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(54) **A vessel comprising a propulsion unit**

(57) A vessel comprising a propulsion unit (10), the propulsion unit having a propeller (14), where the propulsion unit is arranged to be pivoted to any orientation between a first deployed orientation and a second retracted orientation, where in the first orientation the propeller provides thrust in a thrust direction for moving the vessel and in the second orientation is pivoted around a pivoting axis (17), wherein the pivoting axis is proximate to a propeller bearing located near or at the propeller, in a way such that in the second orientation, the propulsion unit is substantially flush with a hull (2) of the vessel, and wherein energy for providing thrust to the propulsion unit is supplied in manner adapted to allow pivoting of the propulsion unit between the first and the second orientation. The document further relates to a use of such a vessel, which is in particular suited for combined operation in deep as well as shallow water.

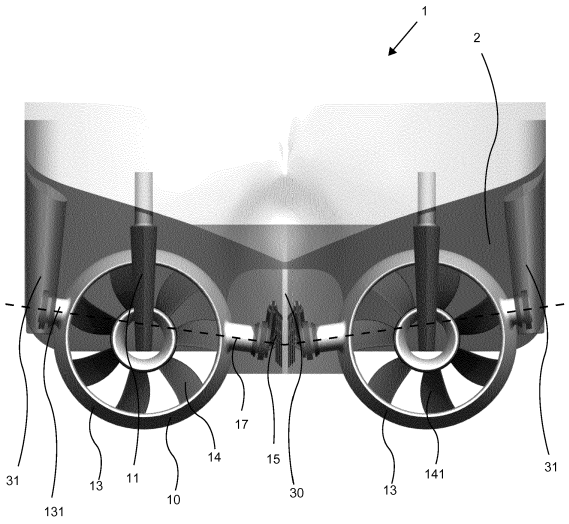

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a propulsion unit for being mounted on a submerged portion of the hull of a waterborne vessel, the propulsion unit comprising a propeller nozzle for being pivotally mounted to the hull, a propeller rotatably arranged inside the nozzle, a drive means for driving the propeller, and a deployment mechanism for controlling the orientation of the propeller nozzle. The present invention further a vessel comprising such propulsion unit.

BACKGROUND OF THE INVENTION

[0002] Waterborne vessels are often operated in both shallow and deeper waters, such as oceans, coastal waters and rivers. When vessels operate in relatively deep waters a propeller is most often used for providing thrust enabling the vessel to move. The size of the propeller is related to the obtainable thrust and large propellers may be needed to provide the necessary trust. Using large propellers may result in the propeller extending below the lowest point of the hull making the propeller the lowermost point of the vessel. The propeller thus determines the draught of the vessel making the propeller vulnerable to impact. This is usually not a problem when vessels are operated in sufficient water depth, but when a vessel is operated close to land, or across a shallow water area, a need may arises for minimizing the draught of the vessel.

[0003] In this regard, US 5,397, 255 disclosed a propeller mounted on a retractable rod. Other existing solutions involve changing the diameter of the propeller by folding the propeller as disclosed in US 4,565,531.

[0004] The above mentioned solutions suffer from various drawbacks, especially when a propeller diameter is made larger to provide more thrust. A retractable propeller will need a heavy attachment so as to absorb forces from the propeller and ensure that the propeller stays in position during use. Hence, an improved propulsion unit for waterborne vessels would be advantageous.

OBJECT OF THE INVENTION

[0005] It is an object of the present invention to provide a propulsion unit for a waterborne vessel that allows a propeller of the propulsion unit to be moved to reduce the draught of the vessel.

SUMMARY OF THE INVENTION

[0006] Thus, the above described object and several other objects are intended to be obtained in a first aspect of the invention by providing a propulsion unit for being mounted on a submerged portion of the hull of a waterborne vessel, the propulsion unit comprising a propeller nozzle for being pivotally mounted to the hull, a propeller rotatably arranged inside the nozzle, a drive means for driving the propeller, and a deployment mechanism for controlling the orientation of the propeller nozzle, wherein the propeller nozzle is pivotally around a nozzle pivoting axis intersecting the propeller nozzle, between a deployed orientation wherein the propeller is arranged in a substantially upright position suitable for providing thrust for moving the vessel and a retracted orientation wherein the propeller is arranged in a tilted or substantially horizontal position to reduce a draught of the vessel.

[0007] Hereby an improved propulsion unit is provided, in particular a more efficient propulsion unit in which a relatively large propeller diameter may be utilized, while at the same time accommodating for low water depths. The propulsion unit is in particular suited for vessels operating in both deep as well as in shallow water. During normal operation, the propulsion unit is flipped down. This allows for much larger propeller diameter than for conventional propulsion unit.

[0008] The propeller and propeller nozzle may be turned to reduce the draught of the vessel and due to the particulars of the invention the turning radius of the propeller and propeller nozzle becomes as little as possible, helping to reduce the spaced needed to accommodate the propulsion unit.

[0009] Further, the nozzle pivoting axis may extending in a direction perpendicular to a direction of an axis of rotation of the propeller. Also, the nozzle pivoting axis may extends in a direction substantially transversal to a direction of sailing of the waterborne vessel.

[0010] In one embodiment of the above described propulsion unit, the nozzle pivoting axis may be offset from the axis of rotation of the propeller. By utilizing an offset pivoting axis attachment points for the propeller nozzle may be arranged closer to the hull of the vessel compared to a propulsion unit wherein the pivoting axis is coincident with an axis of rotation of the propeller. Having attachment points closer to the hull results in a better transmission of forces between the propulsion unit the hull. Hereby the dimensions of the supporting structures may be reduced, which may improve the hydrodynamic characteristics of the hull and reduces drag. Additionally, reducing the dimension of the supporting structure may reduce draught of the vessel when the propeller nozzle is in the retracted orientation. In all, the offset rotating axis enables the use of larger propellers, which may be advantageous.

[0011] In another embodiment the pivoting axis may intersect the axis of rotation of the propeller.

[0012] Additionally, the propeller may be rim-driven and in this embodiment the drive means may be a permanent magnet motor. The principles of a rim driven propeller utilizing permanent magnets have previously been disclosed international application, publication number WO 2010/13480 A2 by the applicant.

[0013] In one embodiment, stationary permanent magnets may be provided in the propeller nozzle and the

propeller may be mounted in a propeller housing provided with permanent magnets and rotatably arranged inside the propeller nozzle. Hereby a bearing for the propeller housing is provided. Further, an advantage of providing a rim-driven propeller is that the transmission for torque is optimized compared to traditional shaft mounted and centre driven propellers. The transmission of torque becomes even more important when large propellers are employed. In this regard, it has been shown that in a vessel having a propulsion unit according to the present invention the required power may be reduced by approximately 20%, while vessel's thrust is maintained. This provides great savings on space, material use, fuel consumption etc. Additionally, other advantages include reduced noise and vibration, and the ability to actively compensate for vessel undulations.

[0014] Still further, the propeller nozzle may be adapted to be attached to supporting structures extending from the submerged portion of the hull.

[0015] In another embodiment the propeller may be mounted on a rotatable propeller shaft supported by a supporting structure extending inside the propeller nozzle and the drive means may be a motor arranged to rotate the propeller shaft.

[0016] Furthermore, the propulsion unit may be adapted to be pivotally mounted to the submerged portion of the hull about a substantial vertical azimuth axis thereby providing an azimuth thruster functionality. Hereby a direction of thrust from the propulsion unit may be directed in other directions than otherwise provided by the propeller, which may be used for enhanced steering of the vessel.

[0017] The invention further relates to a waterborne vessel, such as an offshore supply vessel or an mobile offshore drilling unit, comprising one or more of the above described propulsion unit.

[0018] Different aspects of the present invention may each be combined with any of the other aspects. These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE FIGURES

[0019] The propulsion unit on a vessel according to the present invention will now be described in more detail with reference to the accompanying figures. The accompanying figures illustrates an example of embodiment of the present invention and is not to be construed as being limiting to other possible embodiments falling within the scope of the attached claim set.

Figure 1 shows two propulsion unit mounted on a vessel,

Figure 2a and 2b shows a vessel comprising a propulsion unit,

Figure 3a and 3b shows different orientations of a propulsion unit,

Figure 4a and 4b illustrates the relationship between a thrust axis and a pivoting axis of a propulsion unit according to one embodiment of the invention,

Figure 5a shows propulsion unit, and

Figure 5b and 5c shows a cross section of the propulsion unit of Fig. 5a along line AA' and B, respectively.

DETAILED DESCRIPTION OF AN EMBODIMENT

[0020] Fig. 1 shows two propulsions unit mounted on a submerged portion of a hull 2 in an aft section of a vessel 1. Each propulsion unit comprises a pivotally mounted propeller nozzle 13 and a rotatable propeller 14 arranged inside the nozzle. A deployment mechanism 15 is provided for pivoting the propeller nozzle and the propeller about a nozzle pivoting axis 17 between a deployed orientation and a retracted orientation. Referring to Fig. 2a and 2b, in the deployed orientation shown in Fig. 2a the propeller is arranged in a substantially upright position suitable for providing thrust for moving the vessel as and in the retracted orientation shown in Fig. 2b the propeller is arranged in a tilted or substantially horizontal position to reduce a draught D of the vessel. The propulsion unit further comprises drive means 16 for driving the propeller as will be further described below.

[0021] As seen from Fig. 1, the propulsion units 10 are shown to be mounted between a central supporting structure 30 and side supporting structures 31 extending from the hull 2. However, the propulsion unit may also be mounted to on a hull in a number of other ways without departing from the scope of the invention. Nozzle protrusions 131 extends from the propeller nozzle 13 and provide attachment points for attachment with the supporting structures. As is readily understood by the skilled person, the propeller nozzle is mounted using the necessary bearings to provide the pivotal motion. The deployment mechanism 15 provided for moving the propeller nozzle is shown in further detail in Fig. 4b. The deployment mechanism shown comprises a pivoting arm 151 mounted on the nozzle protrusion 131 that in turn is connected to a linear actuator, such as a hydraulic cylinder 152. When a piston 153 of the hydraulic cylinder is moved forward or backwards, dependent on the operation of an associated hydraulic pump, the movement of the piston is transferred to the pivoting arm 151 that facilitates the movement of the propeller nozzle 13 and propeller 14. The propeller nozzle and the propeller is turned about the nozzle pivoting axis 17 that intersecting the propeller nozzle. As seen from Fig. 4a the pivoting axis extends in a direction perpendicular to a direction of an axis of rotation 142 of the propeller. Thus, when the propeller is moved between the deployed orientation and the retract-

ed orientation, the direction of the axis of rotation of the propeller 142, which may also be denoted the thrust direction of the propeller, gradually shifts. Depending on how the propulsion unit is mounted on the vessel, the nozzle pivoting axis may also extends in a direction substantially transversal to a direction of sailing of the waterborne vessel.

[0022] Figure 2a and 2b shows how movement of the propeller nozzle from the deployed orientation in Fig. 2a to the retracted orientation in Fig. 2b reduces the draught, D of a vessel comprising one or more propulsion units according to the invention. In fig. 2a the lower most point of the propeller nozzle is decisive to the draught of the vessel, where as in Fig. 2b the previous lower most point of the propeller nozzle is now above the lover most point of the vessel and the draught, D is hereby reduced.

[0023] Fig. 4a and 4b illustrates how the pivoting axis 17 may be offset from the axis of rotation 142 of the propeller by an offset-distance, r. The closer the pivoting axis is arranged to the axis of rotation, the lower a dimensioning moment of the propulsion unit may be. Compared to traditional retractable azimuth thrusters that are often supported at a single point high above the propeller, the dimensioning moment of the present propulsion unit may be no more than 1/10.

[0024] The offset-distance, r may be less than or equal to half the maximum diameter of said propeller. For example, the offset-distance, r may be in the range of 0 to 1.5 meter. The support arrangement for the propulsion unit must be dimensioned with respect to the moment of the propeller nozzle and propeller about the pivoting axis and a small offset-distance, r ensures that the moment is correspondingly low. Further, as the pivoting axis 17 is located relatively close to the hull the forces required to pivot the propeller nozzle and propeller is relatively low compared to traditional retractable azimuth thrusters and by being attached to the hull at two points the propulsion unit provides a stiff and strong structure. In addition, the arrangement of the attachment points of the propeller nozzle and the direction of the pivoting axis 17 enables the propeller nozzle and propeller to be substantially flush with the shape and angels of the hull in the retracted orientation.

[0025] Various drive means and configurations for driving the propeller may be used while remaining within the scope of the invention. Referring to Fig. 5a-5c, according to one aspect the propeller may be rim-driven by a permanent magnet motor. The propulsion unit 10 is shown to comprise stationary permanent magnets 163 arranged along an inner circumference of the propeller nozzle and the propeller 14 is mounted in a propeller housing 161 rotatable arranged inside the propeller nozzle. An outer circumference of the propeller housing is provided with rotating permanent magnets 162, and together the stationary and the rotating permanent magnets provide a bearing for the propeller housing able to absorb both axial and radial loads.

[0026] Further, the propeller nozzle constitutes a stator 164 comprising windings for providing a rotating magnetic field adapted to rotate the propeller housing comprising permanent magnets thereby constituting a rotor. By controlling the current running through the windings, the propeller housing may be rotated and a permanent magnet motor for driving the propeller is provided.

[0027] In another embodiment (not shown), a structure for supporting a propeller shaft is provided inside the propeller nozzle. The propeller shaft is arranged in a centre of the nozzle and the supporting structure extends from the circumference of the propeller nozzle towards the centre to support the propeller shaft. The propeller shaft may be supported at several points along the propeller shaft. The propeller is mounted on the propeller shaft and the drive means is a motor arranged to rotate the propeller shaft.

[0028] Figure 3a and 3b show how power lines 165 for supplying power to the drive means 16, such as a permanent magnet motor. The power lines are routed from the interior of the hull to the propulsion unit via attachment point of the propeller nozzle protrusions. As envisaged by the skulled person the power for driving the propeller must be supplied in manner adapted to allow pivoting of the propeller nozzle. Several options are available such as hydraulic, pneumatic as well as electrical drives, where hoses or wiring may be adapted to allow pivoting of the propulsion unit.

[0029] In the drawings, propulsion units according to embodiments of the invention are shown to be arranged in the rear part of a vessel as a main source of propulsion. However, propulsion units according to the invention may also be used for providing thrust elsewhere, such as a bow thruster to reduce turning radius or ease berth by providing a transversal trust force.

[0030] Although the present invention has been described in connection with the specified embodiments, it should not be construed as being in any way limited to the presented examples. The scope of the present invention is set out by the accompanying claim set. In the context of the claims, the terms "comprising" or "comprises" do not exclude other possible elements or steps. Also, the mentioning of references such as "a" or "an" etc. should not be construed as excluding a plurality. The use of reference signs in the claims with respect to elements indicated in the figures shall also not be construed as limiting the scope of the invention. Furthermore, individual features mentioned in different claims, may possibly be advantageously combined, and the mentioning of these features in different claims does not exclude that a combination of features is not possible and advantageous.

10	propulsion unit
11	rudder element
13	Nozzle
131	Nozzle protrusions
14	Propeller
141	Propeller blades

142 axis of rotation of the propeller.
15 Deployment mechanism
151 pivoting arm
152 hydraulic cylinder
153 piston
16 drive means
161 rotatable propeller housing
162 rotating permanent magnets
163 stationary permanent magnets
164 stator
165 power lines
17 pivoting axis
18 pivot drive mechanism
30 central supporting structure
31 side supporting structures

Claims

1. A propulsion unit (10) for being mounted on a submerged portion of the hull (2) of a waterborne vessel (1), the propulsion unit comprising:

- a propeller nozzle (13) for being pivotally mounted to the hull,
- a propeller (14) rotatably arranged inside the nozzle (13),
- a drive means (16) for driving the propeller, and
- a deployment mechanism (15) for controlling the orientation of the propeller nozzle,

wherein the propeller nozzle is pivotally around a nozzle pivoting axis (17) intersecting the propeller nozzle, between a deployed orientation wherein the propeller is arranged in a substantially upright position suitable for providing thrust for moving the vessel and a retracted orientation wherein the propeller is arranged in a tilted or substantially horizontal position to reduce a draught (D) of the vessel.

2. A propulsion unit (10) according to claim 1 wherein the nozzle pivoting axis extends in a direction perpendicular to a direction of an axis of rotation (142) of the propeller.

3. A propulsion unit (10) according to claim 1 or 2 wherein the nozzle pivoting axis extends in a direction substantially transversal to a direction of sailing of the waterborne vessel.

4. A propulsion unit (10) according to any of the previous claims, wherein the nozzle pivoting axis is offset from the axis of rotation of the propeller.

5. A propulsion unit (10) according to any of the claims 1-3, wherein the pivoting axis intersects the axis of rotation of the propeller.

6. A propulsion unit (10) according to any of the previous claims wherein the propeller is rim-driven and the drive means is a permanent magnet motor.

7. A propulsion unit (10) according to claim 6 wherein stationary permanent magnets (163) are provided in the propeller nozzle and the propeller is mounted in a propeller housing (161) provided with rotating permanent magnets (162) and rotatably arranged inside the propeller nozzle.

8. A propulsion unit (10) according to any of the preceding claims wherein the propeller nozzle is adapted to be attached to supporting structures extending from the submerged portion of the hull.

9. A propulsion unit (10) according to any of the claims 1-5, wherein the propeller is mounted on a rotatable propeller shaft supported by a supporting structure extending inside the propeller nozzle and wherein the drive means is a motor arranged to rotate the propeller shaft.

10. A propulsion unit (10) according to any of the previous claims adapted to be pivotally mounted to the hull about a substantial vertical azimuth axis thereby providing an azimuth thruster functionality.

11. A waterborne vessel, such as an offshore supply vessel or a mobile offshore drilling unit, comprising one or more propulsion unit according to any of the claims 1-10.

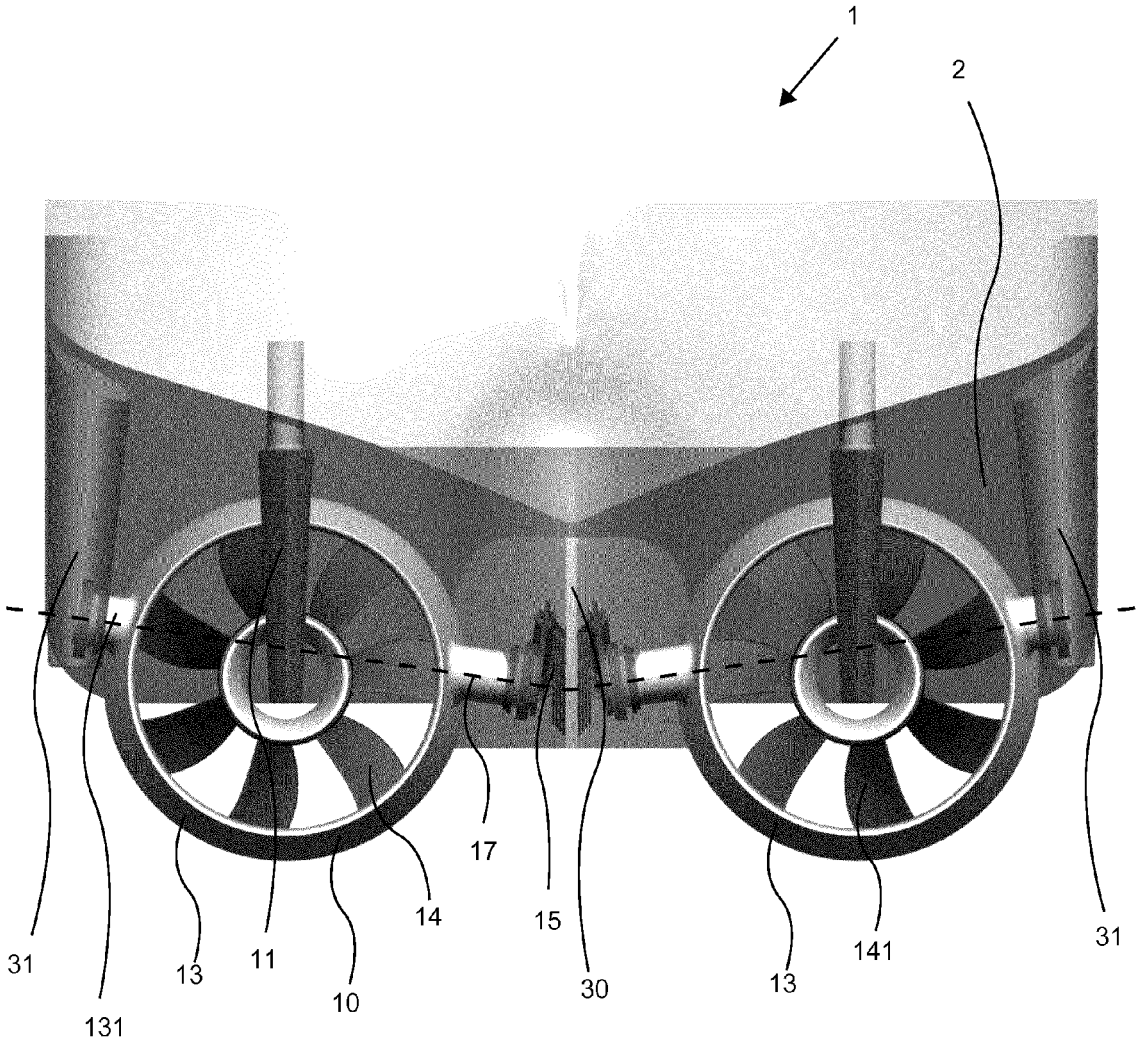


Fig. 1

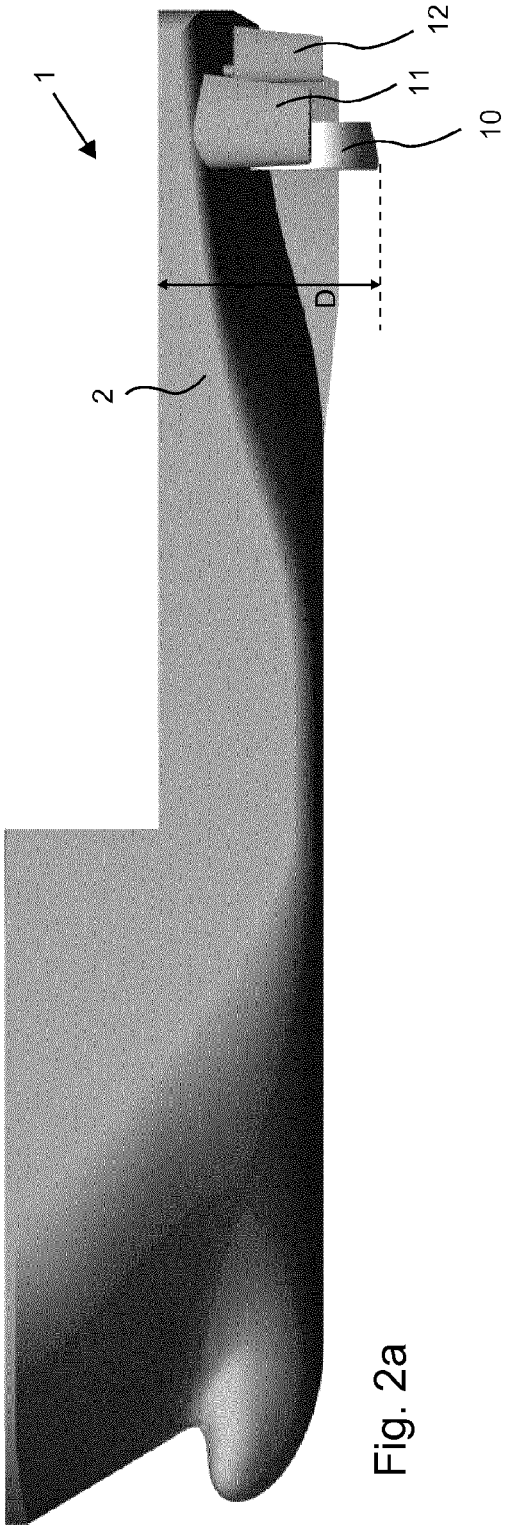


Fig. 2a

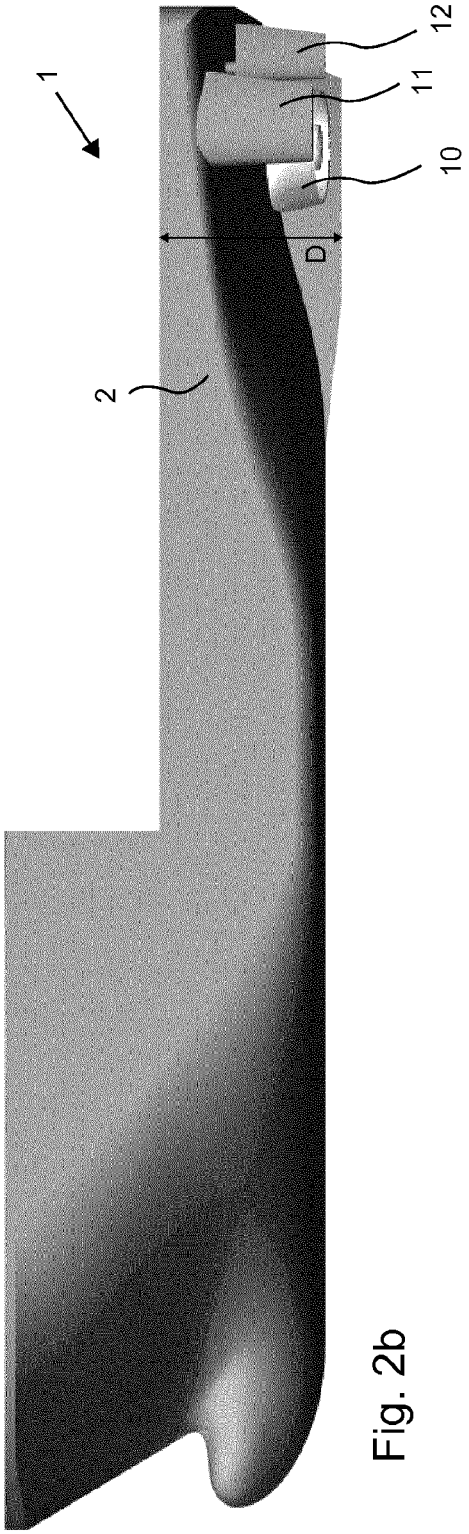


Fig. 2b

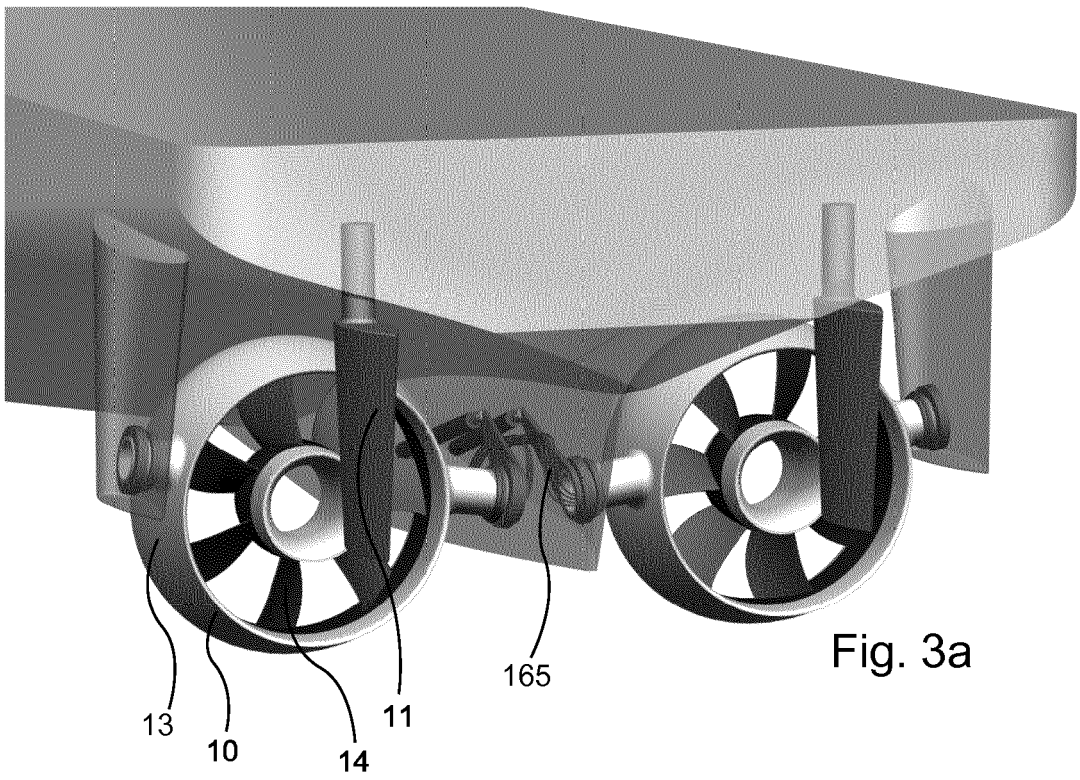


Fig. 3a

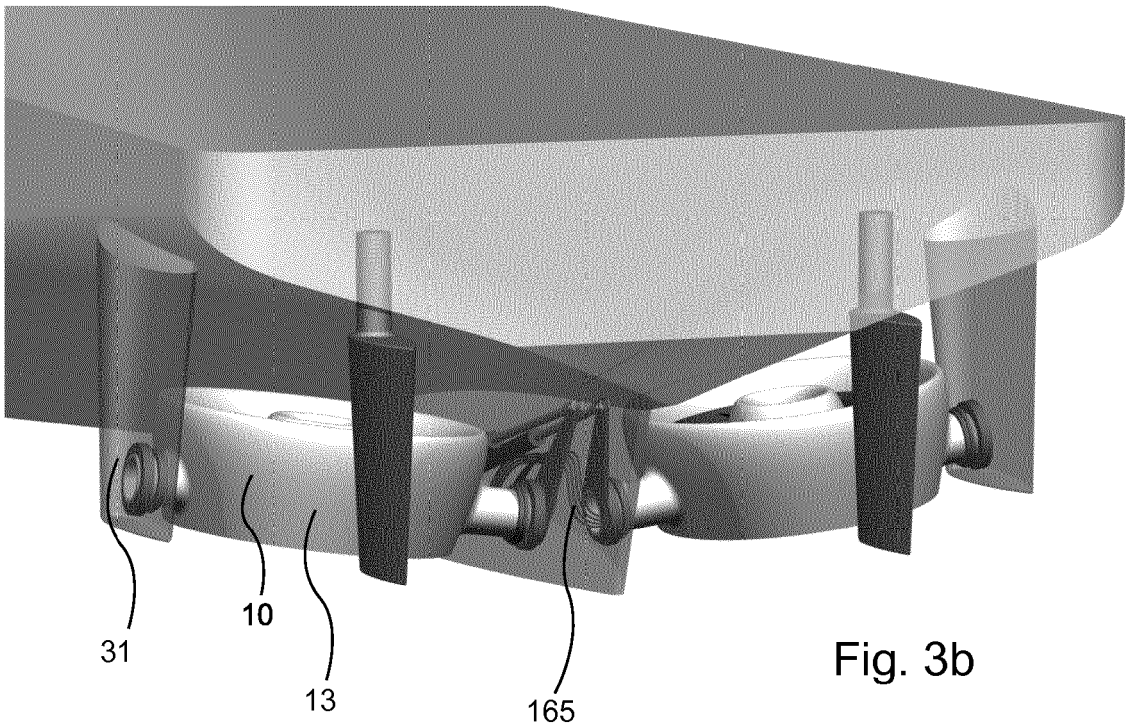


Fig. 3b

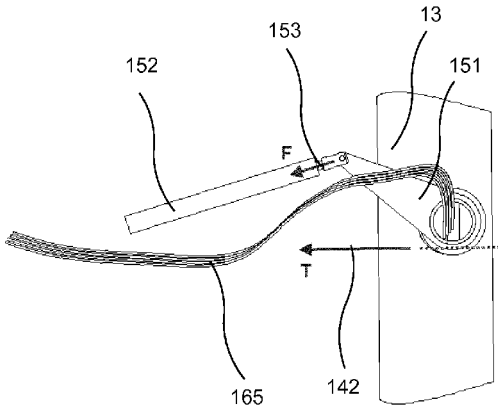


Fig. 4b

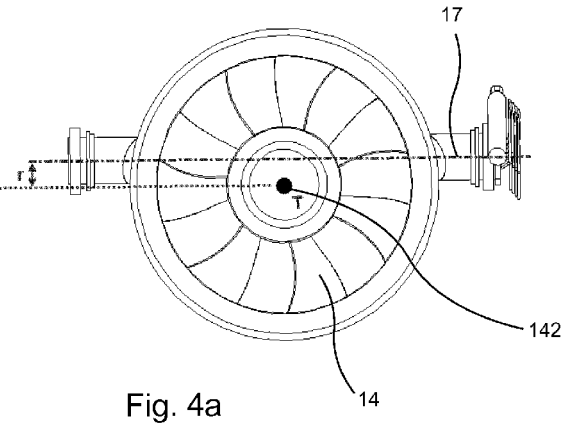
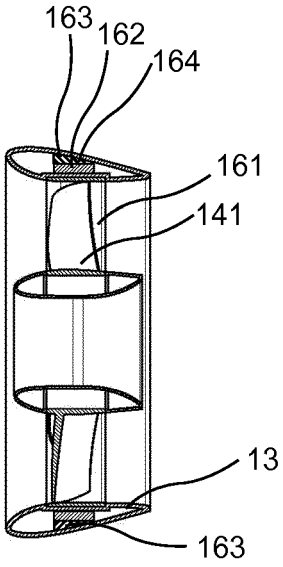


Fig. 4a



SECTION A-A

Fig. 5b

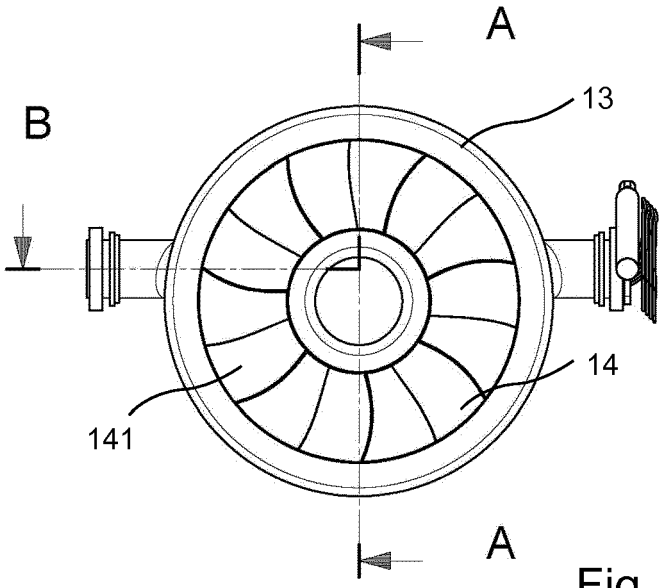
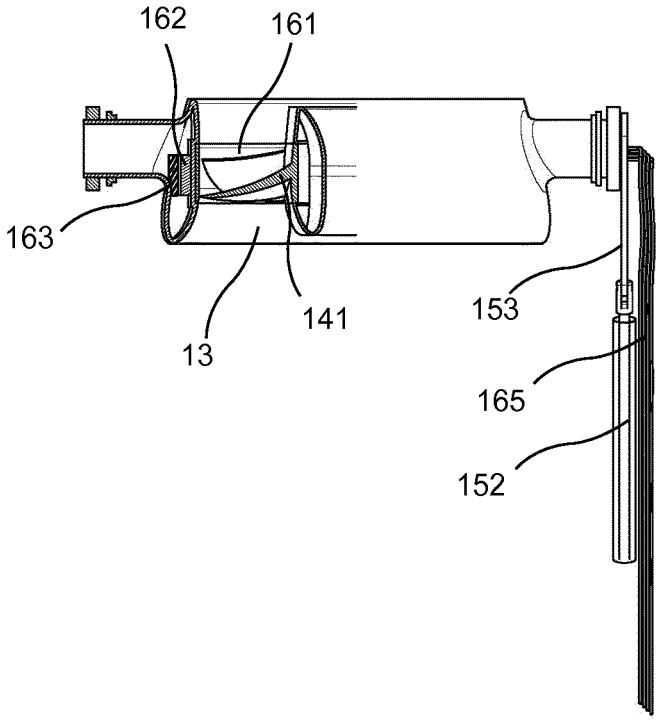


Fig. 5a



SECTION B-B

Fig. 5c

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EUROPEAN SEARCH REPORT

Application Number
EP 14 18 1977

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	GB 2 014 929 A (SCHOTTEL NEDERLAND BV) 5 September 1979 (1979-09-05) * figures 1-4 *	1-11	INV. B63H5/125
A,D	US 5 397 255 A (HEER MANFRED [DE]) 14 March 1995 (1995-03-14) * figures 1,2 *	1-11	
A	WO 98/30440 A1 (ULSTEIN PROPELLER [NO]; GAREN RUNE [NO]) 16 July 1998 (1998-07-16) * figures 1-4 *	1-11	

TECHNICAL FIELDS SEARCHED (IPC)

B63H
B63G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	29 January 2015	Székely, Zsolt

CATEGORY OF CITED DOCUMENTS

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29-01-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2014929 A	05-09-1979	GB 2014929 A	05-09-1979
		JP S5515386 A	02-02-1980
		NL 7802156 A	29-08-1979
		NO 790636 A	28-08-1979
US 5397255 A	14-03-1995	AT 152407 T	15-05-1997
		CA 2116610 A1	02-09-1994
		CN 1095681 A	30-11-1994
		DE 4306323 A1	08-09-1994
		DE 59402573 D1	05-06-1997
		DK 0613817 T3	28-07-1997
		EP 0613817 A1	07-09-1994
		ES 2102704 T3	01-08-1997
		FI 940943 A	02-09-1994
		GR 3024085 T3	31-10-1997
		JP H06316289 A	15-11-1994
		NO 940687 A	02-09-1994
		US 5397255 A	14-03-1995
WO 9830440 A1	16-07-1998	AT 216673 T	15-05-2002
		AU 5579998 A	03-08-1998
		DE 69805053 D1	29-05-2002
		DE 69805053 T2	07-11-2002
		DK 0950005 T3	29-07-2002
		EP 0950005 A1	20-10-1999
		ES 2178140 T3	16-12-2002
		NO 970075 A	10-07-1998
		PT 950005 E	31-10-2002
		WO 9830440 A1	16-07-1998

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5397255 A **[0003]**
- US 4565531 A **[0003]**
- WO 201013480 A2 **[0012]**