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(54) POWERING SYSTEM FOR A WATERCRAFT

(57) A powering system (10) for a watercraft is provided. The powering system for a watercraft comprises a propeller (100), an electric motor (20), and a gearbox (30) coupled to the electric motor. The powering system for a watercraft further comprises an input shaft (50), an intermediate shaft (60), and a propeller shaft (70).

The input shaft has a first end (51) coupled to the gearbox and a second end (52) rotatably coupled to the intermediate shaft. The intermediate shaft has a first end (61) rotatably coupled to the input shaft and a second end rotatably (62) coupled to the propeller shaft. The propeller shaft has a first end (71) rotatably coupled to the intermediate shaft and a second end (72) coupled to the propeller. The intermediate shaft comprises an upper portion (63) extending in a second direction (2) and a lower portion (64), the lower portion being rotatably coupled to the upper portion.

Additionally, the powering system for a watercraft comprises an upper supporting (120) and a lower supporting structure (130). The upper supporting structure is configured to be tiltable coupled to a watercraft. The lower supporting structure is rotatably coupled to the upper supporting structure to rotate about the second direction.

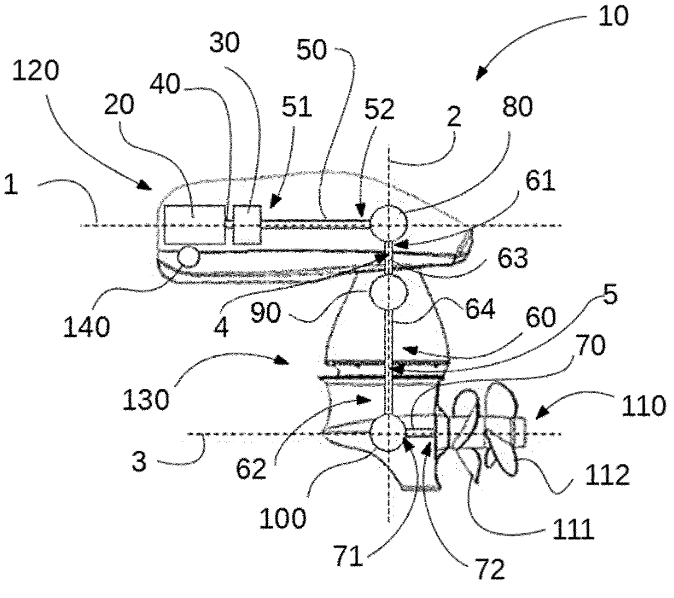

Figure 1

EP 4 144 634 A1

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Description

[0001] The present disclosure relates to powering systems for a watercraft and to watercrafts comprising a powering system.

BACKGROUND

[0002] Watercrafts or boats are moved across water by a thrust force generated by a powering system or propulsion system. The powering system may include a motor, e.g. a diesel motor and/or an electric motor. Depending on the arrangement of the powering system, the powering system may be an inboard powering system, an outboard powering system or a sterndrive powering system.

[0003] Inboard powering systems include a motor situated and supported within the hull of the watercraft. Therefore, a significant space within the hull is required for arranging the motor, which limits the available space to be utilized for other purposes such as cabin space, storage, etc. In addition, as the motor is located inside the hull in a limited space, the accessibility of the motor for maintenance operations is hindered.

[0004] The motor of inboard powering systems generally drives a single propeller shaft having a first end coupled to the motor and a second end coupled to a propeller. The propeller shaft extends along the stern of the watercraft and rotates about the axis of the propeller shaft. The propeller shaft generally forms a fixed angle with the hull of the watercraft which cannot be adjusted or modified with respect to the water level. The position of the propeller is thus fixed relative to the watercraft, allowing incrustation of algae and mollusks onto the propeller shaft and the propeller. Therefore, no tilting operations, i.e. lifting the motor, are available. The hull comprises an aperture for passing the propeller shaft through the hull to connect the motor to the propeller. Although this aperture may be sealed, water and moisture may enter into the hull and may come into direct contact with the inboard powering system. This may result in corrosion and wear may increase. In addition, a precise alignment of the propeller shaft is required to prevent excessive vibrations and/or noise. Therefore, installation of inboard powering systems may involve a labor-intensive process.

[0005] Furthermore, inboard powering systems cannot rotate about a vertical direction to steer the watercraft. One or more rudders located behind the propeller are used for steering the watercraft which may adversely increase the draft of the watercraft.

[0006] In outboard powering systems, the motor is arranged outside the hull of the watercraft. Outboard powering systems typically include an upper structure supporting the motor, a vertical input shaft and a lower structure supporting a horizontal propeller shaft.

[0007] Outboard powering systems are typically attached to a transom of the watercraft. The entire outboard powering system can be rotated about the vertical axis to steer the watercraft. In addition, the entire outboard powering system can be pivoted about an axis extending parallel to the port - starboard direction of the watercraft so as to perform tilting operations, i.e. lifting the outboard powering system above the water level, and/or trimming operations, i.e. slightly adjust the thrust angle of the propeller shaft relative to the hull. Transoms may be subjected to wear which may increase the risk of detaching the outboard powering system from the transom. In addition, transoms may be subjected to high loads since the entire outboard powering system is moved for e.g. steering, tilting, and/or trimming. To withstand these high loads, structural reinforcements of the transom may be required. This may increase the size and/or weight of the transom which may limit the available space within the hull. As the whole outboard powering system can be moved, large actuators are usually required.

[0008] In addition, dimensions of the motor used in outboard powering systems is typically constrained by the forces required to move the outboard powering system with respect to the watercraft (e.g. tilting, trimming, and/or steering). Accordingly, employing larger motors is typically avoided.

[0009] Furthermore, the weight of outboard powering systems using an electric motor increases since the electric motor and the batteries are typically integrated within the outboard powering system. This generates higher loads when the powering system is moved relative to the watercraft. For this reason, powerful electric motors are not typically used in outboard powering systems.

[0010] Sterndrive powering systems include a motor arranged inside the hull of the watercraft and a drive system projecting from the hull coupled to the propeller. Therefore, similarly to inboard powering systems, valuable space inside the hull is used, and accessibility to the motor for maintenance operations is hindered.

[0011] The drive system of a sterndrive powering system generally comprises a horizontal input shaft having a first end coupled to the motor and a second end coupled to a vertical intermediate shaft. This vertical intermediate shaft is connected to the propeller through a horizontal propeller shaft. The horizontal input shaft, the vertical intermediate shaft and the horizontal propeller shaft are typically enclosed and supported by a supporting structure extending outwardly from the hull of the watercraft.

[0012] In addition, the hull comprises an aperture for passing the horizontal input shaft through the hull to connect the motor with the vertical intermediate shaft. Although this aperture may be sealed, water and moisture may enter into the hull and may come into direct contact with the motor of the sterndrive powering system. This may result in corrosion and increased wear.

[0013] In some examples, the supporting structure extending outwardly from the hull may allow trimming operations, i.e. slightly adjust the thrust angle of the propeller shaft with the hull. However, steering movements (i. e. to navigate through a desired direction) and/or tilting movements (i.e. lifting the supporting structure above the water level), are generally restricted by the dimensions of the supporting structure. Only limited steering and/or trimming operations or movement can thus be performed. This may result in incrustation of algae and mollusks onto a portion of the supporting structure below a water level. Wear of the components below the water lever may consequently be increased.

[0014] As explained before, motors can be electric motors. Electric motors typically rotate at an electric motor revolutions per minute which is typically higher than the propeller revolutions per minute. Reductors may thus be used to adapt the electric motor revolutions per minute to the propeller revolutions per minute. These reductors may require a large space. Integrating an electric motor in any of the above-mentioned powering systems may thus be challenging.

[0015] Examples of the present disclosure seek to at least partially reduce one or more of the aforementioned problems.

SUMMARY

[0016] In a first aspect, a powering system for a watercraft is provided. The powering system for a watercraft comprises a propeller, an electric motor, and a gearbox coupled to the electric motor. The powering system for a watercraft further comprises an input shaft, an intermediate shaft, and a propeller shaft.

[0017] The input shaft has a first end coupled to the gearbox and a second end rotatably coupled to the intermediate shaft. The input shaft extends from the first end to the second end in a first direction. The intermediate shaft has a first end rotatably coupled to the input shaft and a second end rotatably coupled to the propeller shaft. The intermediate shaft comprises an upper portion and a lower portion, the lower portion being rotatably coupled to the upper portion. The upper portion of the intermediate shaft extends in a second direction. The propeller shaft has a first end rotatably coupled to the intermediate shaft and a second end coupled to the propeller. The propeller shaft extends from the first end to the second end in a third direction. The first direction is perpendicular to the second direction and substantially parallel to the third direction.

[0018] Additionally, the powering system for a watercraft comprises an upper supporting and a lower supporting structure. The upper supporting structure supports the electric motor and the gearbox. The upper supporting structure is configured to be tiltable coupled to a watercraft. The lower supporting structure supports the propeller and the propeller shaft. The lower supporting structure is rotatably coupled to the upper supporting structure to rotate about the second direction.

[0019] In this aspect, a powering system with an electric motor for moving a watercraft across water by a thrust force is provided. A compact powering system with an electric motor is thus provided. Any suitable electric motor may be used in the powering system according to the present disclosure.

[0020] The entire powering system, i.e. from the electric motor to the propeller, is arranged outside the hull of the watercraft. Therefore, the powering system may save space inside the hull. Furthermore, problems related to water entering into the hull may be avoided.

[0021] In addition, the entire powering system may be manufactured independent from the watercraft. For example, the powering system may be manufactured in a factory and then installed to the watercraft at a boat dealer. Manufacturing and logistics may thus be improved. In addition, less labor-intensive processes are required for installing the powering system into watercraft at the boat dealer. Efficiency and versatility of mounting the powering system in the watercraft may consequently be increased. Furthermore, maintenance operations may be simplified. For example, the entire power system can be detached from the watercraft and maintenance operations can be more easily performed. Therefore, any portion of the powering system may be easily accessed. Cost and time for replacing a failed component may be reduced.

[0022] The electric motor drives the gearbox which is connected to the input shaft. The input shaft extends and is configured to rotate about the first direction. In use, the first direction is substantially horizontal and extends substantially parallel to a bow to stern direction. The rotation of the input shaft about the first direction drives the rotation of the intermediate shaft about the second direction. The input shaft and the intermediate shaft are substantially perpendicular. An input shaft gear may be arranged at the second end of the input shaft to mesh a first intermediate shaft gear arranged at the first end of the intermediate shaft. These gears may be bevel and/or helical gears to transmit power in a perpendicular direction.

[0023] The rotation of the intermediate shaft about the second direction drives the rotation of the propeller shaft about the third direction to rotate the propeller to move the watercraft. Since the third direction and the first direction are substantially parallel, the intermediate shaft and the propeller shaft are substantially perpendicular. A gear associated with the second end of the intermediate shaft may mesh with a gear associated with the first end of the intermediate shaft. For example, these gears may be bevel and/or helical gears.

[0024] The configuration of these shafts allows to efficiently transmit power from the electric motor to the propeller in a compact way. In addition, the rotational speed provided by the electric motor may be adapted to a rotational speed of the propeller. Consequently, the electric motor revolutions per minute provided by the electric motor may be reduced to the propeller shaft revolutions per minute to match the range of revolutions per minute of the propeller. For example, the change of direction of the shafts, e.g. from the input shaft to the intermediate shaft, may be used to reduce the rotational speed.

[0025] In some examples, the electric motor is configured to rotate at an electric motor revolutions per minute and the gearbox is configured to reduce the electric motor revolutions per minute to an input shaft revolutions per minute. Different configurations of gearbox may be used to reduce the rotational speed from the electric motor revolutions per minute to the input shaft revolutions per minute.

[0026] In some examples, the second end of the input shaft and the first end of the intermediate shaft may be configured to reduce an input shaft revolutions per minute to an intermediate shaft revolutions per minute. A pair of gears, each of them associated with one of the input shaft and the intermediate shaft may be used to reduce the rotational speed and to change the direction of the shafts.

[0027] In some examples, the second end of the intermediate shaft and the first end of the propeller shaft may be configured to reduce an intermediate shaft revolutions per minute to a propeller shaft revolutions per minute. For example, a second intermediate shaft gear arranged at the second end of the intermediate shaft may mesh a propeller shaft gear to reduce the revolutions per minute.

[0028] According to the present disclosure, the upper supporting structure may be tilted with respect to the watercraft such that the upper supporting structure and the lower supporting structure may be positioned above a water level. The powering system may thus be tilted with respect to the watercraft as a single unit. Consequently, the electric motor, the gearbox, the shafts, and propeller may be easily accessed to perform maintenance operations. Moreover, tilting the powering system above the water level may prevent water from coming into direct contact with the powering system. Consequently, infiltration of moisture or water to internal critical areas of the powering system may be avoided and thus, corrosion and wear may be reduced. Furthermore, tilting the powering system above the water level may prevent the incrustation of algae and mollusks onto the powering system. Wear may thus be reduced, and performance of the powering system may be improved.

[0029] As the lower supporting structure is rotatably coupled to the upper supporting structure, the propeller may rotate relative to the upper structure. Accordingly, only the rotation of the lower structure may be required to perform steering operations. Consequently, loads required to steer the propeller may be decreased. In addition, drag may be reduced and loads required to maintain a predetermined steering angle or steering direction may be decreased.

[0030] In some examples, the powering system may further comprise a bearing rotatably coupling the lower supporting structure to the upper supporting structure. Examples of suitable bearings may be roller bearings and gliding pad bearings.

[0031] To allow the lower supporting structure to rotate relative to the upper supporting structure, the intermediate shaft comprises an upper portion that can rotate relative to the lower portion about the second direction. The lower portion may thus be driven by the upper portion and rotate with respect to the upper portion about the second direction. Axis of rotation of the lower portion and of the upper portion are thus parallel to the second direction. In some examples, the intermediate shaft may comprise a universal joint rotatably coupling the upper portion to the lower portion of the intermediate shaft.

[0032] In some examples, the powering system may further comprise a steering system to rotate the lower supporting structure about the upper supporting structure. The steering system orientates the lower supporting structure to position the propeller at a predetermined direction, i.e. the steering angle. The steering system may comprise an actuator to cause the rotation of the lower support structure about the upper support structure. The actuator may have a first end coupled to the upper supporting structure and a second end coupled to the lower supporting structure. When the actuator changes its length, the actuator may push or pull its second end coupled to the lower supporting structure. As the lower supporting structure is rotatably coupled to the upper supporting structure, the actuator by changing its length rotates the lower supporting structure about the upper supporting structure. Since the steering system may only rotate the lower supporting structure, loads required to rotate may be reduced. Accordingly, relatively small actuators may be used.

[0033] In a further aspect, a watercraft comprising a hull and the powering system according to any of examples herein disclosed is provided. The hull extends from a port side to a starboard side along a port - starboard direction and from a bow to a stern along a bow - stern direction, the hull comprising a coupling portion. In this aspect, the upper supporting structure of the powering system is tiltable coupled to the coupling portion of the hull.

[0034] Advantages derived from this second aspect may be similar to those mentioned regarding the powering system of the first aspect. Namely, saving space inside the hull, simplifying the installation of the powering system, improving maintenance, and decreasing loads required to maintain the steering angle. Furthermore, corrosion and wear may be prevented, e.g. when the powering system is tilted above the water level.

[0035] In some examples, the coupling portion may be integrated within the hull. In further examples, the coupling portion may be attached to the hull, e.g. to the stern side of the hull.

[0036] In some examples, the watercraft comprises a positioning system to position the power system relative to the water level. The positioning system may thus tilt the powering system with respect to the hull. The positioning system may be arranged at the hull of the watercraft. In some examples, the positioning system may be fixedly coupled to the hull of the watercraft. Alternatively, the positioning system may be placed on the hull when tilting the powering system is required. Rotatory actuators and/or linear actuators may be used to rotate the powering system about an axis parallel to the port - starboard direction, i.e. for tilting the powering system.

[0037] In some examples, the upper supporting structure may comprise a mounting bracket to support a connecting member for connecting the upper supporting structure to the watercraft. The connecting member may connect the coupling portion of the hull to the mounting bracket of the upper supporting structure. The connecting member may be rotatably coupled to the coupling portion of the hull to allow the upper supporting structure to tilt about the watercraft.

[0038] In some of these examples, the mounting bracket may be fixedly connected to the connecting member which extends in a direction parallel to the port-starboard direction. A rotatory actuator may be employed to rotate the connecting member so as to rotate rotating the powering system about an axis parallel to the port - starboard direction.

[0039] Alternatively, the connecting member comprises a first end rotatably coupled to the coupling portion of the hull and a second end rotatably coupled to the mounting bracket of the upper supporting structure. The connecting member may rotate with respect to the coupling portion about a connecting member first end axis and with respect to the mounting bracket about a connecting member second end axis. The connecting member first end axis and the connecting member second end axis may be substantially parallel to the port - starboard direction. Furthermore, the connecting member first end axis may be spaced apart a distance from the connecting member second end axis. Accordingly, the upper supporting structure may rotate about the connecting member first end axis and about the connecting member second end axis. The connecting member first end axis and the connecting member second end axis are separated by a distance substantially corresponding to the length of the connecting member. This increases the precision of the height of the propeller relative to the water level. For example, this arrangement allows performing large tilting and/or trimming operations Therefore, the position of the propeller shaft relative to the watercraft may be modified or adjusted to the water level.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] Non-limiting examples of the present disclosure will be described in the following, with reference to the appended drawings, in which:

Figure 1 is a simplified view of a powering system according to one example of the present disclosure;

Figure 2 is an isometric view of a watercraft comprising a powering system according to an example of the present disclosure;

Figures 3a and 3b respectively shows is a top side view of a powering system according to one example of the present disclosure at different steering angles;

Figures 4a - 4c respectively shows a side view of a powering system coupled to a watercraft according to one example of the present disclosure at different positions;

Figures 5a - 5d respectively shows a side view of a powering system coupled to a watercraft according to one example of the present disclosure at different positions;

Figure 6 is a cross-sectional view of a powering system according to one example of the present disclosure;

Figure 7 is an isometric view of a watercraft comprising a powering system and a coupling portion according to one example of the present disclosure.

DETAILED DESCRIPTION OF EXAMPLES

[0041] In these figures the same reference signs have been used to designate matching elements.

[0042] Figure 1 illustrates a simplified view of one example of a powering system 10 comprising an electric motor 20 and a gearbox 30 coupled to the electric motor 20. The electric motor 20 converts electrical energy into mechanical energy. The electric motor 20 may be an alternating current (AC) motor (e.g. asynchronous motor, synchronous motor) comprising a rotor encircled by a stator. The stator is a stationary element, and the rotor is the rotating element. The rotor may be rotatably mounted on the stator through a bearing so that the rotor may rotate relative to the stator around an axis. On the one hand, the stator comprises slots for receiving winding which passes through the slots of the stator. On the other hand, the rotor comprises an electric motor shaft 40. When an AC current passes through the winding of the stator, a rotating magnetic field is generated. As a result, current is induced in the rotor which results in an induced magnetic field around the rotor. The interaction of the rotating magnetic field and the induced magnetic field results in the rotation of the rotor about the axis of the electric motor shaft 40. Therefore, the electric motor 20 may be configured to rotate the electric motor shaft 40 at an electric motor revolutions per minute.

[0043] The electric motor revolutions per minute may be understood as the number of turns of the electric motor shaft 40 in one minute.

[0044] The gearbox 30 is coupled to the electric motor shaft 40 of the electric motor 20 through a shaft coupling. The gearbox 30 may be a reduction gearbox arranged to reduce the electric motor revolutions per minute.

[0045] In some examples, the gearbox 30 may be a reduction gearbox comprising epicyclic gearing. The epicyclic gearing may include a sun gear, one or more planet gears, a ring gear, and a carrier element supporting the planet gears.

[0046] The sun gear may be coupled to the electric motor shaft 40 such that the rotation of the electric motor shaft 40 may be transferred to the sun gear. The sun gear may rotate about a sun gear axis at the electric motor revolutions per minute.

[0047] The sun gear may engage the planet gears. The sun gear and the planets gears may include gear teeth such that the gear teeth of the sun gear mesh with the gear teeth of the planet gears.

[0048] The planet gears may be arranged between the sun gear and an inner surface of the ring gear. The inner surface of the ring gear may include gear teeth configured to mesh with the gear teeth of the planet gears.

[0049] Upon rotation of the sun gear, the planet gears may rotate concentrically about the sun gear axis and revolve externally of the sun gear and internally of the ring gear. Thus, rotation of the planet gears may rotate the carrier element about the sun gear axis.

[0050] The gear ratio e.g. sun gear relative to the planet gears, sun gear relative to the ring gear, may be selected to reduce the electric motor revolution per minute to predetermined revolutions per minute.

[0051] In this example, the ring gear is stationary (i.e. the ring gear does not rotate about the axis of the sun gear). During operation of the gearbox of the figure 1, the sun gear may be rotated by the electric motor shaft rotating at the electric motor revolutions per minute. In this example, the sun gear meshes with the planet gears and the planet gears rotates concentrically about the axis of the sun gear which in turn rotates the carrier element fixed to the planet gears. As a result, the output of the gearbox 30 with epicyclic gearing may rotate at a decreased revolutions per minute than the electric motor revolutions per minute.

[0052] The powering system further comprises an input shaft 50, an intermediate shaft 60 and a propeller shaft 70. The input shaft 50 extends from a first end 51 to a second end 52 in a first direction 1.

[0053] The first end 51 of the input shaft is coupled to the gearbox 30. Thus, the gearbox 30 may reduce the rotational speed of the electric motor revolutions per minute to an input shaft revolutions per minute. The input shaft revolutions per minute may be understood as the number of turns of the input shaft 50 in one minute. Therefore, the input shaft 50 coupled to gearbox through the first end 51 may perform a number of turns in one minute that is lower to the number of turns of the electric motor shaft in one minute.

[0054] In this example, the electric motor 20 rotates at an electric motor revolutions per minute and the gearbox 30 reduces the electric motor revolutions per minute to an input shaft revolutions per minute.

[0055] In this figure, the intermediate shaft 60 comprises a first end 61 and a second end 62. The intermediate shaft 60 further comprises an upper portion 63 and a lower portion 64. The upper portion 63 extends in a second direction 2 and the propeller shaft 70 extends from a first end 71 to a second end 72 in a third direction 3.

[0056] The first direction 1 is perpendicular to the second direction 2 and parallel to the third direction 3. Consequently, the input shaft 50 is substantially perpendicular to the intermediate shaft 60. Furthermore, the input shaft 50 is substantially parallel to the propeller shaft 70.

[0057] The first end 61 of the intermediate shaft 60 is rotatably coupled to the second end 52 of the input shaft 50 through a first coupling mechanism 80.

[0058] The first coupling mechanism 80 may comprise an input shaft gear and a first intermediate shaft gear. The input shaft gear may mesh with the first intermediate shaft gear (not visible in Figure 1). The second end 52 of the input shaft 50 may comprise the input shaft gear and the first end 61 of the intermediate shaft 60 may comprise the first intermediate shaft gear.

[0059] In some examples, the input shaft gear and the first intermediate shaft gear may be e.g. bevel gears, helical bears, and/or worm gear for changing the direction of the input shaft extending in the first direction 1 to the direction of the upper portion of the intermediate shaft extending in the second direction 2.

[0060] The gear ratio of the input shaft gear and the first intermediate shaft gear may be suitable to reduce the rotational speed of the input shaft revolution per minute to a specific intermediate shaft revolutions per minute, i.e. the number of turns of the intermediate shaft 60 in one minute.

[0061] Therefore, the second end 52 of the input shaft 50 and the first end 61 of the intermediate shaft 60 may be configured to reduce an input shaft revolutions per minute to an intermediate shaft revolutions per minute.

[0062] As herein before mentioned, the intermediate shaft 60 comprises the upper portion 63 and the lower portion 64. In this example, the lower portion 64 is rotatably coupled to the upper portion 63 through a universal joint 90. The universal joint 90 permits the rotation of the lower portion 64 relative to the upper portion 63 about the second direction 2. A torque and/or rotary motion may be transmitted from the upper portion 63 to the lower portion 64.

[0063] In some examples, the universal joint 90 may be a variable velocity joint e.g. cardan joint, cross joint, ball and trunnion joint for transmitting torque and/or rotary motion from the upper portion 63 to the lower portion 64 through a variable angle at a variable rotational speed.

[0064] Alternatively, the universal joint 90 may be a constant velocity joint e.g. double cardan joint, Tracta joint, Rzeppa joint, Birfield joint, Weiss joint, tripod joint, Malpezzi joint, and/or Thompson joint.

[0065] In addition, the universal joint 90 may allow small angle variations between the upper portion 63 and the lower portion 64. The upper portion 63 extends along an upper portion axis 4. The upper portion axis 4 may be substantially parallel to the second direction 2. Similarly, the lower portion 64 extends along a lower portion axis 5. In this figure, the lower portion axis 5 may be substantially parallel to the upper portion axis 4 and/or to the second direction 2.

[0066] In some examples, the lower portion axis 5 may form an angle with the upper portion axis 4. This angle may adopt an angle between +175° and +185°. Consequently, the input shaft 50 extending in the first direction 1 is substantially parallel to the propeller shaft 70 extending in the third direction 3.

[0067] In this figure, the first end 71 of the propeller shaft 70 is rotatably coupled to the second end 62 of the intermediate shaft 60 through a second coupling mechanism 100.

[0068] The second coupling mechanism 100 may comprise a second intermediate shaft gear arranged at the second end 62 of the intermediate shaft 60 meshing with a propeller shaft gear arranged at the first end 71 of the propeller shaft 70 (not visible in Figure 1).

[0069] The second intermediate shaft gear and the propeller shaft gear may be e.g. bevel gears, helical bears, and/or worm gear for changing the direction of the intermediate shaft extending in the second direction 2 to the direction of the propeller shaft extending in the third direction 3.

[0070] The gear ratio of the second intermediate shaft gear and the propeller gear may be selected to reduce the rotational speed of the intermediate shaft revolution per minute. As a result, the second intermediate shaft gear and the propeller gear may reduce the intermediate shaft revolutions per minute to a propeller shaft revolutions per minute, e.g. the number of turns of the propeller shaft 70 in one minute.

[0071] Therefore, the second end 62 of the intermediate shaft 60 and the first end 71 of the propeller shaft 70 may be configured to reduce an intermediate shaft revolutions per minute to a propeller shaft revolutions per minute.

[0072] The second end 72 of the propeller shaft 70 is coupled to a propeller assembly 110 of the powering system 10. In this example, the propeller assembly 110 comprises a first propeller 111 and a second propeller 112. The second end 72 of the propeller shaft 70 may be coupled to a first propeller 111. A shaft may connect the first propeller 111 to the second propeller 112. The propeller shaft 70 may be coupled to a propeller assembly 110 such as the electric motor revolutions per minute may be reduced to the propeller shaft revolutions per minute to match the range of revolutions per minute of the propeller.

[0073] In some examples, the propeller shaft 70 may be coupled to the first propeller 111 and/or the second propeller 112.

[0074] Furthermore, the powering system 10 comprises an upper supporting structure 120 and a lower supporting structure 130.

[0075] The lower supporting structure 130 may be substantially cylindrical or comprising a hollow interior with an inner surface. The inner surface of the lower supporting structure 130 may comprise supports for supporting and receiving the propeller shaft 70 and the propeller assembly 110 such that the inner surface of the lower supporting structure supports the propeller shaft 70 and the propeller assembly 110.

[0076] The lower supporting structure 130 thus supports the propeller shaft 70 and the propeller 110. In some examples, the second coupling mechanism 100 is also supported by the lower supporting structure 130, i.e. the lower supporting structure 130 may further support the second end 62 of the intermediate shaft 60 and the first end 71 of the propeller shaft 70.

[0077] As explained before, the lower supporting structure 130 is rotatably coupled to the upper supporting structure 120 to rotate about the second direction 2. In some examples, a bearing may be arranged to rotatably coupling the lower supporting structure 130 to the upper supporting structure 120.

[0078] In some of these examples, the bearing comprises a first bearing component and a second bearing component. The first bearing component may be coupled to the lower supporting structure 130 whereas the second bearing component may be coupled to the upper supporting structure120. A bearing element may be arranged between the first bearing component and the second bearing component; such that the first bearing component may be configured to rotate with respect to the second bearing component.

[0079] The bearing element may comprise e.g. a gliding pad, and/or a rolling element. The gliding pad may reduce the friction between the first bearing component and the second bearing component. Alternatively, or additionally, a rolling element or a plurality of rolling elements may be arranged between the first and the second components to allow the rotation of the lower supporting structure about the second direction.

[0080] The upper supporting structure 120 may be substantially cylindrical or comprising a hollow interior. The inner surface of the upper supporting structure 120 may comprise supports for holding the electric motor 20 and the gearbox 30 such that the inner surface of the upper supporting structure supports the electric motor 20 and the gearbox 30.

[0081] The upper supporting structure 120 thus supports the electric motor 20 and the gearbox 30. In some examples, the upper supporting structure 120 may further support the input shaft 50 and the upper portion 63 of the intermediate shaft 60.

[0082] In addition, additional components may be supported by the upper supporting structure 120, e.g. the first coupling mechanism 80, the input shaft gear and/or the first intermediate shaft gear.

[0083] In this example, the upper supporting structure 120 houses and covers the electric motor 20, the gearbox 30, the input shaft 50 and the upper portion 63 of the intermediate shaft 60. The lower supporting structure 130 of this figure, houses and covers the lower portion 64 of the intermediate shaft and the propeller shaft 70. These components are thus respectively protected by the upper supporting structure 120 and the lower supporting structure 130. In addition, the lower supporting structure 130 supports the propeller assembly 110.

[0084] In some examples, the lower supporting structure may further support e.g. the second coupling mechanism 100, the second intermediate shaft gear and/or the propeller shaft gear.

[0085] A sealing member may be arranged between the upper supporting structure 120 and the lower supporting structure to prevent water from entering inside these supporting structures.

[0086] In Figure 1, the upper supporting structure 120 comprises a mounting bracket 140 to support a connecting member for connecting the upper supporting structure 120 to a watercraft. Thus, a connection between the upper supporting structure 120 and the watercraft may be established. This connection allows the upper supporting structure to be tiltable coupled to the watercraft. The upper supporting structure 120 may be tilted such that the upper supporting structure 120 and the lower supporting structure 130 may be positioned above a water level. Thus, the electric motor, the gearbox, the shafts, and propeller may be easily accessed to perform maintenance.

[0087] Figure 2 shows a watercraft 400 comprising a powering system 10 according to any of the examples herein disclosed. The watercraft 400 comprises a hull 180 extending from a port side 185 to a starboard side 184 along a port - starboard direction 186 and from a bow 182 to a stern 181 along a bow -stern direction 183. The powering system 10 is tiltable coupled to a coupling portion 190 of the hull 180.

[0088] The powering system may be coupled to the coupling portion of the hull according to any of the examples herein disclosed. In this example, the length of the watercraft may be between 5 and 15 meters. In some examples, the length of the watercraft may be comprised between 5 and 24 meters.

[0089] Figures 3a and 3b respectively shows a top side view of a powering system 10 according to one example of the present disclosure at different steering angles. Figures 3a and 3b illustrate a steering system 150 for steering operations i.e. rotating the lower supporting structure 130 about the upper supporting structure 120.

[0090] In this example, the steering system 150 comprises a pair of actuators, a port side actuator 151 and a starboard side actuator 152. However, in other examples, the steering system may comprise a single actuator. Each of the actuators 151, 152 of these figures has a first end 155, 156 coupled to the upper supporting structure 120 and a second end 157, 158 coupled to the lower supporting structure 130.

[0091] A length may be defined for each of the actuators between from the corresponding first end 155, 156 to the corresponding second end 157, 158. The length of these actuators may be changed, i.e. extended or reduced. By controlling the length of each of the two actuators 151, 152 of these figures, the lower supporting structure 130 rotates about the second direction. The actuators 151, 152 may thus push or pull its respective second ends 157, 158 to rotate the lower supporting structure 130 relative to the upper supporting structure 120.

[0092] The steering angle 13 may be defined as the angle defined by the first direction 1 and the third direction 3. The steering angle 13 is the angle adopted by the propeller assembly 110 to steer or to guide the watercraft. In figure 3a the steering angle 13 is about 30° and in figure 3b about -30°. The steering angle 13 may be varied to steer the watercraft to a specific direction. The steering angle may adopt an angle between +60° and - 60°, optionally between +45° and - 45°.

[0093] In figure 3a, the port side actuator 151 is extended and the starboard side actuator 152 is compressed to cause the rotation of the lower supporting structure 130 in counterclockwise direction. Contrary, in figure 3b the port side actuator 151 is compressed and the starboard side actuator 152 is extended to rotate the lower supporting structure 130 in clockwise direction.

[0094] Therefore, the actuators 151, 152 may be configured to change its length to cause the rotation of the lower supporting structure 130 about the upper supporting structure 120, enabling steering operations. Loads require for steering operations may be reduced as the steering system 150 of these figures only rotates the lower supporting structure 130. This may allow using relatively small actuators.

[0095] The actuators 151, 152 of these figures are linear actuators, e.g. hydraulic and/or pneumatic actuators. However, other suitable actuators may also be used.

[0096] In some examples, the steering system 150 may comprise a rotary actuator, and a circular rack and pinion system. In this example the rotary actuator may comprise a body fixedly coupled to the upper supporting structure and a rotary actuator shaft coupled to the pinion. The pinion may engage the circular rack coupled to the lower supporting structure. The rotary actuator may be configured to rotate the circular rack through the pinion to cause the rotation of the lower supporting structure about the upper supporting structure, enabling steering operations. In this example, the steering angle may adopt an angle between +180° and - 180°.

[0097] In this figure, the upper supporting structure 120 includes a mounting bracket 140. The mounting bracket 140 comprises a port side bracket 141 and a starboard side bracket 142, situated at opposite sides of the upper supporting structure 120. In this example, the mounting bracket 140 receives a connecting member 160 to be coupled to the watercraft.

[0098] In some examples, like this figure, the connecting member 160 extends in a direction parallel to the port - starboard direction. The connecting member 160 of this example comprises a tubular shape. In this figure, the connecting member 160 is fixedly attached to the mounting bracket 140. The connecting member 160 may be connected to the port side bracket 141 and to the starboard side bracket 142. Welding, bolting, using poke yoke elements or shrinking the tube in a through-hole of the brackets may be used to connect the connecting member 160 to the brackets.

[0099] Alternatively, the connecting member 160 may extend in a direction substantially parallel to the bow-stern direction.

[0100] Figures 4a-4c show a side view of a powering system coupled to a watercraft at different positions. The powering system of these figures may comprise a steering system according to any of the examples herein disclosed. The powering system 10 of these figures is rotatably coupled to the hull 180 of the watercraft. The axis of the propeller (parallel to the third direction 3) is substantially parallel to the water level 210 in figure 4a and forms an angle 211 with the water level 210. The powering system 10 of these figures rotates about an axis parallel to the port - starboard direction.

[0101] In figure 4a, the powering system 10 is coupled to the hull 180 such that the distance between the stern 181 of the hull 180 and intermediate shaft (not shown in this figure) is greater than 200 mm, optionally, between 200 mm and 800 mm.

[0102] The powering system 10 of figure 4b is in a trimmed position. The inclination of propeller shaft is thus adjusted to the water level 210 to navigate under specific conditions. In figure 4b the angle 211 is about 7°. In figure 4c, the powering system is a tilted position. The powering system is lifted above the water level as a single unit. In this position, the propeller assembly is not in contact with the water level. As a result, infiltration of moisture or water to internal critical areas of the powering system 10 may be avoided and thus, corrosion and wear may be reduced. Furthermore, when the powering system is lifted above the water level as a single unit, incrustation of algae and mollusks onto the powering system 10 may be avoided. Wear may thus be reduced, and performance of the powering system 10 may be improved. The angle 211 of figure 4c is about 45°. In these figures, the angle 211 may be varied between - 20° to + 70°. This range allows performing trimming and tilting operations.

[0103] In these figures, the hull 180 comprises a coupling portion 190. The powering system 10 is coupled to the hull 180 through the connecting member 160. The connecting member 160 connects the coupling portion 190 of the hull 180 to the mounting bracket of the upper supporting structure 120 of the powering system 10. In these figures, the connecting member 160 extends in a direction parallel to the port-starboard direction and is fixedly connected to the mounting bracket, e.g. welded or bolted. The rotation of the connecting member allows the upper supporting structure to tilt about the watercraft. Therefore, the entire powering system 10 can be tilted to the hull 180. The powering system is thus hingedly connected to the watercraft.

[0104] In these figures, the coupling portion 190 of the hull 180 comprises a pair of plates, each of them having a through-hole to receive the connecting member 160. The connecting member can thus be rotated about these through-holes. The plates may be of any suitable material to reinforce the coupling portion 190.

[0105] The connecting member 160 of these figures may be a single tubular shaft extending from one side to the opposite side of the powering system. However, in further examples, the connecting member may comprise a port side connecting member extending from the port side of the powering system and a starboard side connecting member extending from the starboard side of the powering system.

[0106] The powering system of these figures comprises a positioning system 200 to position the powering system 10 relative to the water level 210. The positioning system 200 of these figures may perform tilting operations such as in figure 4c; and/or trimming operations such as in figure 4b.

[0107] In these figures, the positioning system 200 comprises a linear actuator 201 that changes its length to cause the rotation of the powering system about an axis parallel to the port - starboard direction. The linear actuator 201 comprises a first end 203 and a second end 204. One end 203 of the linear actuator 201 is attached to the hull 180 and the other end 204 is attached to the upper supporting structure. When the actuator 201 changes its length, the actuator may push or pull its second end 204 coupled to the upper supporting structure. Therefore, the linear actuator 201 is configured to change its length to rotate the powering system 10 about an axis parallel to the port - starboard direction. The length of the linear actuator 201 thus defines the angle 211.

[0108] Alternatively, or additionally, the positioning system may comprise a rotatory actuator engaging the connecting member 160. The rotation of the rotatory actuator induces the rotation of the connecting member 160. When the connecting member is rigidly attached to the powering system 10, the rotation of the connecting member induces the rotation of the entire powering system 10.

[0109] The positioning system may comprise a controller to control the operation of the actuator(s). For example, the controller may control the length of the linear actuator so as to position the powering system at a predetermined angle.

[0110] Figures 5a - 5d respectively shows a side view of a powering system coupled to a watercraft according to one example of the present disclosure at different positions. These figures also include a zoom-in view of the connecting member 160. The powering system of these figures may be similar to the powering system depicted in figures 4a - 4c. However, in figures 5a - 5d, the connecting member 160 is rotatably connected to the upper supporting structure.

[0111] In these figures, the connecting member 160 extends from a connecting member first end 161 to a connecting member second end 162. The connecting member of these figures is substantially bar shaped. The connecting member 160 of these figures comprises port side connecting member and a starboard connecting member. In these figures only the port side connecting member is illustrated. The connecting member first end 161 is rotatably coupled to the coupling portion 190 of the hull 180 to rotate about a connecting member first end axis 163. A hinged connection is thus formed between the connecting member first end 161 and coupling portion 190 of the hull 180.

[0112] The connecting member second end 162 is rotatably coupled to the mounting bracket of the upper supporting structure 120 of the powering system 10 forming a hinge connection that allows the connecting member 160 to rotate about a connecting member second end axis 164. The connecting member first end axis 163 and connecting member second end axis 164 are substantially parallel to the port - starboard direction. The connecting member first end axis 163 may be substantially parallel to the port - starboard direction. These axes are spaced apart.

[0113] The connecting member 160 of these figures increases the number of possible positions of the powering system relative to the watercraft and to the water level. As in other examples, the whole powering system may be rotated about the watercraft. In addition, in these figures the distance between the powering system and the stern may adjusted. Furthermore, the height of the powering system relative to the watercraft may be adjusted to the type of navigation, as illustrated in figures 5a and 5d.

[0114] In figure 5a and 5d the third direction 3 is substantially parallel to the water level 210. However, the height, i.e. the vertical distance, of the powering system with respect to the watercraft is greater in figure 5d than in figure 5a. The powering system of figure 5a is raised when compared to the powering system of figure 5d. In figure 5a the connecting member 160 extends substantially parallel to the first direction having the connecting member second end 162 above the connecting member first end 161. This position may be used to navigate at relative low speeds.

[0115] In figure 5d, the connecting member 160 is inclined. The connecting member first end 161 is above the connecting member second end 162. This allows adjusting the vertical position of the propeller assembly. This arrangement may be allow using foils in an efficient way.

[0116] A plurality of foils may be provided at the hull 180 of the watercraft may comprise, for example at the port side and/or the starboard side.

[0117] A foil may be understood as a lifting surface that operates in water. As the watercraft moves through the water, the foils deflect the flow of water, which exerts an upward force on the foil lifting the hull above the water level 210. The position of figure 4d allows maintaining the propeller assembly below the water level 210. Therefore, a sufficient thrust force may be maintained. The lifting effect of the foils may thus be compensated by the capacity of the propeller system to adjust the vertical position of the propeller assembly.

[0118] In this figure 5d, the water level 210 is below the hull. In this figure, a foil coupled to the hull lifts the hull above the water level 210. However, in some examples, depending on navigation conditions the lowest side of the hull may be below the water level 210.

[0119] The powering system 10 of figure 5b is in a trimmed position in which the inclination of the propeller shaft is adjusted to navigated under specific conditions. Similar to figure 4b, the angle 211 is about 7°. As in figure 4c, the powering system 10 of figure 5c is in a tilted position with an angle 211 about 45°. The angle 211 may vary between - 20° to + 70°.

[0120] In this figure 5b, the lowest side of the hull is below the water level 210. However, in some examples, depending on navigation conditions, the water level 210 may be below the hull.

[0121] The powering system 10 of these figures comprises positioning system 200 comprising a linear actuator 201 and a rotatory actuator (not shown in these figures). The rotatory actuator is configured to control the rotation of the connecting member first end 161 about the connecting member first axis 163. The rotatory actuator may comprise a motor arranged at the watercraft driven a shaft that is rigidly connected to the connecting member first end 161. The motor thus caused the rotation of the connecting member 161 about the connecting member first axis 163.

[0122] The linear actuator 201 comprises a first end 203 coupled to the hull and a second end 204 coupled to the upper supporting structure. The linear actuator may change the length between the two ends. A change of the length of the linear actuator may cause the rotation of the powering system relative to the watercraft.

[0123] In these figures, the positioning system 200 comprises a controller to control the operation of the linear actuator 201 and the rotatory actuator.

[0124] The controller may be configured to selectively operate the rotatory actuator to rotate the connecting member 160 about the connecting member first end axis 163 and selectively operate the linear actuator 201 to change its length to rotate the upper supporting structure about the connecting member second end axis 164. By controlling the operation of these two types of actuators, a plurality of precise positions may be reached as shown in figures 5a - 5d.

[0125] For example, the controller may maintain the rotatory actuator at a fixed position, i.e. not rotating, and increase the length of the linear actuator. In this way, the connecting member 160 only rotates about the connecting member second axis 163 due to the action of the linear actuator. Or, if the linear actuator is not actuated, i.e. its length is not changed, but the rotatory actuator rotates the connecting member first end 161, the entire powering system is rotated about the connecting member first axis 163.

[0126] The controller may also rotate the rotatory actuator and actuate the linear actuator. The powering system may be rotated about the connecting member first axis 163 and about the connecting member second axis 164 from a first position to a second position.

[0127] Figure 6 shows a cross-sectional view of a powering system 10 according to an example of the present disclosure. The powering system 10 of figure 6 may be according to any of the examples herein disclosed. For example, the powering system 10 may comprise the connecting member and/or the steering system according to any of the examples herein disclosed.

[0128] In this figure, the powering system 10 comprises an electric motor 20 and a gearbox 30. The electric motor 20 of this figure is an asynchronous motor, however, in other examples, other suitable electric motors may be employed. The gearbox 30 of this example is an epicyclic gearing.

[0129] In this figure, the powering system 10 further comprises the input shaft 50, the intermediate shaft 60, a first propeller shaft 75 having a first end 76, and a second propeller shaft 77 having a first end 78. The first propeller shaft 75 and the second propeller shaft 77 extends in the third direction.

[0130] The first end 51 of the input shaft 50 is coupled to the gearbox and is surrounded by a first input shaft support element 220. The second end 52 of the input shaft 50 is rotatably coupled to the first end 61 of the intermediate shaft 60.

[0131] The first input shaft support element 220 and the second input shaft support element 230 support the input shaft 50. The first input shaft support element 220 and the second input shaft support element 230 comprise a bearing having an outer ring and an inner ring. The outer ring is connected to the inner surface of the upper supporting structure 120 and the inner ring is respectively connected to the first end 51 and to the second end 52 of the input shaft 50.

[0132] An input shaft gear 240 is arranged at the second end 52 of the input shaft. The input shaft gear 240 meshes with a first intermediate shaft gear 250. The first intermediate shaft gear 250 may additionally mesh with a first intermediate shaft gear support element 260. The first intermediate shaft gear support element 260 comprises a gear that meshes with the first intermediate shaft gear 240. The first intermediate shaft gear support element 260 comprises a bearing that allows the gear to rotate about the first direction. The first intermediate shaft gear 250 of this figure is arranged between the input shaft gear 240 and the first intermediate shaft gear support element 260. Misalignments of the upper portion 63 intermediate shaft are thus prevented.

[0133] In addition, the powering system of this figure comprises a first intermediate shaft support element 261 to rotatably support the upper portion 63 of the intermediate shaft. This support element comprises a bearing having an inner ring connected to the end of the upper portion 63 of the intermediate shaft and an outer ring connected to the upper supporting structure.

[0134] Between the upper portion 63 and the lower portion 64 of the intermediate shaft a double cardan joint 91 is provided. In other examples, the upper portion 63 and the lower portion 64 may be coupled according to any of the examples herein disclosed. The double cardan joint 91 allows the lower portion 64 to rotate about the upper portion 63 of the intermediate shaft. In this figure, a bearing 92 connects the upper supporting structure 120 with the lower supporting structure 130.

[0135] The lower portion 64 of the intermediate shaft is rotatably coupled to the first end 76 of the first propeller shaft 75. A second intermediate shaft support element 291 supports and aligns the lower portion 64 of the intermediate shaft.

[0136] A second intermediate shaft gear 270 is arranged at the end of the lower portion 64 of the intermediate shaft and meshes with a first propeller shaft gear 280 arranged at the first end 76 of the first propeller shaft 75. In this figure, the second intermediate shaft gear 270 meshes with a second propeller shaft gear 290. The second propeller shaft gear 290 is arranged at the first end 78 of the second propeller shaft 77. The second propeller shaft gear 290 comprises a gear that rotates about the third direction and meshes with the second intermediate shaft gear 270. The second intermediate shaft gear 270 of this figure is thus arranged between the second propeller shaft gear 290 and the first propeller shaft gear 280 such that the first propeller shaft 75 and the second propeller shaft 77 rotate about the third direction in opposite directions.

[0137] In this figure, the first propeller shaft 75 is mounted concentrically around the second propeller shaft 77. The first propeller shaft 75 and the second propeller shaft 77 are coupled for rotation in opposite directions. In this figure, the second propeller shaft 77 is positioned inside the first propeller shaft that has a hollow portion arranged for receiving the second propeller shaft 77. In other examples, a different configuration may be employed, for example, a single propeller shaft may be used.

[0138] In this figure, the first propeller shaft is coupled to the first propeller 111 and the second propeller shaft is coupled to the second propeller.

[0139] The first end 76 of the first propeller shaft 75 passes through a propeller shaft support element 300. The propeller shaft support element 300 comprises a bearing having an outer ring and an inner ring. The outer ring is connected to the inner surface of the lower supporting structure 130 and the inner ring is connected to the first end 76 of the first propeller shaft 75.

[0140] The first input shaft support element 220, the second input shaft support element 230, the first intermediate shaft support element 260, the first intermediate shaft gear support element 261, the second intermediate shaft gear support element 291 and/or the propeller shaft support element 300 may provide support and proper alignment to their respective shaft and/or shaft gear. The gears according to this example, are bevelled gears. In other examples, other types of gears may also be suitable.

[0141] Figure 7 shows a watercraft 400 comprising a powering system 10 according to any of the examples herein disclosed. For example, the powering system 10 may comprise the connecting member and/or the steering system according to any of the examples herein disclosed. The powering system 10 is tiltable coupled to a coupling portion 190.

[0142] In this figure, the coupling portion 190 is attached to the hull 180. This may allow using different materials for the coupling portion 190 and for the hull 180. In other examples, the coupling portion 190 may be integrated within the hull 180.

[0143] In some examples, the coupling portion 190 may comprise a coupling structure e.g. arms, brackets and/or a cast structure.

[0144] The coupling portion of figure 7 includes two arms 191, 192 extending from the stern 181 of the watercraft to a through-hole 193 of the coupling portion 190. which is fixedly coupled to the hull 180.

[0145] In this figure, the through-hole 193 is arranged such that at least one portion of the connecting member 160 passes through the coupling portion 190.

[0146] Welding, bolting, using poke yoke elements, or shrinking the tube may be used to fixedly couple the arms 191, 192 to the stern 181.

[0147] The connecting member 160 extends in a direction parallel to the port - starboard direction. The connecting member 160 of this example comprises a tubular shape. In this figure, the connecting member 160 is fixedly attached to the mounting bracket 140. Welding, bolting, using poke yoke elements, or shrinking the tube in a through-hole of the brackets may be used to connect the connecting member 160 to the brackets.

[0148] The connecting member 160 is rotatably coupled to the through-hole 193 forming a hinge connection that allows the connecting member 160 to rotate about an axis parallel to the port - starboard direction 186.

[0149] For reasons of completeness, various aspects of the present disclosure are set out in the following numbered clauses:

> Clause 1. A powering system for a watercraft comprising:
>
> > a propeller;
> > an electric motor;
> > a gearbox coupled to the electric motor;
> > an input shaft, an intermediate shaft, and a propeller shaft;
> >
> > > the input shaft having a first end coupled to the gearbox and a second end rotatably coupled to the intermediate shaft, wherein the input shaft extends from the first end to the second end in a first direction;
> > > the intermediate shaft having a first end rotatably coupled to the input shaft and a second end rotatably coupled to the propeller shaft, wherein the intermediate shaft comprises an upper portion and a lower portion, the lower portion being rotatably coupled to the upper portion, and wherein the upper portion extends in a second direction;
> > > the propeller shaft having a first end rotatably coupled to the intermediate shaft and a second end coupled to the propeller, wherein the propeller shaft extends from the first end to the second end in a third direction;
> > > wherein the first direction is perpendicular to the second direction and substantially parallel to the third direction; and
> >
> > an upper supporting structure supporting the electric motor and the gearbox, wherein the upper supporting structure is configured to be tiltable coupled to a watercraft; and
> > a lower supporting structure supporting the propeller and the propeller shaft, wherein the lower supporting structure is rotatably coupled to the upper supporting structure to rotate about the second direction.

Clause 2. The powering system according to clause 1, wherein the gearbox comprises an epicyclic gearing.

Clause 3. The powering system according to any of clauses 1 to 2, wherein the second end of the input shaft comprises an input shaft gear and the first end of the intermediate shaft comprises a first intermediate shaft gear meshing with the input shaft gear.

Clause 4. The powering system according to clause 3, wherein the input shaft gear and the first intermediate shaft gear are bevel gears and/or helical gears.

Clause 5. The powering system according to any of clauses 1 to 4, wherein the second end of the intermediate shaft comprises a second intermediate shaft gear and the first end of the propeller shaft comprises a propeller shaft gear meshing with the second intermediate shaft gear.

Clause 6. The powering system according to clause 5, wherein the second intermediate shaft gear and the propeller shaft gear are bevel gears and/or helical gears.

Clause 7. The powering system according to any of clauses 1 to 6, wherein the intermediate shaft comprises a universal joint rotatably coupling the upper portion to the lower portion of the intermediate shaft.

Clause 8. The powering system according to clause 7, wherein the universal joint comprises a cardan joint.

Clause 9. The powering system according to any of clauses 1 to 8, wherein the electric motor is configured to rotate at an electric motor revolutions per minute and the gearbox is configured to reduce the electric motor revolutions per minute to an input shaft revolutions per minute.

Clause 10. The powering system according to any of clauses 1 to 9, wherein the second end of the input shaft and the first end of the intermediate shaft are configured to reduce an input shaft revolutions per minute to an intermediate shaft revolutions per minute.

Clause 11. The powering system according to any of clauses 1 to 10, wherein the second end of the intermediate shaft and the first end of the propeller shaft are configured to reduce an intermediate shaft revolutions per minute to a propeller shaft revolutions per minute.

Clause 12. The powering system according to any of clauses 1 to 11, wherein the upper supporting structure further supports the input shaft and the first end of the intermediate shaft.

Clause 13. The powering system according to any of clauses 1 to 12, wherein the lower supporting structure further supports the second end of the intermediate shaft and the first end of the propeller shaft.

Clause 14. The powering system according to any of clauses 1 to 13, further comprising a bearing rotatably coupling the lower supporting structure to the upper supporting structure.

Clause 15. The powering system according to clause 14, wherein the bearing comprises:

> a first bearing component coupled to the lower supporting structure;
> a second bearing component coupled to the upper supporting structure;
> a bearing element arranged between the first bearing component and the second bearing component; and
> the first bearing component being configured to rotate with respect to the second bearing component.

Clause 16. The powering system according to clause 15 wherein, the bearing element comprises a gliding pad.

Clause 17. The powering system according to clause 15, wherein the bearing element comprises a rolling element.

Clause 18. The powering system according to any of clauses 1 to 17, further comprising a steering system to rotate the lower supporting structure about the upper supporting structure.

Clause 19. The powering system according to clause 18, wherein the steering system comprises an actuator extending a length from a first end coupled to the upper supporting structure to a second end coupled to the lower supporting structure, wherein the actuator is configured to change its length to rotate the lower supporting structure about the upper supporting structure.

Clause 20. The powering system according to any of clauses 1 to 19, wherein the upper supporting structure comprises a mounting bracket to support a connecting member for connecting the upper supporting structure to a watercraft.

Clause 21. A watercraft comprising:

> a hull extending from a port side to a starboard side along a port - starboard direction and from a bow to a stern along a bow - stern direction, the hull comprising a coupling portion;
> the powering system according to any of clauses 1 to 20, wherein the upper supporting structure of the powering system is tiltable coupled to the coupling portion of the hull.

Clause 22. The watercraft according to clause 21, wherein a distance between the stern of the hull and the intermediate shaft is greater than 200 mm, optionally between 200 mm and 800 mm.

Clause 23. The watercraft according to clauses 21 or 22, wherein the upper supporting structure comprises a mounting bracket; and wherein the watercraft further comprises a connecting member connecting the coupling portion of the hull to the mounting bracket of the upper supporting structure of the powering system.

Clause 24. The watercraft according to clause 23, wherein the connecting member is rotatably coupled to the coupling portion of the hull.

Clause 25. The watercraft according to clause 24, wherein the connecting member extends in a direction parallel to the port-starboard direction.

Clause 26. The watercraft according to any of clauses 23 to 25, wherein the mounting bracket is fixedly connected to the connecting member.

Clause 27. The watercraft according to clauses 23 or 24, wherein the connecting member comprises:

> a first end rotatably coupled to the coupling por-

tion of the hull to rotate about a connecting member first end axis; and
a second end rotatably coupled to the mounting bracket of the upper supporting structure of the powering system to rotate about a connecting member second end axis.

Clause 28. The watercraft according to any of clauses 21 to 27, wherein the coupling portion comprises a through-hole arranged such that at least one portion of the connecting member passes through the coupling portion.

Clause 29. The watercraft according to clause 28, wherein the coupling portion further comprises a plate comprising the through-hole receiving the connecting member.

Clause 30. The watercraft according to any of clauses 21 to 29, further comprising:
a positioning system to position the powering system relatively to a water level.

Clause 31. The watercraft according to clause 30, wherein the positioning system comprises a rotatory actuator configured to rotate the connecting member for rotating the powering system about an axis parallel to the port - starboard direction.

Clause 32. The watercraft according to clause 31, wherein the positioning system comprises a controller to control the rotatory actuator.

Clause 33. The watercraft according to any of clauses 30 to 32, wherein the positioning system comprises a linear actuator changing a length from a first end coupled to the hull to a second end coupled to the upper supporting structure, wherein the linear actuator is configured to change its length to rotate the powering system about an axis parallel to the port - starboard direction.

Clause 34. The watercraft according to clause 33, wherein the positioning system comprises a controller to control the linear actuator.

Clause 35. The watercraft according to any of clauses 30 to 34, wherein the connecting member comprises:

a first end rotatably coupled to the coupling portion of the hull to rotate about a connecting member first end axis, the connecting member first end axis being parallel to the port - starboard direction; and
a second end rotatably coupled to the mounting bracket of the upper supporting structure of the powering system to rotate about a connecting member second end axis, the connecting member second end axis being parallel to the port - starboard direction; and
wherein the positioning system further comprises:

a rotatory actuator configured to rotate the connecting member about the connecting member first end axis;
a linear actuator changing a length from a first end coupled to the hull to a second end coupled to the upper supporting structure, wherein the linear actuator is configured to change its length to rotate the upper supporting structure about the connecting member second end axis; and
a controller configured to:

selectively operate the rotatory actuator to rotate the connecting member about the connecting member first end axis;
selectively operate the linear actuator to change its length to rotate the upper supporting structure about the connecting member second end axis;
such that the positioning system adjusts a first position of the powering system relative to a water level to a second position of the powering system relative to the water level.

Clause 36. The watercraft according to any of clauses 21 to 35, wherein the hull further comprises a plurality of foils.

Clause 37. The watercraft according to clause 36, wherein the plurality of foils is arranged at the port side and/or the starboard side

[0150] Although only a number of examples have been disclosed herein, other alternatives, modifications, uses and/or equivalents thereof are possible. Furthermore, all possible combinations of the described examples are also covered. Thus, the scope of the present disclosure should not be limited by particular examples, but should be determined only by a fair reading of the clauses that follow. If reference signs related to drawings are placed in parentheses in a clause, they are solely for attempting to increase the intelligibility of the clause, and shall not be construed as limiting the scope of the clause.

Claims

1. A powering system for a watercraft comprising:

a propeller;

an electric motor;
a gearbox coupled to the electric motor;
an input shaft, an intermediate shaft, and a propeller shaft;

the input shaft having a first end coupled to the gearbox and a second end rotatably coupled to the intermediate shaft, wherein the input shaft extends from the first end to the second end in a first direction;
the intermediate shaft having a first end rotatably coupled to the input shaft and a second end rotatably coupled to the propeller shaft, wherein the intermediate shaft comprises an upper portion and a lower portion, the lower portion being rotatably coupled to the upper portion, and wherein the upper portion extends in a second direction;
the propeller shaft having a first end rotatably coupled to the intermediate shaft and a second end coupled to the propeller, wherein the propeller shaft extends from the first end to the second end in a third direction;
wherein the first direction is perpendicular to the second direction and substantially parallel to the third direction; and

an upper supporting structure supporting the electric motor and the gearbox, wherein the upper supporting structure is configured to be tiltable coupled to a watercraft; and
a lower supporting structure supporting the propeller and the propeller shaft, wherein the lower supporting structure is rotatably coupled to the upper supporting structure to rotate about the second direction.

2. The powering system according to claim 1, wherein the intermediate shaft comprises a universal joint rotatably coupling the upper portion to the lower portion of the intermediate shaft.

3. The powering system according to any of claims 1 to 2, wherein the electric motor is configured to rotate at an electric motor revolutions per minute and the gearbox is configured to reduce the electric motor revolutions per minute to an input shaft revolutions per minute.

4. The powering system according to any of claims 1 to 3, wherein the second end of the input shaft and the first end of the intermediate shaft are configured to reduce an input shaft revolutions per minute to an intermediate shaft revolutions per minute.

5. The powering system according to any of claims 1 to 4, wherein the second end of the intermediate shaft and the first end of the propeller shaft are configured to reduce an intermediate shaft revolutions per minute to a propeller shaft revolutions per minute.

6. The powering system according to any of claims 1 to 5, further comprising a bearing rotatably coupling the lower supporting structure to the upper supporting structure.

7. The powering system according to any of claims 1 to 6, further comprising a steering system to rotate the lower supporting structure about the upper supporting structure.

8. A watercraft comprising:

a hull extending from a port side to a starboard side along a port - starboard direction and from a bow to a stern along a bow - stern direction, the hull comprising a coupling portion;
the powering system according to any of claims 1 to 7, wherein the upper supporting structure of the powering system is tiltable coupled to the coupling portion of the hull.

9. The watercraft according to claim 8, wherein the upper supporting structure comprises a mounting bracket; and wherein the watercraft further comprises a connecting member connecting the coupling portion of the hull to the mounting bracket of the upper supporting structure of the powering system.

10. The watercraft according to claim 9, wherein the connecting member is rotatably coupled to the coupling portion of the hull.

11. The watercraft according to claim 9 or claim 10, wherein the mounting bracket is fixedly connected to the connecting member.

12. The watercraft according to claims 10 or 11, wherein the connecting member comprises:

a first end rotatably coupled to the coupling portion of the hull to rotate about a connecting member first end axis; and
a second end rotatably coupled to the mounting bracket of the upper supporting structure of the powering system to rotate about a connecting member second end axis.

13. The watercraft according to any of claims 8 to 12, further comprising:
a positioning system to position the powering system relative to a water level.

14. The watercraft according to claim 13, wherein the positioning system comprises a rotatory actuator configured to rotate the connecting member for rotating the powering system about an axis parallel to the port - starboard direction.

15. The watercraft according to claim 13 or claim 14, wherein the positioning system comprises a linear actuator extending a length from a first end coupled to the hull to a second end coupled to the upper supporting structure, wherein the linear actuator is configured to change its length to rotate the powering system about an axis parallel to the port - starboard direction.

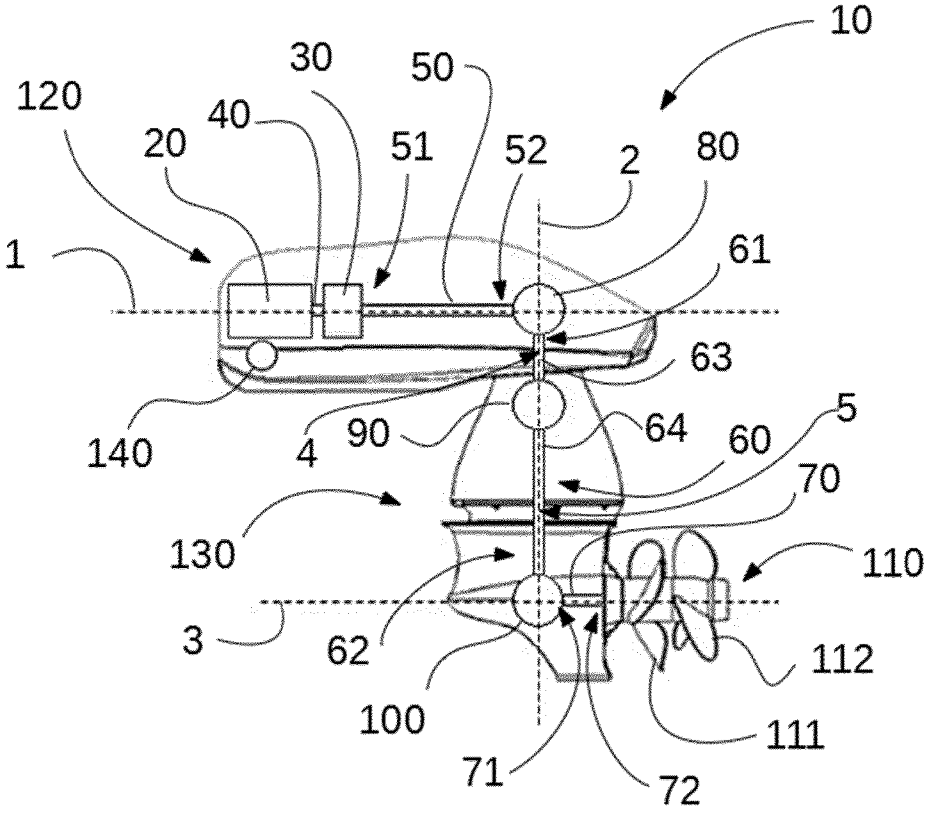


Figure 1

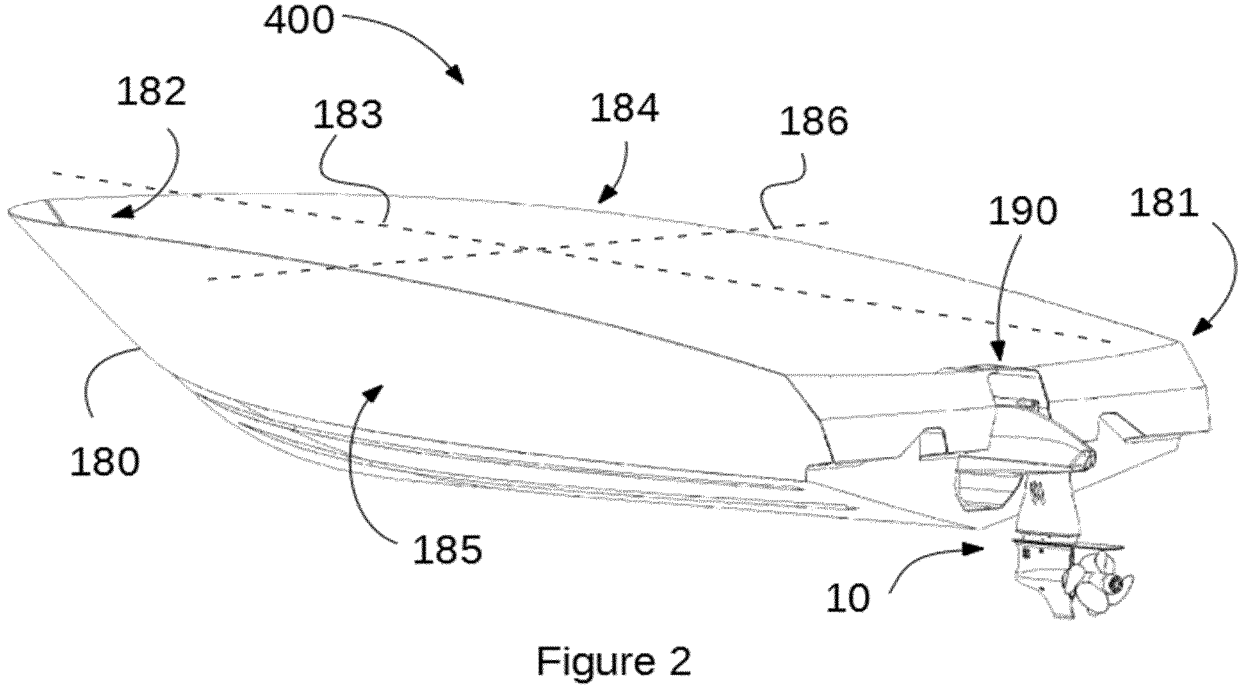


Figure 2

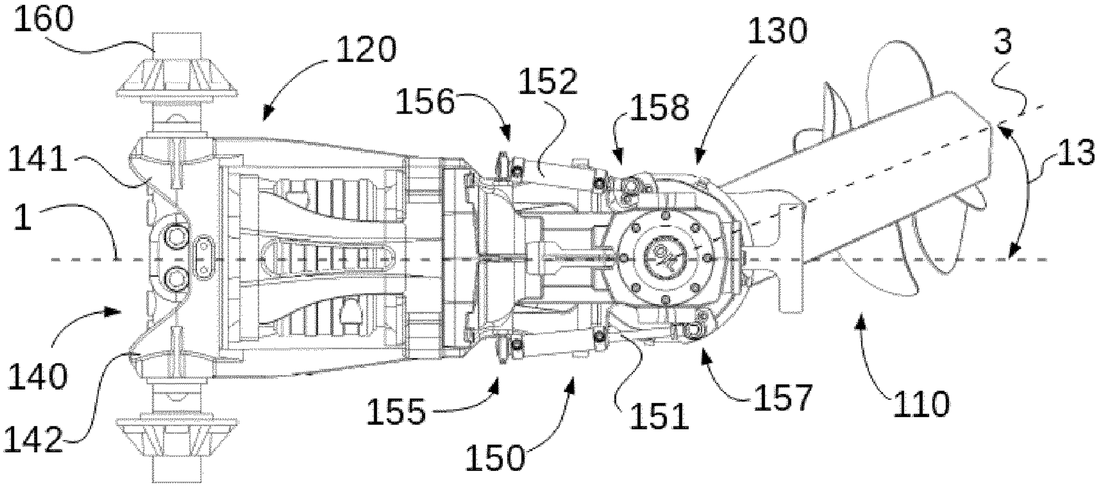


Figure 3a

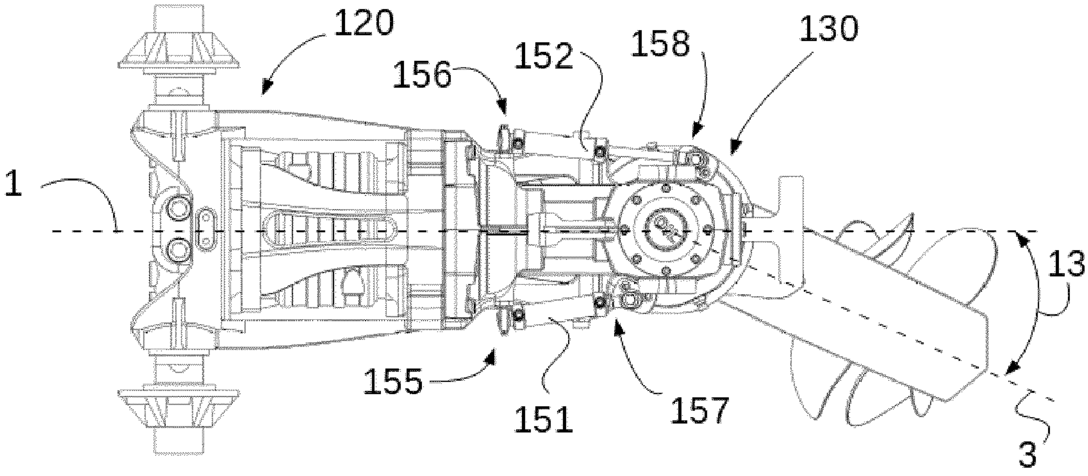
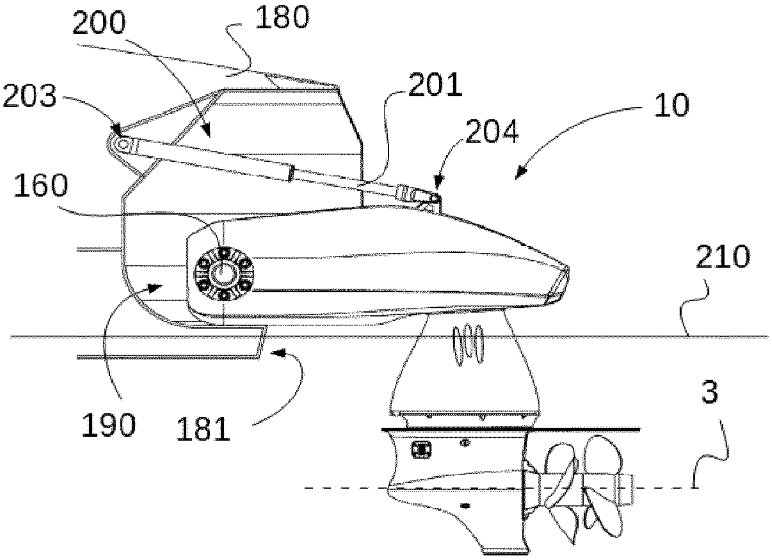


Figure 3b



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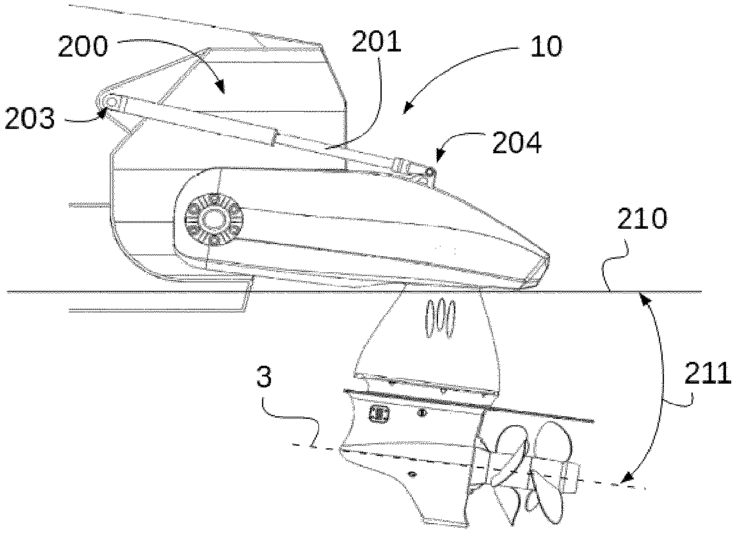

Figure 4b

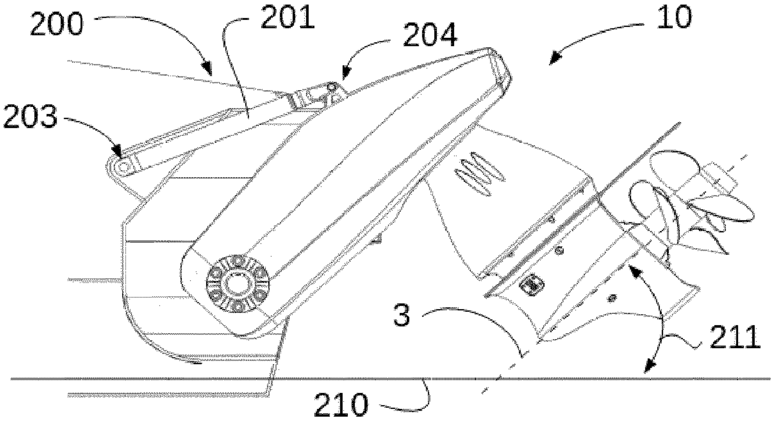

Figure 4c

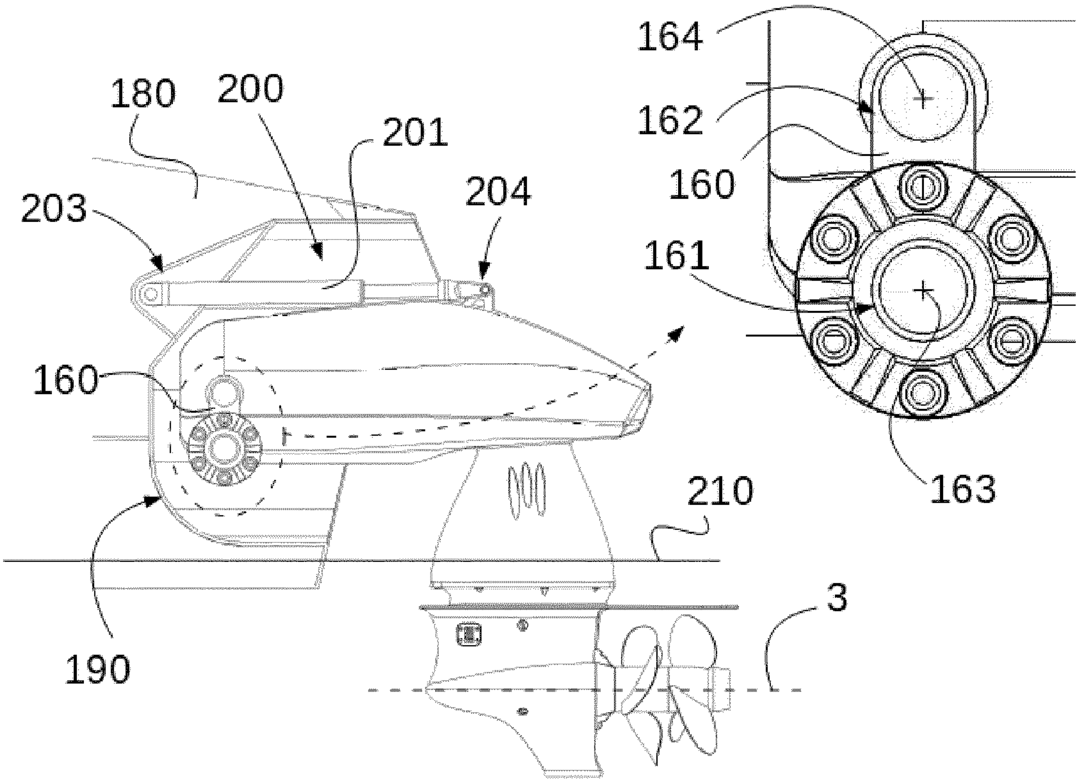

Figure 5a

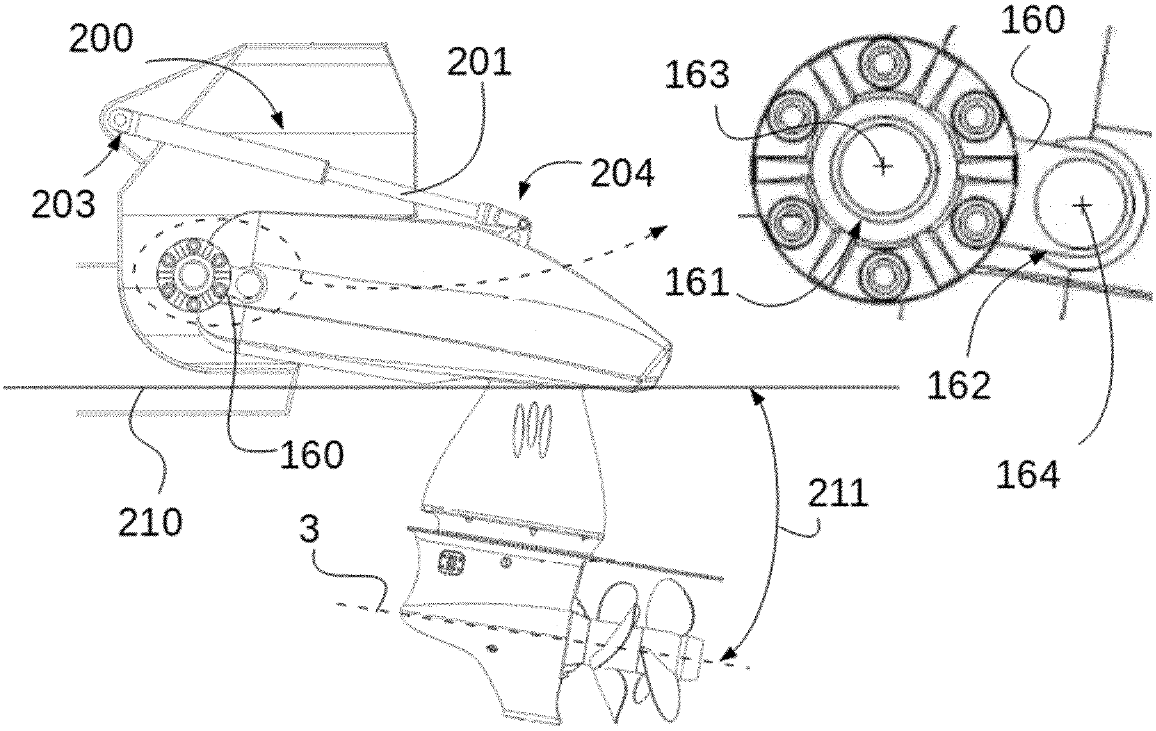

Figure 5b

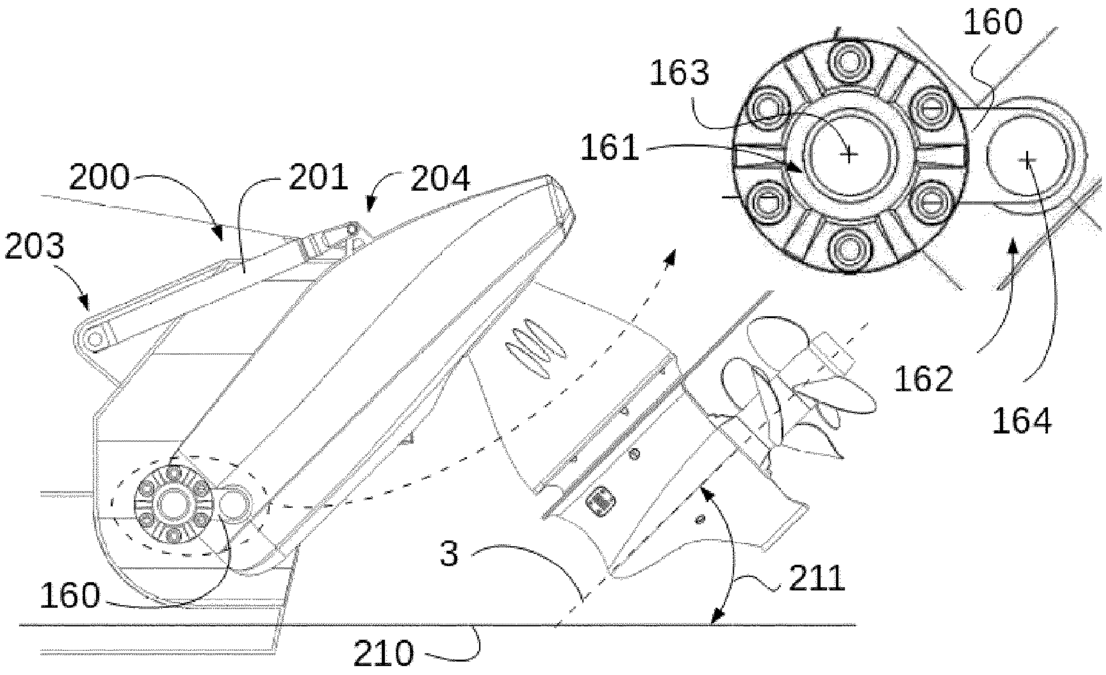

Figure 5c

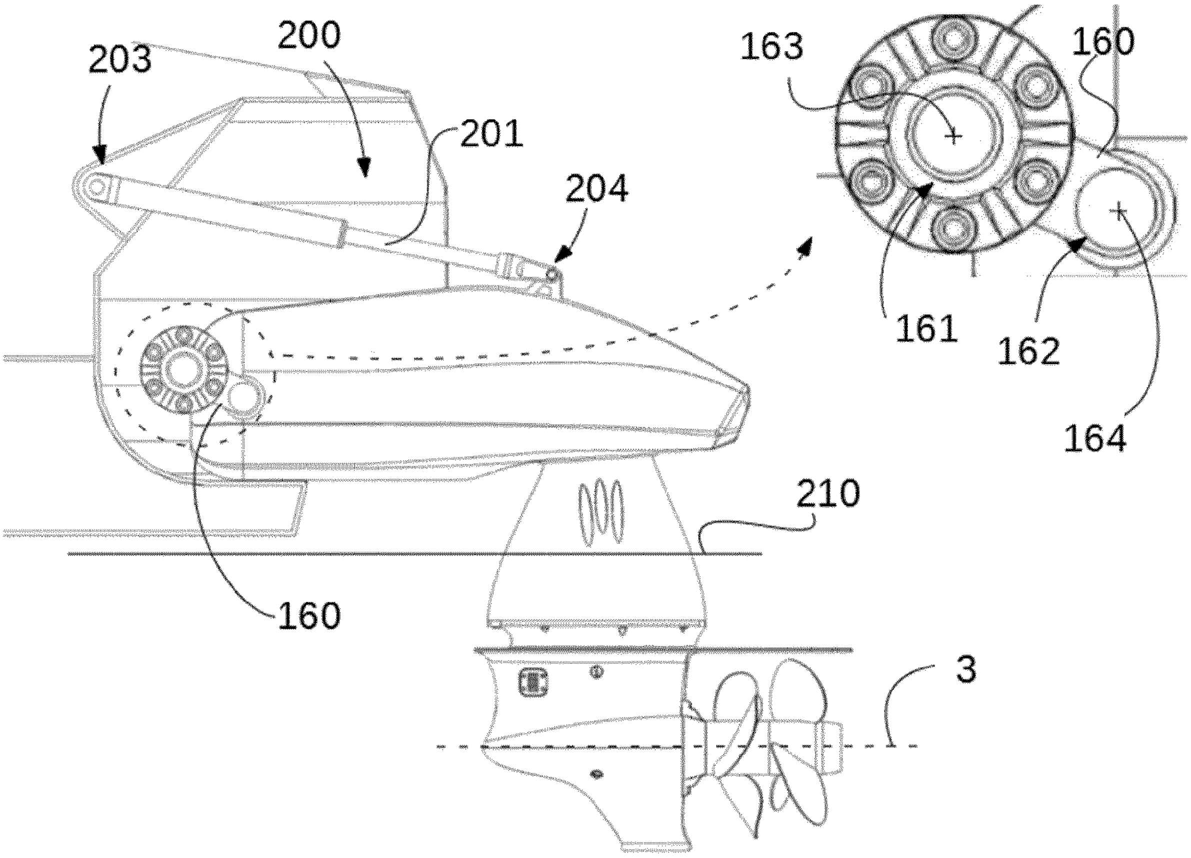

Figure 5d

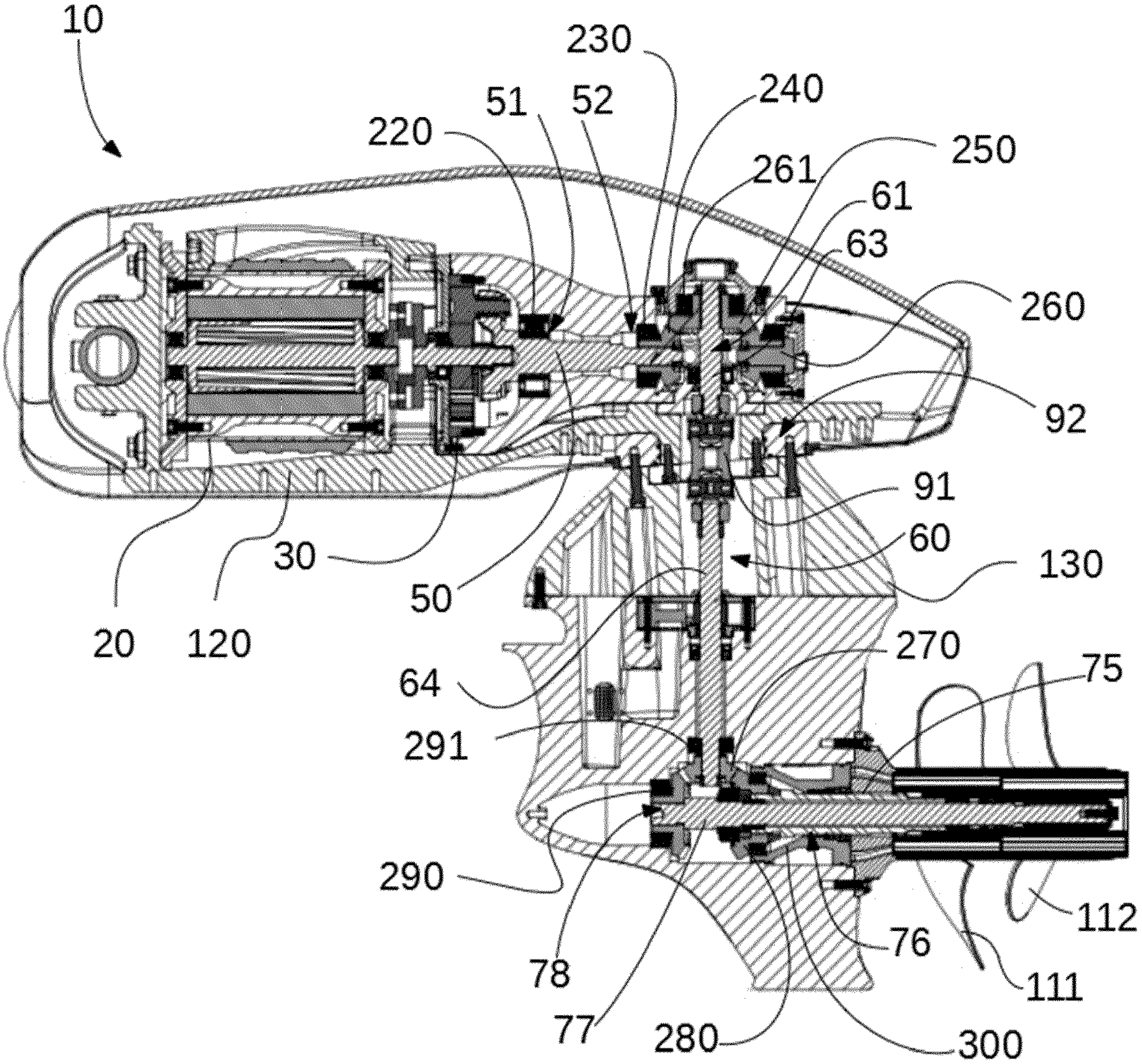
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Figure 6

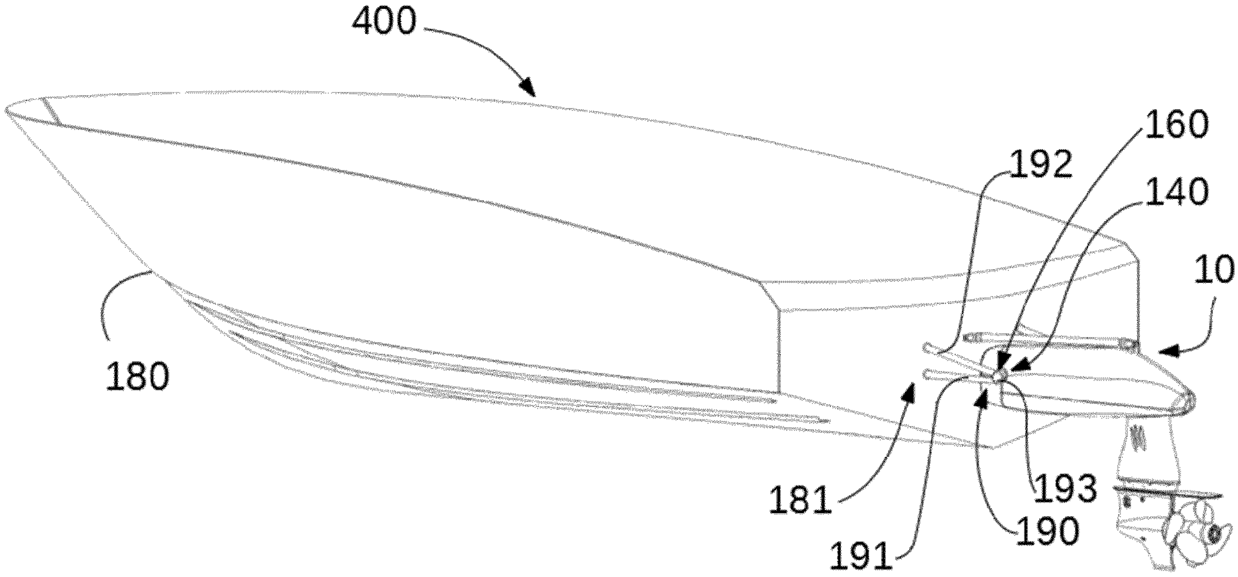

Figure 7

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EUROPEAN SEARCH REPORT

Application Number
EP 21 38 2805

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A	US 2016/059949 A1 (REBELE ANDREW H [US] ET AL) 3 March 2016 (2016-03-03) * figures 1-4 * * paragraph [0021] - paragraph [0029] * -----	1-15	INV. B63H20/14 B63H21/17 B63H20/16
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A	US 2006/258233 A1 (WILSON JIM [US] ET AL) 16 November 2006 (2006-11-16) * figures * * line 33, paragraph 31 * -----	1-15	
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1 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	21 February 2022	Westland, Paul

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