(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 939 876 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
19.01.2022 Bulletin 2022/03

(21) Application number: **20186402.2**

(22) Date of filing: **17.07.2020**

(51) International Patent Classification (IPC):
B63B 1/12 $^{(2006.01)}$
B63B 1/24 $^{(2020.01)}$
B63H 9/072 $^{(2020.01)}$
B63B 1/18 $^{(2006.01)}$
B63B 1/28 $^{(2006.01)}$

(52) Cooperative Patent Classification (CPC):
B63H 9/072; B63B 1/125; B63B 1/242;
B63B 2001/186; B63B 2001/281

(84) Designated Contracting States:
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
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **SP80 Sàrl**
1004 Lausanne (CH)

(72) Inventors:
- **Lepercq, Xavier**
  1007 Lausanne (CH)
- **Gaudiot, Benoit**
  1026 Denges (CH)
- **Van den Broek, Mayeul**
  1004 Lausanne (CH)

(74) Representative: **P&TS SA (AG, Ltd.)**
Avenue J.-J. Rousseau 4
P.O. Box 2848
2001 Neuchâtel (CH)

(54) WIND-POWERED WATERCRAFT

(57) This invention concerns a wind-powered watercraft comprising, a hull (11), at least one buoyant body laterally attached at a distance to the stern section (11 b) of the watercraft, one frame (3) rotatably connected to said hull (11) over a first axis (X; R1), one arm (1) rotatably attached to said frame (3) over a second axis (Z'; R2), one drift (2) rotatably connected to said hull (11), and an aerodynamic towing surface (5), which is connected to an attachment point (1a) at a distal end of said arm.

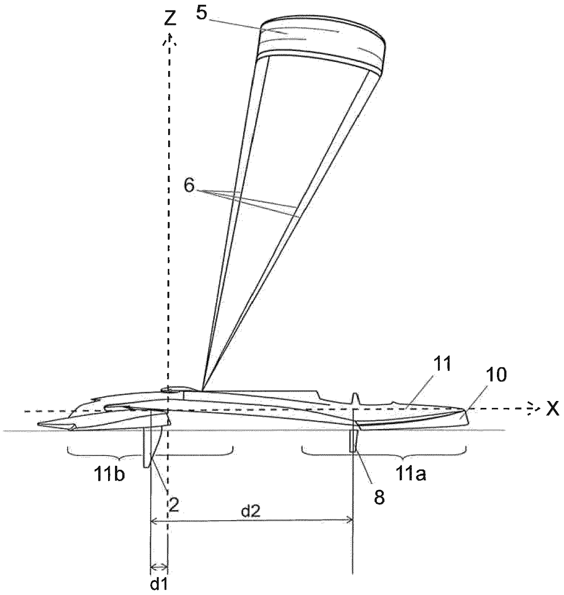

Fig.1a

Printed by Jouve, 75001 PARIS (FR)

Description

Field of the invention

[0001] The present invention concerns a wind-powered watercraft employing a specific arrangement of aerodynamic and hydrodynamic surfaces attached to the watercraft in order to reduce the pitch, roll, yaw moments and resulting Z force acting on the watercraft and thus enhance stability and enable greater speed of the watercraft.

Description of related art

[0002] When designing and constructing a wind-powered watercraft capable of moving at high speed without additional motor-power, the hydro- and aerodynamic forces acting on the craft must be carefully considered in order to arrive at an engineering solution which adequately balances these forces and counteracts the downforces on the craft, such as gravity and overall resistance force or drag. The power acting on the craft is a function of the speed of the vessel multiplied by its drag. Therefore, in order to increase the watercrafts speed at constant power, the drag must be reduced. Given that drag is a key limitation to achieving high speeds, boat and watercraft designers have come up with a variety of solutions to reduce drag on particular vessels.

[0003] A recent popular solution to overcome the drag forces on wind-powered watercrafts is the employment of hydrofoils, which cause the hull of the vessel to raise above the water. This results in reduced friction between the hull and the surrounding water and therefore a decrease in drag and an increase in speed.

[0004] A further major factor affecting a watercrafts performance is stability, which resides in the ability of the vessel to balance aero- and hydrodynamic forces exerted on it in order to reduce the moments along the principal axes or inertia, i.e. the roll moment along the longitudinal or X axis, the pitch moment along the transverse or Y axis and the yaw moment along the vertical or Z axis.

[0005] For conventional boats, such as monohulls, catamarans, trimarans etc, it is well known that increasing the width and/or weight increases the righting moment, which counteracts the roll moment, while an increase in distance between rudder and centreboard counteracts the yaw moment, and an increased length of the vessel counteracts the pitch moment. However, an increase in size and weight to achieve these increased dimensions also results in higher downforces, gravitational pull and drag, which in turn hinders the acceleration of the vessel.

[0006] As boat dimensions to control pitch, roll and yaw moments become too significant, the drag will prevent speed. The design of a boat must therefore carefully balance the features providing stability against the features causing drag. As boats must carry more power and remain light to enable greater speed, additional elements to improve stability must be provided.

[0007] Stability is a major issue in high-performance sailing, as the pitch, roll and yaw moments of the vessel vary greatly with boat speed, boat configuration and wind conditions. As a result, high-performance sailing vessels are designed for specific ranges of speed and wind conditions in order to maximise their performance within a given range. Alternatively, they are designed to be reconfigured under changing conditions in order to reduce their power and adjust to the prevailing conditions, for example by using sails of different sizes.

[0008] Today several approaches of towing a watercraft with a kite-type of sail attached to the vessel have been described, each including one or several elements to improve the stability of the vessel, such as hydrofoils, outriggers, keels, and floats.

[0009] Replacing conventional sails with a kite has several advantages. Firstly, different from conventional sails, the kite does not require a mast or riggings, which allows for a considerable reduction in weight. The fact that kites can fly higher than conventional sails enables kites to take advantage of stronger and steadier, higher-altitude winds. Kites are also easily maneuvered through the air, creating more apparent wind to drive the watercraft.

[0010] Document FR3070157, for example, discloses a boat stabilized by two foils, one port and one starboard and a stabilizer towed by a kite. The stabilizer is movably attached perpendicular to the central longitudinal axis of the boat's bow, allowing the kite to pass from port to starboard in order to carry out a counter-heel.

[0011] Document FR2945025 discloses a boat towed by a kite sail that is movable in rotation with respect to a mast and comprising two hydrofoils.

[0012] Document DE202015006950U1 discloses a trimaran-type boat towed by a kite sail, capable of high speed without a motor.

[0013] Document US6789489 discloses a boat, whereby a board is shown in the drawings, equipped with a mast to which the kite sail is attached, the mast being pivotally connected to the hull and keel, the keel moving with the mast in pitch and roll.

[0014] The embodiments described in document WO18234969 include a wind-powered watercraft in which a rolling force caused by the action of wind on, e.g. one or more sails or kites is counteracted by way of a hydrofoil.

[0015] Document FR2978420 discloses a wind-propelled floating apparatus, in particular by means of a kite wing attached to the end of an arm fixed rotatably with respect to the hull. The vessel has a main buoyancy appendage rotatably mounted on the hull.

[0016] A previous model of a kite-towed water craft designed by the applicant is disclosed on the "Voiles et Voiliers" website https://voilesetvoiliers.ouest-france.fr/bateau/foiler/sp80-un-engin-suisse-vise-80-noeuds-a-la-voile-alors-que-le-record-du-monde-est-a-65-f8b54cae-0ad3-11ea-adb7-776ec54bacaf (date of consultation 05 March 2020), in which the kite is directly linked to the foil of the vessel.

[0017] With an increase in speed, and for high-performance vessels in particular, the control of the roll moment becomes critical and require sails to be adjusted in order to prevent capsizing of the boat.

[0018] In engineering solutions achieving for control of the roll moment, it is usually the yaw moment which poses the biggest challenge and destabilises the boat to a point where it is no longer steerable.

[0019] The use of a kite reduces the pitch moment in a wind-powered vessel. Thus, the pitch moment poses less of an issue for kite-towed vessels.

[0020] Despite the above-mentioned approaches, the control of stability of high-speed, kite-towed watercrafts remains an engineering challenge. As of today, no simple and robust engineering solution has been described to effectively control roll, yaw and pitch moments of a wind-powered watercraft. The control of the Z displacement force, which is the resulting Z-force exerted on the vessel, also causes a significant problem in kite-towed vessels. None of the solutions described in the prior art permits high-performance sailing vessels to adequately control pitch, yaw, roll moments and the resulting Z force to reliably perform over a wide speed range and under a variety of wind conditions.

Brief summary of the invention

[0021] It is one objective of this invention to sufficiently reduce roll, yaw and pitch moments acting on a watercraft in order to permit safe performance at slow, medium and high speed and under a variety of wind conditions.

[0022] It is a further objective of this invention to sufficiently reduce the resulting Z force, i.e. the resulting upward pull, exerted on the kite-towed watercraft.

[0023] The present invention achieves these objectives by providing a simple solution for a watercraft, which dynamically and passively balances aerodynamic and hydrodynamic forces exerted on the wind-powered-watercraft. According to the invention, this objective is achieved by independent claim 1 and, preferably, by the dependent claims.

[0024] In particular, this objective is achieved by a wind-powered watercraft comprising:

- a hull;
- at least one buoyant body laterally attached at a distance to the stern section of the watercraft;
- one frame rotatably connected to said hull over a first axis;
- one arm rotatably attached to said frame over a second axis;
- one drift rotatably connected to said hull;
- an aerodynamic towing surface, which is connected to an attachment point at a distal end of said arm.

[0025] Preferably rotational movements of the arm and the drift, which may be a dagger board, a hydrofoil or another suitable at least partially submerged board or foil, are interconnected.

[0026] In one preferred first embodiment, the first axis R1 is in the yaw axis, which is orthogonal to the yaw (XY) plane of the hull. The second axis R2 is embedded in an XY plane, which is parallel to the yaw plane of the hull but further removed from the drift than said yaw plane.

[0027] In this first embodiment, the drift is rotatably connected to the hull over a third axis R3 in the yaw (XY) plane of the hull and the arm is rotatably connected to the second axis R2. The second axis R2 enables the arm to perform a rotational upwards and downwards movement in respect of the hull.

[0028] The second axis R2 may comprise a first hydraulic cylinder and the third axis R3 may comprise a second hydraulic cylinder. First and second chambers of the hydraulic cylinders are hydraulically connected so that any rotational movement of the arm around the second axis R2 is linked to a rotation of the drift with respect to the hull. Alternatively, the second axis R2 and the third axis R3 may be connected by other means capable of linking the rotational movement of the arm around the second axis R2 to a rotation of the drift with respect to the hull.

[0029] As a result, a rotational movement of the drift around the third axis R3 will cause the arm to perform a rotational upwards or downwards countermovement around axis R2. The hydrodynamic force F2 created by the drift and the aerodynamic force F1 experienced by the arm are therefore dynamically linked. Rotational axis R2 is contained in a plane which is parallel to the yaw XY plane of hull, wherein axis R3 is contained in the yaw XY plane of the hull and corresponds to the longitudinal X axis of the hull. As a result, the two axes are offset with respect to each other. Since axis R2 rotates around axis R1, axis R2 may or may not be parallel to R3. However, regardless of whether axes R2 and R3 are parallel to each other, the extend of the rotational movements of arm and drift around their respective axis is essentially the same. In other words, in their rotational movement the angle of rotation of the arm around axis R2 is matched by the angle of rotation of the drift around axis R3. The term "matched" as used herein means that the angles are identical with or without a tolerance, wherein said tolerance is preferably less than 2 degrees, less than 5 degrees, or less than 10 degrees. The angle of rotation of the arm around axis R2 and the angle of rotation of the drift around axis R3 are connected in their movement to the effect that the Z forces acting on the vessel essentially compensate each other, and the resulting Z force is zero or close to zero. The improved compensation of the forces furthermore enhances the control of the moments of the vessel.

[0030] If the drift does not create any hydrodynamic force F2, the pull force in the cylinder is zero and the arm aligns with the aerodynamic towing device.

[0031] The aerodynamic towing device is preferably a kite.

[0032] If the drift creates a hydrodynamic force F2, the cylinder pulls the arm downwards until an equilibrium for the position of arm and drift is found. This creates an angle between the arm and the guidelines, through which the kite is attached to the arm.

[0033] The aerodynamic force F1 exerted on the arm by means of the kite directs the orientation of the arm. Advantageously, due to its connection to the rotating frame, the arm is capable of performing two distinct rotational movements, one around the first rotational axis R1 and a second around the second rotational axis R2, which is perpendicular to the first rotational axis R1 to adjust for the aerodynamic pull. This design facilitates a better alignment of the arm with the aerodynamic force F1.

[0034] The yaw moment causes a sideway skidding of the vessel, in particular of the bow section, if the aerodynamic force F1 acts on the stern section of the boat. At low or medium speed of the vessel, i.e. when the watercraft experiences a relatively low aerodynamic force F1, the drift at the stern section creates the main part of the counterforce, whereby the rudder at the bow section, creates less of said counterforce. For example, the rear drift may create 80% of the total hydrodynamic counterforce F2, while the front rudder creates 20%.

[0035] An increase in aerodynamic force F1 acting on the stern section results in a shift of the counteracting hydrodynamic force F2 from the submerged element at the rear section, the drift, to the submerged steering element at the bow section, the rudder. Since the rudder is designed for steering and is shorter than the drift, it is not built to withstand substantial hydrodynamic forces. The rudder therefore crashes if it has to counteract a significant percentage of the aerodynamic force F1 exerted on the vessel. The significant percentage which causes the rudder to crash depends on the particular design of the boat and the overall total of the hydrodynamic force, but as a general guideline, such percentage is typically above 30% or above 40%.

[0036] On a conventional sailing vessel using a mast and a sail, the roll angle is greatly affecting yaw moments as the centre point of the aerodynamic force is located high above the centre of gravity of the vessel, thus pushing the vessel leeward or leeway. The resulting yaw moment induced hydrodynamic force on the rudder, is greater than the rudder can withstand. As a result, control of the vessel is lost, and it capsizes.

[0037] The solution provided by this invention prevents a disproportional shift of the yaw counteracting force to the front rudder of the watercraft. In addition, as is the case for other kite-towed vessels, the centre point of the aerodynamic force is closer to the centre of gravity of the watercraft compared to conventional sailing boats. A control of the yaw moment is very challenging and full simultaneous control of roll, pitch and yaw has never been achieved before.

[0038] The control of this moment by introducing a yaw offset. This yaw offset is defined as the offset distance between the pivot of the arm around the Z axis projected on the X axis and the centre of hydrodynamic pressure on the drift projected on the X axis.

[0039] In a further second embodiment, the first axis is a longitudinal axis (X) of said watercraft, and the drift is mounted on the frame so as to rotate with the frame around the first axis (X). In this second embodiment the second axis (Z') is orthogonal to the first longitudinal axis (X).

[0040] The orientation of the arm is defined by the direction of the upward pulling force of the aerodynamic towing device, whereby, in this second embodiment, the orientation of the arm is limited by a the first rotational movement performed by the frame around the first longitudinal axis (X) and the second rotational movement of the arm around the second axis (Z').

[0041] According to this second embodiment the drift is attached to the rotating frame and thereby connected to second rotational axis (Z') of the arm. The frame and axis Z' perform their rotational movement around the X axis together. Therefore, as the aerodynamic force F1 exerted on the arm causes the frame to rotate around the longitudinal X axis, the drift performs the same rotational movement around the longitudinal X axis. The rotational movements, respectively the rotational angles of the arm and the drift around said axis are identical. As a result, the vertical forces caused by the movement of the kite is at least partially compensated by the rotational movement of the drift.

[0042] As is the case for the first embodiment, this second embodiment also features the yaw offset, which is the distance between the pivot of the arm around the Z axis projected on the X axis and the centre of hydrodynamic pressure on the drift projected on the X axis.

[0043] As a result of the yaw offset, a sudden or excessive shift of the hydrodynamic force F2 from the rear drift to the front rudder due to an increase in the aerodynamic force F1 is avoided. In other words, the hydrodynamic force F2 exerted on the rear drift and the front rudder increases linearly with speed. It is distributed at a fixed proportion between the front rudder and the rear drift. Therefore, the force acting on the front rudder also increases linearly with speed.

[0044] The connection between aerodynamic towing surface and the drift is fixed in relation to their rotational movement around the first rotational axis (X), which means that the attachment point of the aerodynamic towing surface at the arm and the centre of hydrodynamic pressure of the drift perform their rotational movement around the first rotational axis (X) together. This fixed rotational arrangement advantageously results in a better control of the roll moment. The orientation of the hydrodynamic force F2, which is counter-balancing the aerodynamic force F1 acting on the attachment point on the arm, therefore intrinsically adjusts to the orientation of said aerodynamic force F1.

[0045] Any residual roll moment around the first longitudinal axis (X) can advantageously be controlled by means of lateral buoyant bodies. Ideally at least two buoyant bodies are positioned on either side of the vessel, preferably at the stern section. Optionally, one lateral buoyant body is sufficient to control the residual roll, of it is wide enough and/or positioned at a sufficiently large distance from the longitudinal (X) axis of the vessel.

[0046] This invention and its embodiments presented here provide the distinct advantage of an efficient combined control of roll, yaw, pitch moment and resulting Z force resulting in an increased working range of the vessel as it relates to true wind angle, true vessel angle, true wind speed and/or true vessel speed. As a consequence, the boat can navigate in a wide range of conditions, such as true wind speed and true wind angle, through a wide range of speed, true boat speed, without losing its stability and without the need for conducting adjustments, such as removing a sail, taking a reef, adding a foil, drift and/or rudder, etc, while the vessel is in motion.

[0047] In the present invention the pitch moment is advantageously reduced due to the position of the centre point of the aerodynamic uplift force, i.e. the attachment point. As mentioned above, in a kite-driven watercraft, this attachment point is vertically close to the centre of gravity of the vessel. Due to the short vertical distance between these two centres the pitch moment of a kite-driven vessel is significantly lower compared to conventional sailing boats.

[0048] In this invention the horizontal distance of the attachment point of the aerodynamic force F1 and the arm to the centre of gravity of the vessel, which is in the middle section of the vessel, changes with the direction of the aerodynamic force. In other words, the attachment point is closest to the centre of gravity if the aerodynamic force is pulling forwards along the longitudinal axis of the vessel. Such a forward aerodynamic forward pull causes a greater pitch moment than an aerodynamic sideways pull. The pitch moment created by the aerodynamic surface is therefore not fully controlled by the rotating arm. The use of a kite is considerably reducing the pitching moment compared to a standard sailing vessel, but this invention leaves a residual pitch moment that needs to be counterbalanced by the overall design of the vessel.

[0049] Any residual pitch moment can be eliminated by positioning buoyant bodies, such as floaters, at the bow and stern sections of the vessel. Such buoyant bodies counteract the upwards movement of the rear or the front end of the vessel.

[0050] The different embodiments of this invention may furthermore advantageously comprise damping systems, which are known in the industry.

[0051] In order to provide further uplift for the watercraft described in this invention comprises rear buoyant bodies and may also advantageously comprise further front buoyant bodies, which can be laterally attached to the bow section at a distance to the hull.

[0052] The arm, the longitudinal axis as well as their connecting frame and any joints, bearing and other pieces of said elements, are advantageously made from durable and robust material, capable of withstanding the significant aerodynamic and hydrodynamic forces acting on them as well as the adverse environmental conditions in an aquatic environment of fresh or salt water.

[0053] Such suitable material comprises, by way of example, a metal, preferably a noble metal, a metal alloy or a surface-treated metal or metal alloy, or a suitable composite material defying the corrosive effect of an aquatic environment, such as, by way of example, galvanized steel, stainless steel, platinum or titanium.

[0054] In order to increase the speed performance of the watercraft, the submerged or partially submerged elements of the vessel have a hydrodynamic shape, whereas elements raised above the water are aerodynamically optimized.

[0055] The profile of the drift and/or the profile of the rudder can be sub cavitating or/and super ventilating and / or super cavitating.

[0056] Advantageously, a pilot of the vessel is seated in a closed cockpit. The cockpit may be located at the bow or at the stern section of the vessel.

Brief Description of the Drawings

[0057] The invention will be better understood with the aid of the description of an embodiment given by way of example and illustrated by the figures, in which:

Fig. 1 shows a first preferred embodiment of the wind-powered watercraft, with

1a showing a side view of the watercraft,

1 b showing a top view of the watercraft, and

1c showing a frontal view of the watercraft.

Fig. 2 shows detail views of the elements of the watercraft according to the first embodiment, the elements pivoting around the rotational axes R1, R2, and R3, with

2a showing a detailed view of the frame with the rotationally connected arm, and

2b showing the hydraulic cylinder and rod agitating the rotational movement of the drift.

Fig. 3 shows top and frontal views of the watercraft of the first embodiment in two different positions, with

3a showing a top view of the watercraft, with the arm rotating around axis R1 being positioned at an angle of 15° with respect to the yaw (YZ) plane, and with arm and drift being positioned at 45° angle with respect to the roll (YZ) plane the of the watercraft, and

3b showing a top view of the watercraft, with the arm rotating around axis R1 being positioned at an angle of 60° with respect to the yaw (YZ) plane of the watercraft, and

3c showing a frontal view of the watercraft, with the arm rotating around axis R1 being positioned at an angle of 15° with respect to the yaw (YZ) plane, and with arm and drift being positioned at 45° angle with respect to the roll (YZ) plane the of the watercraft, and

3d showing a frontal view of the watercraft, with the arm rotating around axis R1 being positioned at an angle of 60° with respect to the yaw (YZ) plane of the watercraft.

Fig. 4 shows a second preferred embodiment of the wind-powered watercraft, with

4a showing a side view of the watercraft,

4b showing a top view of the watercraft, and

4c showing a frontal view of the watercraft.

Fig. 5 shows a detailed view of the frame 3 of the watercraft according to the second embodiment

Fig. 6 shows a top view of the watercraft of the second embodiment in two different positions, with

6a showing a top view of the watercraft, with the arm rotating around axis R1 being positioned at an angle of 15° with respect to the yaw (YZ) plane of the watercraft, and

6b showing a top view of the watercraft, with the arm rotating around axis R1 being positioned at an angle of 60° with respect to the yaw (YZ) plane of the watercraft.

Detailed Description of possible embodiments of the Invention

[0058] The embodiments shown in the figures 1 to 3 depicts a first embodiment of a wind-towed watercraft according to the present invention, A second embodiment is illustrated with figures 4 to 6.

[0059] In both embodiments, the watercraft comprises one hull 11 with a frontal bow section 11a and a stern section 11b at the rear. The watercrafts presented here are town by a kite 5, which is attached to an arm 1 on the attachment point 1a by means of guidelines 6. The arm 1 is rotatably connected to a frame 3, which rotates around a first axis R1 (first embodiment) respectively X (second embodiment) in respect of the hull 11 of the vessel. The arm 1 rotates around a second axis R2 (first embodiment) respectively Z' (second embodiment). The second axis R2, Z' is perpendicular to the first axis R1, X. The watercraft furthermore comprises a rear drift 2 creating a hydrodynamic counter force F2 to the aerodynamic pull F1 of the kite 5. The rear drift rotates around rotational axis R3 (first embodiment) respectively around the longitudinal axis X of the vessel (second embodiment).

[0060] The rotational movements of the arm 1 around the rotational axis R2 (first embodiment) respectively X axis (second embodiment) and the rotational movement of the drift 2 around the axis R3 (first embodiment) respectively X axis (second embodiment) are interconnected. In both embodiments the angle of the rotational movement performed by the arm 1 and angle of the rotational movement performed by the drift 2 with respect to their rotational axis embedded in XY planes with respect to the watercraft, are matched, i.e. identical or near identical with a tolerance of less than 2 degrees, or less than 5 degrees, but no more than 10 degrees. Hence, the arm 1 and the drift 2 perform their movement around their rotational axis contained in a XY plane of the watercraft together. This arrangement has an important advantage for the control of the resulting Z force.

[0061] As a result of the above described interconnected rotational movement of the arm 1 and the drift 2 the forces acting on the vessel are better compensated. An increase in a moment or the Z force on the hull is at least partially compensated by the matched rotating elements, i.e. the arm 1 and the drift 2. This ensures that the remaining structures of the vessel are not required to absorb more than 40%, ideally not more than 20% or no more than 10% of residual roll moment.

[0062] The reference coordinate system XYZ for both embodiments is attached to the hull, wherein X is the longitudinal axis of the hull, Y the transversal axis and Z perpendicular to the XY plane, i.e. vertical to the water surface when the watercraft is floating on water without any wind or waves.

[0063] For efficient control of the yaw moment, embodiments of this invention may comprise a yaw offset distance d1. This yaw offset distance d1 is defined by the projections on the X axis of the pivot of the arm around the Z axis on the one end and the centre of hydrodynamic pressure on the drift on the other end is very important for the control of the yaw moment. In particular, the ratio between the yaw offset d1 and the distance between the rudder and the drift d2 must fall into a suitable range for the control of the yaw moment, as this ratio influences the relative share of hydrodynamic force to be borne by rear drift and by front rudder.

[0064] As a rough approximation it can be said that if d1/d2 is around 0.1, the rear drift will be encounter about 90% of the hydrodynamic counterforce F2. As the ratio increases the hydrodynamic counterforce F2 is shifted towards the front rudder. For sustainable control of the roll and yaw moments the d1/d2 ration should be between 0.05 and 0.3, ideally between 0.1 and 0.2. For values below this range, the yaw moment can no longer be sufficiently controlled for a navigation at high speed and starts to vibrate. On the other hand, a ratio above this range not only causes an unsafe shift of the hydrodynamic force to the rudder, but also severely impacts the control over the roll moment of the vessel.

[0065] The resulting Z force is the resultant Z-force of the aerodynamic, hydrodynamic and gravity forces exerted on the vessel. Its control is important for the navigation of the watercraft. It can be defined as a fourth stability parameter beside the roll, yaw and pitch moment. If the sum of the Z forces acting on the vessel, i.e. the resulting Z force, is positive, the vessel will be lifted out of the water and crash. If the resulting Z force is negative, the rear buoyant bodies of the vessel will compensate the downward pull. However, due to the increased downward pull these buoyant bodies will produce a lot of drag, which slows down the vessel. Ideally, the resulting Z force should be slightly negative, so as to ensure a good contact between the boat and the water. At the same time, the negative resulting Z force must not be so strong as to interfere too much with the forward movement of the watercraft.

[0066] This control of the resulting Z force is attained based the link between the rotational orientation and rotational movement of arm 1, which is subjected to the aerodynamic force F1, and to the rotational movement of the drift 2, which generates the hydrodynamic counterforce F2, as outlined above. The rotational position of the drift 2, specifically its rake angle, which is the angle of the drift with respect to the Y axis, can be set at the beginning prior to setting sail. During sailing the rotational position of the drift 2 then dynamically adjusts in response to the aerodynamic force F1 acting upon the arm due to the connection in rotational movements between arm 1 and drift 2. By changing the rake angle of the drift 2, the Z force component of the drift 2 changes to counteract the change in magnitude of the aerodynamic Z force, thus enabling better control of the overall resulting Z force of the boat. The dynamic adjustment described hereabove is a passive adjustment to the aerodynamic force F1 acting on the vessel. It is however also possible to actively adjust the rake angle. To this end, further elements suited to control the rake angle of the drift, including for example a motor, a mechanical or hydraulic element which can controlled by a user, can be added to the invention.

[0067] The link between arm 1 and drift 2 as outlined above introduces a coupling between the wetted hydrodynamic surface of the drift projected onto the XY plane and the angle between the guidelines of the aerodynamic surface, the kite, and the water surface. This coupling creates a passive regulation of the resulting Z force of the boat. For example, if the aerodynamic upwards force along the Z axis is very strong, the arm1 rotates upwards around axis R2 (first embodiment) respectively around the X axis (second embodiment). Since the arm 1 is pivotally interconnected with the drift 2, this rotational movement of the arm 1 will cause the drift 2 to rotate upwards the X axis of the hull. The projected surface in the XY plane will therefore increase. As a consequence, the hydrodynamic counterforce F2 is increased accordingly. Aerodynamic upward force F1 and hydrodynamic down pull F2 are dynamically and passively adjusted in respect to each other due to the interconnected movement of arm 1 and drift 2. Interconnected means that said movements of arm 1 and drift2 are either hydraulically (first embodiment) coupled or mechanically linked through the frame 3 (second embodiment). As a result of this, the resulting Z force is kept under control. Under control means that the resulting Z force is kept at a value which can be easily compensated by the buoyant bodies without significantly affecting the forward movement of the boat.

[0068] In a preferred embodiment of the invention the watercraft is a monohull. A monohull is defined as a watercraft with a single hull. A monohull may have laterally attached buoyant bodies of varies shapes or sizes. The frame, drift and arm are however attached to the hull. The watercraft may also be a catamaran. Alternatively, the watercraft may be a trimaran.

[0069] In a further preferred embodiment, the watercraft comprises a steering element, preferably one or more rudders 8, which is shorter than the one or multiple drifts 2 and is used to control the movement of the watercraft.

[0070] The watercraft may furthermore comprise buoyant bodies 7 connected to the stern section 11b of the hull. Those buoyant bodies 7 may for example be floats or outriggers, which are laterally attached at a distance to the hull 11. The lateral distance between said buoyant bodies 7, or one buoyant body 7 and the hull 11, increases the width of the watercraft, which contributes to the control of the roll moment. Optionally, the watercraft may comprise further one or multiple buoyant bodies attached to stern section of the hull.

[0071] As a further option, the watercraft may comprise one or multiple additional buoyant bodies 10 located at the bow section 11a of the hull. Said surfaces 10 provide further uplift for the watercraft

[0072] In a possible embodiment the watercraft can navigate in both directions with respect to the wind. In such an embodiment, the watercraft may employ a straight drift. In an alternative embodiment, the drift has a curved shape and the watercraft is more adapted to navigate in one preferred direction.

[0073] In order to reduce the pitch moment acting on the watercraft, one or multiple at least partially submerged foils can optionally be attached to the bow section 11a of the hull 11. The control of the pitch moment increases with the distance between said foil and the rear buoyant body 7, which is ideally sufficiently long to efficiently control the pitch. The chosen shape of the one or multiple front foil can also be designed in such a way as to provide better stability and control the pitch. By way of non-exhaustive example, the foil may have and inverted T shape, straight shape, L shape, J shape, U shape and other shapes.

[0074] In a preferred embodiment the watercraft is a closed hull vessel with a cockpit 12 from which one or more pilots can control the vessel.

[0075] In a further preferred embodiment, the movement of the watercraft is controlled by adjusting the orientation of one or more rudders 8, which are preferably positioned at the bow section 11a of the vessel.

[0076] A first preferred embodiment of the invention is schematically presented in Figures 1 to 3. In this embodiment the drift 2 is connected to a hydraulic cylinder 14 damping the rotational movement of the drift 2 around a further rotational axis R3, which is in the yaw (XY) plane of the watercraft. Ideally axis R3 is aligned with the length of the vessel.

[0077] The hydraulic cylinder 14 of the drift 2 is hydraulically connected to a second hydraulic cylinder (not shown), which damps the rotation of the arm 1 around the second R2 axis.

[0078] Figure 2a shows details of the frame 3, which is attached to the hull 11 and rotates around the first rotational axis R1. The arm 1, which performs the rotational movement around axis R1 together with the frame 3, to which it is rotatably attached. In addition, the arm 1 pivots around the second axis R2. The arm's movement around axis R2 is hydraulically linked to hydraulic cylinder 14, which damps the rotational movement of the drift 2 around a third axis R3.

[0079] For the best control of the roll moment, the offset between the second axis R2 and third axis R3, which is the roll offset dr, is zero. In other words, the roll offset dr is the orthogonal distance between the pivot of the arm around axis R1 and the longitudinal X axis of the hull. If the roll offset dr equals zero, the roll moment is also reduced to zero. However, in this first preferred embodiment, the roll offset is not entirely zero but is kept as small as possible. However, since this roll offset is not too significant, the remaining residual roll moment does not pose a problem for navigation of the vessel. The residual roll moment can easily be counteracted by lateral buoyant bodies.

[0080] As demonstrated in Figure 2b a translational movement of the rod 15, which is dynamically connected to the cylinder 14 and to the drift 2, drives the pivoting of the drift 2 around the third axis R3. The arrows in Figure 2a indicate the direction of these movements.

[0081] Since rotational movements of the drift 2 around axis R3 and the arm1 around axis R2 are linked, the arm 1 and the drift 2 dynamically adjust the counterbalance to the aerodynamic force F1 exerted on the attachment point 1a of the aerodynamic surface 5 on the arm 1 with the hydrodynamic counter force F2 generated by the drift 2.

[0082] To exemplify the interdependent position between arm 1 and drift, Figure 3 shows frontal and top views of the vessel adjusting for different aerodynamic conditions. In Figures 3a and 3c the arm 1 is positioned at an angle of 15° with respect to the roll (YZ) plane, and both, arm 1 and drift 2 are positioned at a 45° angle with respect to their basic position. The basic position corresponds to the position arm 1 and drift 2 are taking, when the vessel is waterborne and no other force but gravity is acting on the arm 1 or the drift 2.

[0083] In Figures 3b and 3d the arm 1 is positioned at an angle of 60° with respect to the roll (YZ) plane, and both, arm 1 and drift 2 are in their basic position.

[0084] As depicted in the comparative top views of Figures 3a and 3b, the aerodynamic sideway pull F1 is counteracted by the hydrodynamic counter forces created by drift F2.1 at the stern section and rudder F2.2 at the bow section. The sideways pull exerted on the vessel of Figure 3a is larger than the sideways pull acting on vessel of Figure 3b, which experiences a greater forward pull. An increased sideway pull would result in an increased yaw moment. However, in this example a significant increase of the yaw moment is avoided through the rotational upwards movement of the arm 1, as visible in Figure 3c, which shows the vessel under the same condition.

[0085] The interconnected movement of the drift 2 and the arm 1 becomes evident in Figures 3c and 3d showing frontal views of the vessel under the above-mentioned conditions. Regardless of the position the arm takes with respect to the roll (YZ) plane, the drift and the arm are interconnected with respect to their rotational movements around their respective rotational, i.e. axis R3 for the drift 2 and R2 for the arm 1. The projections onto the roll (YZ) plane of the hydrodynamic force F2 created by the drift 2 and the aerodynamic force F1 acting on the arm are therefore continuously balanced, but may exhibit small resulting force, which causes a residual roll moment. Any such residual roll moment can be easily absorbed by the forces F4 created by the buoyant bodies 7.

[0086] A second embodiment of the invention is schematically presented in Figures 4 to 6.

[0087] As shown in Figure 4, the watercraft has a frame 3 is rotatably mounted on the hull 11, so that it can rotate around the longitudinal central axis X of the hull (roll axis). One drift 2 is attached to this frame 3. The drift 2 is arranged for being at least partially submerged when the watercraft is in use. Apart from the rotation around the roll axis X, the frame is fixed relative to the hull 11.

[0088] An aerodynamic towing surface 5 such as a kite-type sail is attached to the frame 3. According to an aspect, a distal end of an arm 1 is rotatably mounted on the frame, so that it can rotate around a rotational axis Z' orthogonal to the roll axis X. The rotational Z' axis performs a rotational movement around the X axis together with the frame 3. Apart from the rotation around the axis Z', the arm is fixed relative to the frame 3. The arm 1 extends in a direction orthogonal to Z'. The aerodynamic towing surface 5 is pivotally attached to the distal end of the arm 1 at the attachment point 1a by traction lines 6.

[0089] Since both, arm 1 and drift 2 rotate around the longitudinal X axis of the hull, the roll offset distance is zero resulting in an elimination of the roll moment in this embodiment.

[0090] The arm 1, drift 2, frame 3 and a connector 4, which attaches the arm 1 to the frame 3 and facilitates its rotational movement around the Z' axis, are located in the stern section of the hull 11b.

[0091] Preferably, the embodiment presented in Figures 4 to 6 features a bilateral symmetry, wherein the central longitudinal axis is part of the sagittal plane dividing the watercraft into mirrored left and right half.

[0092] The hull does not rotate around the roll axis X when it moves faster. As a result, both buoyant bodies 7 can be arranged for floating simultaneously in the water, irrespective of the speed of the watercraft.

[0093] Two coordinate systems could be defined in this embodiment. A first coordinate system XYZ is fixed relative to the hull and comprises the roll axis X along the longitudinal axis of the hull, a pitch axis Y horizontal and orthogonal to X, and a yaw axis Z vertical and orthogonal to X and to Y. A second coordinate system X'Y'Z' is fixed relative to the frame and comprises an axis X' identical to X, an Y' inclined relative to Y by an angle corresponding to the rotation of the frame relative to the hull, and an axis Z' inclined relative to Z by the same angle. The origin of both coordinate systems is identical.

[0094] This arrangement ensures a direct connection of the aerodynamic towing surface 5 with the drift 2. This results in an intrinsic adaptation of the rotational orientation of arm 1 and drift 2, which results in a better balance of the opposing aerodynamic uplift force F1 acting on the attachment point 1a and the hydrodynamic downforce F2 of the drift 2. This balance between the forces stabilises both the roll and yaw moments of the vessel.

[0095] In other words, when the wind becomes stronger, the direction of the force exerted by the surface 5 changes, the surface 5 being more inclined toward the water. This results in a rotation of the frame 3 around the roll axis X, and thus in a rotation of the drift 2 into a less vertical position.

[0096] When projected onto the roll (YZ) plane, the aerodynamic uplift force F1 acting on attachment point 1a and the hydrodynamic downforce F2 generated by drift are intrinsically linked and counter balance one another. F1 and F2 are directed in essentially opposing directions, thus contributing to the reduction of the roll moment acting on the watercraft.

[0097] The residual roll moment is further reduced, preferably eliminated, by the addition of the rear buoyant bodies 7, which furnish the vessel with greater width.

[0098] Figure 6 shows frontal views of the vessel adjusting for different aerodynamic conditions. In Figures 6a the arm 1 is positioned at an angle of 15° with respect to the roll (YZ) plane. In Figures 6b the arm 1 is positioned at an angle of 60° with respect to the roll (YZ) plane.

[0099] As schematically demonstrated in these Figures, the aerodynamic sideway pull F1 is counteracted by the hydrodynamic counter forces created by drift F2.1 at the stern section and rudder F2.2 at the bow section. The sideways pull exerted on the vessel of Figure 6a is larger than the sideways pull acting on vessel of Figure 6b, which experiences a greater forward pull. An increased sideway pull would results in an increased hydrodynamic counter forces F2.1 and F2.2 in Figure 6a in comparison to Figure 6b. Different from the first embodiment presented in Figures 1 to 4, the increased sideways pull F1 is not compensated by a rotational upwards movement of the arm 1. Compared to the example depicted in Figure 3a, the rear drift 2 of the embodiment presented in Figure 6a generates therefore a greater hydrodynamic force F2.1 to counteract the aerodynamic pull force F1.

[0100] The rotational movement of the frame 3 relative to the hull is preferably controlled. In one embodiment, the frame 3 comprises a longitudinal axis 13 that can rotate in bearings fixed to the hull. A damping arrangement exerts a counter-moment on the axis 13 in order to bring the frame 13 into a fixed position when there is no wind, for example a position in which the arm 1 is horizontal. In one example, the damping arrangement comprises a gear mounted on the axis 13 that cooperate with a teethed linear element whose displacement are restricted by a linear damper.

[0101] In a similar way, the rotational movement of the arm 1 relative to the frame 3 is preferably controlled. In one embodiment, the arm 1 is mounted onto an arbor that can rotate in a bearing fixed to the frame. A damping arrangement exerts a counter-moment on the arbor in order to bring the arm 1 into a fixed position when there is no wind. Due to the fixed arrangement of arm 1, frame 3, longitudinal central axis 13 and drift 2, the distance between the rotation axis Z' and the centre of pressure on the drift is constant along X axis at all rotational positions of the arm 1 around the Z' axis.

[0102] The frame 3 of this second embodiment is subject to strong forces and may break. Therefore, the frame 3 needs to be made of a strong and resistant material, such as, preferably, metal or composites

[0103] In both embodiments, the frame 3 and its connected elements, such as the connector 4, the longitudinal central axis 13 and the arm 1 are made of rigid and durable material which is resistant to adverse environmental forces, in particular the corrosive effects of the aquatic environment, which may be fresh of salt water dependent on the use of the watercraft, as well as the significant aerodynamic and hydrodynamic forces acting on said frame and elements. Such suitable material may be, by way of example, without being limited to, a non-corrosive metal, preferably a noble metal, or a surface treated metal, including, without limitation, galvanised steel, stainless steel, platinum or titanium. Further suitable metals or other materials are thinkable.

[0104] The first preferred embodiment of this invention has the distinct advantages that it - is structurally extremely robust and therefore suited also for heavy loads. Robustness and reliable design make it scalable. It is therefore suited also for bigger boats. Compared to the second embodiment, it has a better pitch control. In addition, this preferred embodiment avoids that the arm touches the hull when making tacks and gybes.

Claims

1. A wind-powered watercraft comprising:

    - a hull (11),
    - at least one buoyant body laterally attached at a distance to the stern section (11b) of the hull;
    - one frame (3) rotatably connected to said hull (11) over a first axis (X; R1);
    - one arm (1) rotatably attached to said frame (3) over a second axis (Z'; R2);
    - one drift (2) rotatably connected to said hull (11);
    - an aerodynamic towing surface (5), which is attached to an attachment point (1a) at a distal end of said arm.

2. The watercraft according to claim 1, wherein the projection onto the yaw (XY) plane of the pivot of the arm around the Z axis and the projection onto the yaw (XY) plane of the centre of hydrodynamic pressure on the drift are offset.

3. The watercraft according to claim 1 or 2, wherein said first axis (R1) is orthogonal to the yaw plane (XY) of the hull and wherein said second axis (R2) is orthogonal to said first axis (R1).

4. The watercraft according to claim 3, wherein said drift (2) is rotatably connected to the hull (11) over a third axis (R3) in the yaw (XY) plane of the hull (11).

5. The watercraft according to claim 4, wherein the second axis (R2) comprises a first hydraulic cylinder, wherein the third axis (R3) comprises a second hydraulic cylinder (14), and wherein the first and second hydraulic cylinder are hydraulically connected.

6. A wind-powered watercraft according to any of the claims 3 to 5, wherein the second axis (R2) is in a plane which is parallel to the yaw (XY) plane of the hull (11).

7. The watercraft according to claim 1, wherein said first axis (X) is a longitudinal axis (13) of said watercraft, and wherein said drift (2) is mounted on said frame (3) so as to rotate with said frame (3) around said first axis (X).

8. The watercraft according to claim 7, wherein said second axis (Z') is orthogonal to said first axis (X) and performs a rotational movement around said X axis together with said frame 3.

9. A wind-powered watercraft according to any of the claims 7 or 8, comprising damping means for damping the rotational movement of said frame (3) with regard to said hull (11).

10. A wind-powered watercraft according to any of the preceding claims, wherein the rotational movement of the arm (1) around the rotational axis R2 respectively X and the rotational movement of the drift (2) around the axis R3 respectively X are interconnected.

11. A wind-powered watercraft according to any of the preceding claims, wherein the rotational angles of the arm (1) and the drift (2) around their respective rotational axes contained in an (XY) plane with respect to the watercraft, are identical or matched.

12. A wind-powered watercraft according to any of the preceding claims, wherein the vertical forces exerted on the vessel by the aerodynamic towing surface (5) is at least partially compensated by the rotational movement of the drift (2).

13. A watercraft according to any of the preceding claims, whereby said aerodynamic towing surface (5) comprises a kite-type sail, which is connected to the arm (1).

14. A watercraft according to any of the preceding claims, whereby said frame (3) is rotationally attached to or embedded in the stern section (11b) of the hull.

15. A watercraft according to any of the preceding claims, comprising one rudder (8) to steer the watercraft, said rudder being shorter than the drift (2).

16. A watercraft according to any of the preceding claims, whereby the watercraft is a closed hull vessel with a cockpit.

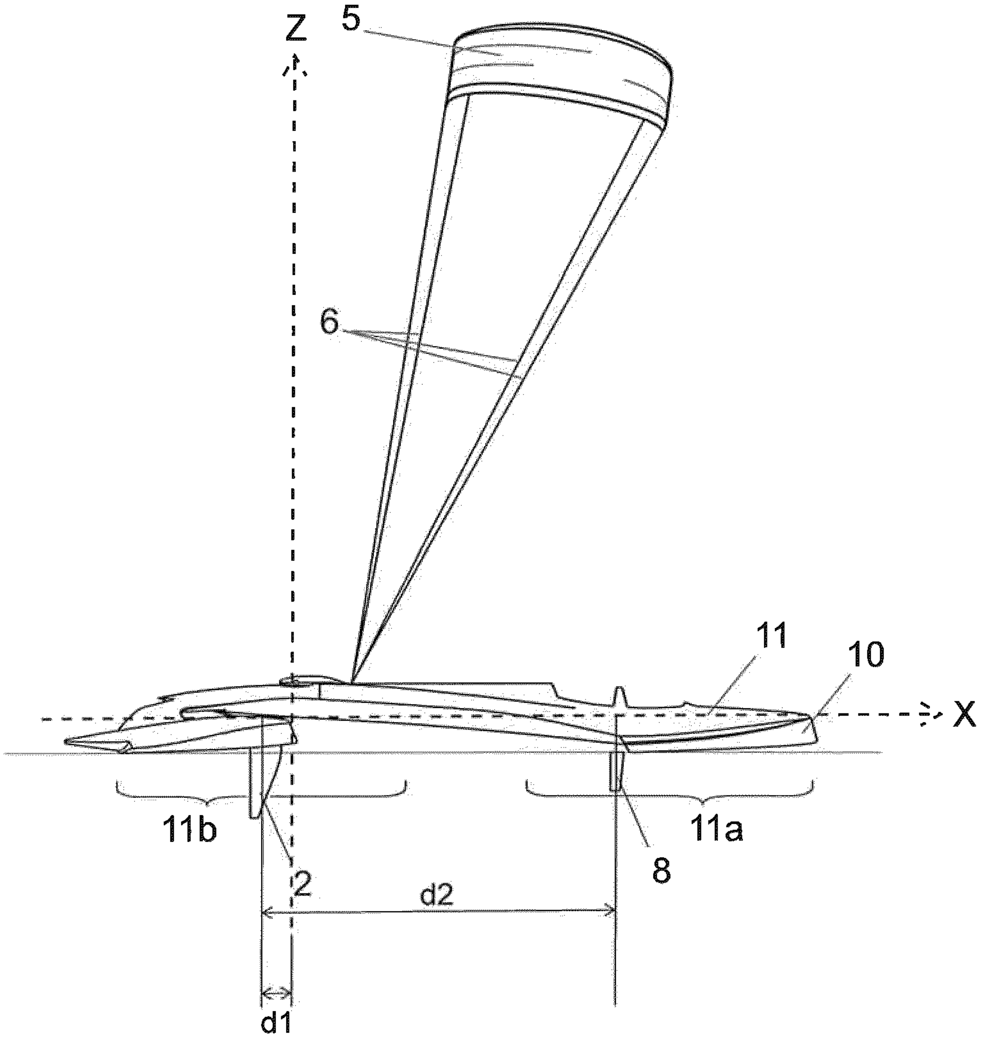

Fig.1a

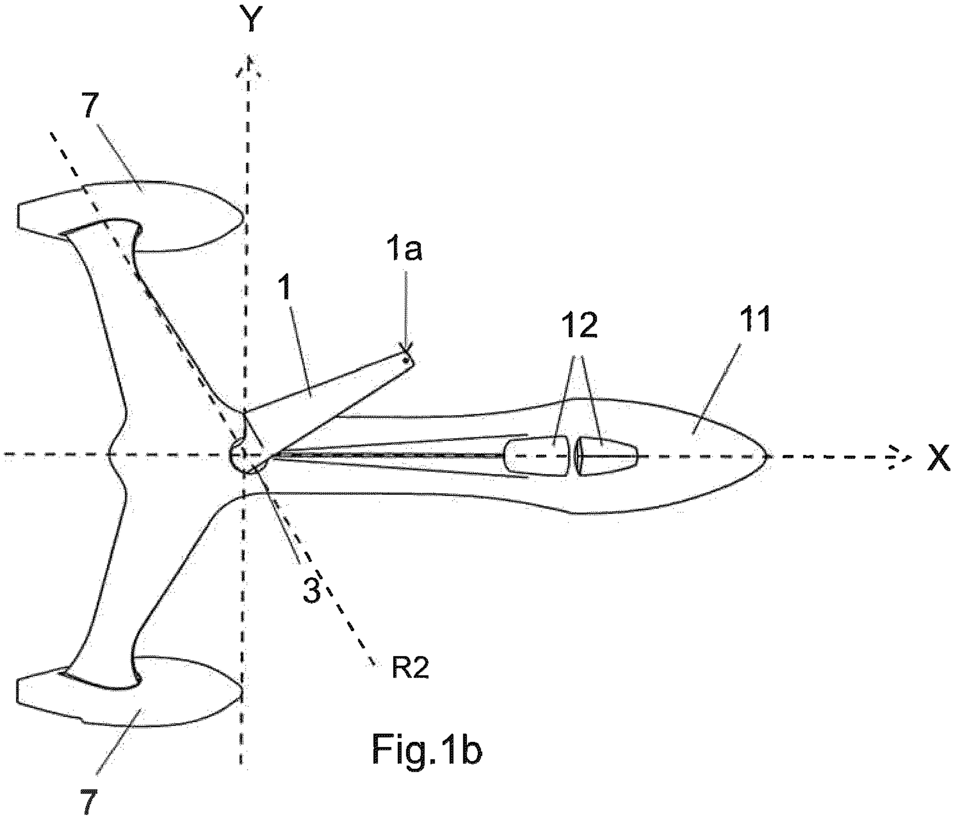

Fig.1b

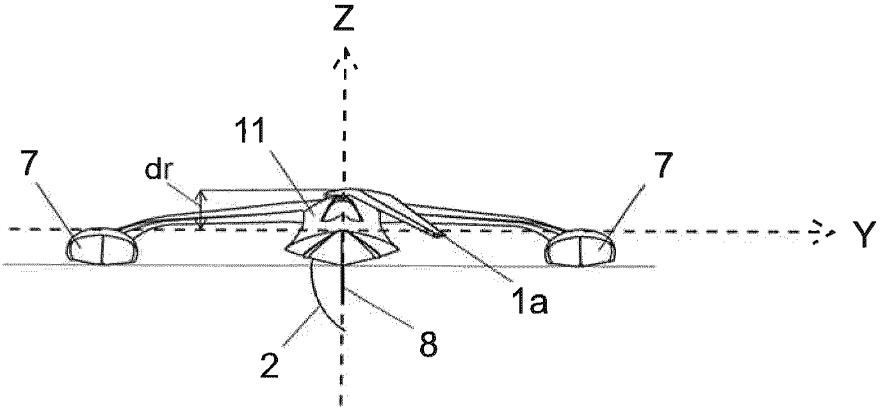

Fig.1c

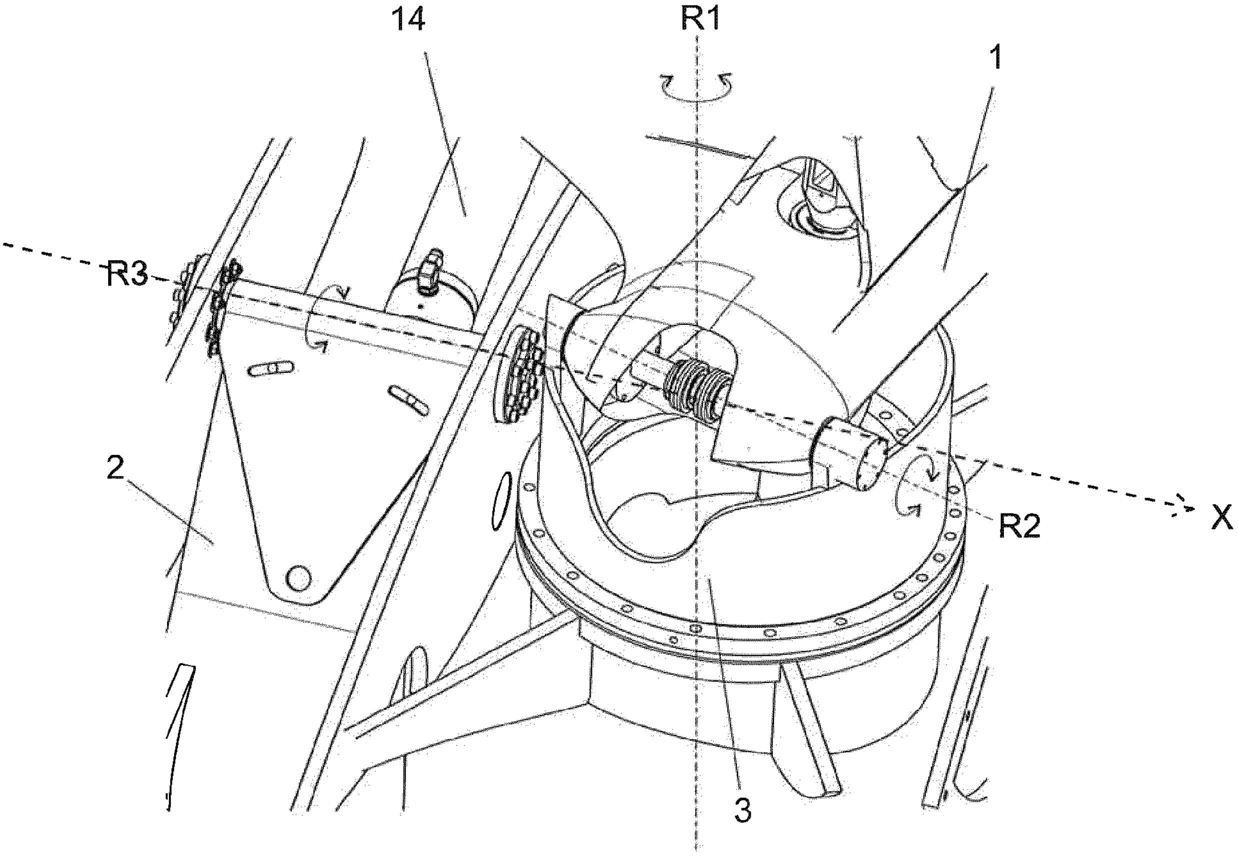

Fig.2a

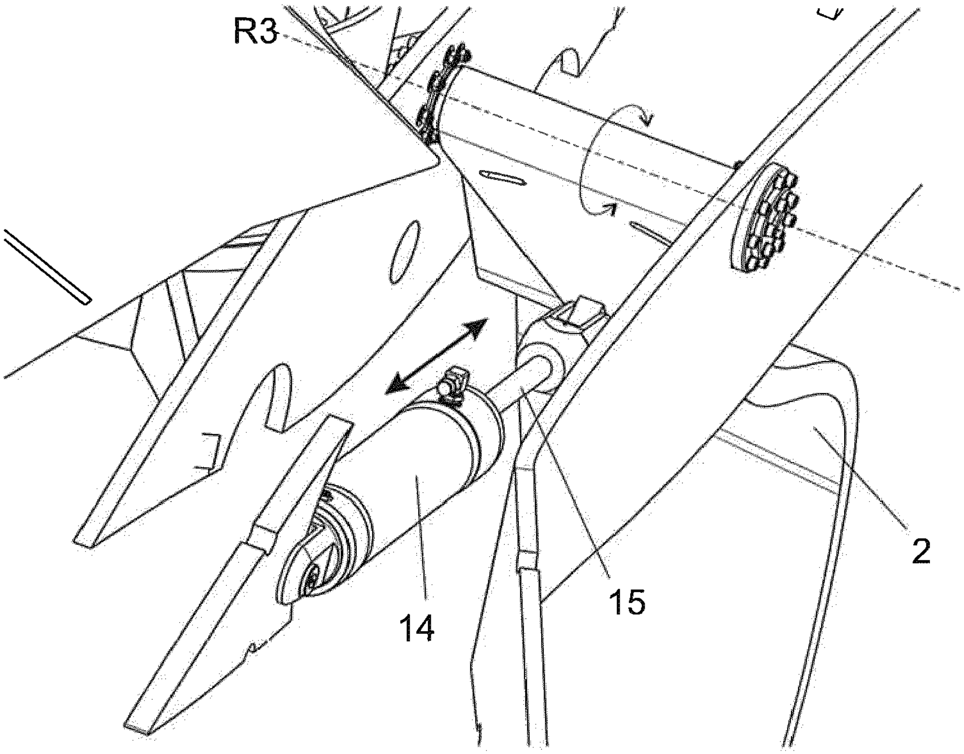

Fig.2b

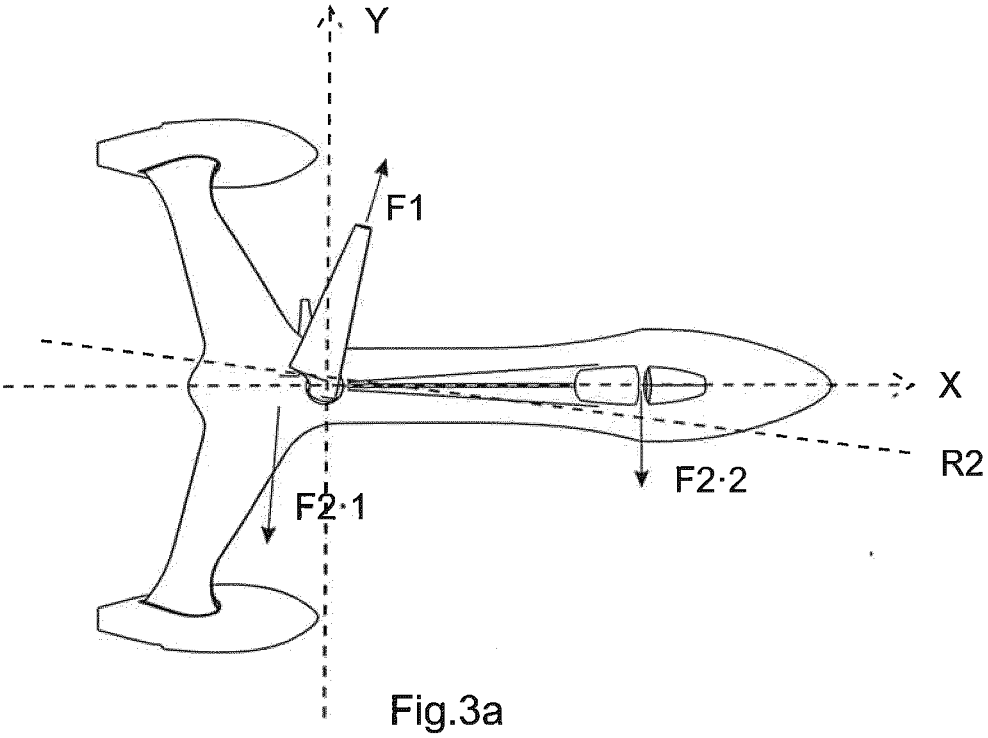

Fig.3a

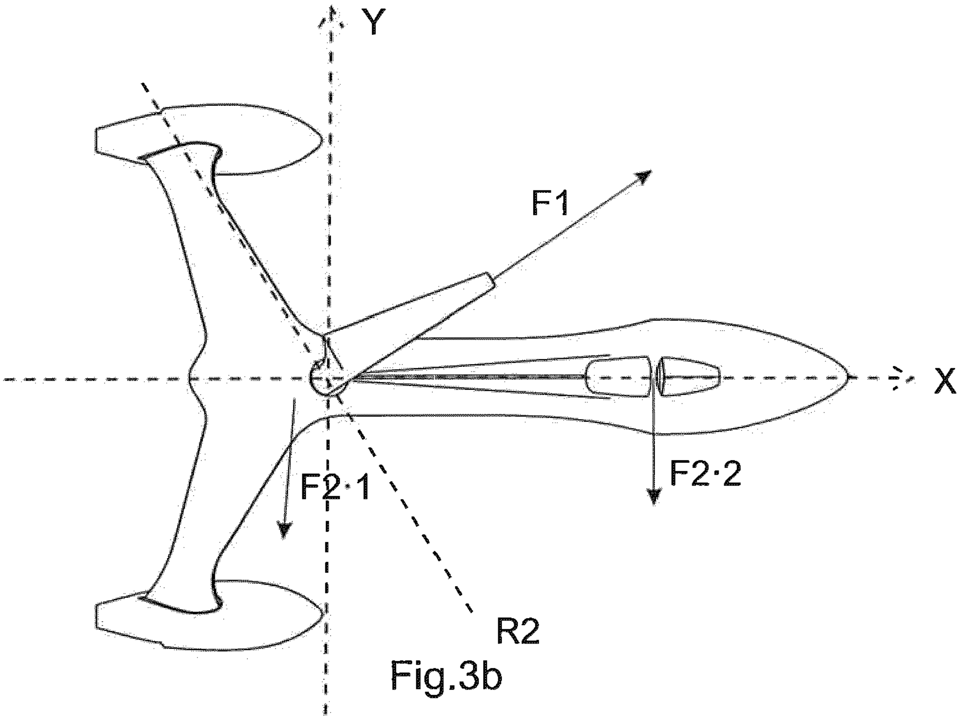

Fig.3b

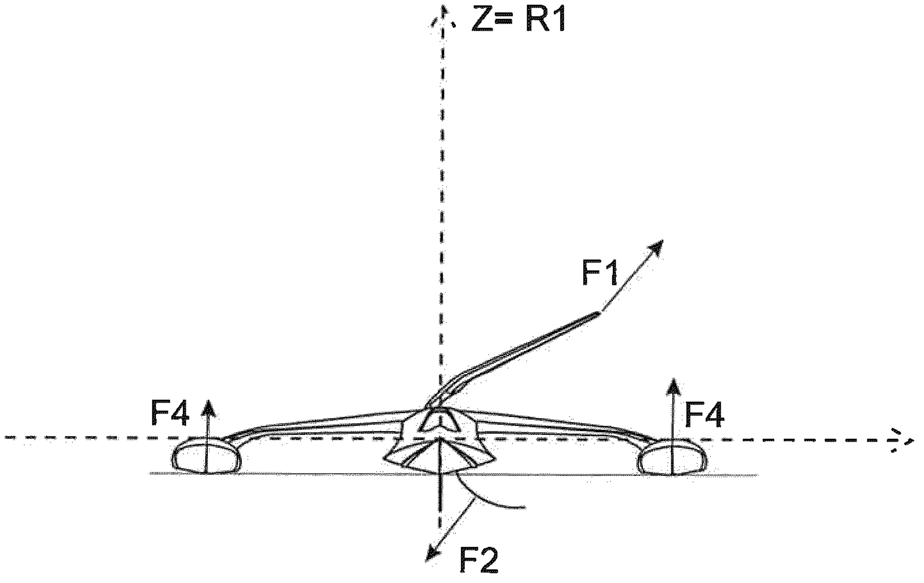

Fig.3c

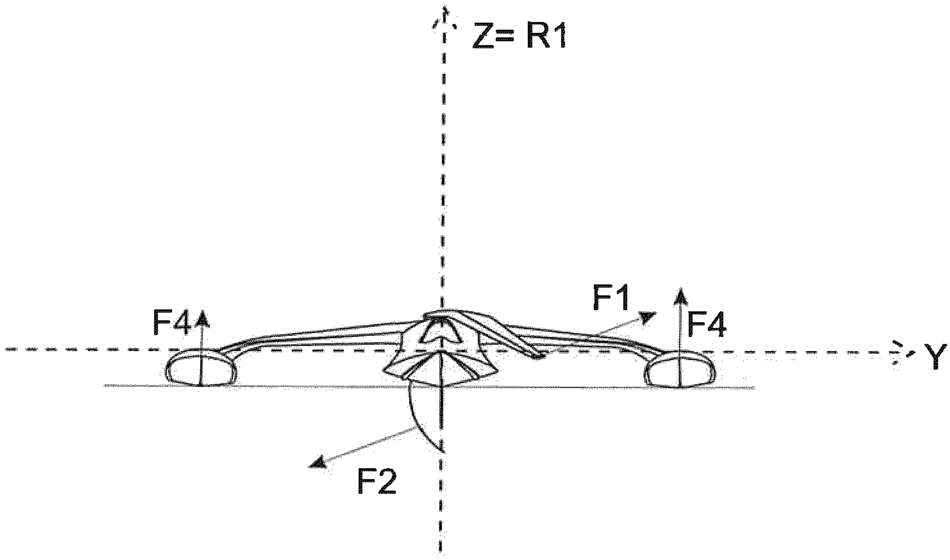

Fig.3d

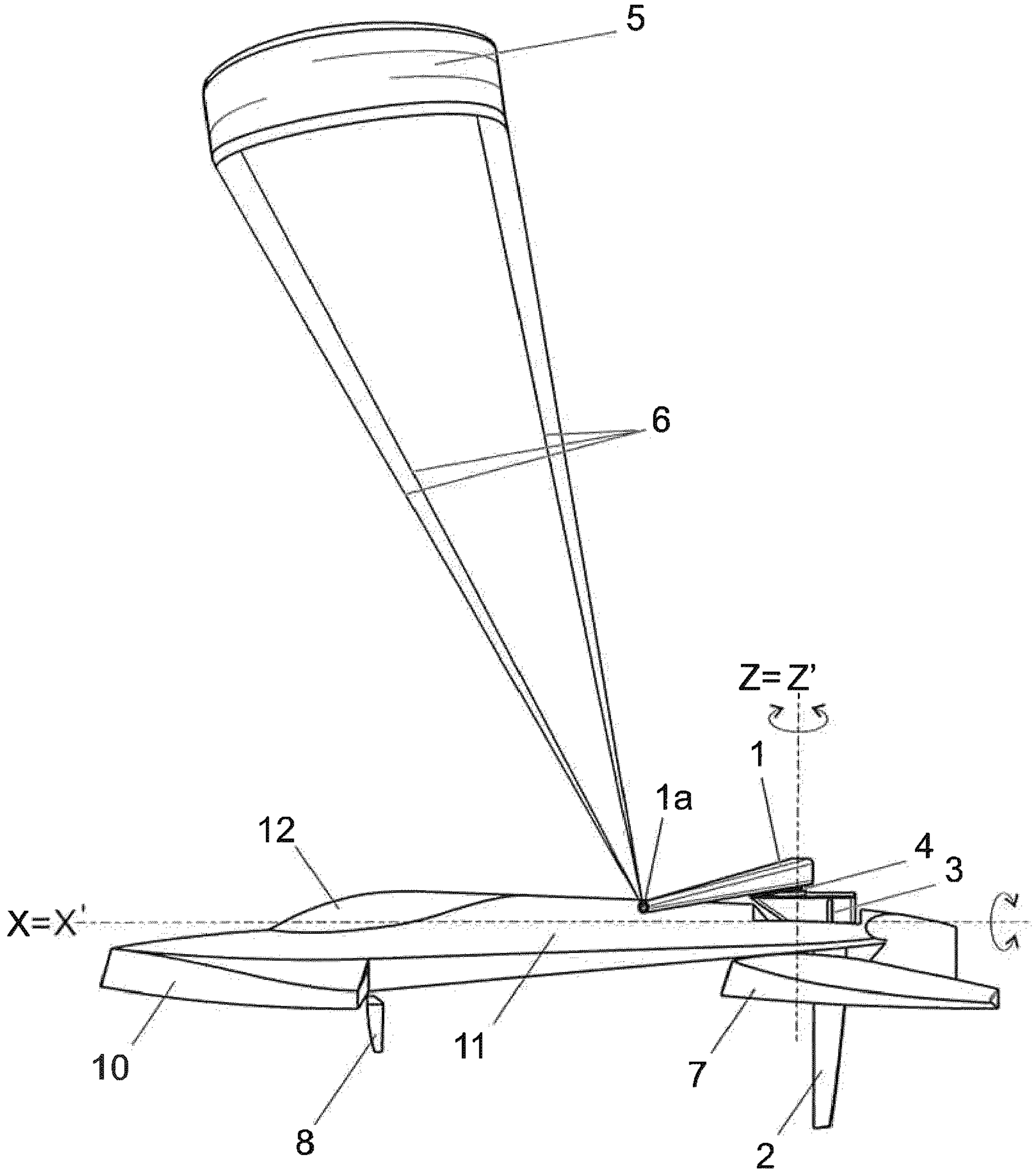

Fig. 4a

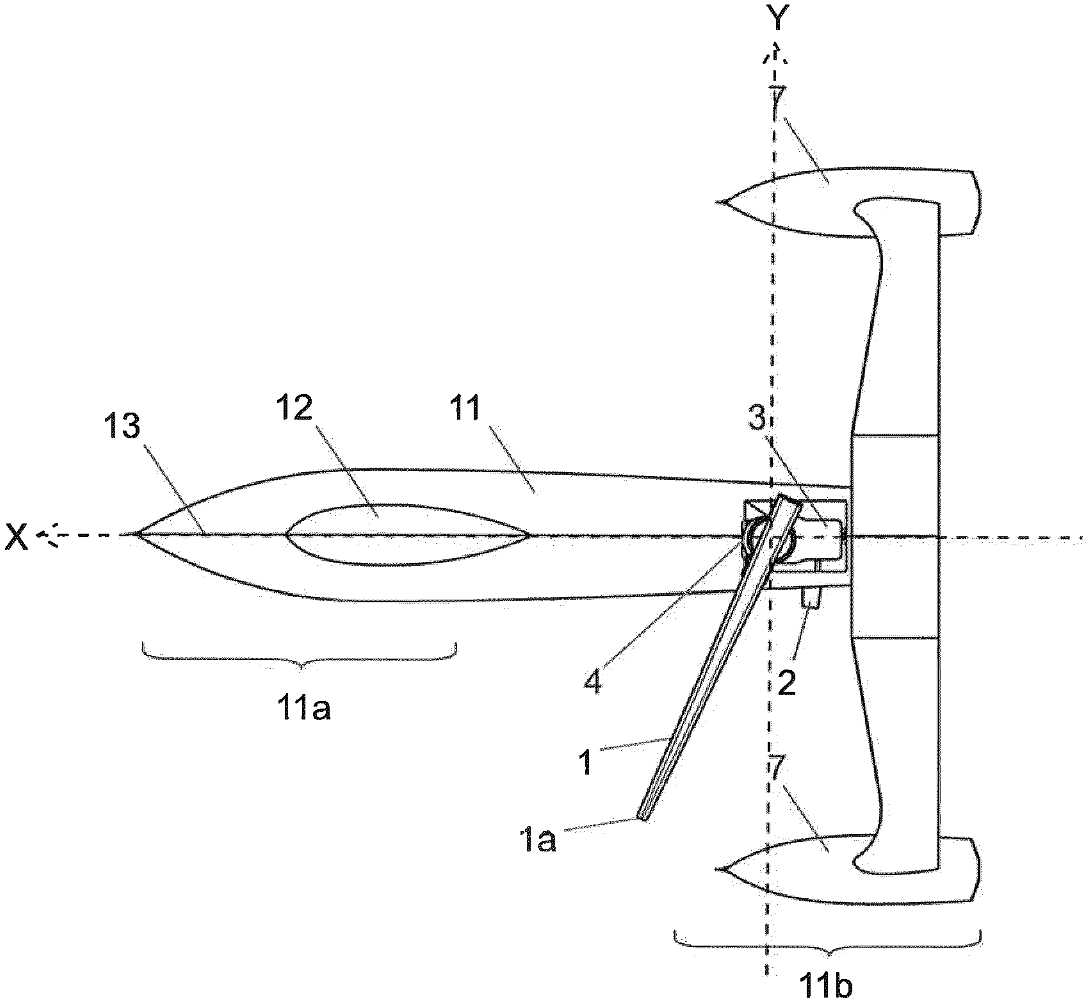

Fig. 4b

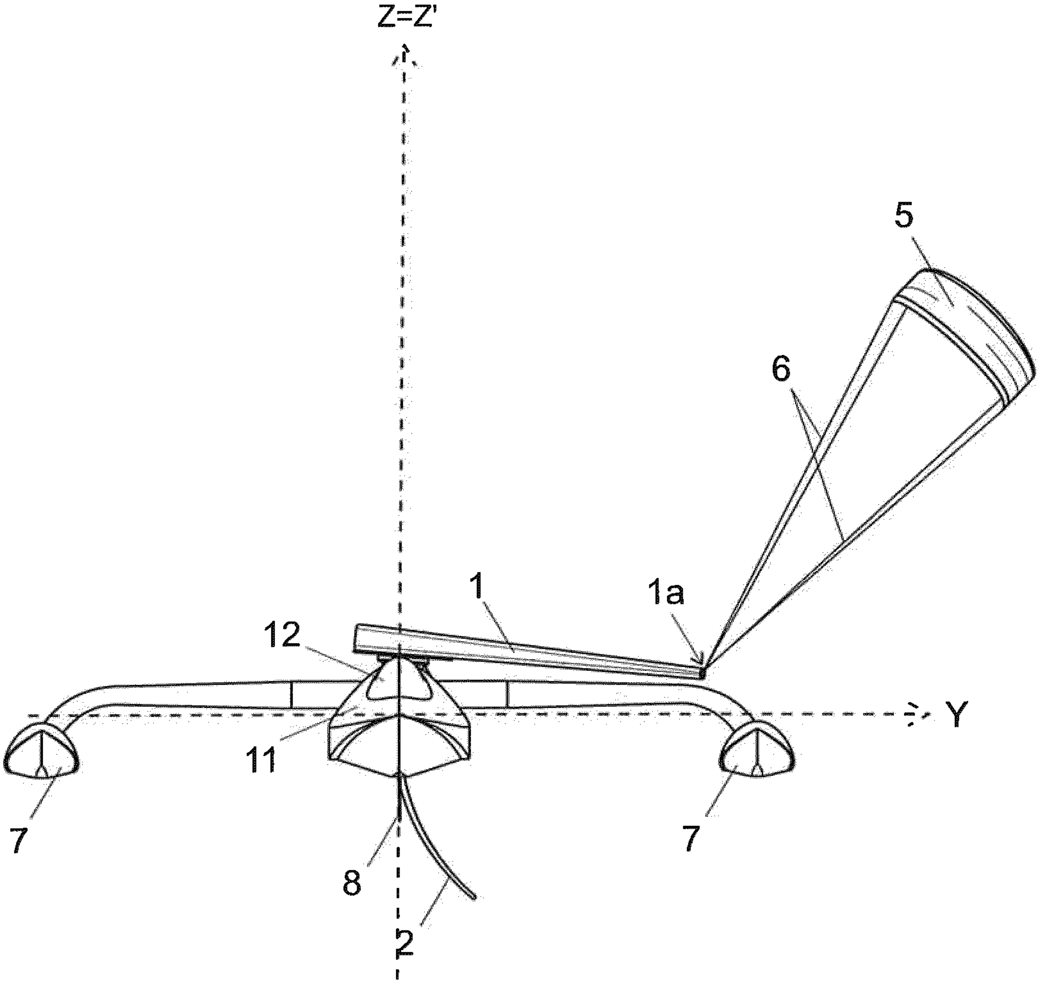

Fig. 4c

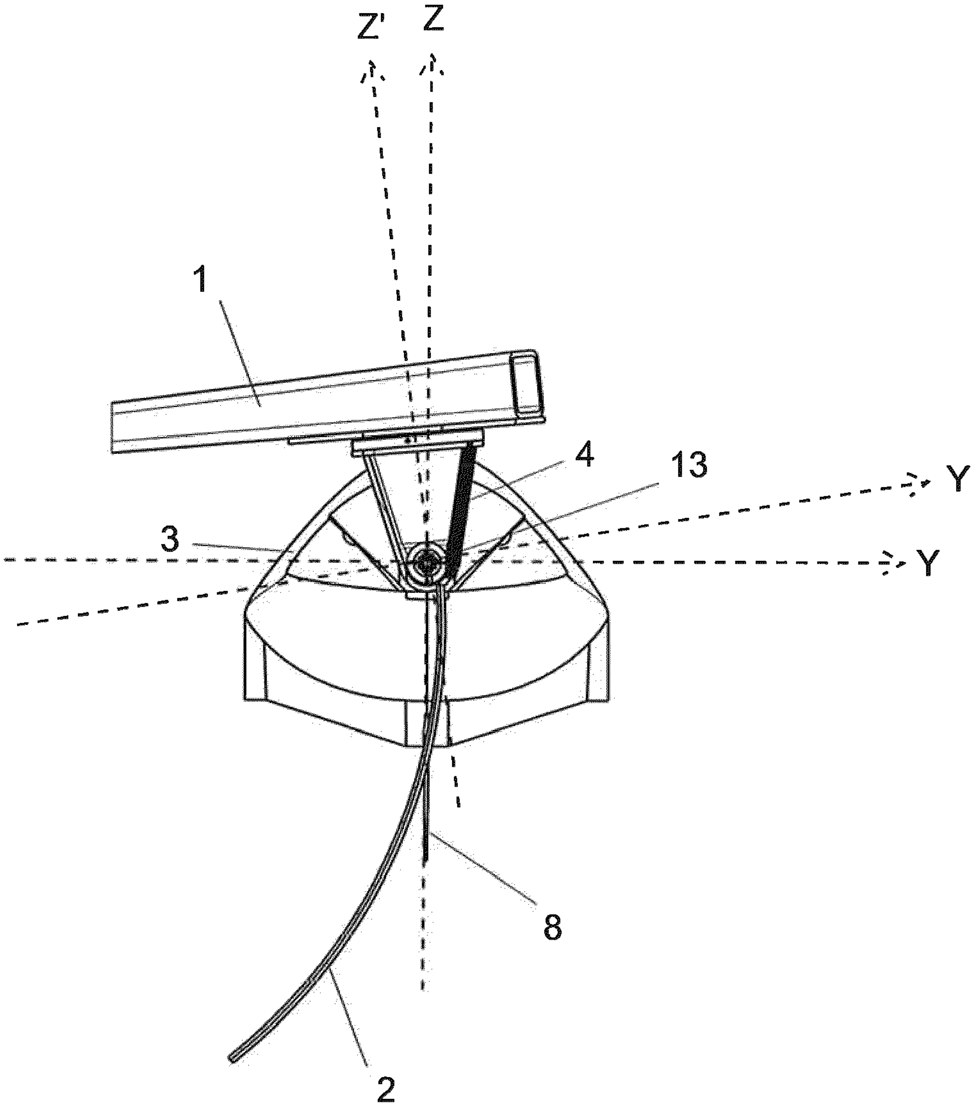

Fig. 5

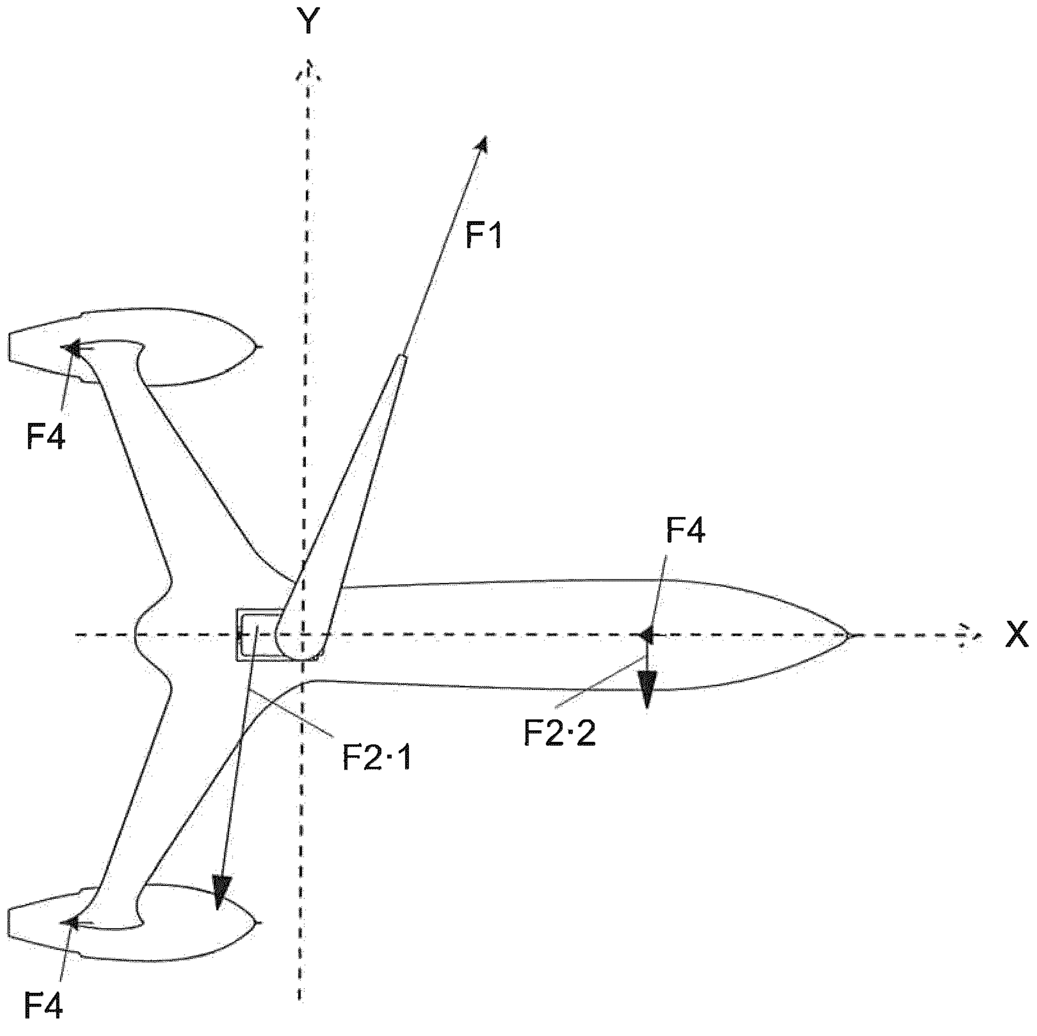

Fig. 6a

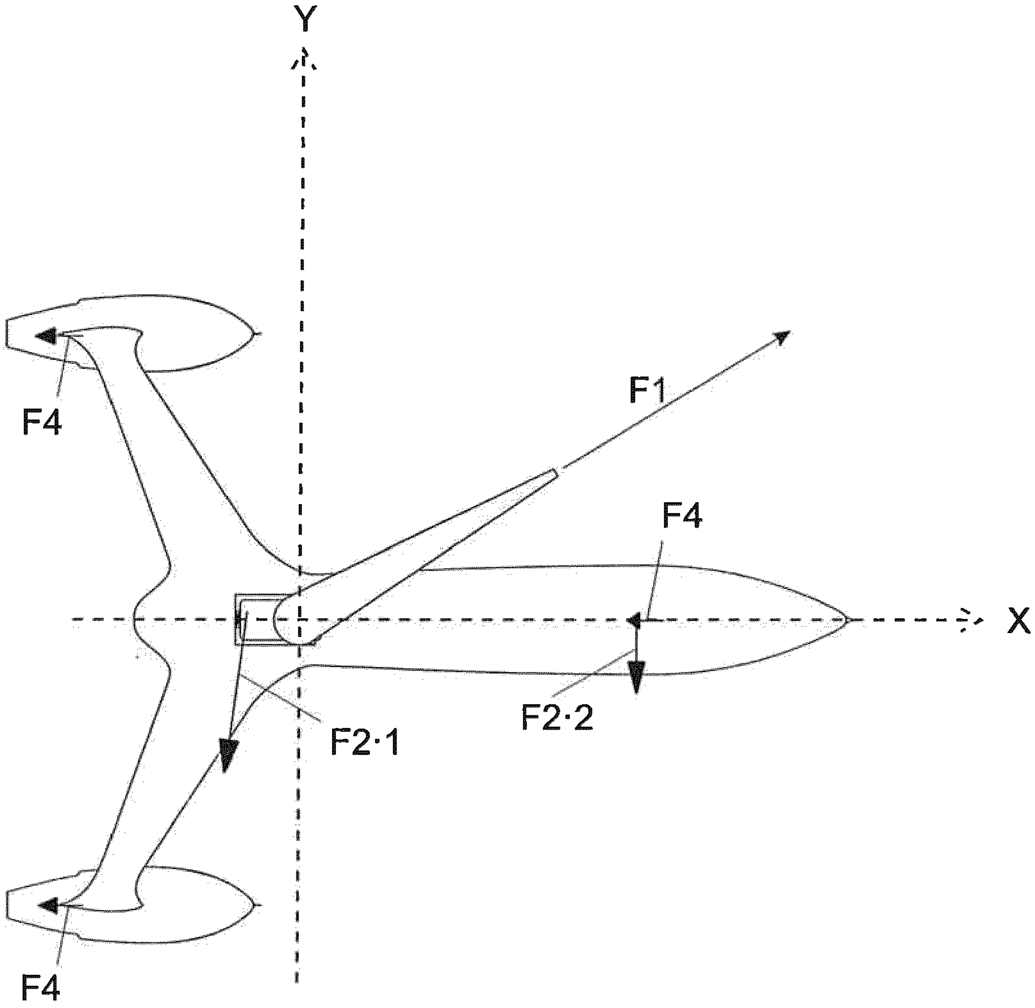

Fig. 6b

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 20 18 6402

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 A	US 2003/121462 A1 (RAYNER WILLIAM RICHARDS [AU]) 3 July 2003 (2003-07-03) * paragraph [0031] - paragraph [0032]; figures 3,10 * -----	1-4,6-9, 11,16 5,10,13	INV. B63B1/12 B63B1/24 B63H9/072
X,D	Editor: "SP80. Un engin suisse vise 80 noeuds à la voile, alors que le record du monde est à 65 !", , 19 November 2019 (2019-11-19), XP055765735, https://voilesetvoiliers.ouest-france.fr/ Retrieved from the Internet: URL:https://voilesetvoiliers.ouest-france.fr/bateau/foiler/sp80-un-engin-suisse-vise-80-noeuds-a-la-voile-alors-que-le-record-du-monde-est-a-65-f8b54cae-0ad3-11ea-adb7-776ec54bacaf [retrieved on 2021-01-15] * the whole document * -----	1,7-9, 12-16	ADD. B63B1/18 B63B1/28
X,D	US 6 789 489 B1 (PHIPPS JEFFREY S [US]) 14 September 2004 (2004-09-14) * column 3, line 9 - column 4, line 38; figures 3-9 * -----	1,3,4, 6-16	TECHNICAL FIELDS SEARCHED (IPC)
X	US 6 003 457 A (CHATELAIN PIERRE [FR]) 21 December 1999 (1999-12-21) * column 4, line 54 - column 5, line 65; figures 1-3 * -----	1,3,6, 13,15,16	B63B B63H
X	WO 2010/002253 A2 (ZWIJNENBERG EVERT HENDRIK WILL [NL]) 7 January 2010 (2010-01-07) * page 5, line 22 - page 6, line 9; figures 4,5 * ----- -/--	1,3,6,13	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	15 January 2021	Schmitter, Thierry

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

2

EPO FORM 1503 03.82 (P04C01)

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 20 18 6402

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	DE 24 31 710 A1 (BARTHOLLY WOLFGANG ING GRAD) 22 January 1976 (1976-01-22) * figures * -----	1,3,6, 15,16	
X	NL 1 023 770 C2 (GOUDRIAAN DONALD HENDRICUS JAC [NL]) 11 December 2003 (2003-12-11) * page 3, line 19 - page 4, line 28; figure 4 * -----	1,3,4, 6-12, 14-16	
A	WO 2011/076270 A1 (DUBOIS PHILIPPE [CH]) 30 June 2011 (2011-06-30) * figures 7, 9a-9d * -----	1-16	
A	FR 2 707 588 A1 (COSTES DIDIER [FR]) 20 January 1995 (1995-01-20) * figures * -----	1-16	

TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	15 January 2021	Schmitter, Thierry

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
....
& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 20 18 6402

15-01-2021

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003121462 A1	03-07-2003	NONE	
US 6789489 B1	14-09-2004	NONE	
US 6003457 A	21-12-1999	AU 7308896 A	15-05-1997
		EP 0853576 A1	22-07-1998
		FR 2740427 A1	30-04-1997
		NZ 320358 A	24-09-1998
		US 6003457 A	21-12-1999
		WO 9715490 A1	01-05-1997
WO 2010002253 A2	07-01-2010	CN 102131697 A	20-07-2011
		EP 2307268 A2	13-04-2011
		JP 2011526855 A	20-10-2011
		KR 20110027794 A	16-03-2011
		NL 2001758 C2	05-01-2010
		US 2011154930 A1	30-06-2011
		WO 2010002253 A2	07-01-2010
DE 2431710 A1	22-01-1976	NONE	
NL 1023770 C2	11-12-2003	NONE	
WO 2011076270 A1	30-06-2011	NONE	
FR 2707588 A1	20-01-1995	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- FR 3070157 **[0010]**
- FR 2945025 **[0011]**
- DE 202015006950 U1 **[0012]**
- US 6789489 B **[0013]**
- WO 18234969 A **[0014]**
- FR 2978420 **[0015]**

Non-patent literature cited in the description

- *Voiles et Voiliers,* 05 March 2020, https://voilesetvoiliers.ouest-france.fr/bateau/foiler/sp80-un-engin-suisse-vise-80-noeuds-a-la-voile-alors-que-le-record-du-monde-est-a-65-f8b54cae-0ad3-11ea-adb7-776ec54bacaf **[0016]**