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(54)

A METHOD FOR CONTROLLING A PROPELLER DRIVE ASSEMBLY

- (57)

The present disclosure relates to a method (M0) of controlling a propeller drive assembly (1) attachable to a hull (2) of a marine vessel, said propeller drive assembly (1) comprising a propeller drive unit (3) carrying at least one propeller shaft for carrying a respective propeller (4) for rotation about a first rotational axis (5),
- wherein the method (1) comprises a first step comprising triggering rotation (M1) of each propeller shaft such that the respective propeller shaft reaches a respective predetermined rotational position (P0a, P0b) and stops at the respective predetermined rotational position (P0a, P0b).

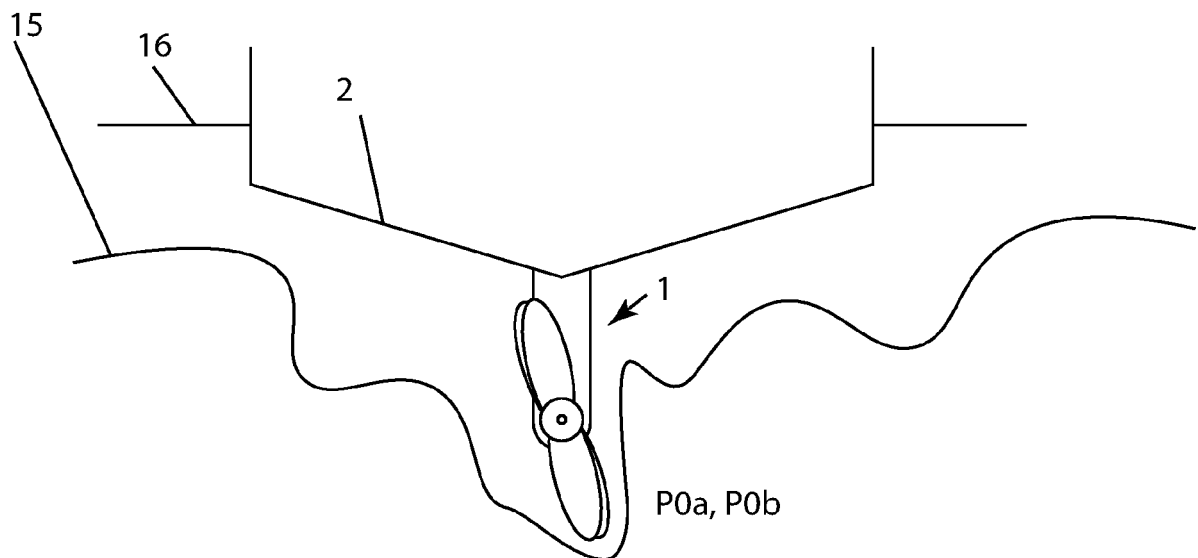


Fig. 11

Description

TECHNICAL FIELD

5 **[0001]** The present disclosure relates to propeller drive systems for marine vessels such as boats and ships.

BACKGROUND

10 **[0002]** Marine vessels, such as boats and ships, may be provided with motorized propulsion devices, such as outboard motors or various types of inboard motors. The propulsion devices may comprise a propeller drive unit, sometimes referred to as a lower unit or pod, carrying one or more propeller shafts for carrying a respective propeller.

[0003] A common challenge when navigating at sea is to avoid underwater obstacles hitting the propeller(s). This is especially true for navigation at shallow waters, and at towing of the marine vessel in such areas.

15 **[0004]** Another challenge is to transport the marine vessel over land on a trailer where height constraints from bridges limit the available height of the marine vessel, forcing the driver to choose longer routes when the marine vessel is too high to be able to be transported under a specific bridge.

SUMMARY

20 **[0005]** An object of the present disclosure is to reduce the risk of propeller damage when a marine vessel is towed. Another object of the present disclosure is to reduce the size of a propulsion system for a marine vessel, i.e., to provide a propulsion system which takes up less space inside marine vessel.

[0006] According to a first aspect, these and other objects are achieved by a method according to claim 1, with specific embodiments defined in dependent claims 2-7.

25 **[0007]** The method is a method of controlling a propeller drive assembly attachable to a hull of a marine vessel. The propeller drive assembly comprises a propeller drive unit, sometimes referred to as a lower unit or pod, carrying at least one propeller shaft for carrying a respective propeller for rotation about a first rotational axis. The method comprises a first step comprising triggering rotation of each propeller shaft such that the respective propeller shaft reaches a respective predetermined rotational position and stops at the respective predetermined rotational position.

30 **[0008]** The rotation of the propeller(s) to a respective predetermined rotational position enables control of where propeller blades of the propeller are positioned when the propellers are not in operation for propulsion of the marine vessel, such as when the marine vessel is anchored or towed.

35 **[0009]** For example, the position may be such as to minimize an extent of the propeller below the vessel, thereby minimizing height of the vessel. Minimizing height of the vessel may be advantageous when moving the vessel through tight passages with limited space available around the vessel, such as when towing the vessel over underground obstacles or during road transport of the vessel on a trailer, where available height under bridges limit what bridges the vessel may be safely transported under.

40 **[0010]** Where the bottom profile of a passage through which the vessel has to be transported only allows passage with the propeller in a specific position, the predetermined position may be chosen such that the vessel is able to pass the passage by triggering rotation of the propeller shaft(s) to respective predetermined positions depending on the bottom curvature.

45 **[0011]** The propeller drive assembly may further comprise at least one electric drive means, for example comprising one or more electric motors. The electric drive means are configured to control a rotational position of each propeller shaft about said first rotational axis. The first step comprises triggering the electric drive means to perform the rotation(s) of the respective propeller shaft(s) to the respective predetermined rotational position(s).

[0012] The use of the electric drive means for control of the respective rotational position of the propeller shaft(s) enables precise control of the rotational position of each propeller shaft.

50 **[0013]** The propeller drive assembly may further comprise a housing for attachment to a hull of the marine vessel on an inside of the hull such that the housing surrounds a first opening of the hull and seals to the hull. The housing defines an inner space and is provided with a second opening through which at least a portion of the propeller drive unit is movable into and out of the inner space. The propeller drive assembly comprises a suspension mechanism attached to the housing and configured to suspend the propeller drive unit, wherein the suspension mechanism is movable along a first longitudinal axis of the housing between a stowed position, in which the propeller drive unit is positioned inside the inner space of the housing, and a deployed position in which at least a portion of the propeller drive unit protrudes outside the housing through the second opening. With this hardware in place, the method may further comprise a second step comprising triggering movement of the suspension mechanism from the deployed position to the stowed position.

55 **[0014]** By moving the propeller drive unit to the stowed position, the propeller is moved in a direction further into the hull of the marine vessel, thus further reducing the extent of the propeller below/outside the hull of the marine vessel,

thereby reducing the risk of the propeller being damaged by underwater objects, such as rocks.

[0015] Each propeller shaft may be provided with a respective propeller, and wherein the respective predetermined position of each propeller shaft be such that each respective propeller is at least partly, such as fully, confined within the inner space of the housing when the propeller drive unit is in the stowed position.

[0016] By combining such rotation of the propeller(s) with the retractable propeller drive unit, the extent of the propeller below/outside the hull of the marine vessel is reduced, thereby reducing the risk of the propeller being damaged by underwater objects, such as rocks.

[0017] The propeller drive unit may comprise two propeller shafts, each carrying one propeller. The propellers are rotatable relatively each other about the first rotational axis such that that a joint projected driving area provided by the propellers in a plane perpendicular to the first rotational axis varies in response to a relative rotation between a maximum joint projected driving area and a minimum joint projected driving area together defining a joint projected driving area range. The method may comprise determining the predetermined positions to be such that the joint projected driving area when the propeller shafts are in their respective predetermined positions is within a lower 10% of the joint projected driving area range or within a lower 5% of the joint projected driving area range, or is the minimum joint projected driving area.

[0018] The propellers are substantially aligned if the joint projected driving area when the propeller shafts are in their respective predetermined positions is within a lower 10% of the joint projected driving area range or within a lower 5% of the joint projected driving area range, or is the minimum joint projected driving area. Such alignment reduces the risk of the propellers striking foreign objects at towing of the marine vessel. Further, such alignment enables less protrusion of the propellers outside the hull into surrounding water when the propeller drive unit is in its stowed position.

[0019] The propellers may have a same number of blades.

[0020] Using two propellers having a same number of blades is advantageous since the two pairs of propeller blades may be rotated such that they align along the first rotational axis and thus minimize the joint projected driving area, making it easier to pass underwater obstacles. Further, it enables design of a more compact housing for retractable propeller drive units.

[0021] The second step may be performed after, and/or simultaneously with said first step.

[0022] By rotating the propellers to the predetermined position before, or during movement of the propeller drive unit towards the stowed position, it is possible to position the propeller drive unit closer to the second opening of the housing whilst maintaining the propeller inside the inner space of the housing. This enables use of a smaller housing of the propeller drive assembly and thus enables installation of the propeller drive assembly in marine vessels with restricted available space.

[0023] Alternatively, said propeller drive unit comprises two propeller shafts each carrying one propeller wherein the propellers are rotatable relatively each other about the first rotational axis such that that a joint projected driving area provided by the propellers in a plane perpendicular to the first rotational axis varies in response to a relative rotation between a maximum joint projected driving area and a minimum joint projected driving area together defining a joint projected driving area range, and wherein the predetermined positions are such that the joint projected driving area when the propeller shafts are in their respective predetermined positions is within a higher 20% of the joint projected driving area range or within a higher 10% of the joint projected driving area range, or is the maximum joint projected driving area (A_{min}).

[0024] By moving the propeller shafts such that the joint projected driving area A is within a higher 20% of the joint projected driving area range, the propellers 4 may be held stationary to provide a great breaking force for slowing down the marine vessel. For retractable propeller drive units, such braking of the marine vessel requires the propeller drive unit to be in its deployed position for maximum breaking effect.

[0025] According to a second aspect of the present disclosure, the above-mentioned objects are also achieved by a control unit for controlling a propeller drive assembly attachable to a hull of a marine vessel, said control unit being configured to perform the method according to any one of claims 1-7, described above.

[0026] According to a third aspect of the present disclosure, the above-mentioned objects are also achieved by a propeller drive system comprising a propeller drive assembly and a control unit. The propeller drive unit carries at least one propeller shaft for carrying a respective propeller for rotation about a first rotational axis. The control unit is configured to trigger rotation of each propeller shaft such that the respective propeller shaft reaches a respective predetermined rotational position and stops at the respective predetermined rotational position.

[0027] The propeller drive system may further comprise at least one electric drive means configured to control a rotational position of each propeller shaft about said first rotational axis, wherein the control unit is configured to trigger the electric drive means to perform the rotation(s) of the propeller shaft(s) to the respective predetermined rotational position(s).

[0028] The propeller drive system may further comprise a housing for attachment to a hull of the marine vessel on an inside of the hull such that the housing surrounds a first opening of the hull and seals to the hull. The housing defines an inner space and the housing is provided with a second opening through which at least a portion of the propeller drive

unit is movable into and out of the inner space. The propeller drive assembly comprises a suspension mechanism attached to the housing and configured to suspend the propeller drive unit, wherein the suspension mechanism is movable along a first longitudinal axis of the housing between a stowed position, in which the propeller drive unit is positioned inside the inner space of the housing, and a deployed position in which at least a portion of the propeller drive unit protrudes outside the housing through the second opening. The control unit is further configured to trigger movement of the suspension mechanism from the deployed position to the stowed position.

[0029] Each propeller shaft may be provided with a respective propeller, wherein the respective predetermined position of each propeller shaft is such that each respective propeller is at least partly, such as fully, confined within the inner space of the housing when the propeller drive unit is in the stowed position.

[0030] The propeller drive unit may comprise two propeller shafts each carrying one propeller. The propellers are rotatable relatively each other about the first rotational axis such that that a joint projected driving area provided by the propellers in a plane perpendicular to the first rotational axis varies in response to a relative rotation between a maximum joint projected driving area and a minimum joint projected driving area together defining a joint projected driving area range. The predetermined positions are such that the joint projected driving area when the propeller shafts are in their respective predetermined positions is within a lower 10% of the joint projected driving area range or within a lower 5% of the joint projected driving area range, or is the minimum joint projected driving area.

[0031] The control unit may be configured to trigger movement of the suspension mechanism from the deployed position to the stowed position after, and/or simultaneously with, said triggering of rotation of each propeller shaft such that the respective propeller shaft reaches a respective predetermined rotational position and stops at the respective predetermined rotational position.

[0032] According to a third aspect of the present disclosure, the above-mentioned objects are also achieved by a marine vessel comprising the above-mentioned propeller drive system according to any one of claims 9-14.

[0033] According to a fourth aspect of the present disclosure, the above-mentioned objects are also achieved by a computer program product comprising program code means for performing the above-mentioned method of any one of claims 1-7 when said program is run on a control unit.

[0034] The above aspects, accompanying claims, and/or examples disclosed herein above and later below may be suitably combined with each other as would be apparent to anyone of ordinary skill in the art.

[0035] Additional features and advantages are disclosed in the following description, claims, and drawings, and in part will be readily apparent therefrom to those skilled in the art or recognized by practicing the disclosure as described herein. There are also disclosed herein a control unit, and computer program products associated with the above discussed technical effects and corresponding advantages.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036]

Figs. 1-21 show schematic cross-sectional views of various embodiments of a propeller drive system according to the present disclosure.

Fig. 22 shows a schematic view of an embodiment of a method according to the present disclosure.

Figs. 23a-b and 24a-b schematically illustrate propeller positions in figs. 23a and 24a, and in black fill corresponding projected drive surfaces in a reference plane P in figs. 23b and 24b.

FIG. 25 is a schematic diagram of a computer system 2500 for implementing examples disclosed herein.

Figs. 1-5, 12-16 and 17-21 illustrate embodiments of the propeller drive system configured such that their respective propeller drive unit is retractable into the hull of the marine vessel.

Figs. 6-11 illustrate embodiments of the propeller drive system which are fixed to the hull and provided with a respective propeller drive unit non-retractably attached to the hull of the marine vessel.

Figs. 1-8 illustrate embodiments of the propeller drive system provided with a single propeller.

Fig. 9-21 illustrate embodiments of the propeller drive system provided with two propeller shafts, each carrying a respective propeller.

Figs. 1-5 illustrate how a propeller is rotated to be saved from striking the bottom at shallow areas, for example

when being towed or anchored in such an area.

Figs. 6-11 illustrate how a propeller is rotated to be saved when passing an area with a known bottom curvature, wherein the propeller(s) are rotated to a respective predetermined position chosen such that the propellers fit with a known recess in the bottom curvature, thus enabling the propellers to be saved from striking the bottom.

DETAILED DESCRIPTION

[0037] With reference to the appended drawings, below follows a more detailed description of embodiments of the present disclosure cited as examples.

[0038] As mentioned above, an object of the present disclosure is to reduce the risk of propeller damage when a marine vessel is towed. Another object of the present disclosure is to enable design of a compact propulsion system for a marine vessel, i.e. a propulsion system which takes up less space inside marine vessel.

[0039] To achieve these and other object, a propeller drive system 6 and a method M0 of controlling such a propeller drive system 6 is proposed herein. The method M0 can be used for any suitable propeller drive system 6 comprising a propeller drive assembly 1 provided with drive means enabling control of the rotational position of one or more propeller shafts carried by a propeller drive unit 3 of said propeller drive assembly. Typically, such drive means could comprise one or more electric motors operatively connected to a respective propeller shaft, said electric motors being of a type operable to stop at one or more predetermined discrete rotational positions, for example at one specific rotational position or at any one of a plurality of rotational positions. Alternatively, the drive means may comprise any other suitable type of motor, which may be combined with one or more stop members movable by an actuator between a position in which the stop member is moved such that the respective propeller 4/propeller shaft is free to rotate, to a position in which the stop member stops the propeller 4 or the propeller shaft from further rotation, for example by blocking a propeller hub or propeller blade to stop movement of the propeller shaft at the predetermined rotational position P0a, P0b.

[0040] An exemplary embodiment of the method M0 will be described in conjunction with the exemplary embodiment of the propeller drive system 6 illustrated in figs. 12-16. As used in some of the appended figures, reference numeral 16 refers to a sea surface and reference numeral 15 refers to a sea bottom or underwater obstacle.

[0041] The method M0 is for controlling a propeller drive assembly 1 attachable to a hull 2 of a marine vessel. The propeller drive assembly 1 comprises a propeller drive unit 3 carrying at least one propeller shaft (not shown) for carrying a respective propeller 4 for rotation about a first rotational axis 5. As shown in fig. 22, the method M0 comprises a first step M1 comprising triggering rotation of each propeller shaft such that the respective propeller shaft reaches a respective predetermined rotational position P0a, P0b and stops at the respective predetermined rotational position P0a, P0b.

[0042] The rotation of the propeller shaft(s) to a respective predetermined rotational position enables control of where propeller blades of the propeller 4 are positioned when the propellers 4 are not in operation for propulsion of the marine vessel, such as when the marine vessel is anchored or towed.

[0043] The propeller drive assembly may comprise locking means for locking the position of propeller shaft(s), such that the propellers 4 cannot rotate by the water pressure acting on the propeller 4 at towing of the marine vessel. The locking means may for example comprise a friction break movable by an actuator between a breaking position in which the friction break acts on the propeller shaft to prevent it from rotating, and a non-breaking position in which the friction break does not prevent rotation of the propeller shaft.

[0044] For example, the position may be such as to minimize an extent of the propeller 4 below the marine vessel, thereby minimizing height of the marine vessel. Minimizing height of the marine vessel may be advantageous when moving the marine vessel through tight passages with limited space available around the marine vessel, such as when towing the marine vessel over underground obstacles or during road transport of the marine vessel on a trailer, where available height under bridges limit what bridges the marine vessel may be safely transported under.

[0045] Where the bottom profile of a passage through which the marine vessel has to be transported only allows passage with the propeller 4 in a specific position, the predetermined position may be chosen such that the marine vessel is able to pass the passage by rotating the propeller shafts to respective predetermined positions depending on the bottom curvature.

[0046] The propeller drive assembly 1 further comprises at least one electric drive means 7 configured to control a rotational position of each propeller shaft about said first rotational axis 5. The first step M1 comprises triggering the electric drive means 7 to perform the rotations of the respective propeller shafts to the respective predetermined rotational positions P0a, P0b.

[0047] The use of the electric drive means 7 for control of the respective rotational position of the propeller shafts enables precise control of the rotational position of each propeller shaft.

[0048] The method is especially advantageous when used with retractable propeller drive units 3, such as the one depicted in figs. 12-16. Accordingly, the propeller drive assembly 1 comprises a housing 8 for attachment to a hull 2 of the marine vessel on an inside of the hull 2 such that the housing 8 surrounds a first opening 9 of the hull 2 and seals

to the hull 2. The housing 8 defines an inner space 10 and wherein the housing 8 is provided with a second opening 11 through which at least a portion of the propeller drive unit 3 is movable into and out of the inner space 10. The propeller drive assembly 1 comprises a suspension mechanism 12 attached to the housing 8 and configured to suspend the propeller drive unit 3, wherein the suspension mechanism 12 is movable along a first longitudinal axis 13 of the housing 8 between a stowed position P1, in which the propeller drive unit 3 is positioned inside the inner space 10 of the housing 8, and a deployed position P2 in which at least a portion of the propeller drive unit 3 protrudes outside the housing 8 through the second opening 11. Accordingly, the method M0 further comprises a second step M2 comprising triggering movement of the suspension mechanism 12 from the deployed position P1 to the stowed position P2.

[0049] By moving the propeller drive unit 3 to the stowed position, the propeller 4 is moved in a direction further into the hull 2 of the marine vessel, thus further reducing the extent of the propeller 4 below/outside the hull 2 of the marine vessel. In other embodiments, the propeller drive unit 3 may be non-retractable and hence no housing 8 and no suspension mechanism 12 provided.

[0050] As shown in figs. 12-16, each of the two propeller shafts is provided with a respective propeller 4. The respective predetermined position P0a, P0b of each propeller shaft is such that each respective propeller 4 is fully confined within the inner space 10 of the housing 8 when the propeller drive unit 3 is in the stowed position P1. In other embodiments of the method, the respective predetermined position P0a, P0b of each propeller shaft may alternatively be such that each respective propeller 4 is only partly confined within the inner space 10 of the housing 8 when the propeller drive unit 3 is in the stowed position P1.

[0051] The propeller drive unit 3 comprises two propeller shafts each carrying one propeller 4. Each propeller 4 has two blades, but each propeller 4 may alternatively in other embodiments, have any other suitable number of blades. Further, as an alternative to having a same number of blades on each propeller 4 (not limited to two blades), the propellers 4 may alternatively have different number of blades; For example, one propeller 4 may have two blades and the other propeller 4 three blades.

[0052] The propellers 4 are rotatable relatively each other about the first rotational axis 5 such that that a joint projected driving area A provided by the propellers 4 in a plane P perpendicular to the first rotational axis 5 varies in response to a relative rotation between a maximum joint projected driving area Amax and a minimum joint projected driving area Amin together defining a joint projected driving area range.

[0053] The relationship between rotational positions of propellers 4 and joint projected driving area A is shown in figs. 23a-b and 24a-b, however with propellers 4 with different blade size. The black area in figs. 23b and 24b depict the respective joint projected driving area A for each relative rotational position of the propellers 4.

[0054] In this embodiment, the predetermined positions P0a, P0b are such that the joint projected driving area A when the propeller shafts are in their respective predetermined positions P0a, P0b is within a lower 10% of the joint projected driving area range or within a lower 5% of the joint projected driving area range, or is the minimum joint projected driving area Amin.

[0055] The propellers 4 are substantially aligned if the joint projected driving area when the propeller shafts are in their respective predetermined positions is within a lower 10% of the joint projected driving area range or within a lower 5% of the joint projected driving area range, or is the minimum joint projected driving area. Such alignment reduces the propellers 4 striking foreign objects at towing of the marine vessel. Further, such alignment enables less protrusion of the propellers 4 outside the hull 2 into surrounding water when the propeller drive unit 3 is in its stowed position.

[0056] In this embodiment, the second step M2 is performed after said first step, such that the propeller 4 blades are oriented in the predetermined positions P0a, P0b before the propeller drive unit 3 is retracted. This way, the housing 8 may be adapted to the predetermined position of the propellers 4, as governed by the predetermined positions of the propeller shafts, such that the housing 8 conforms to the shape of the propellers 4 when the propeller drive unit 3 is in its stowed position P1. Accordingly, there is no need to provide extra room in the housing 8 for rotation of the propeller shafts to bring them to their predetermined positions when the propeller drive unit 3 is in its stowed position P1.

[0057] The first step of triggering rotation of the propeller shafts is typically made by providing a control signal to the drive means such that the drive means rotates the respective propeller shaft to the respective predetermined position P0a, P0b.

[0058] In the embodiments of the figures 1-22, a control unit 14 is provided for controlling the propeller drive assembly 1, said control unit 14 being configured to perform the method according to any one of claims 1-7.

[0059] The control unit 14 may be provided separately from the propeller drive assembly 1 and communicate wirelessly with the propeller drive assembly 1 or by wire.

[0060] Typically, the propeller drive assembly 1 is provided as part of a propeller drive system 6 comprising the propeller drive assembly 1 and the control unit 14. This is the configuration used in the embodiments of the figures 1-22.

[0061] The propeller drive unit 3 carries at least one propeller shaft for carrying a respective propeller 4 for rotation about a first rotational axis 5. The control unit 14 is configured to trigger rotation M1 of each propeller shaft such that the respective propeller shaft reaches a respective predetermined rotational position P0a, P0b and stops at the respective predetermined rotational position P0a, P0b. In this embodiment, two propeller shafts and two propellers 4 are provided.

[0062] The propeller 4 may be provided separately from the propeller drive system 6 and such that an installer orders propellers 4 separately based on a choice made by the installer according to the needs of the marine vessel to which the propeller drive system 6 is to be installed.

[0063] The propeller 4 may alternatively be attached to the respective propeller shaft already at manufacturing of the propeller drive system 6.

[0064] The propeller drive assembly 1 may be provided with means for ensuring the propeller 4 is aligned on each respective propeller shaft in a predetermined relative rotational position with respect to the propeller shaft. For example, each propeller shaft may be provided with splines configured to mate with corresponding splines of each respective propeller 4 such that the propeller 4 only fits in a specific orientation on the respective propeller shaft. Alternatively, the control unit 14 may be provided with a calibration mode where the control unit 14 moves each respective propeller shaft to a predetermined calibration position and stops the propeller shaft at the predetermined calibration position, waiting for the installer to fit the propeller 4 such that the propeller 4 is aligned with a reference, such as matching reference marks on the propeller drive unit 3 and the propeller 4, or simply by aligning the propeller 4 according to instructions, for example with one blade pointing straight upwards along the first longitudinal axis 13. The control unit 14 may also be configured to obtain data provided by the installer relating to the dimension and type of propeller(s) 4 installed.

[0065] Any other suitable method or means for ensuring that the relative rotational position of each propeller 4 with respect to the rotational position of each respective propeller shaft is known, may alternatively be used instead. For example, sensors could be provided for determining the rotational position of the propeller 4 relatively the propeller drive unit 3, such as a camera-based system configured to determine the type of propeller 4 and its orientation, optical sensors, or electro-magnetic sensors sensing proximity of a specific portion of each respective propeller 4 to the sensor which is provided on a known location of the propeller drive assembly 1.

[0066] The propeller drive system 6 comprises at least one electric drive means 7 configured to control a rotational position of each propeller shaft about said first rotational axis 5. In this embodiment, the electric drive means 7 comprises two electric motors coupled to both propeller shafts via gears such that each motor drives a respective one of the propeller shafts. In other embodiments, other types of drive means may alternatively be provided instead of the electric drive means 7.

[0067] The control unit 14 is configured to trigger the electric drive means 7 to perform the rotations of the propeller shafts to the respective predetermined rotational positions P0a, P0b.

[0068] In this embodiment, the propeller drive assembly 1 further comprises a housing 8 for attachment to a hull 2 of the marine vessel on an inside of the hull 2 such that the housing 8 surrounds a first opening 9 of the hull 2 and seals to the hull 2. The housing 8 defines an inner space 10 and wherein the housing 8 is provided with a second opening 11 through which at least a portion of the propeller drive unit 3 is movable into and out of the inner space 10. The propeller drive assembly 1 comprises a suspension mechanism 12 attached to the housing 8 and configured to suspend the propeller drive unit 3, wherein the suspension mechanism 12 is movable along a first longitudinal axis 13 of the housing 8 between a stowed position P1, in which the propeller drive unit 3 is positioned inside the inner space 10 of the housing 8, and a deployed position P2 in which at least a portion of the propeller drive unit 3 protrudes outside the housing 8 through the second opening 11. A similar arrangement is provided in the embodiments shown in figs. 1-5 and 17-21.

[0069] For such embodiments with propeller drive unit 3 retractable into a housing 8, the control unit 14 is further configured to trigger movement of the suspension mechanism 12 from the deployed position P2 to the stowed position P1, typically in response to a command obtained by the control unit 14 from an operator of the marine vessel, or from an automated navigation system.

[0070] As shown in figs. 12-16, the respective predetermined position P0a, P0b of each propeller shaft is such that each respective propeller 4 is fully confined within the inner space 10 of the housing 8 when the propeller drive unit 3 is in the stowed position P1. In other embodiments, the respective predetermined position P0a, P0b of each propeller shaft may alternatively be such that each respective propeller 4 is only partly confined within the inner space 10 of the housing 8 when the propeller drive unit 3 is in the stowed position P1.

[0071] The propeller drive unit 3 comprises two propeller shafts each carrying one propeller 4, wherein the propellers 4 are rotatable relatively each other about the first rotational axis 5 such that that a joint projected driving area A provided by the propellers 4 in a plane P perpendicular to the first rotational axis 5 varies in response to a relative rotation between a maximum joint projected driving area A_{max} and a minimum joint projected driving area A_{min} together defining a joint projected driving area range, and wherein the predetermined positions P0a, P0b are such that the joint projected driving area A when the propeller shafts are in their respective predetermined positions P0a, P0b is within a lower 10% of the joint projected driving area range or within a lower 5% of the joint projected driving area range, or is the minimum joint projected driving area A_{min}.

[0072] The control unit 14 is configured to trigger movement M1 of the suspension mechanism 12 from the deployed position P2 to the stowed position P1 after, and/or simultaneously with said triggering of rotation M1 of each propeller shaft such that the respective propeller shaft reaches a respective predetermined rotational position P0a, P0b and stops at the respective predetermined rotational position P0a, P0b.

[0073] Alternatively, said propeller drive unit 3 comprises two propeller shafts each carrying one propeller 4 wherein the propellers 4 are rotatable relatively each other about the first rotational axis 5 such that that a joint projected driving area provided by the propellers 4 in a plane P perpendicular to the first rotational axis 5 varies in response to a relative rotation between a maximum joint projected driving area P_{max} and a minimum joint projected driving area P_{min} together defining a joint projected driving area range. The predetermined positions P0a, P0b may be such that the joint projected driving area when the propeller shafts are in their respective predetermined positions P0a, P0b is within a higher 20% of the joint projected driving area range or within a higher 10% of the joint projected driving area range, or is the maximum joint projected driving area (A_{min}).

[0074] By moving the propeller shafts such that the joint projected driving area A is within a higher 20% of the joint projected driving area range, the propellers 4 may be held stationary to provide a great braking force for slowing down the marine vessel. For retractable propeller drive units 3, such braking of the marine vessel requires the propeller drive unit 3 to be in its deployed position for maximum braking effect.

[0075] As shown in figs. 1-22, a marine vessel may be provided, said marine vessel comprising the propeller drive system 6 according to any one of the above-mentioned embodiments.

[0076] Further, a computer program comprising program code means for performing the method of any one of claims 1-7 when said program is run on a control unit 14 may be provided.

[0077] It is to be understood that the present disclosure is not limited to the embodiments described above and illustrated in the drawings; rather, the skilled person will recognize that many changes and modifications may be made within the scope of the appended claims.

[0078] FIG. 25 is a schematic diagram of a computer system 2500 for implementing the method disclosed herein. The computer system 2500 is adapted to execute instructions from a computer-readable medium to perform these and/or any of the functions or processing described herein. The computer system 2500 may be connected (e.g., networked) to other machines in a LAN, an intranet, an extranet, or the Internet. While only a single device is illustrated, the computer system 2500 may include any collection of devices that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein. Accordingly, any reference in the disclosure and/or claims to a computer system, computing system, computer device, computing device, control system, control unit, electronic control unit (ECU), processor device, etc., includes reference to one or more such devices to individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein. For example, control system may include a single control unit or a plurality of control units connected or otherwise communicatively coupled to each other, such that any performed function may be distributed between the control units as desired. Further, such devices may communicate with each other or other devices by various system architectures, such as directly or via a Controller Area Network (CAN) bus, etc.

[0079] Accordingly, the control unit 14 mentioned in the claims could be implemented as a computer system 2500 provided locally in the marine vessel, or as a distributed computer system performing the same tasks as the control unit 14 discussed herein.

[0080] The computer system 2500 may comprise at least one computing device or electronic device capable of including firmware, hardware, and/or executing software instructions to implement the functionality described herein. The computer system 2500 may include a processor device 2502 (may also be referred to as a control unit), a memory 2504, and a system bus 2506. The computer system 2500 may include at least one computing device having the processor device 2502. The system bus 2506 provides an interface for system components including, but not limited to, the memory 2504 and the processor device 2502. The processor device 2502 may include any number of hardware components for conducting data or signal processing or for executing computer code stored in memory 2504. The processor device 2502 (e.g., control unit) may, for example, include a general-purpose processor, an application specific processor, a Digital Signal Processor (DSP), an Application Specific Integrated Circuit (ASIC), a Field Programmable Gate Array (FPGA), a circuit containing processing components, a group of distributed processing components, a group of distributed computers configured for processing, or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. The processor device may further include computer executable code that controls operation of the programmable device.

[0081] The system bus 2506 may be any of several types of bus structures that may further interconnect to a memory bus (with or without a memory controller), a peripheral bus, and/or a local bus using any of a variety of bus architectures. The memory 2504 may be one or more devices for storing data and/or computer code for completing or facilitating methods described herein. The memory 2504 may include database components, object code components, script components, or other types of information structure for supporting the various activities herein. Any distributed or local memory device may be utilized with the systems and methods of this description. The memory 2504 may be communicably connected to the processor device 2502 (e.g., via a circuit or any other wired, wireless, or network connection) and may include computer code for executing one or more processes described herein. The memory 2504 may include non-volatile memory 2508 (e.g., read-only memory (ROM), erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), etc.), and volatile memory 2510 (e.g., random-access memory

(RAM)), or any other medium which can be used to carry or store desired program code in the form of machine-executable instructions or data structures and which can be accessed by a computer or other machine with a processor device 2502. A basic input/output system (BIOS) 2512 may be stored in the non-volatile memory 2508 and can include the basic routines that help to transfer information between elements within the computer system 2500.

[0082] The computer system 2500 may further include or be coupled to a non-transitory computer-readable storage medium such as the storage device 2514, which may comprise, for example, an internal or external hard disk drive (HDD) (e.g., enhanced integrated drive electronics (EIDE) or serial advanced technology attachment (SATA)), HDD (e.g., EIDE or SATA) for storage, flash memory, or the like. The storage device 2514 and other drives associated with computer-readable media and computer-usable media may provide non-volatile storage of data, data structures, computer-executable instructions, and the like.

[0083] A number of modules can be implemented as software and/or hard-coded in circuitry to implement the functionality described herein in whole or in part. The modules may be stored in the storage device 2514 and/or in the volatile memory 2510, which may include an operating system 2516 and/or one or more program modules 2518. All or a portion of the examples disclosed herein may be implemented as a computer program product 2520 stored on a transitory or non-transitory computer-usable or computer-readable storage medium (e.g., single medium or multiple media), such as the storage device 2514, which includes complex programming instructions (e.g., complex computer-readable program code) to cause the processor device 2502 to carry out the steps described herein. Thus, the computer-readable program code can comprise software instructions for implementing the functionality of the examples described herein when executed by the processor device 2502. The processor device 2502 may serve as a controller, or control system, for the computer system 2500 that is to implement the functionality described herein.

[0084] The computer system 2500 also may include an input device interface 2522 (e.g., input device interface and/or output device interface). The input device interface 2522 may be configured to receive input and selections to be communicated to the computer system 2500 when executing instructions, such as from a keyboard, mouse, touch-sensitive surface, etc. Such input devices may be connected to the processor device 2502 through the input device interface 2522 coupled to the system bus 2506 but can be connected through other interfaces such as a parallel port, an Institute of Electrical and Electronic Engineers (IEEE) 1394 serial port, a Universal Serial Bus (USB) port, an IR interface, and the like. The computer system 2500 may include an output device interface 2524 configured to forward output, such as to a display, a video display unit (e.g., a liquid crystal display (LCD) or a cathode ray tube (CRT)). The computer system 2500 may also include a communications interface 2526 suitable for communicating with a network as appropriate or desired.

[0085] The operational steps described in any of the exemplary aspects herein are described to provide examples and discussion. The steps may be performed by hardware components, may be embodied in machine-executable instructions to cause a processor to perform the steps, or may be performed by a combination of hardware and software. Although a specific order of method steps may be shown or described, the order of the steps may differ. In addition, two or more steps may be performed concurrently or with partial concurrence.

[0086] The terminology used herein is for the purpose of describing particular aspects only and is not intended to be limiting of the disclosure. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. It will be further understood that the terms "comprises," "comprising," "includes," and/or "including" when used herein specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0087] It will be understood that, although the terms first, second, etc., may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and, similarly, a second element could be termed a first element without departing from the scope of the present disclosure.

[0088] Relative terms such as "below" or "above" or "upper" or "lower" or "horizontal" or "vertical" may be used herein to describe a relationship of one element to another element as illustrated in the Figures. It will be understood that these terms and those discussed above are intended to encompass different orientations of the device in addition to the orientation depicted in the Figures. It will be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element, or intervening elements may be present. In contrast, when an element is referred to as being "directly connected" or "directly coupled" to another element, there are no intervening elements present.

[0089] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. It will be further understood that terms used herein should be interpreted as having a meaning consistent with their meaning in the context of this specification and the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0090] It is to be understood that the present disclosure is not limited to the aspects described above and illustrated in the drawings; rather, the skilled person will recognize that many changes and modifications may be made within the scope of the present disclosure and appended claims. In the drawings and specification, there have been disclosed aspects for purposes of illustration only and not for purposes of limitation, the scope of the inventive concepts being set forth in the following claims.

Table of reference numerals

1	propeller drive assembly
2	hull of marine vessel
3	propeller drive unit
4	propeller
5	first rotational axis
6	propeller drive system
7	electric drive means
8	housing
9	first opening (of hull of marine vessel)
10	inner space of housing
11	second opening (of housing)
12	suspension mechanism
13	first longitudinal axis
14	control unit
15	sea bottom
16	sea surface
2500	computer system
2502	processor device
2504	memory
2506	system bus
2508	non-volatile memory
2510	volatile memory
2512	basic input/output system (BIOS)
2514	storage device
2516	operating system
2518	program module
2520	computer program product
2522	input device interface
2524	output device interface
2526	communications interface
POa	predetermined rotational position of first propeller
P0b	predetermined rotational position of second propeller
M0	method of controlling a propeller drive assembly
M1	triggering rotation
M2	moving

(continued)

P1	stowed position of propeller drive unit
P2	deployed position of propeller drive unit
A	joint projected driving area
Amax	maximum joint projected driving area
Amin	minimum joint projected driving area
P	plane orthogonal to first rotational axis

Claims

1. A method (M0) of controlling a propeller drive assembly (1) attachable to a hull (2) of a marine vessel, said propeller drive assembly (1) comprising a propeller drive unit (3) carrying at least one propeller shaft for carrying a respective propeller (4) for rotation about a first rotational axis (5), wherein the method (M0) comprises:
a first step (M1) comprising triggering rotation of each propeller shaft such that the respective propeller shaft reaches a respective predetermined rotational position (POa, P0b)) and stops at the respective predetermined rotational position (POa, P0b).
2. A method (M0) according to claim 1, wherein the propeller drive assembly further comprises at least one electric drive means (7) configured to control a rotational position of each propeller shaft about said first rotational axis (5) and wherein the first step (M1) comprises triggering the electric drive means (7) to perform the rotation(s) of the respective propeller shaft(s) to the respective predetermined rotational position(s) (POa, P0b).
3. A method (M0) according to any one of claims 1-2,
wherein the propeller drive assembly (1) comprises a housing (8) for attachment to a hull (2) of the marine vessel on an inside of the hull (2) such that the housing (8) surrounds a first opening (9) of the hull (2) and seals to the hull (2), wherein the housing (8) defines an inner space (10) and wherein the housing (8) is provided with a second opening (11) through which at least a portion of the propeller drive unit (3) is movable into and out of the inner space (10), and
wherein the propeller drive assembly (1) comprises a suspension mechanism (12) attached to the housing (8) and configured to suspend the propeller drive unit (3), wherein the suspension mechanism (12) is movable along a first longitudinal axis (13) of the housing (8) between a stowed position (P1), in which the propeller drive unit (3) is positioned inside the inner space of the housing, and a deployed position (P2) in which at least a portion of the propeller drive unit (3) protrudes outside the housing (8) through the second opening (11),
wherein the method (M0) further comprises a second step (M2) comprising triggering movement of the suspension mechanism (12) from the deployed position (P1) to the stowed position (P2).
4. A method (M0) according to claim 3, wherein each propeller shaft is provided with a respective propeller (4), and wherein the respective predetermined position (POa, P0b) of each propeller shaft is such that each respective propeller (4) is at least partly, such as fully, confined within the inner space (10) of the housing (8) when the propeller drive unit (3) is in the stowed position (P1).
5. A method (M0) according to claim 4, wherein said propeller drive unit (3) comprises two propeller shafts each carrying one propeller (4) wherein the propellers (4) are rotatable relatively each other about the first rotational axis (5) such that that a joint projected driving area (A) provided by the propellers (4) in a plane (P) perpendicular to the first rotational axis (5) varies in response to a relative rotation between a maximum joint projected driving area (Amax) and a minimum joint projected driving area (Amin) together defining a joint projected driving area range, and wherein the predetermined positions (POa, P0b) are such that the joint projected driving area (A) when the propeller shafts are in their respective predetermined positions (POa, P0b) is within a lower 10% of the joint projected driving area range or within a lower 5% of the joint projected driving area range, or is the minimum joint projected driving area (Amin).
6. A method (M0) according to claim 5, wherein the propellers have a same number of blades.

7. A method (M0) according to any one of claims 3-6, wherein said second step (M2) is performed after, and/or simultaneously with said first step.
8. A method (M0) according to any one of claims 1-3, wherein said propeller drive unit (3) comprises two propeller shafts each carrying one propeller (4) wherein the propellers (4) are rotatable relatively each other about the first rotational axis (5) such that that a joint projected driving area (A) provided by the propellers (4) in a plane (P) perpendicular to the first rotational axis (5) varies in response to a relative rotation between a maximum joint projected driving area (Amax) and a minimum joint projected driving area (Amin) together defining a joint projected driving area range, and wherein the predetermined positions (POa, P0b) are such that the joint projected driving area (A) when the propeller shafts are in their respective predetermined positions (POa, P0b) is within a higher 20% of the joint projected driving area range or within a higher 10% of the joint projected driving area range, or is the maximum joint projected driving area (Amin).
9. A control unit (14) for controlling a propeller drive assembly (1) attachable to a hull (2) of a marine vessel, said control unit (14) being configured to perform the method according to any one of claims 1-8.
10. A propeller drive system (6) comprising a propeller drive assembly (1) and a control unit (14), wherein the propeller drive unit (3) carries at least one propeller shaft for carrying a respective propeller (4) for rotation about a first rotational axis (5), and wherein the control unit (14) is configured to trigger rotation (M1) of each propeller shaft such that the respective propeller shaft reaches a respective predetermined rotational position (POa, P0b) and stops at the respective predetermined rotational position (POa, P0b).
11. A propeller drive system (6) according to claim 10, further comprising at least one electric drive means (7) configured to control a rotational position of each propeller shaft about said first rotational axis (5), wherein the control unit (14) is configured to trigger the electric drive means (7) to perform the rotation(s) of the propeller shaft(s) to the respective predetermined rotational position(s) (POa, P0b).
12. A propeller drive system (6) according to any one of claims 10-11, further comprising a housing (8) for attachment to a hull (2) of the marine vessel on an inside of the hull (2) such that the housing (8) surrounds a first opening (9) of the hull (2) and seals to the hull (2), wherein the housing (8) defines an inner space (10) and wherein the housing (8) is provided with a second opening (11) through which at least a portion of the propeller drive unit (1) is movable into and out of the inner space (10), and
 wherein the propeller drive assembly (1) comprises a suspension mechanism (12) attached to the housing (8) and configured to suspend the propeller drive unit (3), wherein the suspension mechanism (12) is movable along a first longitudinal axis (13) of the housing (8) between a stowed position (P1), in which the propeller drive unit (3) is positioned inside the inner space of the housing (8), and a deployed position (P2) in which at least a portion of the propeller drive unit (3) protrudes outside the housing (8) through the second opening (11), and wherein the control unit (14) is further configured to trigger movement of the suspension mechanism (12) from the deployed position (P2) to the stowed position (P1).
13. A propeller drive system (6) according to claim 12, wherein each propeller shaft is provided with a respective propeller (4), and wherein the respective predetermined position (POa, P0b) of each propeller shaft is such that each respective propeller (4) is at least partly, such as fully, confined within the inner space (10) of the housing (8) when the propeller drive unit (3) is in the stowed position (P1).
14. A propeller drive system (6) according to claim 13, wherein said propeller drive unit (3) comprises two propeller shafts each carrying one propeller (4), wherein the propellers (4) are rotatable relatively each other about the first rotational axis (5) such that that a joint projected driving area (A) provided by the propellers (4) in a plane (P) perpendicular to the first rotational axis (5) varies in response to a relative rotation between a maximum joint projected driving area (Amax) and a minimum joint projected driving area (Amin) together defining a joint projected driving area range, and wherein the predetermined positions (POa, P0b) are such that the joint projected driving area (A) when the propeller shafts are in their respective predetermined positions (POa, P0b) is within a lower 10% of the joint projected driving area range or within a lower 5% of the joint projected driving area range, or is the minimum joint projected driving area (Amin).
15. A propeller drive system (6) according to any one of claims 12-14, wherein the control unit (14) is configured to trigger movement (M1) of the suspension mechanism (12) from the deployed position (P2) to the stowed position

(P1) after, and/or simultaneously with said triggering of rotation (M1) of each propeller shaft such that the respective propeller shaft reaches a respective predetermined rotational position (POa, P0b) and stops at the respective predetermined rotational position (POa, P0b).

- 5 **16.** A marine vessel comprising a propeller drive system (6) according to any one of claims 10-15.
- 17.** A computer program comprising program code means for performing the method of any one of claims 1-8 when said program is run on a control unit (14).

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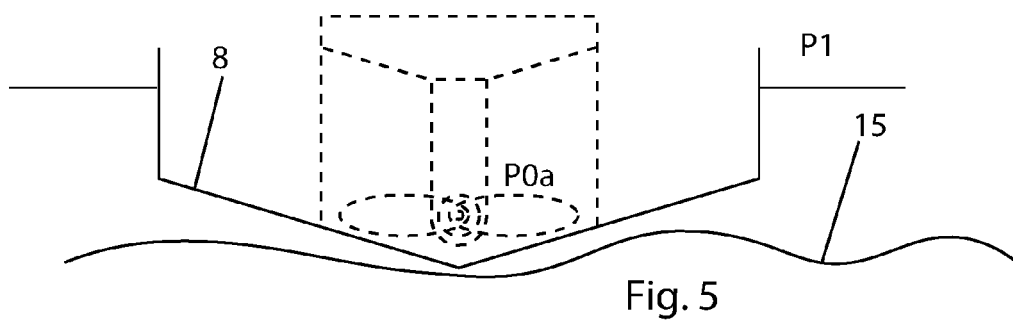
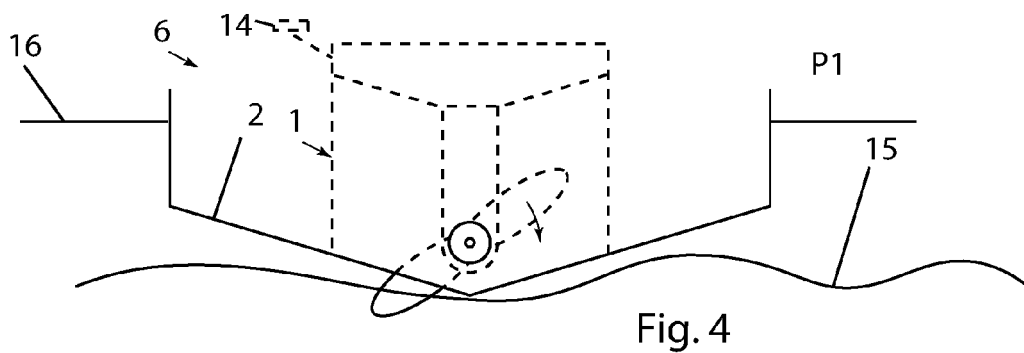
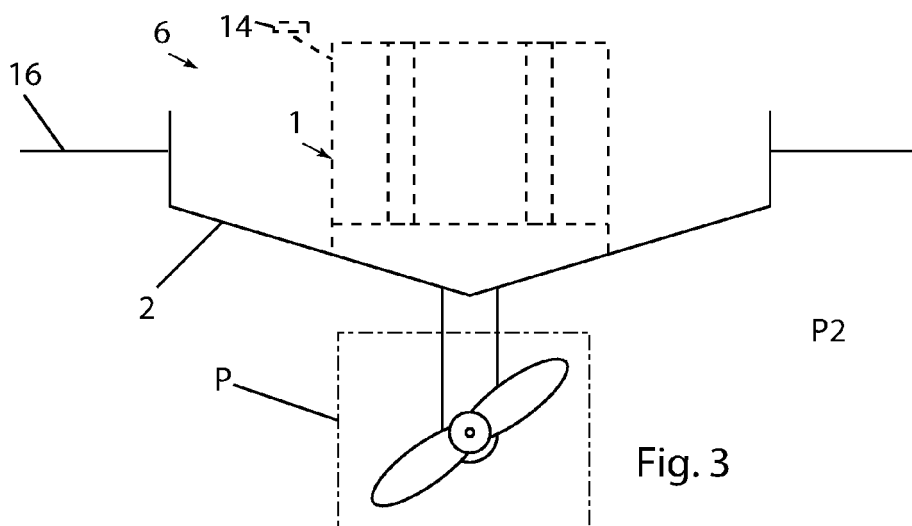
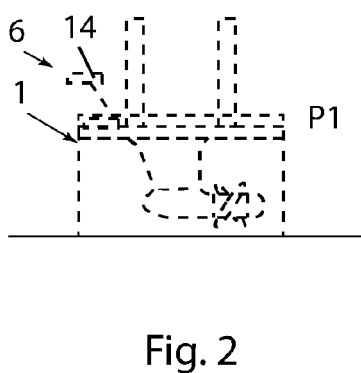
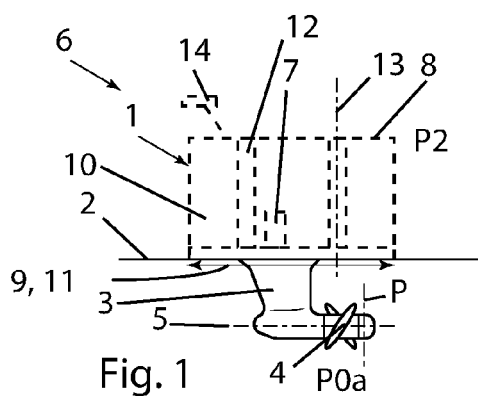
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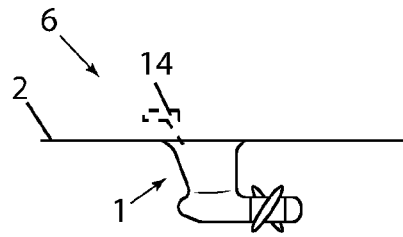


Fig. 6

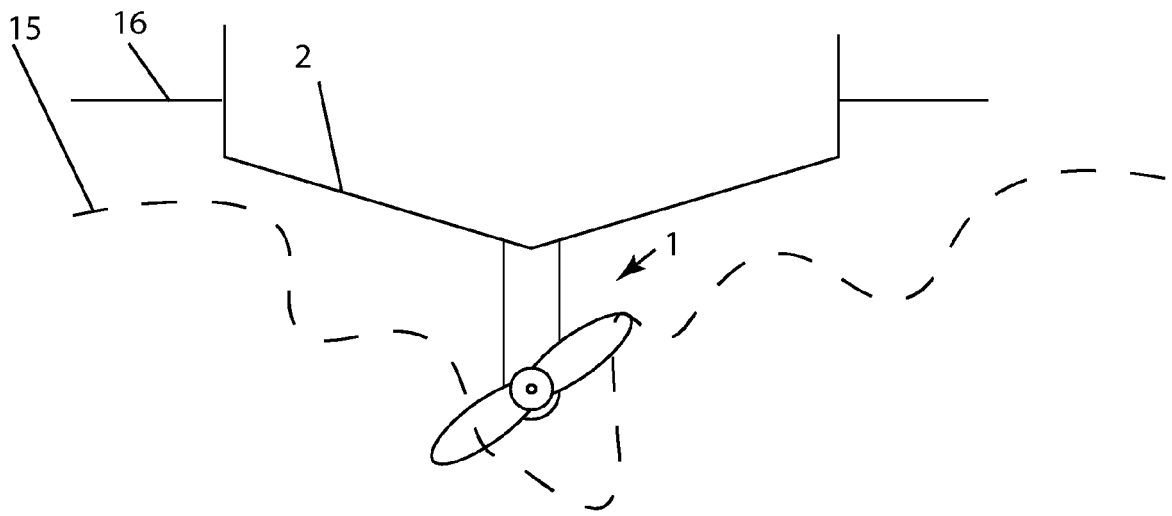


Fig. 7

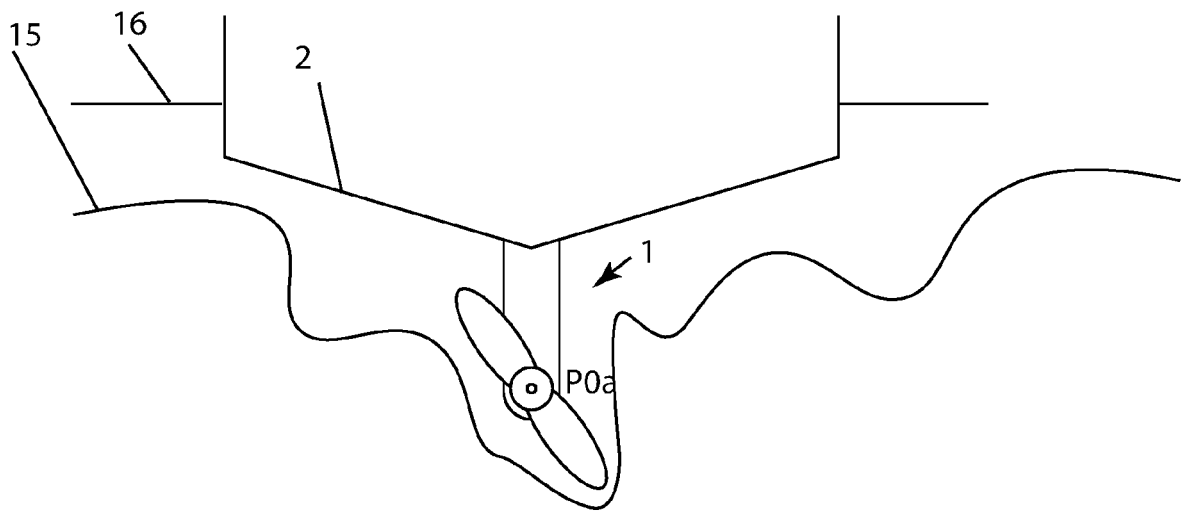


Fig. 8

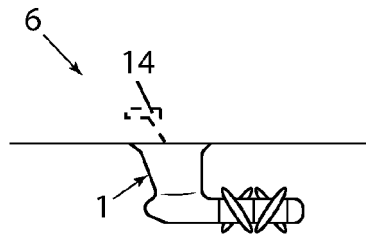


Fig. 9

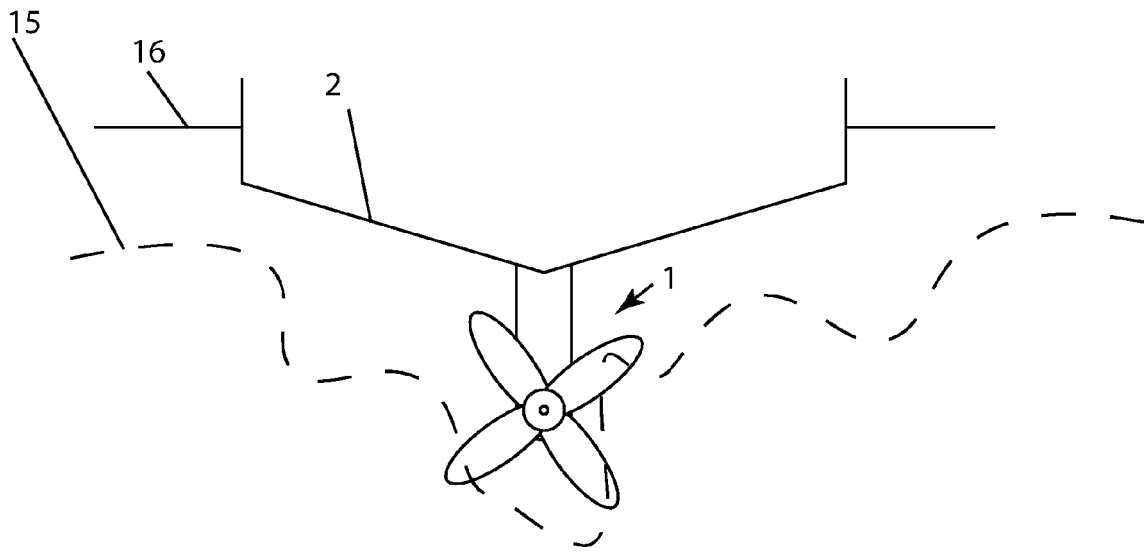


Fig. 10

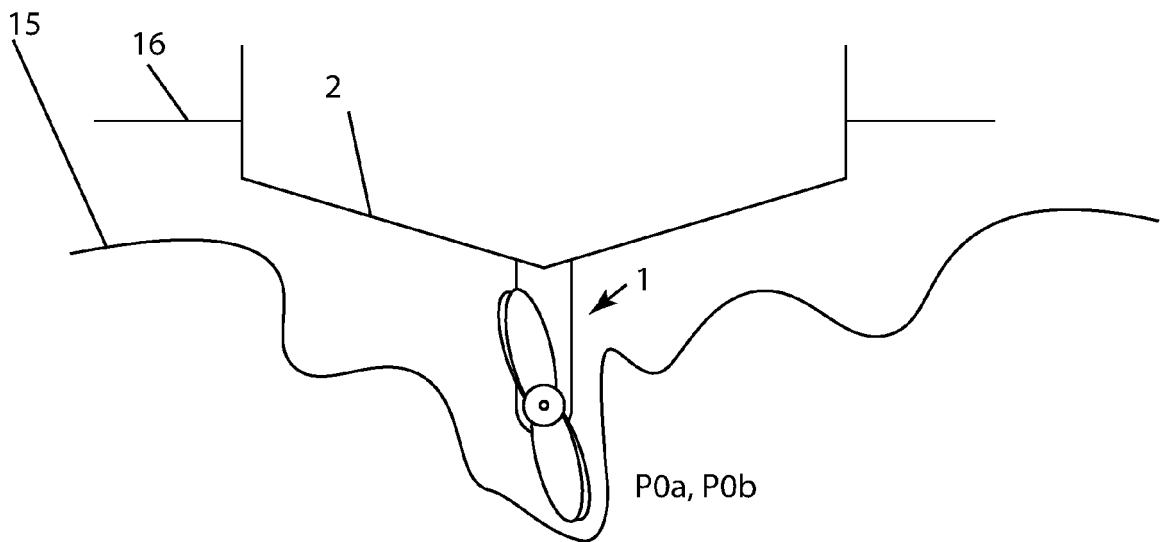
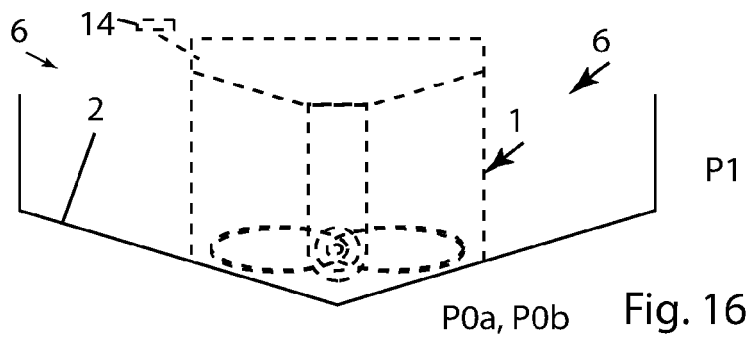
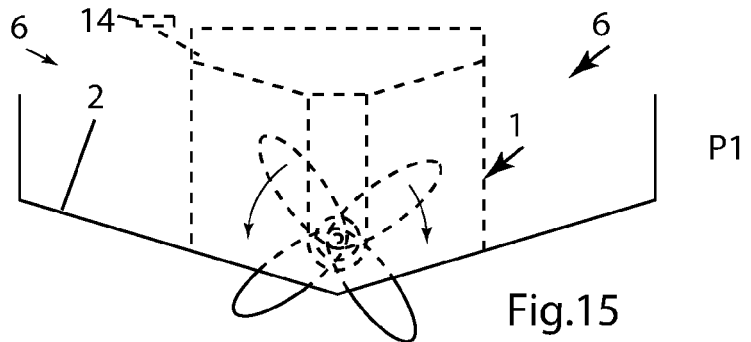
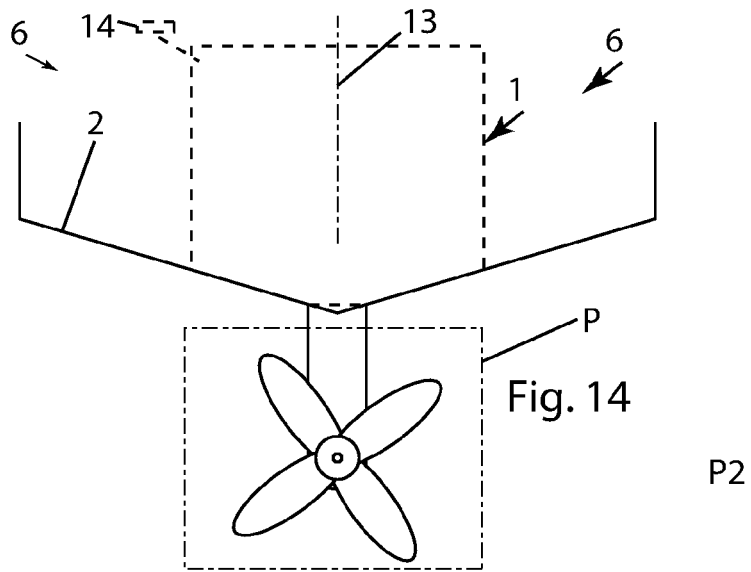
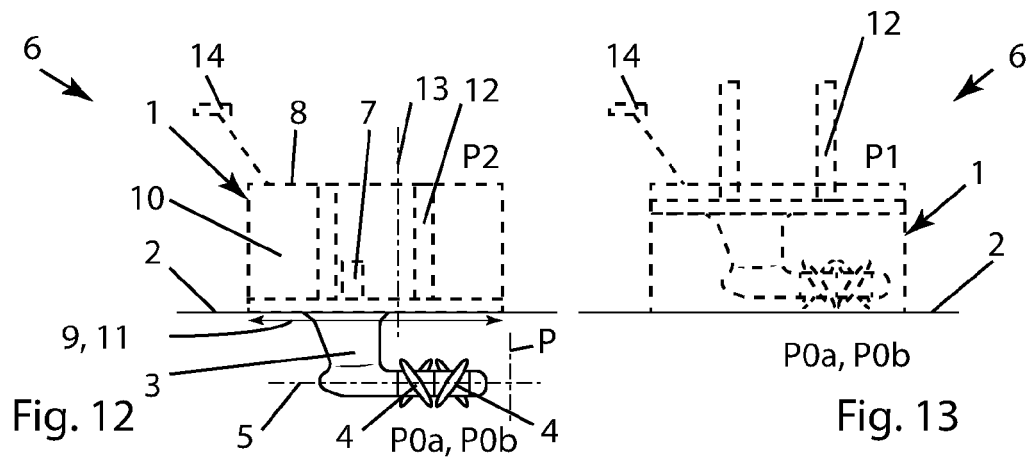
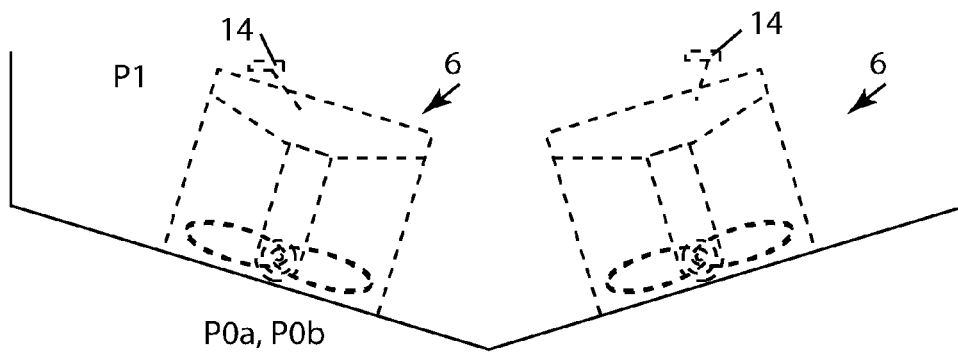
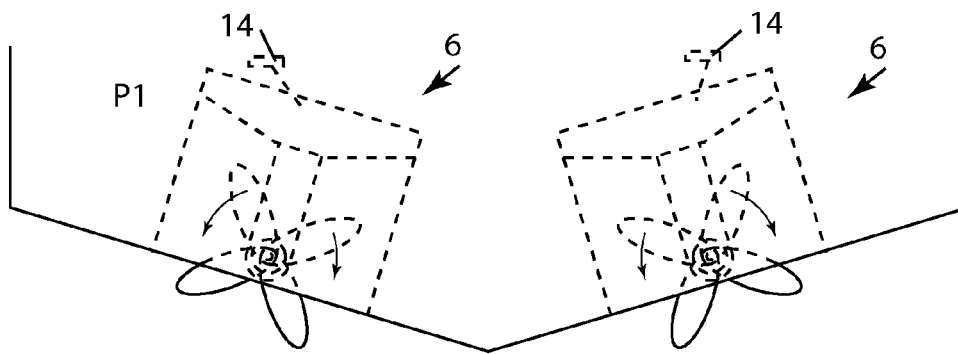
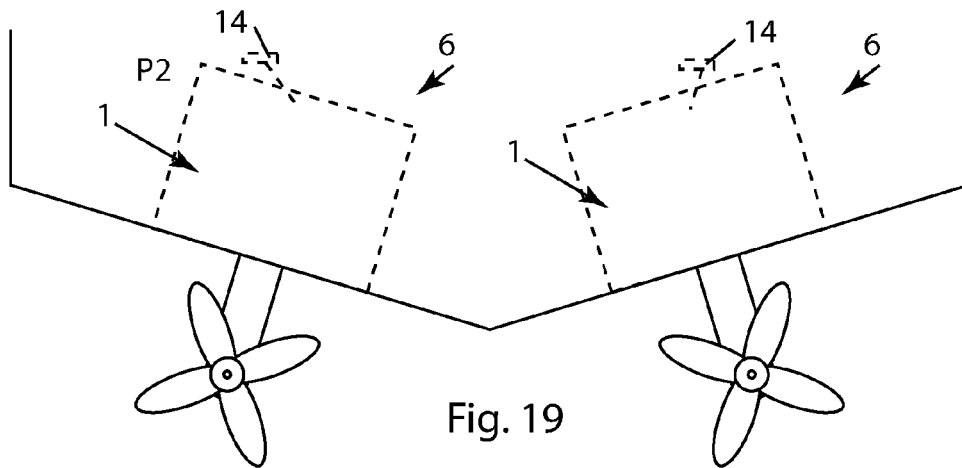
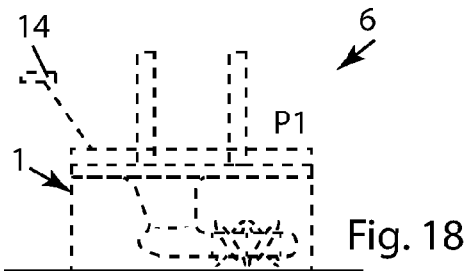
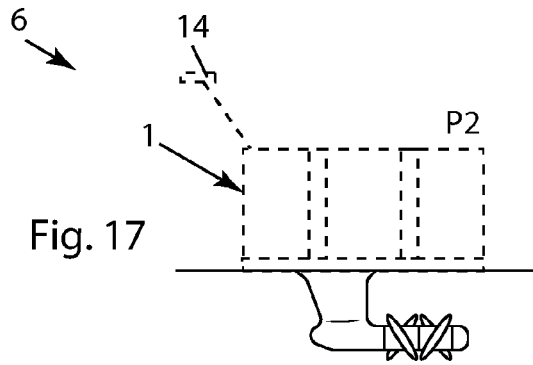


Fig. 11





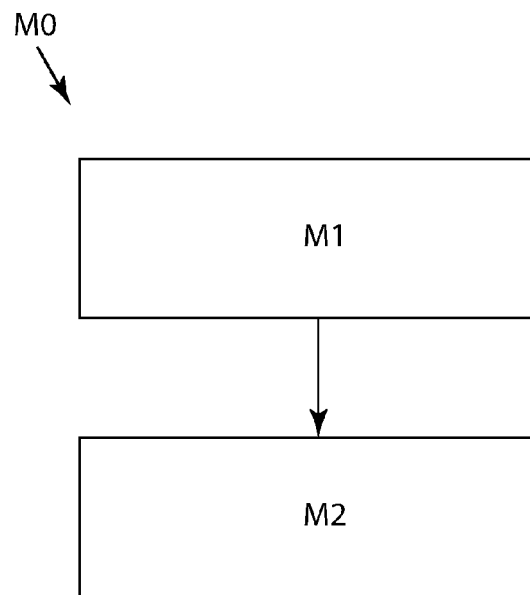


Fig. 22

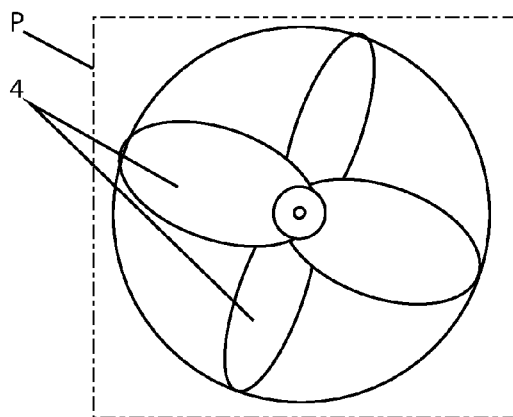


Fig. 23a

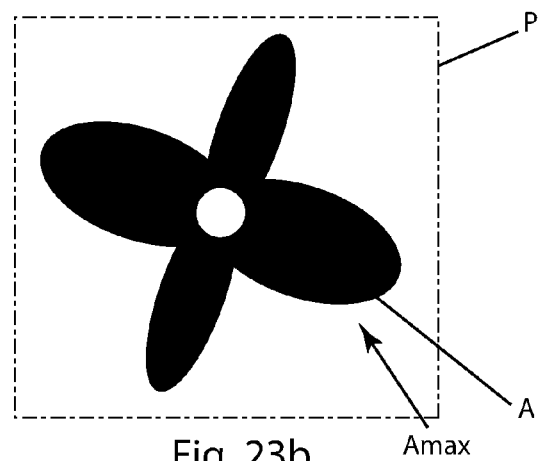


Fig. 23b

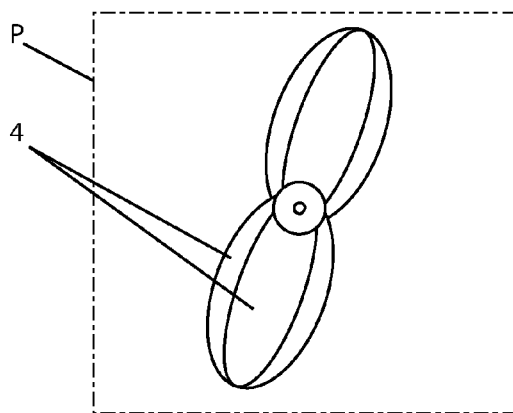


Fig. 24a

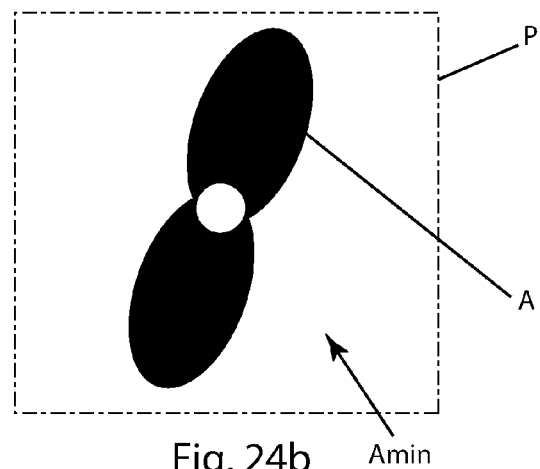


Fig. 24b

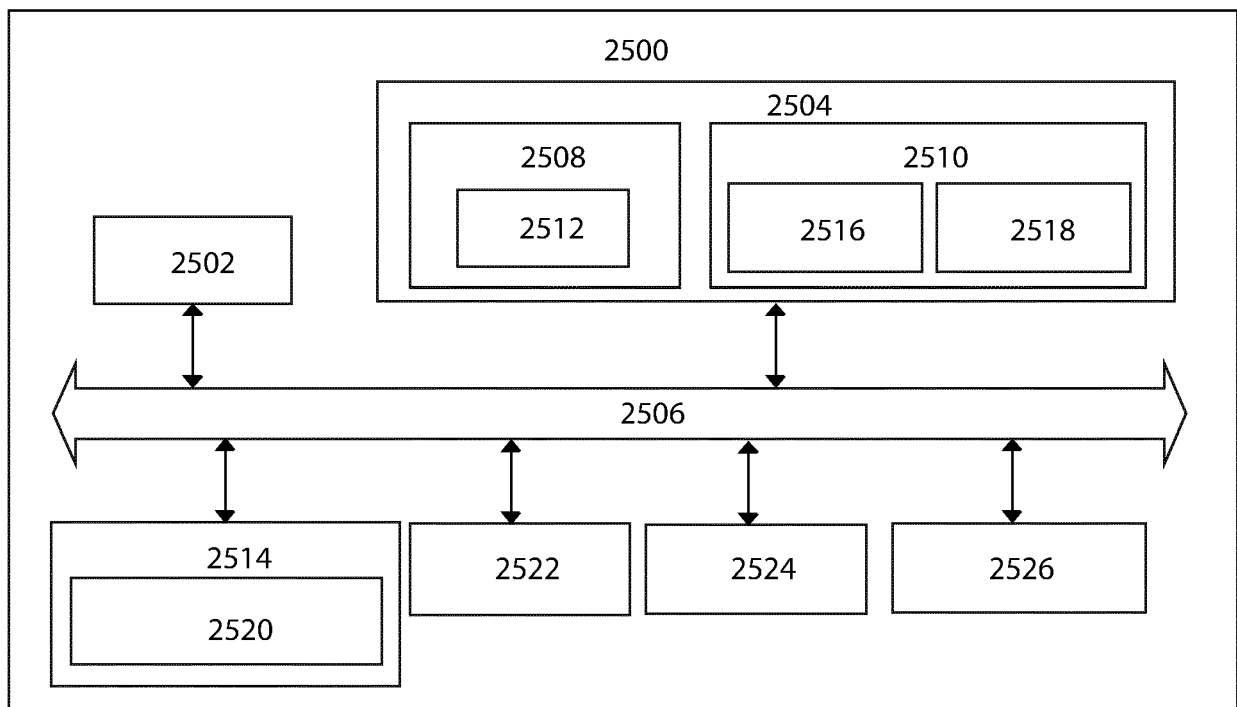


Fig. 25



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Application Number

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 10 January 2023	Examiner Balzer, Ralf
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