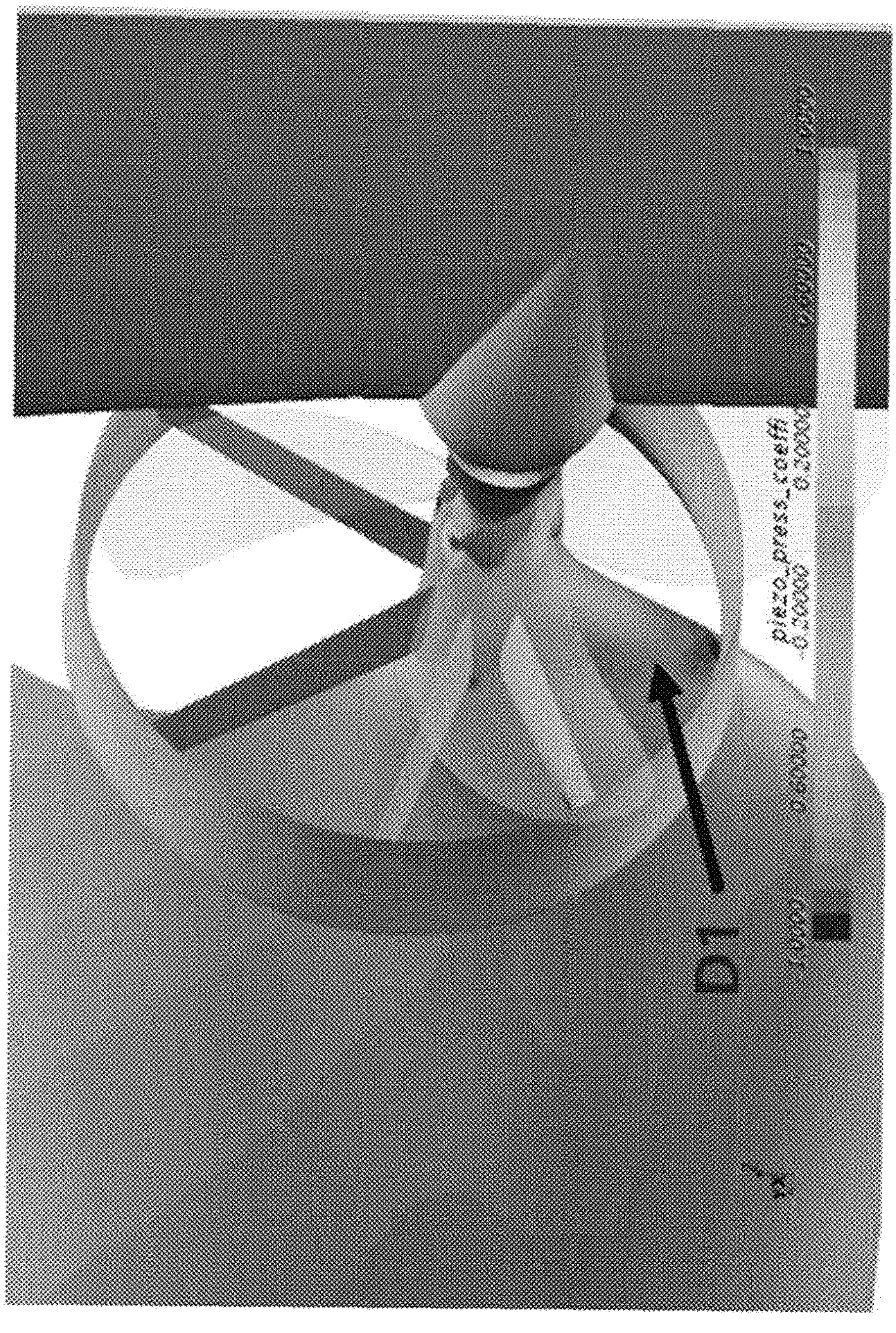
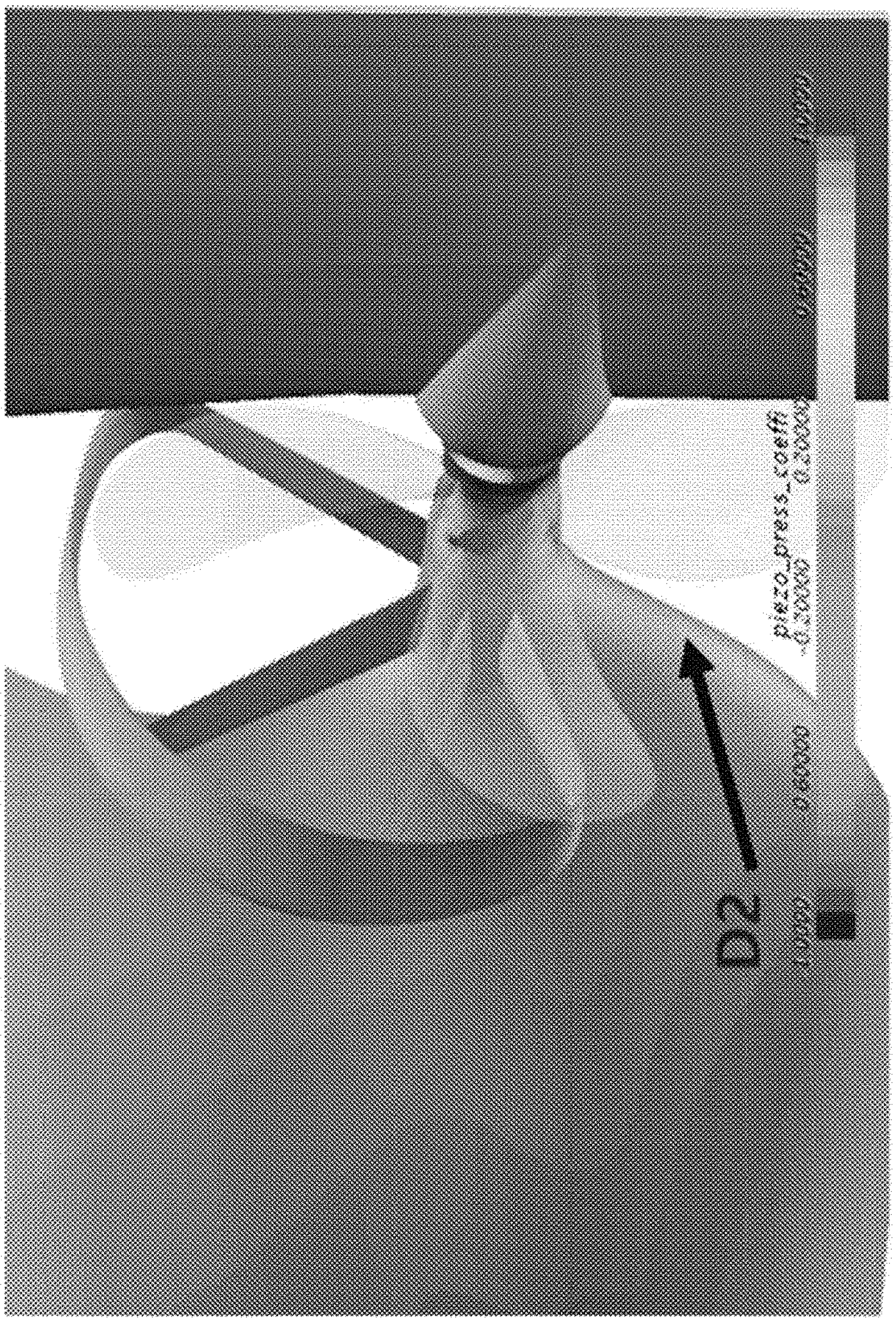


Fig. 24



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

- KR 20160058370 A **[0006]**