

VERTICAL WATER-JET PROPULSION DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a vertical water-jet propulsion device of a structure capable of reducing turning power required to turn a casing.

2. Description of the Related Art

A vertical water-jet propulsion device is designed such that an intake and a discharge opening to be flush with a ship bottom. The device which does not protrude from the bottom can be often applied to a special ship operating on shallow waters such as a floating crane ship which cannot ensure sufficient propeller immersion and cannot be equipped with an ordinary tunnel type thruster due to shallow draft. Japanese Unexamined Patent Application Publication Nos. 6-278692, 6-286693, 7-52882, 8-58689 and the like disclose prior art of the vertical water-jet propulsion devices of this type. The vertical water-jet propulsion device of this type allow a casing main body including a discharge opening to be turned by up to 360° in any directions, so that thrust can be generated in freely chosen directions and ship maneuverability can enhance.

FIG. 6 is a cross-sectional view of a vertical water-jet propulsion device disclosed in Japanese Unexamined Patent Application Publication No. 7-52882 cited above. FIG. 7 is a plan view thereof seen at the point of a diffuser.

As shown therein, a discharge flow sucked from an intake 53 at the central portion of a bottom 52a of a casing 52 and flowing upstream of an impeller 51 accompanies a turning flow caused by the rotation of the impeller 51. A diffuser 54 downstream of the impeller 51 functions to curve the turning flow using vanes 55 and also to change the direction of the turning flow to the radial direction at vane outlets using the vanes 55. With the turning flow remaining, if discharge flow enters the

pressure chamber of the casing 52, turning energy causes friction loss between the discharge flow and the wall surface of the casing 52, resulting in large energy loss. As for the function of the diffuser 54, since it is formed such that the sectional area of a flow passage gradually increases, the kinetic energy of water flow is gradually transformed to pressure energy to thereby increase occurrence of thrust. The diffuser 54 provided with the vanes 55 is, thus, one of indispensable constituent elements to the vertical water-jet propulsion device.

According to the conventional vertical water-jet propulsion device cited above, the diffuser 54 is integral with or integrally assembled with the casing 52. Due to this, the device has a structure in which both the casing 52 and the diffuser 54 are turned by driving a steering motor 56.

As shown in FIG. 7, the vanes 55 of the diffuser 54 generate a turning force (turning moment) Y in an arrow direction due to a reactive force F applied from water flow. The turning force is large enough to turn the casing 52 by up to 360° in any directions and has a significant effect on the determination of the capacity of the steering motor. That is, if the casing 52 is turned by means of the steering motor 56 and the diffuser 54 turns in the same direction as that in which the diffuser 54 receive the turning force (turning moment) Y in the arrow direction of FIG. 7, then the casing 52 turns by itself and the steering motor 56 turns with a small amount of power (which means conversely that it is required to stop turning with the steering motor). On the other hand, if the diffuser 54 turns in the opposite direction, the power is required to be large enough to overcome the sum of "frictional resistance and moment resulting from the overall inertial force of the casing" + "turning moment resulting from water flow incomparably large to the former two forces". The capacity of the steering motor has to be determined based on the power. Power consumption is, however, a serious issue, particularly for a work barge with a low generating capacity. Power consumption is,

therefore, desirably as low as possible in view of initial and running costs. The steering motor needs to be arranged in a limited space, so that it is also required that the capacity of the motor be reduced to a minimum and the size of the motor be as small as possible. In the above-stated prior art, an impeller shaft seal 57 is attached to the turning casing 52, as shown in FIG. 6. If the casing 52 turns in the direction opposite to the rotating direction of the impeller 51, the relative circumferential speed of a seal contact portion amounts to a value of a combination of the turning speed and the impeller rotating speed. Due to this, the seal application requirements becomes strict and the service life of the seal is thereby shortened.

According to the above-stated Japanese Unexamined Patent Application Publication No. 7-52882, three discharge openings are provided at the bottom of the casing 52 in which the intake-side end face of the central discharge opening is arc-shaped which appears to be concentric with the intake. The interior of each discharge opening is not provided with a guide vane which will be described later in the present application. It appears that the reference does not take into consideration that the discharged water flows efficiently in horizontal direction. As a result, part of water flow apparently escapes in substantially right under the bottom of the casing 52. It is, meanwhile, considered that torque required to turn a casing assembly involves a turning force resistant to the kinetic energy of discharge fluid, that resulting from the inertial force of the casing assembly and the like. If the amounts and directions of water discharged from two side discharge openings which put the central discharge opening therebetween are imbalanced, the resulting turning force has a great effect on the torque and the amount of the force becomes a dominant factor of the turning torque. To prevent the occurrence of such turning moment, the reference 7-52882 teaches setting the dimensions and positions of the discharge openings. In practice, however, balance



is determined unavoidably so that a turning moment in a certain direction is likely to undesirably remain. As the remaining turning moment increases, the capacity of the steering motor increases. This results in a larger hydraulic source or higher power consumption as in the case of the above.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a vertical water-jet propulsion device of a structure capable of reducing turning power required to turn a casing.

In one aspect of a vertical water-jet propulsion device according to the present invention, a vertical water-jet propulsion device includes a casing which can be turned by a steering motor, pushes upward running water taken from a bottom of the casing by rotation of an impeller, passes the water through a diffuser to fill an pressure chamber of the casing with water flow and discharges the water flow from discharge openings provided at the bottom of the casing, and is characterized in that a inner ring supported by a hull side and having an impeller shaft inserted therein is provided at an upper portion of the casing to support the casing through a swivel bearing, and in that the diffuser is integral with or integrally fixed to the inner ring.

With this configuration, the inner ring forms a stationary portion supported by the hull side, and the diffuser is separated from the casing to function as an independent member. The turning moment caused by changing the direction of the turning flow at the diffuser is not applied to the casing. In addition, even if the casing is turned, the diffuser remains stationary. The capacity of the steering motor required to turn the casing itself can be, thus, reduced.

In this case, a simpler configuration can be provided if a lower end portion of a

cylindrical inner ring connected to a gear box and extending downward is positioned within the casing and the diffuser is integrally installed to the lower end portion of the inner ring.

Further, an impeller shaft seal may be provided between a stationary portion of the diffuser or inner ring and the rotating impeller shaft to isolate a sea water portion from a lubricant chamber. It is, thus, possible to prevent leakage or entry of sea water or lubricant between the sea water portion and the lubricant chamber.

Moreover, if a turning seal is provided between a stationary portion of the diffuser or inner ring and the turning casing to isolate a sea water portion from a lubricant chamber, then it is possible to prevent leakage or entry of sea water or lubricant between the sea water portion and the lubricant chamber.

Additionally, a contact surface between the diffuser and the inner ring fitted into the diffuser may be formed to be tapered to push the diffuser and the inner ring against each other by a turning force caused by a reactive force of water flow applied to the diffuser. A self-locking system is thereby realized and the diffuser can be mounted with smaller or fewer diffuser mounting bolts.

Another vertical water-jet propulsion device according to the present invention includes a casing which can be turned on a horizontal plane, an intake provided at a center of a bottom of the casing, an impeller provided above the intake, a diffuser communicating with the intake, a pressure chamber communicating with the diffuser and discharge openings communicating with the pressure chamber and provided at the bottom of the casing, and is characterized in that discharge guide vanes are provided at the discharge openings and inclined at an angle such that jet from the discharge openings is as parallel to the bottom of the casing as possible.

As a result, it is possible to orient the jet from the discharge openings in as a

generally horizontal direction as possible without being flown right downward and to thereby enhance efficiency in the generation of thrust.

In this case, the discharge guide vanes may be provided to be inclined at an angle such that jet from the discharge openings is discharged outside of the casing in a direction opposite to a direction of the intake. It is, thus, possible to prevent the jet from the discharge openings from being quickly sucked into the intake and to thereby enhance efficiency in the generation of thrust. In addition, suction guide vanes may be provided at the intake and the suction guide vanes may be inclined at an angle to suck water in a direction opposite to a direction of jet discharged from the discharge openings. It is, thereby, possible to prevent sucking the jet from the discharge openings and to enhance efficiency in the generation of thrust.

Further, a central discharge opening symmetric about a diametral line passing through a center of the intake and/or side discharge openings symmetrically provided about the diametral line may be provided as the discharge openings, and an intake-side end face of the central discharge opening may be formed in a direction perpendicular to the diametral line. In this case, the inclination angle of the discharge guide vanes of the side discharge opening can be varied and adjusted. If so, the magnitudes of the left and right thrusts are made imbalanced and a moment to offset a turning moment resulting from the turning flow due to the rotation of impeller can be generated. As a result, the capacity of the steering motor to turn the casing can be reduced.

Moreover, if the inclination angle of the guide vanes of the central discharge opening can be changed and adjusted, the load of the impeller can be adjusted, as well. That is, if the areas of the discharge opening are increased, the load is reduced. If the areas are reduced, the load is increased. It is possible to easily matching-adjust a prime mover with a constant rotation speed to the impeller by delicately adjusting the

inclination angle.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic cross-sectional view of a water-jet propulsion device WJ according to the present invention;

FIGS. 2A and 2B are a schematic view and a perspective view showing important parts of an example of a structure which allows enhancing the function to fix a diffuser to a inner ring while utilizing the turning force of the diffuser generated as a reactive force of vanes, respectively;

FIG. 3 is a cross-sectional block diagram of the vertical water-jet propulsion device;

FIG. 4 is a view showing the bottom of a casing of the vertical water-jet propulsion device;

FIG. 5A is a cross-sectional view of a discharge opening portion (with a fixed discharge guide vane); and FIG. 5B is a block diagram of a variable discharge guide vane;

FIG. 6 is a cross-sectional view of a conventional vertical water-jet propulsion device; and

FIG. 7 is a plan view of the conventional vertical water-jet propulsion device seen at the point of the diffuser.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiments of the present invention will be described hereinafter with reference to the accompanying drawings.

FIG. 1 is a schematic cross-sectional view of a water-jet propulsion device WJ

according to the present invention.

A water-jet propulsion device WJ is installed to a hull 1. The water-jet propulsion device WJ consists of a platform 4 having a vertically provided gear box 3 including a power transmission mechanism 2 at a center thereof, a inner ring 5 extending in the lower direction of the central portion of the platform 4, an impeller shaft 7 inserted into the inner ring 5 in vertical direction and having an impeller 6 at a lower end thereof, a diffuser 8 positioned downstream of the impeller 6 and fitted to the inner ring 5, a casing 10 which can be turned by a steering motor 9 and supported by the inner ring 5 and the like.

The platform 4 is provided on an opening 1c of the hull 1 and fixed onto a inner base plate 1a of the hull 1. A drive shaft 11 extending from a prime mover (not shown) is inserted into and supports the gear box 3 provided vertically at the central portion of the platform 4. A pinion gear 2a is provided on the tip end portion of the gear box 3. There is also provided a wheel gear 2b engaged with the pinion gear 2a and constituting a power transmission mechanism 2. The impeller shaft 7 is vertically inserted into the interior of the cylindrical inner ring 5 below the wheel gear 2b and supported by upper and lower bearings 7a.

The inner ring 5 connects to and contacts with the gear box 3 and extends cylindrically in the downward direction. A diffuser 8 and an impeller shaft seal 12 slidably contacting with the impeller shaft 7 are installed to the flange portion 5a provided on the lower end portion of the inner ring 5 by many mounting bolts 8b. The inner ring 5 is attached to the platform 4 fixed to the hull 1 to serve as a stationary portion. The diffuser 8 attached to the inner ring 5 also serves as a stationary portion (fixed portion) not to rotate.

As stated, a sea water portion 12a and a lubricant chamber 12b are shut off or

isolated from each other and leakage or entry of sea water and lubricant between the sea water portion 12a and the lubricant chamber 12b are prevented by providing the impeller shaft seal 12 between the stationary portion of the diffuser 8 or inner ring 5 portion and the rotating impeller shaft 7.

Meanwhile, the cylindrical casing 10 is provided to fit into the opening portion 1c and has a outer ring 13 provided concentrically with the inner ring 5 at a central portion thereof. The outer ring 13 is engaged with and supported by the inner ring 5 through a swivel bearing 14. The outer ring 13 is separated from the diffuser 8 and can be turned independent of the diffuser 8. Specifically, the diffuser 8 of the stationary portion and the casing 10 of the turning portion are only engaged with and slidably contacted with each other through a turning seal 15 but are separate from or independent of each other.

Likewise, the sea water portion 12a and the lubricant chamber 12b are shut off or isolated from each other and leakage or entry of sea water and lubricant between the portion 12a and the chamber 12b is prevented by providing a turning seal 15 between the stationary portion of the diffuser 8 or inner ring 5 and the casing 10. A seal 4a is also provided between the casing 10 and the platform 4 to thereby isolate the sea water portion 12a and the lubricant chamber 12b from each other.

An engagement gear 13a is formed at the outer ring 13 of the casing 10. The gear 13a is engaged with a gear 9b at the lower end of a shaft 9a of the steering motor 9 provided on the platform 4 to allow the casing 10 to turn independently by driving the steering motor 9.

An intake 16 is provided at the central portion of the bottom 10a of the casing 10 and an inner wall 10b is provided vertically to surround the impeller 6. The diffuser 8 stated above is provided separately from the inner wall 10b (i.e., casing 10) in such a

manner that the diffuser 8 is provided continuous to the upper end of the inner wall 10b. A passage of water thrust up from the impeller 6 and flown through and radial vanes 8a to guide the water flow are provided within the diffuser 8. As described above, the water flow from the impeller 6 becomes a turning flow and acts on the vanes 8a. However, since the diffuser 8 is fixed to the hull side and separate from the casing 10, the turning moment caused by a reactive force is applied to the hull and has no effect on the turning of the casing 10. The steering motor 9, thus, suffices if it has a small amount of power necessary to turn the casing 10 itself.

The water flow from the diffuser 8 enters the pressure chamber 17 of the casing 10 connected to the diffuser 8 and the water existing in the pressure chamber 17 is exhausted from the discharge openings 18 having guide vanes 18a formed at the casing bottom 10a to thereby generate thrust. By turning the casing 10, the position of the discharge openings 18 can be freely varied by up to 360°.

FIGS. 2A and 2B show an example of a structure which enhances the feature of fixing the diffuser 8 to the inner ring 5 by using the turning force of the diffuser 8 generated as the reactive force of the vanes.

Specifically, a taper 18a is formed to push an annular member 8c protruding at the central portion of the diffuser 8 and the flange 5a at the lower end of the inner ring 5, to which the annular member 8c is fitted, against each other at a connection surface 18 between the annular member 8c and the flange 5a by a turning force Y caused by the reactive force of water flow applied to the diffuser 8. Thus, a self-locking system is realized, so that fewer or smaller mounting bolts 8b (shown in FIG. 1) may be required for mounting the diffuser 8.

Another embodiment will be described with reference to FIGS. 3 through 5.

FIG. 3 is a cross-sectional block diagram showing a vertical water-jet



propulsion device, whereas FIG. 4 shows the bottom of a casing. The vertical water-jet propulsion device WJ is installed to a vessel bottom portion 21. A cylindrical casing 23 of the propulsion device is concentrically fitted into an circular opening portion 22 provided in the bottom portion 21. The casing 23 is held at the vessel bottom portion 21 by a platform 24. That is, a swivel bearing 40 is provided to roll between the upper portion of the inner ring 34 and an annular outer ring 39 provided at the inner end of an upper wall 23c of the casing 23. The casing 23 can be, thereby, turned and is supported by the hull side as a whole. As a result, the casing 23 is held by the platform 24 fixed to the hull while the turning of the casing 23 is ensured. A gear box 28 is provided at the central portion of the platform 24 and an input shaft 29 is transversely inserted into the gear box 28 and supported by a bearing 30. A pinion 31 is provided at the tip end portion of the input shaft 29. A bevel wheel 33 provided at the upper end of an output shaft 32 is engaged with the pinion 31 to form a bevel gear. The output shaft 32 extends vertically in the downward direction and passes through a hollow inner ring 34 extended to the lower portion of the gear box 28. A boss 35 is provided at the lower end of the output shaft 32 and impellers 36 are formed at the boss 35. The output shaft 32 is rotatably supported by bearings 32a provided between the shaft 32 and the inner rings 34.

The casing 23 has a conical central wall 3a depressed downward to surround the outer periphery of the inner rings 34 at an upper central portion thereof. The lower end of the central wall 3a extends over the upper end of the boss 35. The central portion of the bottom 23e of the casing 23 pushed out upward from where very narrow clearances are provided between the central portion thereof and the tip end portions of the impellers 36 to thereby form an inner wall 23b. The inner wall 23b flares upward, extends further from the same position as that of the lower end of the conical central



wall 23a and forms the diffuser 37 while keeping a certain distance from the central wall 23a. A current plate 38 is provided radially at the portion of the diffuser 37, that is, between the central wall 23a and the upper portion of the inner wall 23b.

A pinion 41a on the lower end of the shaft of the steering motor 41 provided on the platform 24, is engaged with the outer ring 39. Accordingly, if the steering motor 41 is activated to rotate the pinion 41a in a predetermined direction, then the casing 23 integral with the outer ring 39 engaged with the pinion 41a turns around the center of the output shaft 32. Thus, the position of a discharge opening 42, which will be described later, can be freely varied by up to 360°. Besides, an annular projection 25 is provided on the upper portion within the cylindrical casing 23. A guide ring 26 protruding downward from the platform 24 is concentrically engaged with the outer periphery of the projection 25 through a seal 27.

A circular opening portion surrounded by the inner wall 23b below the impellers 36 serves as a water intake 43. The intake 43 is provided continuous to the diffuser 37 and communicates with the pressure chamber 44 provided between the outer wall 23d and inner wall 23b of the casing 23. A discharge opening 42 (in FIG. 3, which is a central discharge opening 45 to be described later) is formed at part of the bottom wall such that a jet from the pressure chamber 44 is discharged from the discharge opening 42. A plurality of embowed discharge opening guide vanes 42a are provided at the discharge opening 42 with such inclination angles that a discharge flow can be jetted in as horizontal direction as possible or in a direction as parallel as possible to the bottom 23e of the casing 23. This is because the more the components of the discharge flow in the horizontal direction are, the more efficiently the greater thrust can be generated. Since both the intake 43 and the discharge opening 42 are provided on the bottom 23e of the casing 23, a plurality of suction guide vanes 43a with inclination



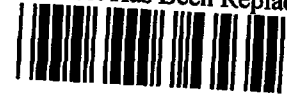
angles opposite to those of the discharge opening guide vanes 42a are provided at the intake 43 so that a flow of water discharged from the discharge opening 42 cannot be quickly sucked into the intake 43. With the configuration of the vertical water-jet propulsion device WJ stated above, water is sucked from the intake 43 by the rotation of impellers 36 as indicated by arrows of FIG. 3, water pressure increases at the impellers 36 and water is discharged from the diffuser to the pressure chamber 44. The pressure energy of water in the pressure chamber 44 is transformed into kinetic energy and the water is jetted from the discharge opening 42, thereby providing desired thrust.

As shown in FIG. 4, discharge openings 42 involve a central discharge opening 45 and side discharge openings 46 around the central opening 45. The central discharge opening 45 is formed into rectangular shape longer than the diameter of the circular intake 43 in the tangent direction of the intake 43. It is preferable that the intake 43-side end face 45a of the central discharge opening 45 is formed in a direction perpendicular to a diametral line O passing the center of the circular intake 43. The reason is that water flow can be efficiently utilized as thrust without losing part of water flow right downward. The end face may be formed concentrically with the intake 43 as indicated by an imaginary line 45B, in which case efficiency in use of water flow as thrust is slightly decreased. The side discharge openings 46 are formed to have the same size symmetrically about the diametral line O. Discharge guide vanes 42a are provided at not only the central discharge opening 45 but also the side discharge openings 46. The cross-section of the guide vane 42a is shown in FIG. 5A. The guide vane 42a provided at the side discharge opening 46 is inclined at an angle opposite to that of the intake guide vane 43a to prevent jet from the discharge opening 42 from being quickly sucked into the intake 43.

As shown in FIG. 5B, the discharge guide vanes provided at the central

discharge opening 45 and the side discharge openings 46 may be formed as variable guide vanes 42b inclined at variable angles. That is, the center of each of the variable guide vanes 42b is rotatably supported and a working rod 49 extended from a rod 48 of a drive cylinder 47 is coupled to the upper ends of the guide vanes 42b through coupling materials 50, respectively. The variable guide vanes 42b may be inclined at desired angle in the block by activating the drive cylinder 47 to expand or contract the rod 48.

If the guide vanes of the central discharge opening 45 are variably inclined, they can be used to adjust the discharge openings to match the impellers while a driving prime mover coupled to the input shaft normally rotates at a constant rotation speed. If the guide vanes of the side discharge openings 46 are variably inclined, they can be used to change the balance of discharge flow rate between the left and right discharge openings to thereby change fluid force and to offset imbalanced turning moment. This makes it possible to reduce the capacity of the steering motor.



CLAIMS

1. A vertical water-jet propulsion device comprising a casing which can be turned by a steering motor, pushing upward running water taken from a bottom of the casing by rotation of an impeller, passing the water through a diffuser to fill an pressure chamber of the casing with water flow and discharging the water flow from discharge openings provided at the bottom of the casing, wherein a inner ring supported by a hull side and having an impeller shaft inserted therein is provided at an upper central portion of the casing ;and

the casing is supported by the inner ring through a swivel bearing; and
the diffuser is integral with or integrally fixed to the inner ring.

2. The vertical water-jet propulsion device according to claim 1, wherein a lower end portion of a cylindrical inner ring connected to a gear box and extending downward is positioned within the casing; and

the diffuser is integrally installed to the lower end portion of the inner ring.

3. The vertical water-jet propulsion device according to one of claims 1 and 2, wherein an impeller shaft seal is provided between a stationary portion of the diffuser or inner ring and the rotating impeller shaft to thereby isolate a sea water portion from a lubricant chamber.

4. The vertical water-jet propulsion device according to one of claims 1, 2 and 3, wherein a turning seal is provided between a stationary portion of the diffuser or inner ring and the turning casing to thereby isolate a sea water portion from a lubricant chamber.





5. The vertical water-jet propulsion device according to one of claims 1 through 4, wherein a contact surface between the diffuser and the inner ring fitted into the diffuser is formed to be tapered to push the diffuser and the inner ring against each other by a turning force caused by a reactive force of water flow applied to the diffuser.
6. A vertical water-jet propulsion device comprising a casing which can be turned on a horizontal plane, an intake provided at a center of a bottom of the casing, an impeller provided above the intake, a diffuser communicating with the intake, a pressure chamber communicating with the diffuser and discharge openings communicating with the pressure chamber and provided at the bottom of the casing, wherein discharge guide vanes are provided at said discharge openings and inclined at an angle such that jet from the discharge openings is as parallel to the bottom of the casing as possible.
7. The vertical water-jet propulsion device according to claim 6, wherein the discharge guide vanes are provided to be inclined at an angle such that jet from the discharge openings is discharged outside of the casing in a direction opposite to a direction of the intake.
8. The vertical water-jet propulsion device according to one of claims 6 and 7, wherein suction guide vanes are provided at the intake and said suction guide vanes are inclined at an angle to suck water in a direction opposite to a direction of jet discharged from the discharge openings.
9. The vertical water-jet propulsion device according to one of claims 6 through 8, wherein a central discharge opening symmetric about a diametral line passing through a



center of the intake and/or side discharge openings symmetrically provided about the diametral line is provided as the discharge openings; and

an intake-side end face of the central discharge opening is formed in a direction perpendicular to said diametral line.

10. The vertical water-jet propulsion device according to claim 9, wherein the inclination angle of the discharge guide vanes of the side discharge opening can be varied and adjusted.

11. The vertical water-jet propulsion device according to claim 10, wherein the inclination angle of the guide vanes of the central discharge opening can be changed and adjusted.

