(19) DANMARK

(10) **DK/EP 4001084 T3**

Patent- og Varemærkestyrelsen

(12) Oversættelse af europæisk patentskrift

(51) Int.Cl.: ***B 63 B 1/24 (2020.01)*** ***B 63 B 1/26 (2006.01)*** ***B 63 B 1/28 (2006.01)*** ***B 63 H 1/14 (2006.01)*** ***B 63 H 5/16 (2006.01)*** ***B 63 H 21/17 (2006.01)***

(45) Oversættelsen bekendtgjort den: **2025-03-17**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2025-02-19**

(86) Europæisk ansøgning nr.: **20207223.7**

(86) Europæisk indleveringsdag: **2020-11-12**

(87) Den europæiske ansøgnings publiceringsdag: **2022-05-25**

(84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

(73) Patenthaver: **Artemis Technologies Limited, Towngate House , Parkstone Road, Poole, BH15 2PW, Storbritannien**

(72) Opfinder: **PERCY, Iain, , Slough, Berkshire SL1 4NH, Storbritannien**
INGOUF, Romain, , Slough, Berkshire SL1 4NH, Storbritannien

(74) Fuldmægtig i Danmark: **Plougmann Vingtoft A/S, Strandvejen 70, 2900 Hellerup, Danmark**

(54) Benævnelse: **BÅD SOM INKLUDERER ET HYDROFOILSYSTEM MED GEARKASSESYSTEM.**

(56) Fremdragne publikationer:

EP-B1- 0 453 529
US-A- 4 092 946
US-A1- 2018 072 383
US-A1- 2018 370 600
US-A1- 2020 189 691

DESCRIPTION

Description

[0001] The present invention relates to boats. such as yachts, sailboats, ships, and the like, that include hydrofoil systems comprising gearbox systems. In particular, the present invention relates to such a gearbox with heat transfer cooling system.

BACKGROUND OF THE INVENTION

[0002] A sailing hydrofoil is a wing-like structure mounted under the hull of a boat, such as a yacht, that provides a speed advantage over more traditional boat designs. The sailing hydrofoil works with its wing-like appendage. Just like a wing on an aircraft provides lift, a hydrofoil in the water accomplishes the same thing. The main difference is that a hydrofoil does not need to be as large as an airplane wing, because the water is much denser than air. As the boat increases its speed the hydrofoils lifts most of the hull, or even the entire hull, up and out of the water, greatly reducing the wetted area, resulting in decreased drag and increased speed as the craft cuts through the water.

[0003] Most types of boats can accommodate hydrofoils, and sailboats are no different. A sailing hydrofoil could be a single hull, often referred to as a mono hull, a catamaran (which has two hulls), or a trimaran (which has three hulls). In the case of multiple hulls, the hulls are held together by a single upper deck. The wider and longer the ship, the more stable the sailing hydrofoil is.

[0004] Conventional hydrofoils are used in either a passive way i.e. there is no active control on their geometry, or in an active way i.e. using flaps to cause the craft to ascend or descend and to control the craft about its pitch, heave, and roll axes. However, all control is manual e.g. using a control system with a mechanical lever arm, and the flaps require human intervention, which inherently requires extensive experience by a user and exposes the craft control to human error. In the same way as for aircraft, there is an inherent trade-off between a requirement for faster and more accurate control and overall drag (a lower drag foil will come at the cost of inherent stability).

[0005] Hydrofoil water vessels may be wind powered (e.g. yachts, sailing boats), or powered using an engine and gearbox mounted on the hull and mechanically engaged with a propeller system mounted adjacent the foil on the underside of the hull. There are obvious drawbacks to this arrangement including efficiency losses due to mechanical distance between the engine/gearbox and the propeller system.

[0006] However, it is not practical for the engine to be located beneath the hull because of additional hydrodynamic drag due to mechanical linkage between engine, gearbox and propeller (propeller shaft, bearings). It also creates a challenge for the system integrity as the foils deform under hydrodynamic loading.

[0007] There is therefore a need for an improved engine and gearbox arrangement that increases efficiency and reduces delay and energy loss via mechanical connections and results in a reduction in overall fuel/energy usage, while minimizing the packaging, to reduce hydrodynamic drag. EP0453529B1 discloses a boat, partially supported by a pair of asymmetric hydrofoil assemblies. Each hydrofoil assembly is generally L-shaped and including a motor and propeller connected to one end of an associated hydrofoil and to one end of a mounting leg having its other end connected to the watercraft at a location spaced from the other hydrofoil assembly thus defining the asymmetric hydrofoils. A driven propeller is located in alignment with an angle joint between a supporting leg and the associated hydrofoil, and is driven in a direction wherein upwardly moving blades of a propeller intercept a downwardly moving water wake of the vehicle and also water downwash flowing past the trailing edges of the associated asymmetric hydrofoils.

[0008] US2018/072383 discloses a watercraft device that comprises a board, a throttle coupled to a top surface of the board, a hydrofoil coupled to a bottom surface of the board, and an electric propeller system coupled to the hydrofoil. The electric propeller system powers the watercraft device using information generated from the throttle.

[0009] US2020/189691 discloses a hydrofoil system having a fuselage with a propeller mounted to one end of the fuselage and a wing extending laterally from the fuselage. The fuselage is configured for removable attachment to a mast, so that the mast when attached extends from the fuselage in a direction substantially orthogonal to the longitudinal axis and also substantially orthogonal to the wing. A tail wing is connected to the fuselage by a tail strut, so that the tail wing is positioned beyond the end of the fuselage to which the propeller is attached. A motor is housed in the fuselage and has a cable connected thereto, the cable extending outside the fuselage, wherein a removable sealing system inhibits water ingress to the motor at the location where the cable is connected when the sealing system is installed in the fuselage.

[0010] US4092946 discloses an electric motor for trolling at slow speeds comprising an elongated and generally cylindrical submersed unit which houses an electric motor that in turn drives a planetary gear system that in turn drives the propeller. The planetary gear system includes a compact gear assembly which can be assembled ahead of time and quickly inserted in the gear housing. The internal gear ring of the planetary gear system is quickly and easily secured within and to the gear housing only and by means of cap bolts extending through the gear housing and into engagement with the ring gear, the ring gear being preassembled in the gear housing. The motor also includes a bearing support in which are preassembled anti-friction bearing assemblies. A rear sleeve thrust bearing and a front sleeve thrust bearing are located on opposite sides of the gear assembly and act to threadably support the gear assembly and absorb axial thrust.

SUMMARY OF THE INVENTION

[0011] The present invention seeks to address the problems of the prior art. Aspects of the present invention are set out in the attached claims. The invention is defined by the independent claims, to which reference should now be made. Preferred features are set out in the dependent claims.

[0012] A first aspect of the present invention provides a boat including a hydrofoil system as in claim 1.

[0013] By locating the gearing system and engine within a housing provided at least in part by the hydrofoil, the profile of the gearbox system is significantly reduced. This layout significantly reduces the wetted area of the drive train, therefore reducing hydrodynamic drag of the eFoil system, improving efficiency and autonomy.

[0014] In an alternative embodiment, the gearbox system is mounted on the hydrofoil. This allows the gearbox system to be completely separated from the Foil, allowing for Drive train fast replacement in case of maintenance, therefore minimizing downtime for commercial vessels.

[0015] In one embodiment, the gearing system and engine are a close fit within the interior space of the housing.

[0016] The close fit allows the engine and gearbox to be in thermal contact with the gearbox casing such that heat generated by the engine and/or gearbox during use may be transferred by contact to the gearbox casing, which is subsequently cooled by the surrounding water in which it is submerged. No mechanical or forced water flow is required to cool the engine and gearbox.

[0017] Preferably, the engine is located adjacent the gearbox. The gearbox casing forms part of the foil and locates the engine to the foil structure.

[0018] The gearbox casing is thermally conductive in order to cool the engine and gearbox by heat transfer into the surrounding environmental water. Preferably, the gearbox casing comprises metal, and preferably coated or non-corrosive/corrosive resistant raw metal. However, it is to be appreciated that any suitable known to the skilled person and highly resistant to corrosion could be used as an alternative to, or in addition to, using metal for the gearbox casing.

[0019] In a further embodiment, the gearbox housing further comprises a power train engagement portion. In use, the power train engagement portion engages with a power train connected to the controller on the hull of the vessel. This provides electrical communication between the controller and the engine and gearbox.

[0020] Preferably, the power train engagement portion is located distal to the propeller shaft engagement portion. This prevents any fouling of the power train by the moving parts of the propeller.

[0021] According to the invention, the gearing system is an epicyclic gearbox (also known as planetary gearbox). However, it is to be appreciated, that any other suitable reduction system known to the skilled person and suitable for function could be used in addition to an epicyclic gearbox.

[0022] In a further embodiment, the engine comprises a high-power density electrical engine, referred to as a Motor Generator Unit (MGU).

[0023] Thus, the engine may comprise an MGU and the gearbox may include epicyclic reduction hardware, both being located within the watertight gearbox casing.

[0024] The gearbox casing may comprise, but is not limited to, any one or more of the following materials, including stainless steel (all grades), titanium alloy, aluminium (aluminum). However, it is to be appreciated that any other suitable material known to the skilled person may be used to make up the gearbox casing. Preferably, an appropriate sea water coating is applied to the gearbox casing to render the gearbox more resistant to sea water erosion.

[0025] It is to be appreciate that any other material known to the skilled person and suitable for function may be used in addition to, or as an alternative to, the aforementioned materials. Such other materials may include, but are not limited to, one or more of a composite material such as Aramid fibre, or carbon fibre reinforced resin material.

[0026] According to the invention, the boat further includes a hydrofoil system, the hydrofoil system comprising a controller; a foil for engagement with the waterborne vessel, the foil comprising a plurality of adjustment members operable to vary the lift characteristics of the waterborne vessel; a propeller mounted on the foil; and the above described gearbox system, wherein the propeller is mechanically engaged with the propeller shaft engagement portion and the gearbox system is in mechanical communication with the propeller.

[0027] In one embodiment, the hydrofoil system further comprises a plurality of sensors in electrical communication with the controller, each sensor configured to monitor flight parameters of the waterborne vessel and generate measured flight parameter data, wherein the controller is in communication with the adjustment members, the engine and the sensors and wherein the controller is configured to receive measured flight parameter data from the sensors and to control the operation of the engine and the position of the adjustment members in dependence upon the received measured flight parameter data.

[0028] In one embodiment, each of the adjustment members is operable to vary one or more of pitch, roll, heave, and yaw of the waterborne vessel.

[0029] In one embodiment, each adjustment member comprises a flap and an actuator, wherein the flap is moveable relative to the foil on activation of the actuator by the controller. Preferably, the adjustment member further comprises a hydrodynamic fairing within which the flap is arranged.

[0030] Preferably, the actuators are integrated within the foil. However, it is to be appreciated that the actuators may alternatively be integrated inside the vessel, depending on the respective sizes of the foil and vessel.

[0031] In one embodiment, each of the plurality of flaps is independently adjustable. This provides greater control over the position of the vessel within the water.

[0032] In a further embodiment, the plurality of flaps comprises at least one set of two aligned flaps. However, additional flaps may be provided within each set of flaps if required.

[0033] Preferably, the propeller is located adjacent to the gearbox, and distal to the engine. Preferably, the propeller is located adjacent to the gearbox, and distal to the engine, via a short propeller shaft, in order to minimise efficiency loss.

[0034] As with conventional foils, each foil of the present invention is composed of two lifting surfaces: the elevator (horizontal part) which provides vertical lift; and a shaft, whose main purpose is to carry the elevator and also provide side force in turns and manoeuvres.

[0035] The measured flight parameter data may comprise any one or more selected from the group comprising acceleration data, vessel position data (pitch, heave, yaw, roll), actuator positional data, external environmental factors (e.g. wind, wave-height) and any other useful data relating to the movement of the vessel through the water, and the environment the vessel is moving in.

[0036] Preferably, the controller is located within the hull of the waterborne vessel and the foil is located beneath the floating waterline on the hull exterior of the waterborne vessel.

[0037] In a further embodiment, the hydrofoil system further comprises a battery system in electrical communication with the engine and optionally the actuator, wherein the battery system is operable to provide power to the engine and optionally the actuator. Alternatively, the adjustment member may be actuated using hydraulic power. Such a battery system may comprise a Power Electronics Control Unit (PECU). It is to be appreciated that the boat including a hydrofoil system may be provided integrally as part of a new vessel during manufacture, or may be provided for retrofit to an existing vessel. In both cases, the vessels will then have all the advantages provided by the hydrofoil system. Such advantages include:

- the reduced hydrodynamic drag provides increased autonomy (for a given amount of battery power)
- human-free optimised control of the vessel during travel, thereby avoiding human errors;
- controlled positioning of the vessel within the water e.g. ride height via adjustment of the flaps in response to real-time measured flight parameter data;
- no mechanical engine cooling system is required as heat from the engine and gearbox is transmitted to the gearbox casing and subsequently into the surrounding water;
- No fossil fuel usage is required during travel of the vessel and all power is provided in a carefully controlled manner from the battery system in dependence upon the needs of the vessel to optimise the ride;
- Increased ride comfort for passengers as the position of the vessel within the water is carefully controlled and the optimised ride height reduces the amount of hull exposed to the water conditions; and
- Vessel wash significantly reduced.

[0038] Thus, the boat including a hydrofoil system of the present invention provides a high efficiency and low consumption propulsion system for high speed marine travel whilst providing autonomous control of a fully submerged actively controlled foiling waterborne vessel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039]

Figure 1 shows an embodiment of the boat including a hydrofoil system in accordance with a first aspect of the present invention integrated into a mono-hull vessel;

Figure 2 is a front view of a foil and propeller of the boat including a hydrofoil system of figure 1

Figure 3 is a side view of the foil and propeller of figure 2;

Figure 4 is a perspective view of the foil and propeller of figure 2;

Figure 5 is a view from above of the foil and propeller of figure 2;

Figure 6 is an X-Y cross-section through the foil and propeller of figure 2 showing a first disclosed but not claimed example of a gearbox and engine arrangement with water flow cooling between the gearbox and engine arrangement and the interior surface of the foil body;

Figure 7 is a Z-X cross-section through the foil and propeller of figure 2 showing the gearbox and engine arrangement of figure 6;

Figure 8 is an X-Y cross-section through the foil and propeller of figure 2 showing a second example according to the claimed invention of a gearbox and engine arrangement with heat-transfer cooling via the gearbox casing;

Figures 9A to 9D are cross-sectional views showing variants of the gearbox and engine arrangement of figure 8 where the housing is mounted on the foil;

Figures 10A and 10B are cross-sectional views showing further variants of the gearbox and engine arrangement of figure 8 where the housing is provided by a portion of the foil; and

Figure 11 is a cross-sectional view showing a further variant of the gearbox and engine arrangement where the housing is separate from the foil.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0040] Figure 1 shows a waterborne vessel in the form of a monohulled vessel 10 provided with an embodiment of a hydrofoil system in accordance with a first embodiment of the present invention. The hydrofoil system comprises a controller 12 located within the hull 14 of vessel 10.

[0041] A battery system 16 is located adjacent controller 10, and in electrical communication with controller 10. In the embodiment of figure 1, battery system 16 comprises a Power Electronics Control Unit (PECU).

[0042] A foil 18 is located on the outer surface of the foil hull below the floating waterline. Foil 18 comprises a plurality of adjustment members 19 operable to vary the lift characteristics of the vessel 10 during travel. Each adjustment member comprises a flap 20 and associated actuator 22. Actuators 22 can be either electric or hydraulic and may be integrated within foil 18 (as shown in figure 1) or may be located within the vessel 10 itself depending on the vessel size and associated foil size. Actuators 22 operate to control the position of associated flaps 20 to control the ship in heave i.e. ride height 24 relative to the floating water line 26), pitch, roll and thrust. Ride height 24 is shown in figure 1 and is based on the distance between the water surface (floating water line 26) and the foiling water line 28. Foiling water line refers to where the water free surface sits, relative to the foils/hull, while airborne. When the boat is floating, the water line is defined by how much the hull needs to sink to obtain the volume of displacement (under Archimedean hydrostatic force). When foiling, the foiling water line is the optimum between minimum foil immersion (the vertical part "shaft") to reduce drag without having the elevator 52 ventilating because of the free surface proximity.

[0043] In the embodiment of figure 2, the adjustment member 13 further comprises a hydrodynamic fairing 21 within which the flap 20 is arranged.

[0044] In figures 2 to 5, each foil comprises four flaps 20, each flap 20 is independently operable by an associated actuator 22.

[0045] Foil 18 is connected to the hull 14 of vessel 10 by means of a vertical shaft 30.

[0046] A propeller 32 is mounted on foil 18 for driving the vessel 10 through the water during travel. The propeller 32 and foil 18 are shown in more detail in figures 2 to 7.

[0047] In disclosed but not claimed a first embodiment shown in figures 6 and 7, foil 18 comprises a body 34 defining an elongate channel 36. Elongate channel 36 has a first open end 38 and a second end 40 opposing the first end 38, first and second ends 38, 40 being in fluid communication with one another. Propeller 32 is mounted on the foil at the second end 40 of channel 36.

[0048] An engine 42 and aligned gearbox 44 are mounted within elongate channel 36 and mechanically coupled to propeller drive shaft 46. At a first end, electrical harness 50 is electrically coupled to engine 42. Engine 42 is an MGU.

[0049] At a second opposing end, engine 42 is electrically coupled to battery system 16 and controller 10 via electrical harness 50 that extends through vertical shaft 30, such that, in use, electrical harness 50 transfers energy from the battery system 16 to engine 42 which drives propeller drive shaft 46 via gearbox 44 to rotate propeller 32. The engine 42 acts as a generator, deploying energy from the battery system 16 to drive gearbox 44.

[0050] Electrical harness 50 is a flexible electrical connection, rather than a conventional mechanical linkage. The presence of a flexible electrical harness 50 extending vertically through foil 18, rather than a mechanical linkage, allows for more streamlined containment of the connection within the foil, thus permitting an improved foil profile with increased hydrodynamic efficiency.

[0051] Fluid inlets 42 are provided radially around body 34 such that channel 36 is in fluid communication with the exterior of foil 18 i.e. exterior water may flow through fluid inlets 42 into channel 44. Thus, when vessel 10 is travelling through the water, water flows through fluid inlets 42 into channel 36 and flows past engine 42 and gearbox 44 in a direction towards the second end 40 of channel 36. Further, water will be drawn in through open first end 38 of channel 36 and also flow past engine 42 and gearbox 44 towards second end 40. The flow of exterior water into channel 36 and around engine 42 and gearbox 44 serves to cool the engine and gearbox during use, preventing overheating and allowing operation of the engine and gearbox at higher speeds than possible in the absence of a cooling system. In the figures, fluid inlets 48 are shown as slots or gills However, it is to be appreciated that any suitable shape of fluid inlet known to the skilled person and suitable for the circulation of water from the exterior of foil 18 into channel 36 and around engine 42 and gearbox 44 may be used in addition to, or as an alternative to, the slots or gills shown in figures 6 and 7. Further, the number and location of fluid inlets 42 may be varied from that shown in the figures provided a sufficient volume of fluid flow past engine 42 and gearbox 44 is possible to provide the required cooling to be achieved during travel of vessel 10.

[0052] According to the invention as shown in figure 8, foil 18 comprises a housing 60 defining a receiving space in which engine 42 and gearbox 44 are received. Housing 60 provides a watertight housing for engine 44. Engine 42 and gearbox 44 are located adjacent one another within housing 60housing 60 and are connected via shaft 66 that transmits the torque and rotation from engine 42 to the gearbox 44. The outer surfaces of both engine 42 and gearbox 44 are located adjacent the interior surface of housing 60 such that heat generated during use is absorbed from engine 42 and gearbox 44 by housing 60 and subsequently dissipated into the surrounding water, thus providing an efficient cooling system that avoids the need for mechanical or forced flow of fluid past the engine 42 and/or gearbox 44 within housing 60.

[0053] Propeller 32 is connected to gearbox 44 distal to engine 42 and is engaged with gearbox 44 via propeller shaft 33. Propeller 32 connects to propeller shaft 33 by means of a conical arrangement with a key 35 in a conventional manner. Propeller shaft 33 enters the gearbox 44 through bearings and connects with the gearbox toothed wheels (not shown).

[0054] Propeller shaft 33 enters housing 60 through seals that maintain the water-tight integrity of housing 60.

[0055] At the opposing side of housing 60, housing 60 connects to foil 18 at interface 62. Housing 60 is bolted to a flange on the foil (not shown). Interface 62 is sealed and channels are provided for the electrical harnesses 63 of power train assembly 64 to exit the housing 60 and extend vertically along vertical shaft 30 of foil 18, to provide an electrical connection between the engine 42 and gearbox 42 and the controller located in the hull 14 of vessel 10.

[0056] Seals are provided at the point of exit of the electrical harnesses 64 from housing 60 to maintain the water-tight integrity of the housing 60.

[0057] According to the invention as shown in figure 8, gearbox 44 is an epicyclic gearbox and engine 42 is a motor generator unit (MGU). However, it is to be appreciated that this is just one embodiment and a skilled person may use an alternative engine to achieve the same arrangement within gearbox housing 60.

[0058] In the boat including a hydrofoil system of the present invention, the vessel 10 is further provided with a plurality of sensors (not shown) in electrical communication with controller 12, each sensor configured to monitor one or more flight parameters of vessel 10 and generate measured flight parameter data based on the monitored flight parameter. This measured flight parameter data is then provided to controller 10 which uses the measured flight parameter data to determine what adjustments are required to the engine and adjustment members 13 to optimise the vessel 10 travel through the water. Adjustment member 13 is shown in figures 2 and 3 with its hydrodynamic fairing. Controller 10 then communicates engine 42 to control the operation of propeller 32. Controller 12 also communicates with actuators 22 to control the position of the adjustment members 13 in dependence upon the measured flight parameter data. This has the effect of influencing the speed of the vessel through the water and/or the position of vessel 10 within the water i.e. the heave, pitch, roll and/or thrust of vessel 10 within the water.

[0059] The sensors may provide measured flight parameter data to the controller on a continuous basis or on demand from the controller or in a predetermined programmed manner. Obviously, continuously provided data will produce continuous feedback from controller 12 to influence the operation of the engine and the position of the vessel 10 within the water, providing continuously optimised travel of the vessel 10 through the water.

[0060] The sensors may be located in multiple positions embedded in the hull and foils, and measure various flight parameters of vessel 10 including, but not limited to monitoring/measuring acceleration, position (pitch, heave, yaw, roll), ride-height data, actuator positional data, and any other useful parameter relating to the movement of the vessel through the water.

[0061] Figure 9A shows the arrangement where the housing 60 is mounted on foil 18, whilst figures 9B to 9D show variations on how this can be achieved.

[0062] Figure 9B shows an arrangement wherein housing 60 is provided as part of the gearbox 42, and during assembly, engine 44 is slotted into gearbox housing 60, and housing 60 subsequently made water-tight in a conventional manner.

[0063] In figure 9C, housing 60 is provided as part of the engine 44 and, during assembly, gearbox 42 is slotted into engine housing 60, and housing 60 subsequently made water-tight in a convention manner.

[0064] Figure 9D shows an arrangement wherein housing 60 is distinct from both engine 42 and gearbox 44. Engine 42 and gearbox 44 are slotted into housing 60 towards one another from opposing ends of housing 60. Alternatively, engine 42 and gearbox 44 may be sequentially slotted into housing 60 from the same end. Housing 60 is subsequently made water-tight in a conventional manner to contain both engine 42 and gearbox 44 therewithin. Figure 10A shows an arrangement where housing 60 is provided by a portion of foil 18. Engine 42 is slotted into housing 60, followed by gearbox 44 before housing 60 is made water-tight in a convention manner to retain both engine 42 and gearbox 44 within foil 18.

[0065] Alternatively, housing 60 may be provided as a channel through foil 18. Engine 42 and gearbox 44 are slotted into housing 60 towards one another from opposing ends of housing 60. Housing 60 is subsequently made water-tight in a conventional manner to contain both engine 42 and gearbox 44 within foil 18.

[0066] Finally, figure 11 shows an arrangement wherein housing 60 is spatially separated from foil 18. It is to be appreciated that the assembly of housing arrangement may be as described for figures 9B to 9D.

[0067] Figure 1 shows a vessel 10 with two foils 18, one of which is hydrofoil system in accordance with the present invention and the other is a foil without the propulsion system of the present invention. It is to be appreciated that a vessel will comprise a minimum of two foils (one towards the front and one towards the rear of the vessel), one or both of which may include the propulsion features of the present invention. Where multiple foils 18 are provided, the actuators 22 for each flap 20 of each foil 18 are independently controlled by a single controller 12.

[0068] A vessel could be equipped with one hydrofoil system in accordance with the present invention and one non-propulsion foil unit. However, if the weight of the vessel requires more thrust to move around then the vessel could be equipped with two foils provided with propulsion.

[0069] The boat including a hydrofoil system of the present invention therefore allows human-free flight control. As each foil 18 is always tuned and set for optimum performance i.e. low drag, significantly reduced drag through the water is ensured. This provides the technical advantage of either a greater autonomy range or an increase cruise speed for a given battery capacity.

[0070] The engine cooling used by the boat including a hydrofoil system of the present invention, whether water-flow cooling or according to the invention heat-transfer cooling, negates the requirement for a separate mechanical cooling system, thereby reducing the complexity and weight of the system, which contributes to efficiency and increasing battery life.

[0071] It is to be appreciated that the boat including a hydrofoil system of the present invention may be an integral part of a newly built vessel 10 or may be retrofitted to existing vessels 10 to achieve optimal performance.

[0072] Finally, use of the boat including a hydrofoil system of the present invention provides optimal performance with increase ride comfort for passengers as less of the hull 14 of vessel 10 is exposed to the surrounding water conditions, thereby ensuring a smoother ride.

REFERENCES CITED IN THE DESCRIPTION

Cited references

Patent documents cited in the description

- EP0453529B1 **[0007]**
- US2018072383A **[0008]**
- US2020189691A **[0009]**
- US4092946A **[0010]**

Patentkrav

1. Båd (10) som inkluderer et hydrofoilsystem, hvor hydrofoilsystemet omfatter

- en styreenhed (12);
- en hydrofoil (18) til indgreb med båden, hvilken hydrofoil omfatter en flerhed af justeringselementer (19), der kan betjenes til at variere bådens løfteegenskaber;
- en propel (32) monteret på hydrofoilen; og **kendetegnet ved**
- et gearkassesystem, hvor gearkassesystemet omfatter:

  et hus (60) med en indre overflade, der definerer et indre rum med defineret dimension;

  et gearsystem placeret i husets indre rum og omfattende en propelakselindgrebsdel og en gearkasse (44) i mekanisk forbindelse med propelakselindgrebsdelen; og

  en motor (42) placeret inden i husets indre rum og i mekanisk forbindelse med gearkassen;

  hvor huset er vandtæt, hvor gearkassen og motoren er i termisk kontakt med husets indre overflade; og

  hvor gearkassen (44) er en epicyklisk gearkasse; og

  hvor mindst en del af huset er integreret med hydrofoilen, eller huset er monteret på hydrofoilen; og

  hvor propellen er mekanisk i indgreb med propelakselindgrebsdelen, og gearkassesystemet er i mekanisk forbindelse med propellen.

2. Båd ifølge et hvilket som helst af de foregående krav, hvor gearkassen og motoren er anbragt tæt ind i husets indre rum.

3. Båd ifølge et hvilket som helst af de foregående krav, hvor huset yderligere omfatter en transmissionssystemindgrebsdel.

4. Båd ifølge krav 3, hvor transmissionssystemindgrebsdelen er placeret distalt i forhold til propelakselindgrebsdelen.

5. Båd ifølge et hvilket som helst af de foregående krav, hvor motoren er en MGU (motor-generator-enhed).

6. Båd ifølge et hvilket som helst af de foregående krav, hvor huset omfatter et eller flere af følgende materialer: rustfrit stål, titanlegering, aluminium (aluminium) eller et kompositmateriale såsom aramidfiber eller kulfiberforstærket resin.

7. Båd ifølge et hvilket som helst af de foregående krav, hvor hydrofoilsystemet yderligere omfatter:

- en flerhed af sensorer i elektrisk forbindelse med styreenheden, hver sensor er konfigureret til at overvåge bådens flyparametre og generere målte flyparameterdata,
- hvor styreenheden er i forbindelse med justeringselementerne, motoren og sensorerne, og hvor styreenheden er konfigureret til at modtage målte flyparameterdata fra sensorerne og til at styre driften af motoren og positionen af justeringselementerne afhængig af de modtagne målte flyparameterdata.

8. Båd ifølge et hvilket som helst af de foregående krav, hvor hvert af justeringselementerne kan betjenes til at variere en eller flere af bådens hældning, rulning, hævning og krøjning.

9. Båd ifølge et hvilket som helst af de foregående krav, hvor hvert justeringselement omfatter en flap (20) og en aktuator (22), hvor flappen er bevægelig i forhold til hydrofoilen ved aktivering af aktuatoren via styreenheden.

10. Båd ifølge et hvilket som helst af de foregående krav, hvor propellen er placeret ved siden af gearkassen, distalt i forhold til motoren.

11. Båd ifølge et hvilket som helst af de foregående krav, hvor de målte flyparameterdata omfatter en eller flere valgt fra gruppen omfattende accelerationsdata, fartøjspositionsdata (hældning, hævning, krøjning, rulning), aktuatorpositionsdata, eksterne omgivelsesfaktorer og de omgivelser, fartøjet bevæger sig i.

12. Båd ifølge et hvilket som helst af de foregående krav, hvor styreenheden er placeret inden i bådens skrog (14), og hydrofoilen er placeret under den flydende vandlinje på bådens ydre skrog.

13. Båd ifølge et hvilket som helst af de foregående krav, yderligere omfattende et batterisystem (16) i elektrisk forbindelse med motoren og eventuelt aktuatoren, hvor batterisystemet kan betjenes til at levere strøm til motoren og eventuelt aktuatoren.

DRAWINGS

Drawing

FIG. 1

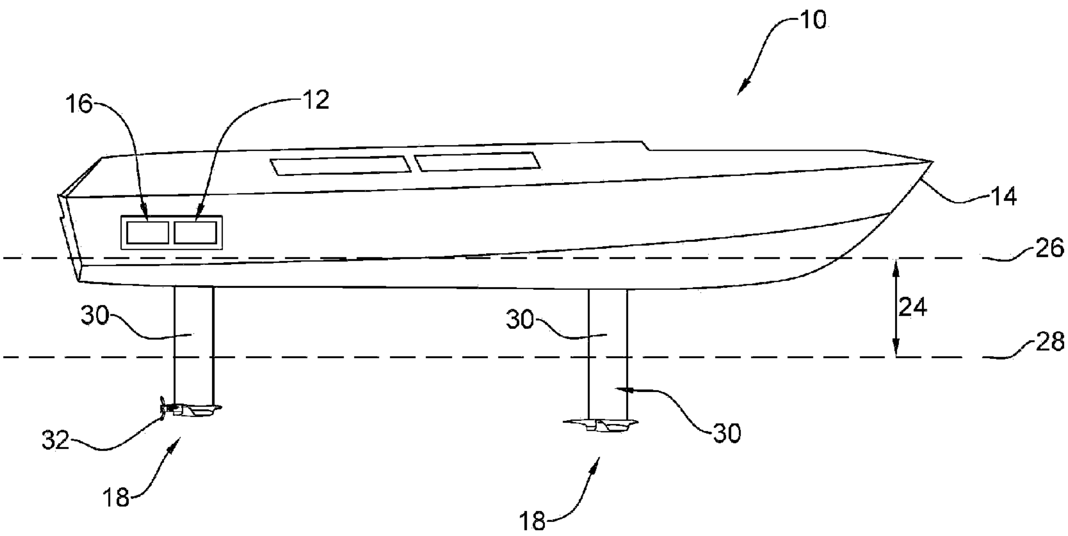

FIG. 2

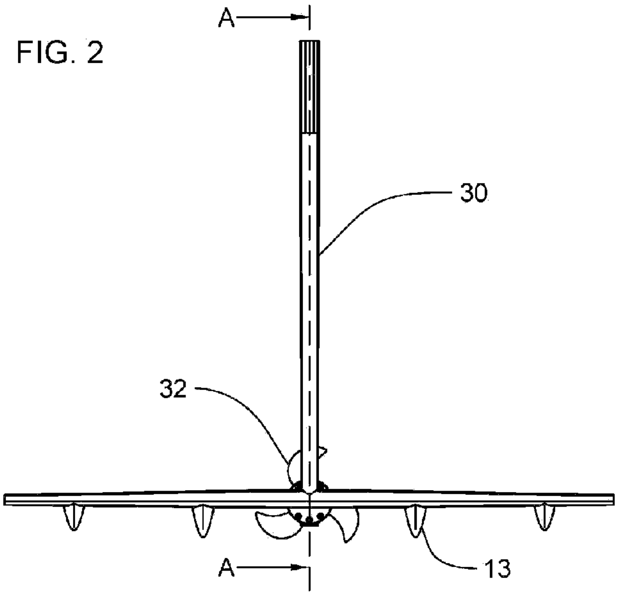

FIG. 3

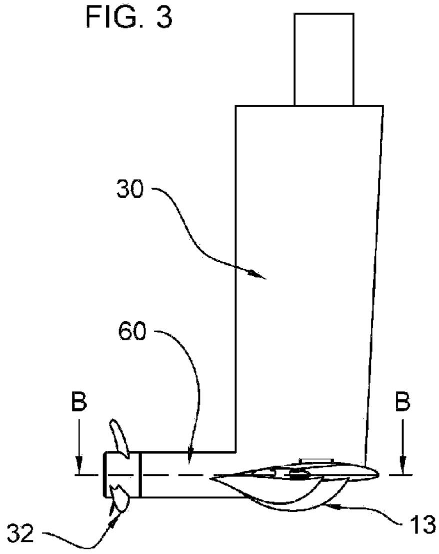

FIG. 4

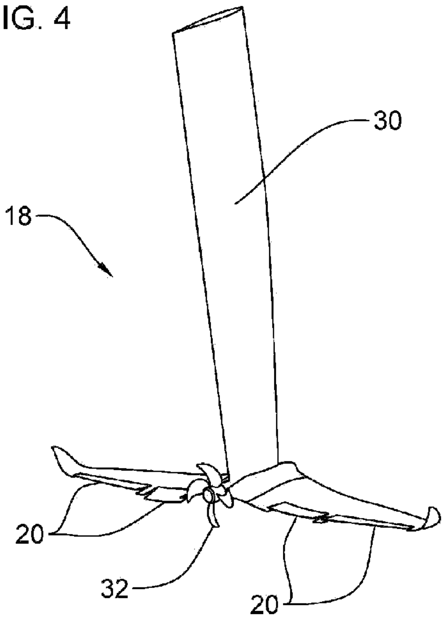

FIG. 5

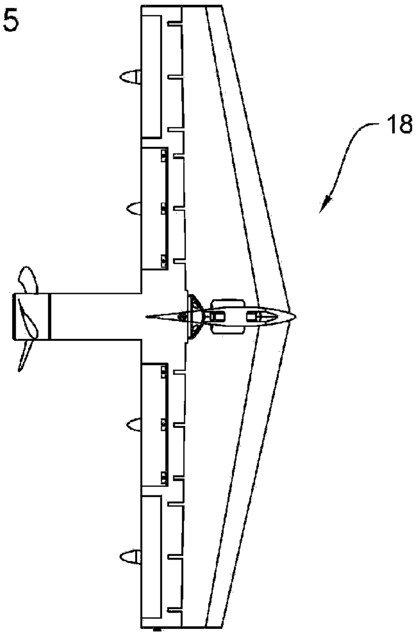

FIG. 6

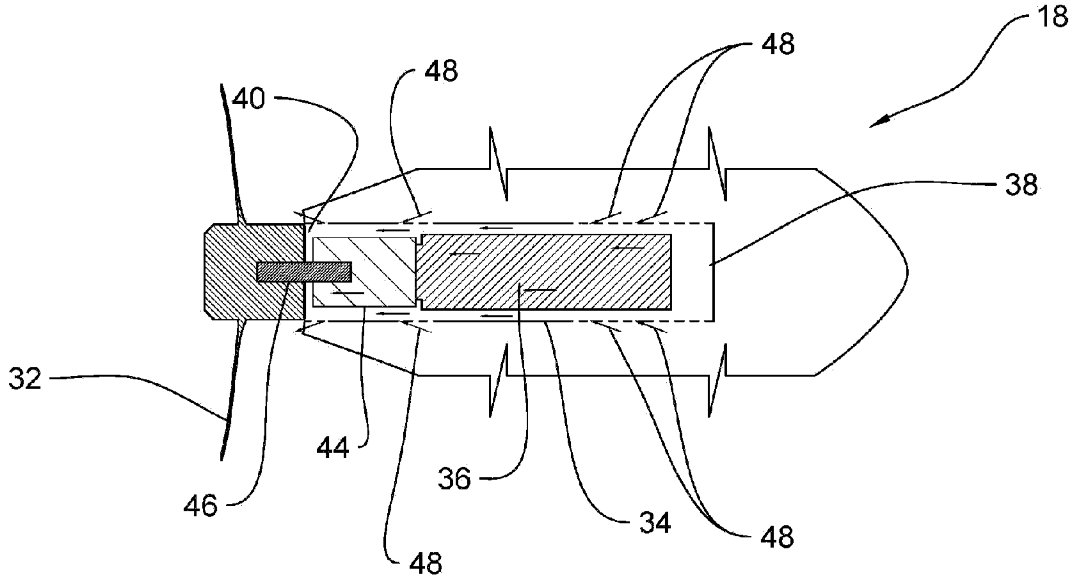

FIG. 7

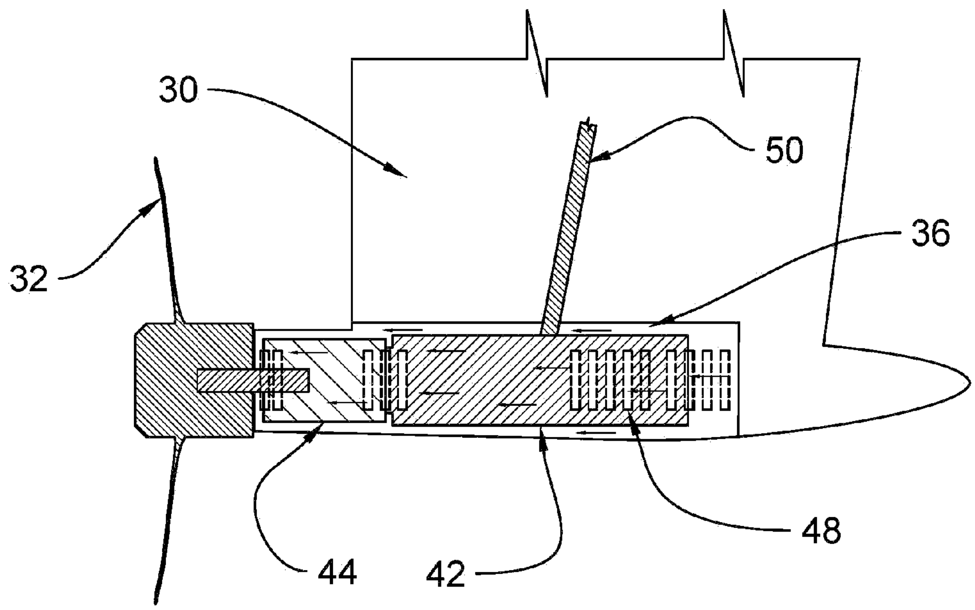

FIG. 8

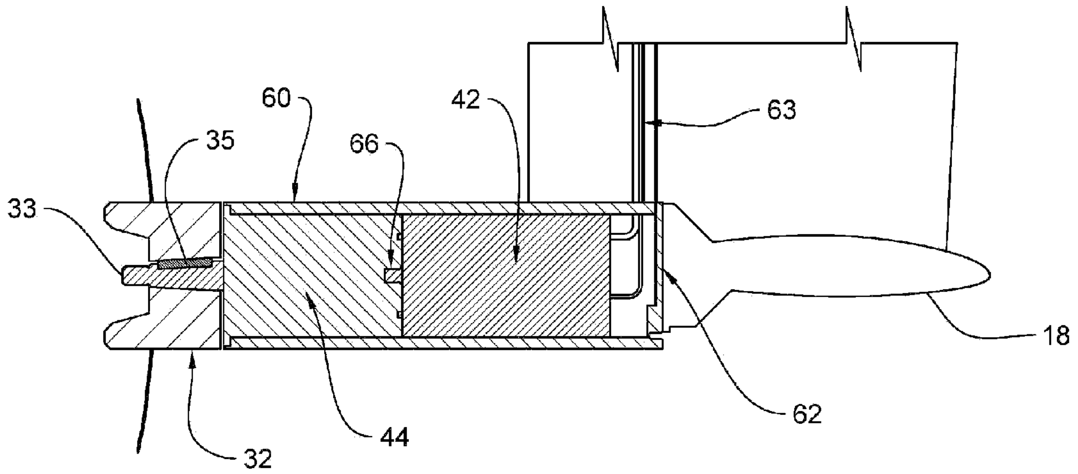

FIG. 9A

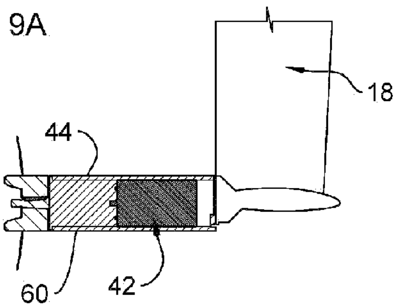

FIG. 9B

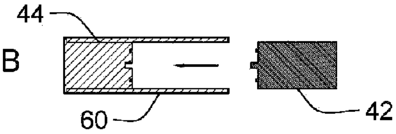

FIG. 9C

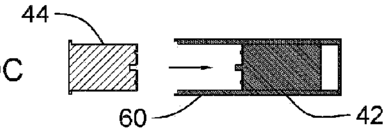

FIG. 9D

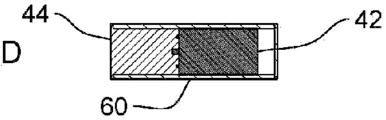

FIG. 10A

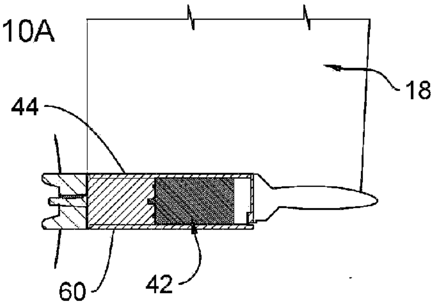

FIG. 10B

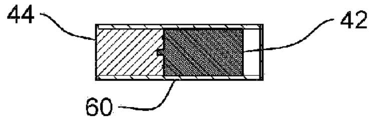

FIG. 11