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(54) **HYDROFOILS, HYDROFOIL ATTACHMENTS AND VESSELS**

(57) A hydrofoil assembly comprising a fin configured to protrude beyond a bottom of a vessel, and a foil configured to be coupled to the fin at a point of connection is disclosed. The hydrofoil further comprises an actuator to move the foil between a stowed configuration in which the foil does not provide a lifting force, and a deployed configuration in which the foil does provide a lifting force to lift the vessel at least partially out of a body of water. Also disclosed are hydrofoils, vessels comprising such hydrofoils, kits of hydrofoils, methods for attaching a hydrofoil to a fin, and methods of stowing a hydrofoil connected to a fin at a bottom of a vessel.

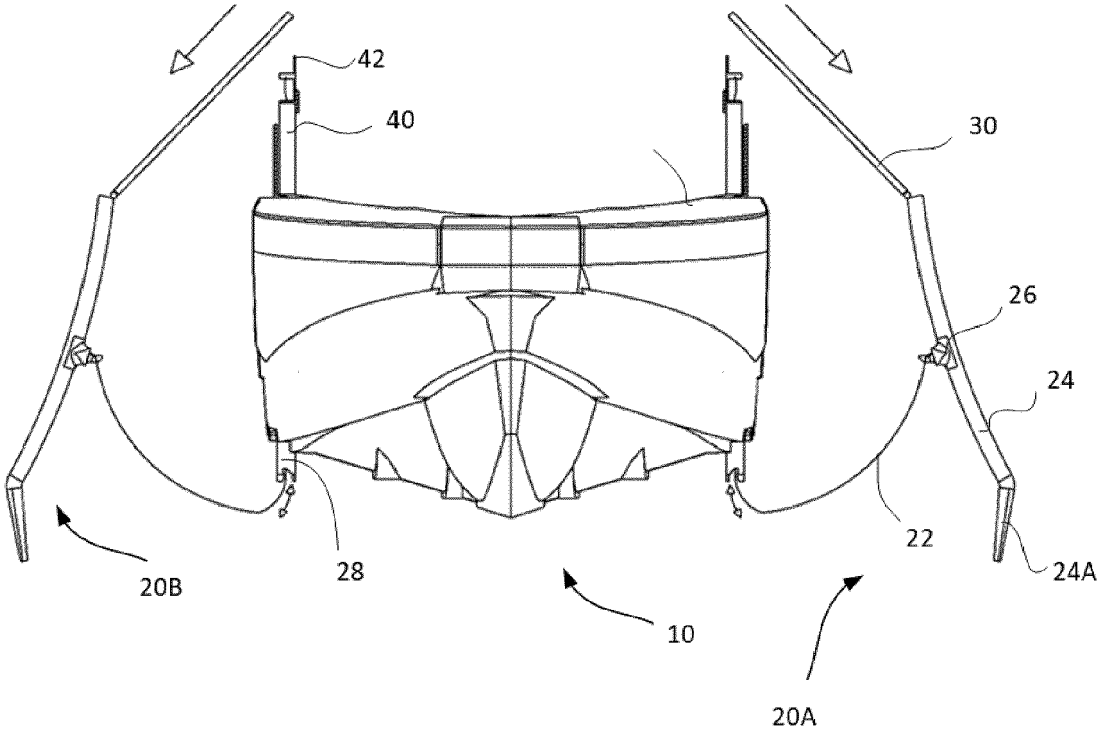


Fig. 1C

EP 4 046 900 A1

Description

[0001] The present disclosure relates to hydrofoils, and to vessels comprising hydrofoils. The present disclosure in particular relates to hydrofoils that can be moved from a stowed configuration to a deployed configuration. The present disclosure further relates to kits of hydrofoils which may be used on vessels, and to methods for attaching and detaching hydrofoils to a structure of a vessel.

BACKGROUND

[0002] A hydrofoil is a lifting surface, or foil, that operates in water. A cross-section of a foil may resemble a cross-section of profiles used on wings of e.g. aircraft. The term "hydrofoil" is sometimes used to describe a boat that use a hydrofoil. In the present disclosure, the term "hydrofoil" is used to describe a lifting surface, whereas a vessel incorporating such hydrofoils is called a hydrofoil craft. As a hydrofoil craft gains speed, the hydrofoils lift the vessel's hull partially or completely out of the water, decreasing drag and allowing greater speeds.

[0003] Hydrofoils have been known and used for decades and they have been used both on sail vessels and on motor vessels. Different types of hydrofoils exist, including e.g. surface piercing hydrofoils and fully submerged hydrofoils. Surface piercing hydrofoils remain partially submerged when the hull of the vessel is lifted out of the water. The hydrofoils may be connected to the hull of the vessel through sideways outwardly extending struts. Surface piercing hydrofoils are typically self-stabilizing, which can avoid the need for active control of the hydrofoil but on the other hand can make the hydrofoil less efficient in a rough sea.

[0004] Also fully submerged hydrofoils exist, which remain fully underwater even if the hull is lifted out of the water. They may be connected to the hull of the vessel through substantially vertical struts. Control systems are typically provided to actively control the inclination of the hydrofoils to stabilize the vessel.

[0005] Advantages of the use of hydrofoils include stable and efficient navigation which can increase speed and/or comfort. This can be particularly attractive for passenger vessels, and more particularly for passenger vessels operating at relatively high speed. Hydrofoils however have also been used on sailboats and sailboats used in races or competitions. Generally speaking, efficient navigation is however only possible in relatively calm waters. If the sea is rough, with high waves, the hydrofoils do not add to the efficiency and may indeed decrease the efficiency of a vessel in rough sea.

[0006] On the other hand, hydrofoils can be sensitive to impacts with floating objects or marine animals. When hitting something, a hydrofoil may get damaged. Moreover, hydrofoils can be expensive to build and to maintain. Hydrofoils allow for growth of algae, barnacles and vegetation since they always remain under water. The unwanted growth on the hydrofoils makes the hydrofoils less efficient and causes them to behave differently in operation from what was intended.

[0007] Other possible disadvantages include the lateral dimensions of vessels with hydrofoils which can complicate mooring and maneuvering in tight port areas. Hydrofoils further limit the ability for vessels to navigate in shallow waters, since the hydrofoils can hit the sea bed.

[0008] It is an object of the present disclosure to provide hydrofoils, vessels, and methods that at least partially resolve some of the aforementioned disadvantages.

SUMMARY

[0009] In a first aspect, a hydrofoil assembly comprising a fin configured to protrude beyond a bottom of a vessel, and a foil configured to be coupled to the fin at a point of connection is provided. The hydrofoil assembly further comprising an actuator to move the foil between a stowed configuration in which the foil does not provide a lifting force, and a deployed configuration in which the foil provides a lifting force to lift the vessel at least partially out of a body of water. The actuator comprises a connector attached to the point of connection and the foil is configured to be moved or maintained in the active configuration by tensioning the connector.

[0010] With a hydrofoil assembly according to this aspect, a foil can be moved between a stowed configuration, which it may assume e.g. when mooring or in case of a rough sea or when in shallow waters, and a deployed configuration, which it may assume e.g. when navigating at high speed. The hydrofoil assembly can thus provide advantages of efficient and fast navigation while avoiding disadvantages related to increased dimensions. The foil can be attached and detached by applying tension to a connector providing a relatively easy control mechanism.

[0011] In a further aspect, a vessel comprising a hydrofoil assembly is provided.

[0012] In a further aspect, a method of stowing a hydrofoil connected to a fin protruding beyond a bottom of a vessel in a body of water is provided. Herein, the hydrofoil is connected to the fin with a tensioned connector. And the method comprises: reducing a tension in the connector to release the hydrofoil from the fin, picking the hydrofoil from the surface of the body of water, and storing the hydrofoil at a deck of the vessel.

[0013] In yet a further aspect, a method for attaching a hydrofoil to a fin protruding beyond a bottom of a vessel in a body of water is provided. The method comprises positioning the hydrofoil in the body of water, and applying tension to a connector connecting the hydrofoil to the fin, such that the hydrofoil is pulled towards the fin.

[0014] In yet a further aspect, a hydrofoil for a vessel is provided. The hydrofoil is configured to be removably coupled to a point of connection of a fin protruding from a bottom of a vessel. And the hydrofoil is attachable and detachable by varying tension in a connector connecting the hydrofoil to the fin.

[0015] And in yet a further aspect, a kit of hydrofoils is provided, which comprises a first hydrofoil according to any of the examples disclosed herein, and a second hydrofoil according to any of the examples disclosed herein, wherein the first and the second hydrofoil can be coupled to the same fin. With this kit of hydrofoils, one hydrofoil may be substituted for another relatively easily. The first hydrofoil may be different from the second hydrofoil. In such a case, a vessel may be adapted for one purpose (e.g. smooth navigation) or for another purpose (e.g. high speed competition sailing).

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Non-limiting examples of the present disclosure will be described in the following, with reference to the appended drawings, in which:

Figures 1A - 1D schematically illustrate a vessel with a first example of a hydrofoil assembly, in which the foil is shown to be installed, and in a deployed configuration and also in a stowed configuration.

Figures 2A - 2D schematically illustrate another example of a hydrofoil assembly in an active and in a stowed configuration.

Figures 3A - 3B schematically illustrate an example of a detail of a coupling of a fin to a foil according to an example; and

Figures 4A and 4B schematically illustrate a method and system for controlling a foil in use.

DETAILED DESCRIPTION OF EXAMPLES

[0017] Figures 1A - 1D schematically illustrate a vessel with a first example hydrofoil assembly, in which the foil is shown to be installed, and in a deployed configuration and also in a stowed configuration.

[0018] Figure 1A schematically illustrates a vessel 10 including a hydrofoil assembly in a deployed configuration. Figure 1D schematically illustrates the same vessel 10 with the same hydrofoil assembly, in which the hydrofoils have are in their stowed configuration. Figures 1B and 1C show the same vessel and hydrofoil assembly in intermediate positions or configurations.

[0019] The vessel 10 in this example includes two hydrofoil assemblies 20A, 20B, each including a fin 28 and a lifting surface 24. Each of the lifting surfaces is inclined with respect to a horizontal plane. The hydrofoil assemblies may be surface piercing. One hydrofoil assembly may be generally arranged on a port side and another hydrofoil assembly may be generally arranged on a starboard side of the vessel 10. The vessel 10 of this example may be a passenger vessel, and may be a motor vessel.

[0020] Figure 1A shows a hydrofoil assembly comprising a fin 28 configured to protrude beyond a bottom of a vessel 10, and a foil 20A, 20B configured to be coupled to the fin 28 at a point of connection 25.

[0021] The hydrofoil assembly further includes an actuator 42 to move the foil 20A, 20B between a stowed configuration (figure 1D) in which the foil does not provide a lifting force, and a deployed configuration (figure 1A) in which the foil provides a lifting force to lift the vessel 10 at least partially out of a body of water. The actuator 42 comprises a connector 22 attached to the point of connection and the foil 20A, 20B is configured to be moved or maintained in the deployed configuration by tensioning the connector 22. Tensioning the connector 22 in this case may be understood to mean that traction is applied to the connector, i.e. the actuator 42 pulls on the connector 22. Actuator 42 may be arranged on a post 40. Post 40 may be an extension of or integrally formed with fin 28.

[0022] As may be seen in figure 1D, in the stowed configuration the foil is stored at a deck of the vessel 10 in this example. A fixture or support rack may be provided at a level of the deck of the vessel to support foil surfaces 24. In examples, the gunwale 29 of the vessel may include a suitable fitting for receiving the foils, and particularly the (male) coupling portion of the foils. The deck of the vessel may herein be regarded as including the gunwale 29. The deck or gunwale may include a retention mechanism to receive the hydrofoils 20A, 20B and retain them, e.g. lock them in a secure position.

[0023] In examples, the fin 28 may be movably mounted with respect to the vessel. I.e. the fin may be displaced vertically with respect to the vessel to protrude more or less from the vessel (or to not protrude at all from the vessel and be stowed inside).

[0024] The fin may be configured to assume an extended position, and a retracted position, wherein in the extended position, the fin protrudes from the bottom of the vessel to a larger extent than in the retracted position. The fin may be formed like a daggerboard in this respect.

[0025] The fin and foil(s) may have a female-male coupling, i.e. one of the fin and foils may comprise a male connector portion and the other of the fin and foils may comprise a female connector portion, wherein the male and female connector portions are configured to mate.

[0026] In some examples, the foils 20A, 20B comprise a male coupling portion 26 configured to be received by a female coupling portion 28 at the point of connection, the female coupling portion 28 having a substantially complementary shape to the male coupling portion.

[0027] In examples, the female coupling portion 28 may have a varying cross-section, wherein dimensions of the cross-section are larger at an opening of the female coupling portion. Such a configuration helps mating of the male and female coupling portions as the fin approaches the foil, when tension is applied to the connector pulling the fin towards the point of connection.

[0028] In examples, the female coupling portion may have one or more curved guiding surfaces. In the example of figure 1, the male coupling portion has substantially

a shark fin tail shape, and the female coupling portion of the foil has a complementary shape. The shark fin tail shape has been found to facilitate coupling at a relatively low level of friction.

[0029] In the example of figure 1, the connector 22 may extend through the fin 28. The actuator 42 may be arranged on the deck of the vessel 10. The connector 22 in the example may be a cable. The actuator in this case may be a winch. The cable may be pulled by the winch to apply tension F to bring the foil 20A, 20B to the deployed configuration, and to maintain the foils in that position. That is, tension may be maintained as long as the foils 20A, 20B are to be maintained in their deployed configuration.

[0030] In other examples, other connectors may be used. The connector may be or comprise a cable, rope, wire or bar. In particular, high strength cables such as cables from high strength steel or from advanced polymer materials such as materials including ultrahigh-molecular-weight polyethylene, e.g. Dyneema™ may be used. Depending on the connector used, different actuators may be used including e.g. a hydraulic, or pneumatic mechanism or piston or an electric mechanism.

[0031] In the example of figure 1, the foils in their deployed configuration (see particularly figure 1A), comprise a substantially horizontal lifting surface 24A, and an inclined lifting surface 24. The inclined lifting surface 24A may remain only partially submerged in use and extend through the water surface.

[0032] As may be seen in figure 1, the hydrofoil assemblies 20A, 20B may include a pole 30, e.g. a spinnaker pole attached or connectable to a lifting surface 24, and particularly at or near an outer end of the lifting surface 24. The pole 30 may be used to pick the foils and lift the foils out of the water when they are to be stored at the deck, see e.g. figure 1D. The poles (see figure 1C) may also be used to release the foils from their stowed position at the deck of the vessel and guide them into the water. When tension is then applied to connector 22, the foils will be drawn closer to the fin(s) and can be connected to the fin.

[0033] Figures 1A - 1D schematically illustrate a sequence of steps between the foils in their deployed configuration (figure 1A) to their stowed configuration (figure 1D). It will be clear that the sequence of steps may be reversed to bring foils from their stowed configuration (figure 1D) to their deployed configuration (figure 1A).

[0034] In accordance with an aspect of the present disclosure, and with reference to figures 1A - 1D, a method of stowing a hydrofoil 20A, 20B connected to a fin 28 protruding beyond a bottom 13 of a vessel 10 in a body of water, wherein the hydrofoil 20A, 20B is connected to the fin 28 with a tensioned connector. The method comprises reducing a tension in the connector 22 to release the hydrofoil 20A, 20B from the fin 28, picking the hydrofoil 20A, 20B from the surface of the body of water, and storing the hydrofoil 20A, 20B at a deck of the vessel. The method for attaching a hydrofoil may be used in combination with any of the examples of fins and foils, disclosed herein.

[0035] In examples, picking the hydrofoil 20A, 20B from the surface of the body of water comprises using a pole 30 to lift the hydrofoil 20A, 20B to the deck of the vessel. The deck of the vessel may comprise a retention mechanism for receiving and retaining the male coupling portion of the hydrofoil. Optionally, the gunwale 29 of the vessel may include the retention mechanism.

[0036] After navigating, as the vessel approaches a port or mooring site, the hydrofoils may be stored. The sideways dimension of the vessel may thus be reduced, easing the approach and mooring of the vessel. At the same time, growth of algae and barnacles etc. on the hydrofoils may be reduced or avoided. Maintenance is facilitated, and maintenance needs may be reduced and efficiency and effectivity of the hydrofoils can be maintained throughout the lifetime of the hydrofoils.

[0037] It should be noted that the longitudinal position for storing the foils does not need to coincide with their longitudinal position when in use. The foils may be stored closer to the bow or closer to the stern than their longitudinal position (from bow to stern) in use. Depending on the layout of the vessel, in particular including e.g. passenger seating arrangement, the foils may be stored in a different longitudinal position.

[0038] Again, with reference to figures 1A - 1D, a method for attaching a hydrofoil 20A, 20B to a fin 28 protruding beyond a bottom 13 of a vessel 10 in a body of water is provided. The method comprises positioning the hydrofoil 20A, 20B in the body of water, and applying tension to a connector 22 connecting the hydrofoil 20A, 20B to the fin 28, such that the hydrofoil 20A, 20B is pulled towards the fin. The method for attaching a hydrofoil may be used in combination with any of the examples of fins and foils, disclosed herein.

[0039] The method may include positioning the hydrofoil in the body of water comprising a pole, such as a spinnaker pole 30. The spinnaker pole 30 may be permanently attached to the hydrofoil assemblies 20A, 20B. The spinnaker pole 30 may be used also to guide the foils to some extent towards their point of coupling with their respective fin 28.

[0040] After unmooring of the vessel, for navigating, the foils may be put in their deployed configuration. With a suitable speed of the vessel, the hull of the vessel will at least partially lift out of the body of water, thereby reducing drag.

[0041] In examples, the method may comprise maintaining tension in the connector to maintain the hydrofoil in the deployed position.

[0042] Figures 2A - 2D schematically illustrate a different example of a hydrofoil assembly in accordance with the present disclosure. Figure 2A illustrates the hydrofoil assembly in a stowed configuration, and figure 2C illustrates the hydrofoil assembly in a deployed configuration. Figure 2B illustrates the assembly in an intermediate configuration. Figure 2D schematically illustrates a detail of

the assembly.

[0043] In the example of figure 2, a hydrofoil assembly 60A, 60B comprising a fin 70 configured to protrude beyond a bottom of a vessel 50 and a foil 62 configured to be coupled to the fin 70 at a point of connection is provided. The assembly further comprises an actuator to move the foil 62, 64 between a stowed configuration (figures 2A, and 2B) in which the foils 62, 64 do not provide a lifting force, and a deployed configuration (figure 2C) in which the foil (when in use) provides a lifting force to lift the vessel 10 at least partially out of a body of water. The actuator comprises a connector 72 attached to the point of connection and the foils 62, 64 are moved or maintained in the deployed configuration by tensioning the connector 72.

[0044] The connector 72 and actuator mechanism may be the same or similar as described with reference to figure 1.

[0045] The fin 70 in this example is shown to be vertically displaceable with respect to the vessel. The fin 70 may be configured to assume an extended position (figures 2B, 2C), and a retracted position (figure 2A), wherein in the extended position, the fin protrudes from the bottom of the vessel 50 to a larger extent than in the retracted position.

[0046] Some differences between the examples of figures 1 and 2 are detailed herein. In the stowed configuration of the foil, the foil 62,64 is arranged substantially contiguously with the fin 70.

[0047] In the example of figure 2, the hydrofoil assemblies 60A, 60B comprise a first hinge 65 connecting a first foil portion 62 to the fin 70, and a second hinge 68 connecting the second foil portion 64 to the fin 70. In the stowed configuration (figure 2A), the first and second foil portions 62, 64 are folded, particularly the foil portions 62, 64 are folded to lie against an outer surface of the fin 70.

[0048] As in the example of figure 1, the connectors 72 extend through the fin 70. Each fin 70 in this case has two connectors 72, one for each foil portion 62, 64. By applying tension to the connectors 72, the foil portions 62, 64 can be brought to mate with the fin 70, assume and maintain their deployed configuration.

[0049] The methods for deploying and stowing the foils are slightly different in the example of figure 2 than in the example of figure 1. In order to bring the foils from a stowed configuration (figure 2A) to a deployed configuration, firstly fin(s) 70 may be displaced vertically to protrude to a larger extent beyond a bottom of the vessel 50. Then, tension may be applied to connectors 72. Because of the point of connection of connectors 72 with respect to hinges 65, 68, the foil portions are rotated towards a deployed configuration, in which the foils are arranged more horizontally than in the stowed configuration. In order to stow the foils, the opposite sequence of steps may be followed.

[0050] Details of the connection of the foil portions 62, 64 to fins 70 are shown in figure 2D. Hinges 65, 68 may have a similar configuration. Hinge 65 is provided to connect foil portion 62 to fin 70 and allow foil portion 65 to move between a folded configuration and unfolded (deployed) configuration. Similarly, hinge 68 is configured to do the same for foil portion 64.

[0051] Each of the hinges 65, 68 may have two leaves 69A, 69B, which are joined at a central axis of rotation 68. Each of the leaves 69A, 69B comprises a mounting portion 67A, 67B for mounting either to fin 70 or foil portion 62, 64. The mounting potions 67A, 67B are movable with respect to the axis of rotation 68 i.e. a distance between central axis of rotation 68 and mounting portions 67A, 67B may be shortened to bring the foils to a deployed configuration and the distance may be increased to bring the foils to a stowed configuration (as in figure 2D).

[0052] Figures 3A and 3B shown an example of a hinge mechanism and coupling mechanism which may be used in examples of the hydrofoil assemblies of the present disclosure.

[0053] A fin 70 is shown to extend in a generally vertical direction. As commented before, the fin 70 may be fixed in place or may be configured to change between a retracted position and extended position.

[0054] Through an inside of fin 70, connectors 72A, 72B may connect between a male coupling portion 61 of a foil portion 62, 64 and an actuator mechanism (not shown in figure 3). The connectors 72A, 72B may be cables, and tension may be applied to them using e.g. a winch.

[0055] Two foil portions 62, 64 can be connected to each fin 70. The foil portions 62, 64 may be folded to a substantially vertical position. In this substantially vertical position, the foil portions 62, 64 may lie against or be contiguous with an outer surface of fin 70. The foil portions 62, 64 may be in their folded to vertical position in the stowed configuration of the hydrofoil assembly.

[0056] Each of the foil portions 62, 64 may have a male coupling portion 61, which may include a curved inner surface 61B, and a curved outer surface 61A. The curved inner and outer surfaces 61A, 61B may be received in a recess or female coupling portion 80 of fin 70. The recess 80 may have a shape that is complementary to the shape of male coupling portion 61. In this example, the male coupling portion is shaped substantially like a shark fin, but other shapes are possible.

[0057] Each of the hinges 65A, 65B includes central rotation axis 68 and leaves on either side of central rotation axis 68. Each of the leaves 67A, 67B may have a fixed base or mounting portion, and a displaceable shaft inside the base. The displacement of the shaft 77 inside the base can cause a distance between the base or mounting portion and the central axis of rotation to vary. This variation of distance allows the foils to be smoothly attached to the fin i.e. without gaps or spaces in between and in the folded configuration there is sufficient space created for the foils to be folded against a side surface of the fin. The leaves of the hinge thus may perform a combined rotational and translational movement as they

are opening.

[0058] The movement of shaft 77 with respect to mounting portion 67A, 67B is limited by a translation of a shaft 78 within an end portion of the base or mounting portion.

[0059] An actuator 79 such as a hydraulic piston may be arranged with each of the hinges to push them to an opened position and increase a distance between central rotation axis and mounting potions 67A, 67B. To allow the hinges to move back and for the foils to be attached with the fin, the hydraulic pressure may be removed. At the same time, tension may be applied to connectors 72A, 72B, pulling the foils to a more horizontal positions as shown in figure 3B.

[0060] A further aspect of examples of the present disclosure is illustrated with reference to figures 4A and 4B. Figures 4A and 4B illustrate a vessel 100 including one or more hydrofoil assemblies 120. The vessel has a bow 170 and stern 190.

[0061] The hydrofoil assembly 120 may include a fin 130 and one or more foils 124. A control system for changing an inclination of the foils 124 in the deployed configuration is provided. The control system may be configured to rotate the fin 130 with respect to a substantially horizontal axis 135. To this effect, the control system may comprises a linear actuator 110, e.g. a hydraulic or pneumatic piston, or a bar which is linearly displaced by an electric motor. The direction of actuation of the actuator may be generally in the bow-stern direction.

[0062] The linear actuator may act on fin 130 in an upper area of the fin, i.e. above the axis 135 and the point of actuator may be at or near an upper end of fin 130. By pushing or pulling against the fin 130, the fin 130 may be rotated around axis 135. This is schematically illustrated in figure 4B. By rotating the fin 130 around axis 135, the foils 124 are displaced in a direction substantially along a bow-stern direction.

[0063] The control system may further comprise a processor configured to receive signals from sensors and to determine a desirable inclination of the foil. The sensors may provide information on any of the following: a velocity of the vessel, a distance from the bottom of the vessel to a surface of the body of water, an inclination of the vessel with respect to a horizontal plane, and an inclination of the vessel with respect to a vertical plane. Based on the available information (which may also include meteorological conditions, and information on the body of water e.g. height of waves), the control system may adjust the position of the foils in bow-stern direction, and also the orientation of the foils with respect to the body of water. The foils may have a fixed orientation with respect to fin 130, but by rotating the fin, the orientation of the foils or their lifting surface with respect to the body of water (angle of attack) may be varied.

[0064] Even though in the depicted examples, the vessels were all motor vessels and configured for passenger transport, in other examples, the vessels may be sail vessels and may or may not be used for passenger transport. In all depicted examples, the vessels include two hydrofoil assemblies, one on a port side and one a starboard side. It should be clear that in other examples, one or more centrally arranged hydrofoil assemblies may be used, e.g. which the fin is configured to protrude from the bottom of a vessel substantially in a central longitudinal plane of the vessel. In further examples, such hydrofoil assemblies may be combined, a vessel may include a first hydrofoil assembly according to any of the examples disclosed herein substantially on a port side of the central longitudinal plane, and a second hydrofoil assembly according to any of the examples disclosed herein, substantially on a starboard side of the central longitudinal plane, and also a centrally arranged hydrofoil assembly.

[0065] For completeness, several aspects of the present disclosure will be set out in the following numbered clauses:

Clause 1. A hydrofoil assembly comprising a fin configured to protrude beyond a bottom of a vessel, and a foil configured to be coupled to the fin at a point of connection, and
an actuator to move the foil between a stowed configuration in which the foil does not provide a lifting force, and a deployed configuration in which the foil provides a lifting force to lift the vessel at least partially out of a body of water,
the actuator comprising a connector attached to the point of connection and wherein
the foil is moved or maintained in the deployed configuration by tensioning the connector.

Clause 2. The assembly of clause 1, wherein in the stowed configuration the foil is stored at a deck of the vessel.

Clause 3. The assembly of clause 1, wherein in the stowed configuration the foil is arranged substantially contiguously with the fin.

Clause 4. The assembly of clause 3, comprising a first hinge connecting a first foil portion to the fin, and a second hinge connecting the second foil portion to the fin.

Clause 5. The assembly of clause 4, wherein in the stowed configuration, the first and second foil portions are folded.

Clause 6. The assembly of any of clauses 1 - 5, wherein the actuator is arranged at the deck of the vessel.

Clause 7. The assembly of any of clauses 1 - 6, wherein the actuator comprises a winch or piston.

Clause 8. The assembly of any of clauses 1 - 7, wherein the connector extends through the fin.

Clause 9. The assembly of any of clauses 1 - 8, wherein the fin is configured to assume an extended position, and a retracted position, wherein in the extended position, the fin protrudes from the bottom of the vessel to a larger extent than in the retracted position.

Clause 10. The assembly of any of clauses 1 - 9, wherein the foil comprises a male coupling portion configured to be received by a female coupling portion at the point of connection, the female coupling portion having a substantially complementary shape to the male coupling portion.

Clause 11. The assembly of clause 10, wherein the female coupling portion has a varying cross-section, wherein dimensions of the cross-section are larger at an opening of the female coupling portion.

Clause 12. The assembly of clause 10 or 11, wherein the female coupling portion has one or more curved guiding surfaces.

Clause 13. The assembly of clause 12, wherein the male coupling portion has substantially a shark fin tail shape.

Clause 14. The assembly of any of clauses 1 -13, further comprising a control system for changing an inclination of the foil in the deployed configuration.

Clause 15. The assembly of clause 14, wherein the control system is configured to rotate the fin with respect to a substantially horizontal axis.

Clause 16. The assembly of clause 14 or 15, when the control system comprises a linear actuator.

Clause 17. The assembly of any of clauses 14 - 16, wherein the control system further comprises an electric motor.

Clause 18. The assembly of any of clauses 14 - 17, wherein the control system further comprises a processor configured to receive signals from sensors and to determine a desirable inclination of the foil.

Clause 19. The assembly of clause 18, wherein the sensors provide information on any of a velocity of the vessel, a distance from the bottom of the vessel to a surface of the body of water, an inclination of the vessel with respect to a horizontal plane, and an inclination of the vessel with respect to a vertical plane.

Clause 20. The assembly of any of clauses 1 - 19, wherein the connector comprises a cable, rope, wire or bar.

Clause 21. A vessel comprising the hydrofoil assembly according to any of clauses 1 -20.

Clause 22. The vessel of clause 21, in which the fin is configured to protrude from the bottom of a vessel substantially in a central longitudinal plane of the vessel.

Clause 23. The vessel of clause 21 or 22, comprising a first hydrofoil assembly according to any of clauses 1 - 20 substantially on a port side of the central longitudinal plane, and a second hydrofoil assembly according to any of clauses 1 - 20, substantially on a starboard side of the central longitudinal plane.

Clause 24. The vessel of any of clauses 21 - 23, wherein the vessel is a sail vessel.

Clause 25. The vessel of any of clauses 21 - 23, wherein the vessel is a motor vessel.

Clause 26. The vessel of clause 25, wherein the motor vessel has an outboard motor.

Clause 27. A method of stowing a hydrofoil connected to a fin protruding beyond a bottom of a vessel in a body of water, wherein the hydrofoil is connected to the fin with a tensioned connector, the method comprising:

reducing a tension in the connector to release the hydrofoil from the fin,
picking the hydrofoil from the surface of the body of water, and
storing the hydrofoil at a deck of the vessel.

Clause 28. The method of clause 27, wherein the connector comprises a rope, wire, cord or cable connecting the hydrofoil to the fin when the hydrofoil is stored at the deck of the vessel.

Clause 29. The method of clause 27 or 28, wherein picking the hydrofoil from the surface of the body of water comprises using a pole to lift the hydrofoil to the deck of the vessel.

Clause 30. The method of any of clauses 27 - 29, wherein the hydrofoil comprises a male coupling portion configured to be received by a female coupling portion of the fin.

Clause 31. The method of clause 30, wherein the deck of the vessel comprises a retention mechanism for receiving and retaining the male coupling portion of the hydrofoil.

Clause 32. A method for attaching a hydrofoil to a fin protruding beyond a bottom of a vessel in a body

of water, the method comprising:

positioning the hydrofoil in the body of water, applying tension to a connector connecting the hydrofoil to the fin, such that the hydrofoil is pulled towards the fin.

Clause 33. The method of clause 32, wherein the connector comprises a rope, wire, cord or cable connecting the hydrofoil to the fin when the hydrofoil is stored at the deck of the vessel.

Clause 34. The method of clause 32 or 33, wherein positioning the hydrofoil in the body of water comprises the use a pole.

Clause 35. The method of any of clauses 32 - 34, wherein the hydrofoil comprises a male coupling portion configured to be received by a female coupling portion of the fin, and wherein the method comprises applying tension to the connector such that the male coupling portion of the hydrofoil is received in the female portion of the fin.

Clause 36. The method of any of clauses 32 - 35, further comprising maintaining tension in the connector to maintain the hydrofoil in the deployed position.

Clause 37. A hydrofoil for a vessel, the hydrofoil being configured to be removably coupled to a point of connection of a fin protruding from a bottom of a vessel, wherein
the hydrofoil is attachable and detachable by varying tension in a connector connecting the hydrofoil to the fin.

Clause 38. The hydrofoil of clause 37, wherein the hydrofoil comprises a male coupling portion configured to be received in a female coupling portion of the fin.

Clause 39. The hydrofoil of clause 38, wherein the male coupling portion of the hydrofoil has substantially a shark fin tail shape.

Clause 40. A kit of hydrofoils, comprising a first hydrofoil according to any of clauses 37 - 39, and a second hydrofoil according to any of clauses 37 - 39, wherein the first and the second hydrofoil can be coupled to the same fin.

[0066] 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 claims that follow.

Claims

1. A hydrofoil assembly comprising a fin configured to protrude beyond a bottom of a vessel, and a foil configured to be coupled to the fin at a point of connection, and
an actuator to move the foil between a stowed configuration in which the foil does not provide a lifting force, and a deployed configuration in which the foil provides a lifting force to lift the vessel at least partially out of a body of water,
the actuator comprising a connector attached to the point of connection and wherein
the foil is configured to be moved or maintained in the deployed configuration by tensioning the connector.

2. The assembly of claim 1, wherein in the stowed configuration the foil is stored at a deck of the vessel.

3. The assembly of claim 1, wherein in the stowed configuration the foil is arranged substantially contiguously with the fin.

4. The assembly of claim 3, comprising a first hinge connecting a first foil portion to the fin, and a second hinge connecting the second foil portion to the fin.

5. The assembly of claim 4, wherein in the stowed configuration, the first and second foil portions are folded.

6. The assembly of any of claims 1 - 5, wherein the actuator is arranged at the deck of the vessel.

7. The assembly of any of claims 1 - 6, wherein the connector extends through the fin.

8. The assembly of any of claims 1 - 7, wherein the fin is configured to assume an extended position, and a retracted position, wherein in the extended position, the fin protrudes from the bottom of the vessel to a larger extent than in the retracted position.

9. The assembly of any of claims 1 - 8, further comprising a control system for changing an inclination of the foil in the deployed configuration, and optionally wherein the control system is configured to rotate the fin with respect to a substantially horizontal axis.

10. The assembly of any of claims 1 - 9, wherein the connector comprises a cable, rope, wire or bar.

11. A vessel comprising the hydrofoil assembly accord-

ing to any of claims 1 - 10.

12. A method of stowing a hydrofoil connected to a fin protruding beyond a bottom of a vessel in a body of water, wherein the hydrofoil is connected to the fin with a tensioned connector, the method comprising:

reducing a tension in the connector to release the hydrofoil from the fin,
picking the hydrofoil from the surface of the body of water, and
storing the hydrofoil at a deck of the vessel.

13. The method of claim 12, wherein picking the hydrofoil from the surface of the body of water comprises using a pole to lift the hydrofoil to the deck of the vessel.

14. A method for attaching a hydrofoil to a fin protruding beyond a bottom of a vessel in a body of water, the method comprising:

positioning the hydrofoil in the body of water,
applying tension to a connector connecting the hydrofoil to the fin, such that the hydrofoil is pulled towards the fin.

15. A hydrofoil for a vessel, the hydrofoil being configured to be removably coupled to a point of connection of a fin protruding from a bottom of a vessel, wherein the hydrofoil is attachable and detachable by varying tension in a connector connecting the hydrofoil to the fin.

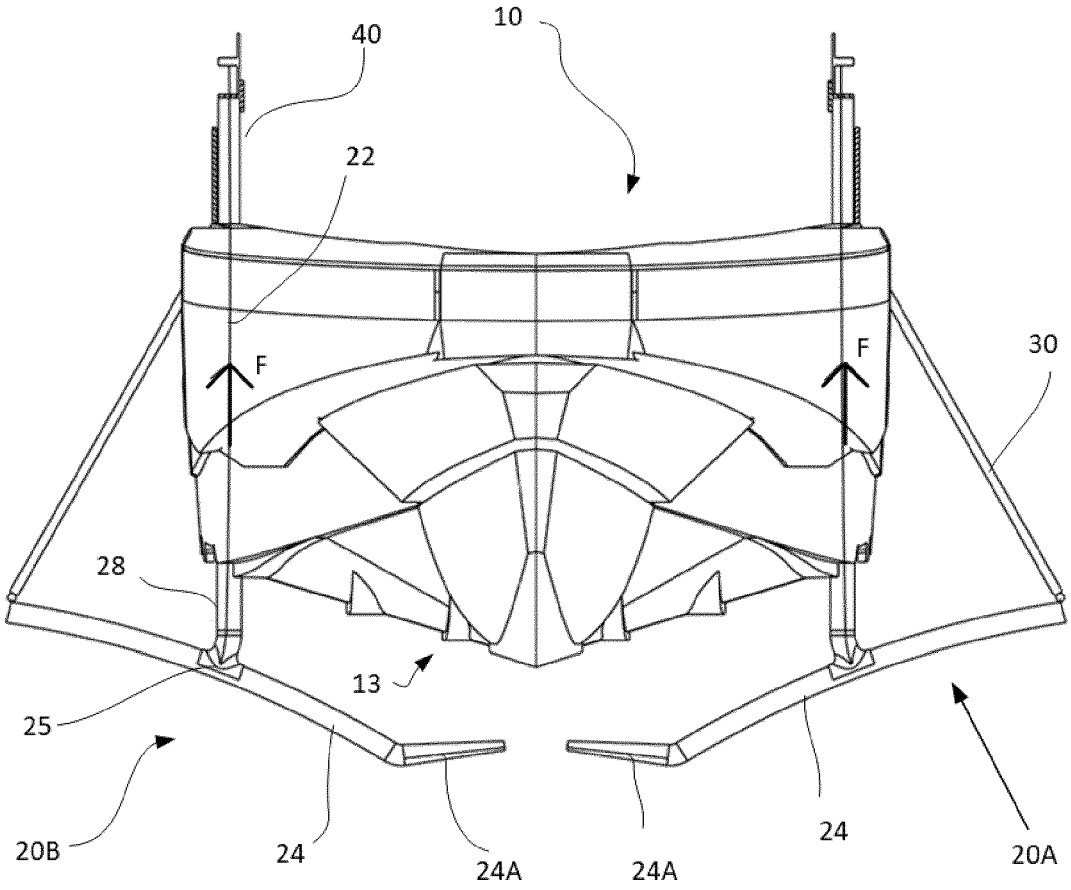


Fig. 1A

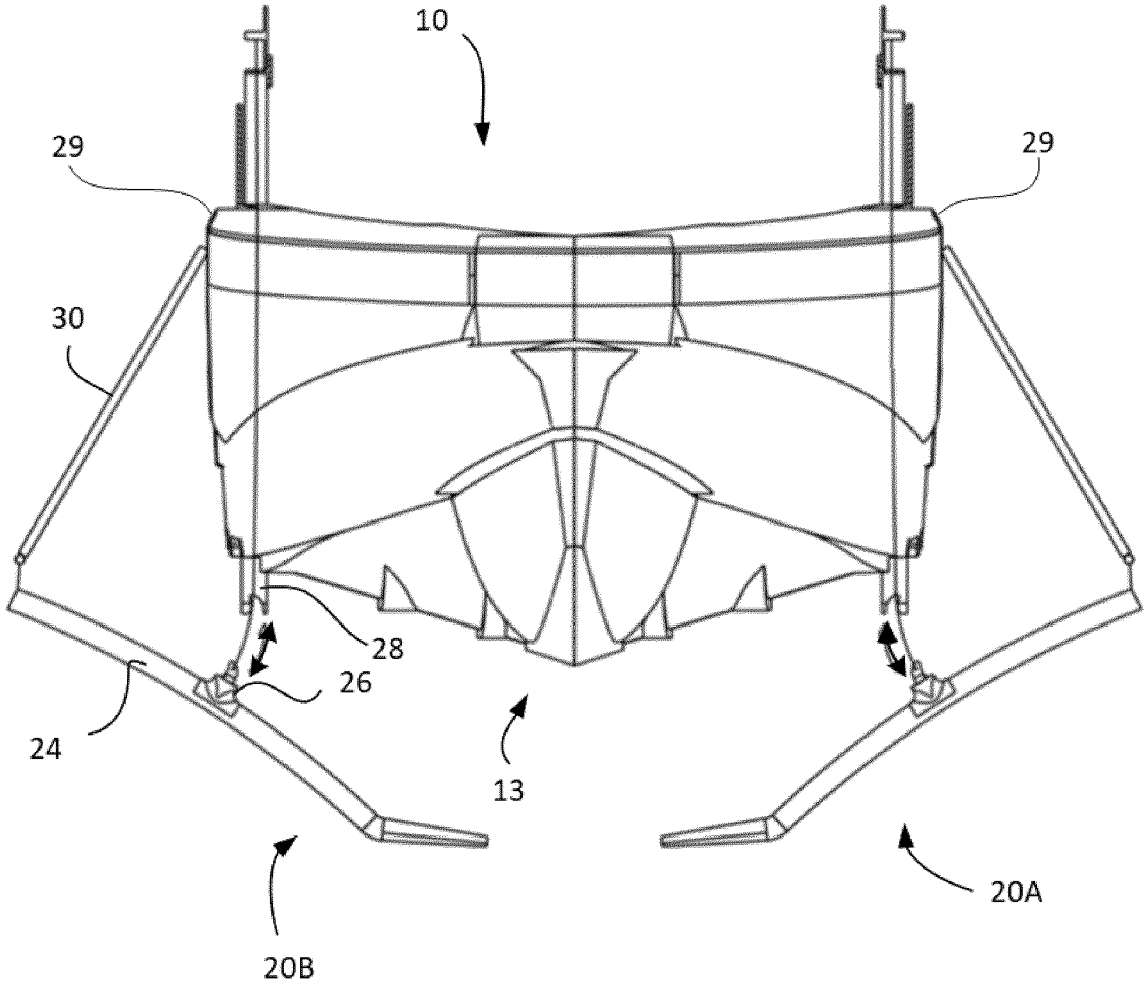


Fig. 1B

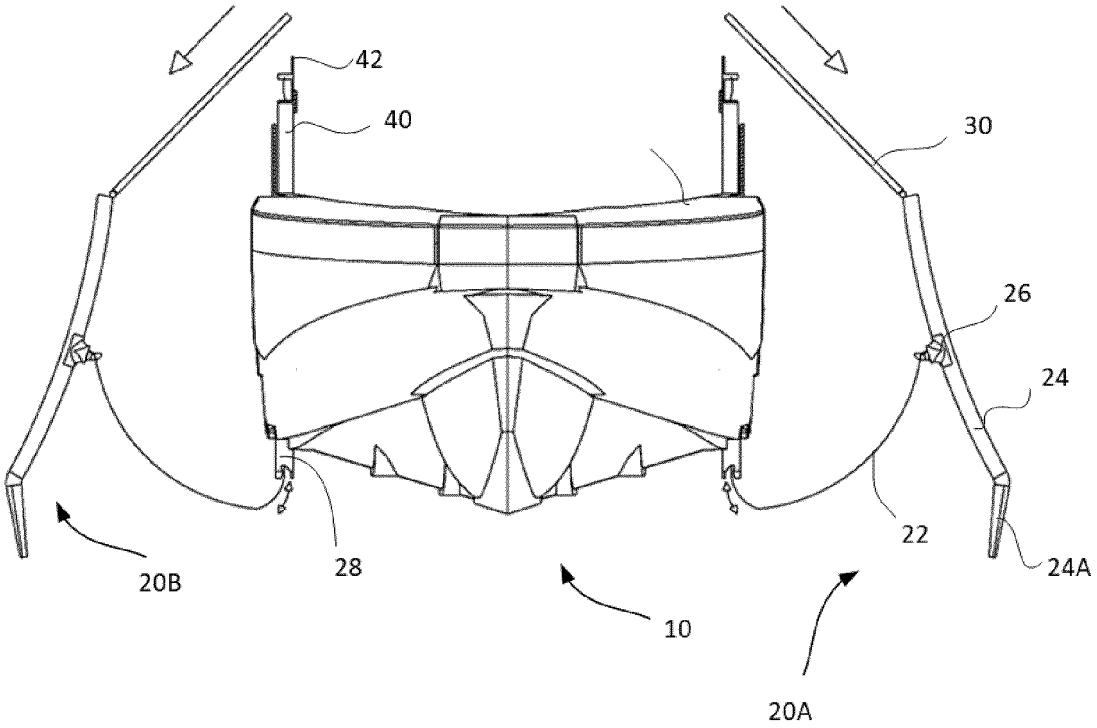


Fig. 1C

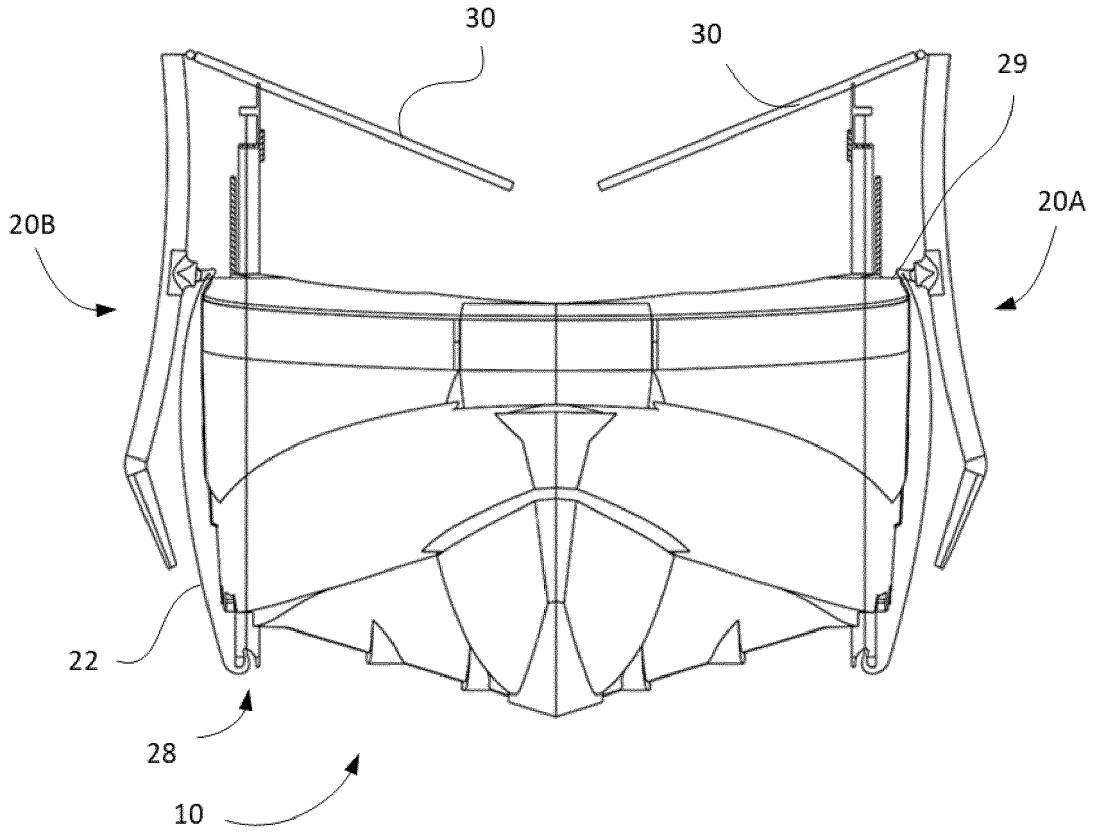


Fig. 1D

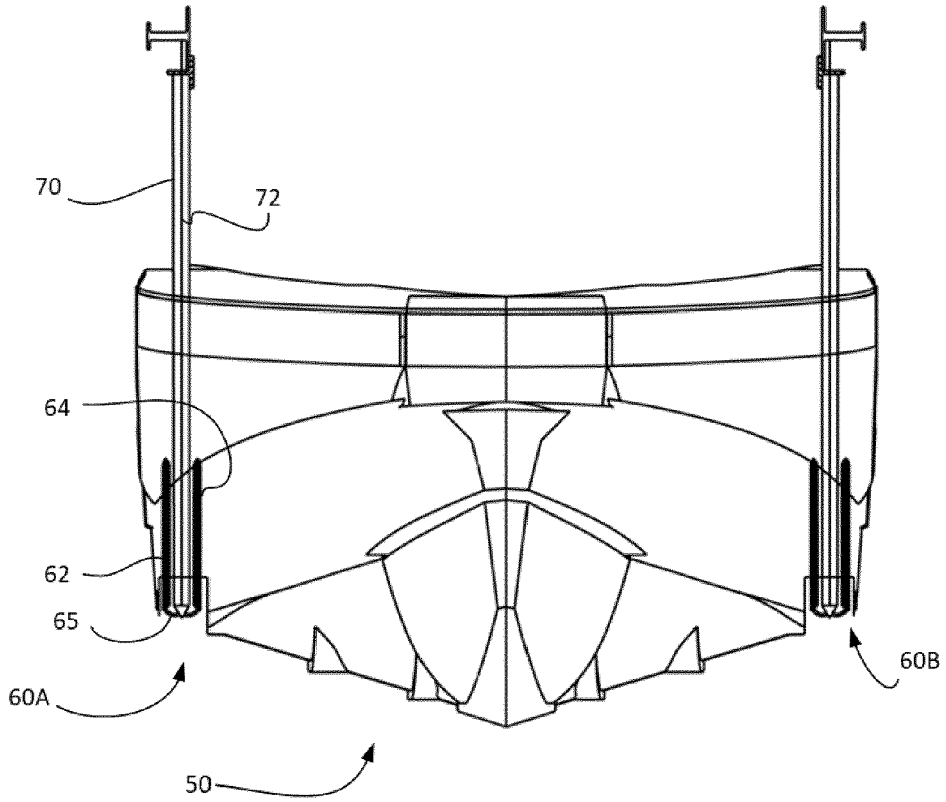


Fig. 2A

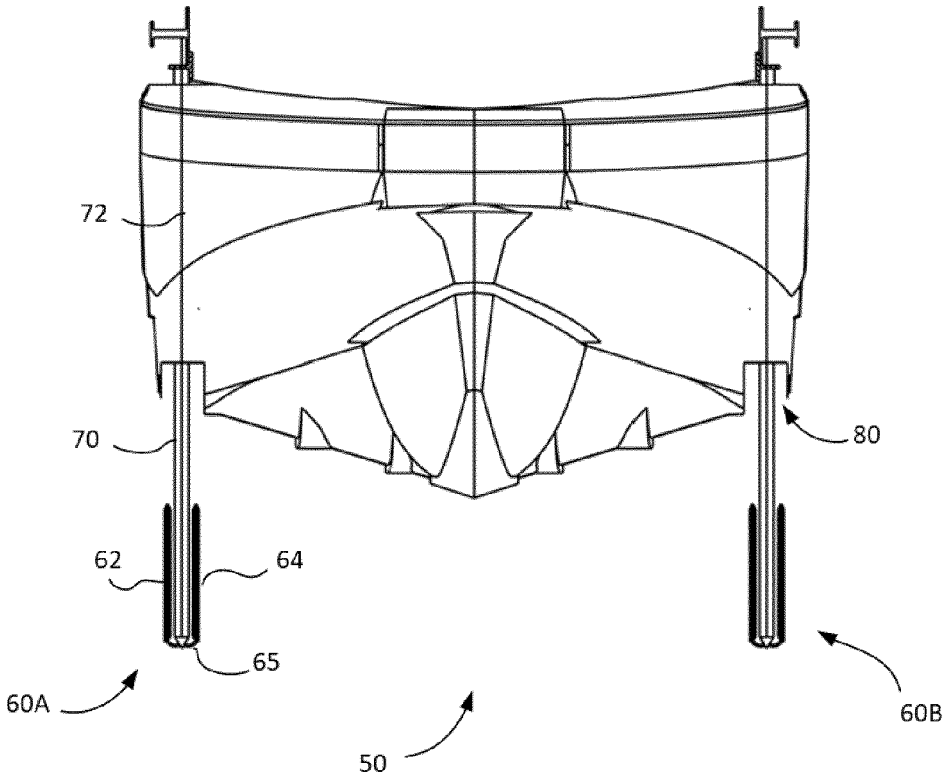


Fig. 2B

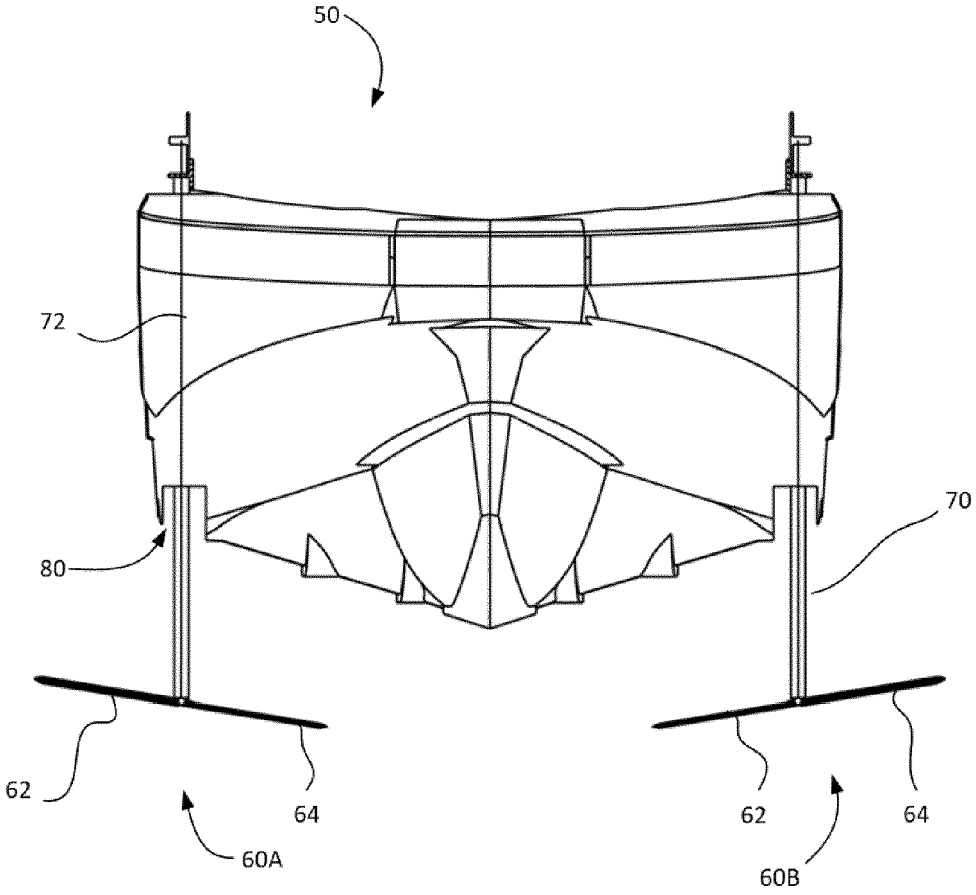


Fig. 2C

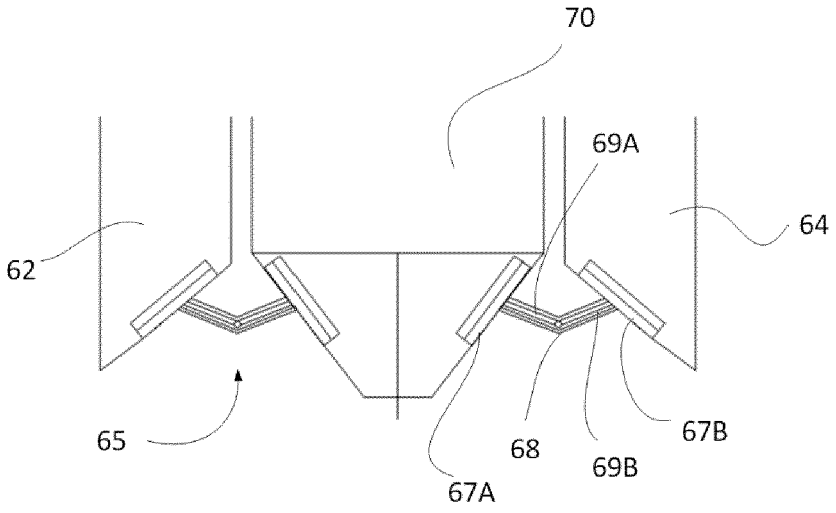
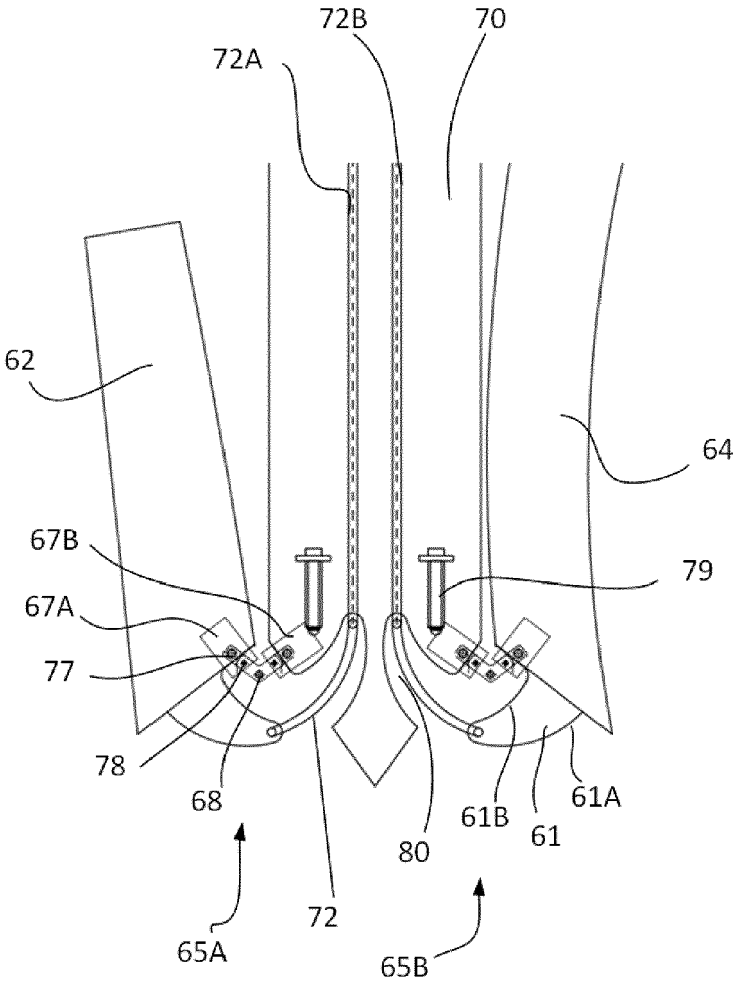


Fig. 2D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72A
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Fig. 3A

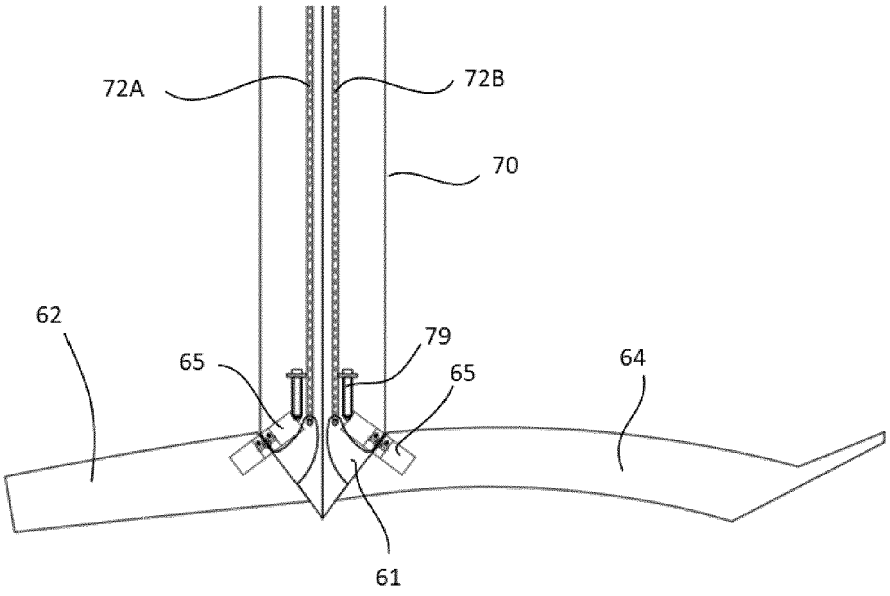
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Fig. 3B

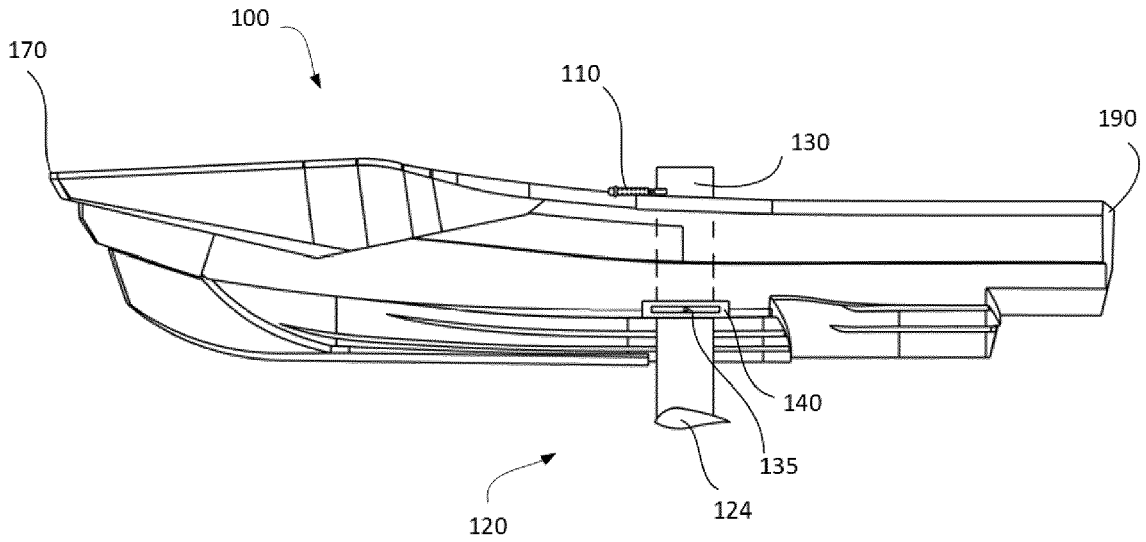

Fig. 4A

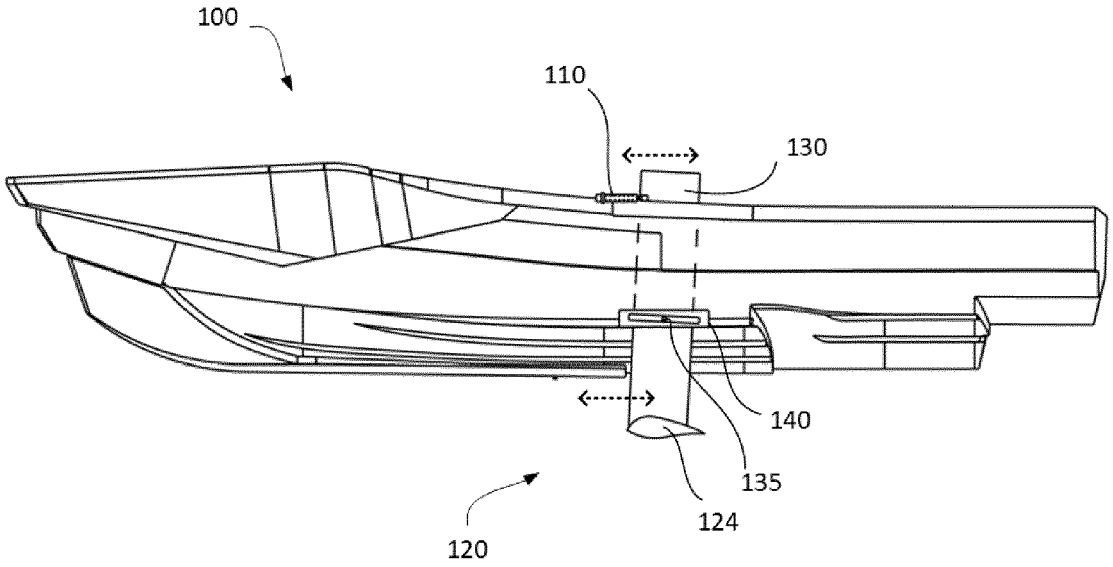

Fig. 4B

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EUROPEAN SEARCH REPORT

Application Number
EP 21 38 2140

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 6 499 419 B1 (BUSSARD ROBERT W [US]) 31 December 2002 (2002-12-31) * column 2, line 44 - line 51 * * column 3, line 66 - column 4, line 20 * * column 9, line 55 - line 65 * * claim 1 * * figures 6,9 *	1-15	INV. B63B1/24 B63B1/30 ADD. B63B1/28
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X	US 3 200 781 A (KEITARO TAKAGI) 17 August 1965 (1965-08-17) * figures 2, 2' *	1,3,8-12	
X A	FR 3 090 564 A1 (CANAL BERNARD [FR]) 26 June 2020 (2020-06-26) * claims; figures *	1 2-15	
X A	US 3 763 811 A (DANAHY P) 9 October 1973 (1973-10-09) * figure 4 *	1 2-15	TECHNICAL FIELDS SEARCHED (IPC) B63B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	24 August 2021	Schmitter, Thierry

CATEGORY OF CITED DOCUMENTS

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L : document cited for other reasons

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