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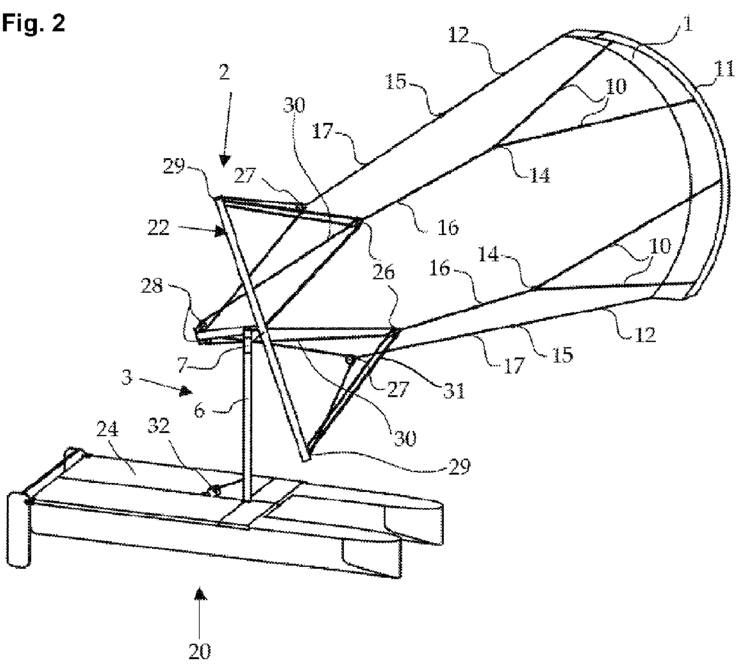
(54) **Title**: STABILIZATION AND ORIENTATION CONTROL MECHANISMS FOR WINGS OR POWER KITES INCLUDING A WING

Fig. 2



(57) **Abstract**: A stabilization mechanism (2) is disclosed, for automatically providing flight stability in variable winds to a wing (1) or to a power kite including a wing (1), the wing having a group of suspension front lines (10, 66) and a group of suspension steering lines (12, 67) each of which has a front attachment point (14), respectively, a steering attachment point (15). This mechanism comprises a frame (22) wherein at least three connection points are provided on the frame for connecting the kite attachment points in order to connect the wing to the stabilization mechanism. The latter is characterized by the fact that the connection points are distributed on the frame along at least two distinct lines. In a preferred embodiment, the mechanism further comprises stabilization organs (30) arranged to mechanically connect each steering attachment point (15) to at least one of the front attachment points (14), such that each steering attachment point presents a distance to the stabilization mechanism that is a function of the characteristics of the tension incurred by at least one of the front lines (10, 66). To achieve this result, front and steering lines (10, 66, 12, 67) may be mechanically connected to each other by means of guiding organs (26, 27, 28, 29, 70), which preferably include pulleys. The invention also relates to a control device including a stabilization mechanism and further comprising an orientation unit that links the stabilization mechanism to a platform that is pulled by the kite and provides for the stabilizer frame with at least two degrees of rotation freedom.

Description

STABILIZATION AND ORIENTATION CONTROL MECHANISMS FOR WINGS OR POWER KITES INCLUDING A WING

Technical field

[0001] The present invention relates to a stabilization mechanism or stabilizer, for automatically providing flight stability in variable winds to a wing or to a power kite including a wing, the wing having a group of suspension front lines and a group of suspension steering lines each of which has a front attachment point, respectively, a steering attachment point. The stabilization mechanism has a frame wherein at least three connection points are provided on the frame for connecting the kite attachment points in order to connect the wing to the stabilization mechanism.

[0002] The invention further relates to a control device comprising such a stabilization mechanism as well as an orientation unit including a base and a linking organ arranged to mechanically link the base to the stabilization mechanism such that the latter is provided with at least one degree of rotation freedom with respect to the base.

[0003] The invention still further relates to a vehicle propelled by means of a wing or of a power kite including a wing, and comprising such a stabilization mechanism or such a control device.

Background art

[0004] Aerodynamic wings flying captive in windy conditions when attached with rope(s) or line(s) to the ground or a vehicle have been existing for many centuries and are best known as kites.

[0005] However collecting the wind energy with kites has only been developed during the past decades. These developments concern both: the traction of vehicles, as disclosed for instance in EP 1740452 A1 and the transformation of energy, as disclosed for instance in US 2009/0090815 A1.

[0006] To satisfy these applications, the force has to be controlled in direction and magnitude, and therefore the kite has to have orientation capabilities while having a variable incidence angle (pitch).

[0007] Advanced power kites, for instance in EP 1878659 A2 or in US 3,285,546, that gained steering capability and efficiency present poor stabilities that require them to be constantly steered to maintain them flying, i.e. wind inconsistencies produce kite rotation (yaw) and angular translation (pitch and roll) that have to be compensated by active steering. Until now, active steering has been used to provide both: kite stability to the kite and kite orientation relative to the wind and the vehicle.

[0008] Unfortunately, such demanding effort of the pilot has prevented a wide use of power-kites in some applications.

[0009] On the one hand, active kite steering is very useful in some towing applications like kite surfing where one needs to maintain the kite stability by keeping the pull constant or create time limited strong pulls to lift the kite surfer.

[0010] On the other hand, in other applications only orientation of the kite is required. For instance on a boat towed by a kite, one wants to orient the kite in a manner that enables the boat to maintain a certain orientation and speed relative to the wind, but there is no need to achieve a constant pull to maintain boat stability, boats being relatively self-stable. On boats, a kite that shows self-stability and safety for the boat and the boats around is advantageous.

[0011] The length of the lines attaching the kite is a major issue for watercrafts around in case the kite falls into the water, shorter lines being safer. Unfortunately, kites attached with short lines have high speed of oscillation and become difficult to control by manual steering. Also shortening attaching line length tends to deform the power kite shape if it is designed to fly with longer lines.

[0012] An example of free flying kite attached to a boat is described in US 2005/0127240. This kite, while presenting the advantage of not requiring constant steering, has poor aerodynamic efficiency. Such a kite does not allow a boat to reach high speed or cruise upwind (close hauled).

[0013] An example of traction kite that can be oriented by a rigid frame is given in FR 2690129 A1. This orientation system enables the kite to be oriented only around one axis, not allowing the leading edge of the kite to deviate from an essentially horizontal orientation, thereby limiting the use of this system. In this system, a gas which is lighter than air fills the kite chambers to contribute to the kite stability. No automatic stabilization within the control options other than steering has been considered.

[0014] An example of orientation of a wing attached with rigid links very close to the boat is given in US 2003/0121462. This system presents the advantage of allowing full orientation of the wing in suitable direction relative to the apparent wind. However, the rigid link between the boat and the wing practically limits the distance to the wing and thereby its size. Since the positioning of the wing is rigid no stabilization is used. Also the orientation is provided by actions from the boat pilot on the wing itself.

[0015] Another example of the quest for sails attached to a boat that can be oriented is given in US 4,068,607. In this disclosure, a complex structure allows a sail having a rigid leading edge to be oriented while being maintained at the top of a mast. While this system presents the sail orientation advantage, the structure appears very heavy what certainly limits its practical use.

[0016] Examples of stabilization of the kite/wing with elements that fly with the kite are given in US 4,497,272 and EP 1373065 B1. In these systems designed for boats, during the launching phase, a smaller self-stable single line kite or balloon guides the main steerable kite. This stabilizing approach presents the drawback of increasing kites drag during the navigation, thereby reducing the aerodynamic efficiency of the system.

[0017] An example of positioning the kite relative to the boat is given in EP 1313642 A1. Since the orientation of traction of a kite relative to the boat varies for different points of sailing (orientation of the boat relative to the wind), some have looked for a system to keep the kite pilot facing the kite. This system enables also the kite pilot to steer the boat.

[0018] Another example of positioning the kite relative to the boat is given in DE 19928166 A1. This disclosure focuses on the optimization of the location of the resultant kite traction force. A system for steerable power kite is presented that enables to adjust the position of the kite traction force along the length of the boat as well as vertically.

[0019] An example of facilitating the steering of a kite attached to a platform is given in FR 2886917 A1. A stick is proposed to steer a kite with only one hand. This steering system can be advantageous on boats where other operations than kite steering have to be conducted.

[0020] An example of electric control of power kites for boat traction is given in EP 1740452 A1. This document discloses the advantageous characteristic of comprising a flying control unit that is located close to the kite and attached to the boat with a single line. This attachment line has two functions: providing a mechanical link with the boat and carrying electric power transmission to the flying control unit. The system is designed to let the kite fly at a high altitude to reach stronger winds. This system is completely electrically controlled and is particularly well suited on large watercrafts.

[0021] Only power kites that have efficient aerodynamic profiles such as ram air foil kite (US 3,285,546) or semi-rigid leading edge kite (EP 1878659 A2) enable vehicles to reach high speed and to be driven upwind (close hauled). Unfortunately these efficient kites are also the most unstable. Reported approaches to control efficient power kites on vehicles assume they have to be continuously steered, either by a pilot (DE 19928166 A1) or by an electronic control system (EP 1740452 A1).

Disclosure of the invention

[0022] A goal of the present invention is to provide a system that enables the pilot of a vehicle towed by a power kite to not continuously steer the kite to maintain it flying, but only modify the kite orientation when desired, especially when the vehicle trajectory relative to the wind changes on purpose.

[0023] In addition, other goals of the invention are to facilitate the use of a kite on a boat and to reduce the risk of collision with other watercraft or obstacles by keeping the kite close to the vehicle.

[0024] Stabilizing, with a mechanical system, efficient power kites to the point where they don't have to be continuously steered, i.e. behave as self-stable kites, while enabling them to maintain various orientations is an approach that has not been explored yet. This opens a different area of kite control, where developments related to kite active steering are not applicable. With such an approach the control of a power kite can be decomposed into two units, a kite stabilizer and a stabilizer orientation unit, thus enabling the pilot to limit its actions to punctual changes of kite orientation, thereby providing free time for other actions such as boat steering.

[0025] As a consequence, the present invention relates to the decomposition of the control of a kite into two separate units: a 1st unit to provide self-stability to a power steerable kite with a mechanical system, and a 2nd unit to orient the stabilizer and the kite relative to the wind and/or to a vehicle or a fixed support. The second unit may allow modifying the orientation of the stabilizer and blocking it in any suitable position. When the second unit is blocked, the kite self-flies with a defined orientation without requiring steering of the pilot. The system self-compensates for moderate wind inconsistencies making the control of the kite less astringent.

[0026] To that end, embodiments of the present invention include in particular a stabilization mechanism as described above, characterised by the fact that the kite suspension line connection points are distributed on the stabilization mechanism frame along at least two distinct lines.

[0027] The fact that at least some of the connection points are distant from each other, while being not distributed on a single line, provides a stabilization effect.

[0028] According to a preferred embodiment, the stabilization mechanism comprises stabilization organs, which may be lines for instance, arranged to mechanically connect each steering attachment point to at least one of the front attachment points, such that each steering attachment point presents a distance to the stabilization mechanism that is a function of the characteristics of the tension incurred by at least one of the front lines. In particular, the length of the steering lines may vary as a function of the tension value or of the tension direction, or both.

[0029] Thanks to this feature, such a mechanical stabilization unit for power/traction kites makes a steerable kite self-stable. A steerable kite attached to this stabilization system becomes self-flying and does not need to be steered. More precisely, the stabilization mechanism according to the invention stabilizes the power kite in angular translation (roll and pitch) and rotation (yaw). The combination of these stabilization effects prevents the kite from the need to be steered manually. Making the kite follow a lateral trajectory that has a radius of curvature larger than as with direct simple lines connections reduces oscillation frequency in translation (roll), thereby providing time for the rotation corrections (yaw) to take effect. The stabilization in rotation is obtained by an inner stabilizer measurement of the elevation of the front lines attachment points. A difference of elevation between the front lines attachment points corresponds to a rotation of the kite (yaw tilt) when perturbed by inconsistent winds. This mechanical measurement of the front lines elevation (height in the kite flying window) is made possible by a link between elements guided by the front lines and the back lines. This automatic control of the front lines elevation controls as well the elevation of the kite in its flying window and its incidence angle (its pitch).

[0030] By way of the line connection, a kite stabilization feedback is provided based on the use of the greater traction force of kite front lines compared to its steering back lines. The system measures the elevation of the kite attachment points to the stabilization mechanism and uses it as an input to vary the length of the stabilizer back lines. To do so, the suspension lines are linked to each other through the stabilization mechanism in a way that some lines provide a feedback to the steering lines in order to automatically compensate for kite rotational (yaw) or elevation perturbations.

[0031] In a preferred embodiment, the front and steering lines are mechanically connected to each other by means of guiding organs arranged in the stabilizer, such as pulleys for instance, while the distance between the kite and the stabilization mechanism may be extended by using pre-lines.

[0032] The stabilization mechanism frame may further bear at least a first pair and a second pair of pulleys, the front lines or front pre-lines bearing at least a third pair of pulleys, the steering lines or steering pre-lines bearing at least a fourth pair of pulleys. A first stabilization line and a second stabilization line may then be mechanically connected to a first, respectively a second, pulley of each of the first, second, third and fourth pairs of pulleys. The stabilization lines may be ropes or cables, for instance.

[0033] Such a purely mechanical kite stabilization mechanism is particularly efficient when the kite flies close to the towed vehicle, i.e. at a distance smaller than 3 times the wingspan.

[0034] The ropes and pulleys are arranged in a way to reduce instabilities of the kite. The frame, which may be large, provides spaces between some ropes and pulleys attachment points that favor kite shape preservation and kite stability. The frame may typically measure 0.3 to 1.5 times the wingspan.

[0035] According to a preferred embodiment, the frame may have a substantially T shape having a small beam and a large beam substantially perpendicular to each other. Such a shape helps in providing space between front-lines, between back-lines and between front and back-lines, making their respective connection points on the frame be distant from each other. Fixed guiding organs such as pulleys may be located on each beam, preferably close to its extremities.

[0036] Based on what precedes, it appears that the stabilization mechanism may guide the attachment points of the kite suspension lines or pre-lines to follow elliptic trajectories when the kite shows a lateral motion. Elliptic trajectories reduce the natural frequency of oscillation of the system when the kite flies close to the frame. The elliptic trajectories may be obtained by guiding the kite attachment pulleys on ropes that are connected to two points and form a triangle of variable shape. Front stabilization ropes may be respectively connected at one extremity to the end of the long frame beam, and at the other to the middle of the long beam. In that case where only the long beam of the frame is required, the kite needs to be actively steered by a pilot by pulling on stabilization mechanism steering lines. Such a system enables manual steering of a kite in short lines as well as in long lines. The elliptic trajectories of kite attachment points greatly stabilize the kite in translation and, by reducing the lateral oscillation frequency, enables a feedback on the steering lines to have time to take effect. Elliptic trajectories of kite attachment points may also be implemented in a kite electric control system to facilitate the kite stabilization in short lines.

[0037] Advantageously, each stabilization line, or feedback steering line, may be characterized by the fact that both of its extremities are attached together as well as to a front line attachment point to form a loop. This feedback line loop passes also through two pulleys attached to the frame respectively at the long and small beam extremities. The pulleys of the rear attachment pre-lines/suspension lines are in this case also guided to induce essentially elliptic trajectories. With such connections, the active automatic feedback is only active for rotation and elevation perturbations, but it does not perturb the stabilization in translation provided by the elliptic trajectories of the attachment points. Both the tilt of the frame around the long beam axis and the variable length of the front stabilization lines control the incidence angle of the kite (pitch).

[0038] For safety, the front lines may be connected to a tightening device, which may include a quick release blocker, on the vehicle that allows to quickly lengthen the front lines to make the kite fly backward and land, greatly reducing its pull. The front line lengths are typically chosen to position their attachment points between 0.1 to 1 wingspan away from the frame. Also in such configuration the stability of the system is highly linked to the shape and dimensions of the frame that have to be optimized for specific kites.

[0039] Typically an initial tilt between 20° to 80° of the small frame beam relative to the vertical may provide a better stability of the kite.

[0040] As previously stated, the present invention also relates to a control device, for controlling the orientation of and automatically providing flight stability in variable winds to a wing or to a power kite including a wing, comprising a stabilization mechanism of the above-mentioned kind as well as an orientation unit.

[0041] According to a preferred embodiment, the linking organ is arranged to mechanically link the base to the stabilization mechanism such that the latter is provided with at least two degrees of rotation freedom with respect to the base.

[0042] Preferably, the control device further comprises control organs arranged to act on the linking organ such as to control the orientation of the stabilization mechanism. Control organs including ropes or cables the length of which can be adjusted by means of blockers or winches may advantageously be provided.

[0043] Such an orientation unit, when combined with the kite stabilization unit, makes the kite tend to reproduce any tilt of the stabilizer frame. This orientation unit can be oriented manually and blocked in any desired position or through the help of interfaces such as ropes and winches. This control system presents also the advantage of not inducing strong deformation of a soft kite when it flies close to the towed vehicle.

[0044] The kite stabilization and orientation units provide orientation capabilities to a power kite while making it self-stable. This control system can be used with any type of power kite having at least two steering lines, such as inflatable leading edge, foil kite, semi-rigid, or any other type of aerodynamic wing. Also the system is most efficient with kites having in addition to two steering lines/attachment points at least two front lines/attachment points. Since the stabilizer is particularly attractive when the kite flies close to the frame, the use of pre-lines between the stabilizer and the kite suspension lines is not required. This system is well suited for standard steerable kites without modification of either the wing/sail or its suspension lines, as well as for specifically designed kites.

[0045] According to another aspect, the invention further relates to the use of this control device on a vehicle, for instance a boat, towed by a kite. On boats, reducing the capsizing momentum while keeping the traction force high is particularly attractive for reaching high speed and keeping it safe. With this control system the point of application of the resultant traction force is at a short distance above the boat compared to a classical sailboat while having the force directed slightly upward, lifting the boat and reducing its drag. Furthermore, with this system, to each frame orientation angle corresponds a boat trajectory relative to the wind that does not require important corrections with the rudder. Therefore when the frame is locked relative to the boat, the boat has a tendency to self-orient relative to the wind, further reducing the actions of the pilot. These characteristics make this control device particularly attractive on boats. While there is no limitation on the type of boat or watercraft that this control system can be mounted on, catamarans are particularly attractive, thanks to their stability, potential speed and large flat surface. This kite control system can also be used as a safety system in case the main boat propulsion system is out of order.

[0046] It should further be noted that, while three degrees of liberty could also be well suited, in the case of a boat, limiting the rotation freedom to two axis simplifies the positioning and blocking of the frame when navigating. Typically, one of the rotation axis corresponds to a pole axis attached to the boat that maintains the frame above the boat at a distance ranging from 0.2 to 1 wingspan, high enough to enable yaw rotation of the kite. The other rotation axis, typically substantially orthogonal to the first axis, is implemented by a rigid link that also provides some space between the pole and the stabilizer frame. The geometry of the link can greatly change depending on the kite and the boat. For instance, the pole can be tilted relative to the vertical axis or the angle between axes of rotation can be chosen as a function of the needs.

[0047] Further, the pole can be fixed to the vehicle or boat with various types of mechanical links such as being attached only by its base or by having additional fixation links along its length. The position of the rotation axis relative to the boat is normally in the vicinity of a classical mast.

[0048] Nevertheless, the use of a pole is not required, the joint that links the frame to the boat can be attached to the boat with other means having a more complex shape, for instance to free space on the boat platform for the controlling ropes and the crew.

[0049] It should further be noted that orientation ropes may be positioned to allow an orientation of the frame suited for navigation while enabling good stability of the frame when blocked. Especially on large boats, the manual positioning of the frame can be replaced with electric winches or other electrically operated link.

Brief description of the drawings

[0050] Other characteristics and advantages of the present invention will become more clearly apparent on reading the following detailed description of exemplary embodiments, given with reference to the appended drawings that are provided by way of non limiting examples, and in which:

[0051] FIG. 1 is a schematic general view of a control device, for automatically providing flight stability in variable winds to a wing, according to a preferred embodiment of the present invention;

[0052] FIG. 2 is a perspective simplified view, with more construction details, of the control device of FIG. 1 when it is implemented on a boat;

[0053] FIG. 3 is a perspective schematic view of a detail of the device of FIG. 2 according to a first embodiment;

[0054] FIG. 4 is a perspective schematic view of a detail of the device of FIG. 3;

[0055] FIG. 5 is a different perspective schematic view of a portion of the device as shown on FIG. 4;

[0056] FIG. 6 is a perspective schematic view of a detail of a control device according to a second embodiment;

[0057] FIG. 7 is a perspective schematic view of a detail of the control device of FIG. 1 when it is arranged on a boat;

[0058] FIG. 8 is a perspective view of a complete control device according to the invention when it is arranged on a boat, and

[0059] FIG. 9a to 9d illustrate, in perspective schematic views, the point of sailing for a control device according to the present invention mounted on a boat.

Mode(s) for carrying out the invention

[0060] FIG. 1 is a schematic general view of a control device, for automatically providing flight stability in variable winds to a wing, according to a preferred embodiment of the present invention.

[0061] More precisely, FIG. 1 shows the principle of the present invention, i.e. how a power kite 1 may be automatically stabilized with a stabilization mechanism 2 and oriented with an orientation unit 3 and, furthermore, how the stabilization mechanism and the orientation unit may be connected to each other.

[0062] The orientation unit comprises a base or platform 4 and, extending there from, an arm 6 carrying the stabilization mechanism 2 through a linking organ 7.

[0063] The orientation unit is arranged to provide orientation to the stabilization mechanism. It may thus be capable of both: changing the stabilization mechanism orientation through actions coming from the platform and blocking its position in adequate positions. The means for modifying the orientation of the stabilization mechanism are illustrated by orientation ropes or bars 8 that induce modifications of the stabilization mechanism orientation. The orientation unit imposes orientation, relative to the platform, of the stabilization mechanism and to the power kite.

[0064] As a way of illustrative and non-limiting representation, the power kite 1 has groups of suspension front-lines 10 attached to its leading edge 11 and single or groups of steering suspension lines 12. At the free extremity of the suspension lines 10, 12, front and back attachment points 14, 15 allow to attach the kite to front pre-lines 16 and steering or back pre-lines 17. Provision of these pre-lines is optional for the implementation of the present invention.

[0065] FIG. 2 represents with more construction details the control device of FIG. 1 when it is implemented on a vehicle, which is illustrated here as a boat 20 in a non limiting manner.

[0066] In the embodiment shown in FIG. 2, the orientation unit 3 is typically positioned for crosswind navigation (beam reach). While on this simplified drawing, the ropes 8 for controlling the stabilization mechanism are not included for sake of simplicity, the stabilizer mechanism may be considered as being temporary blocked in the illustrated position.

[0067] The stabilization mechanism comprises a frame 22 presenting an essentially T-shape and connected to the suspension lines 10,12, on the one side, and fixed to the orientation unit 3, on the other side, the latter being arranged on a boat platform 24. The linking organ 7, illustrated here as a mechanical articulated joint and located at the top of arm 6, provides the stabilization mechanism 2 with two degrees of rotation freedom.

[0068] The non-limiting embodiment of FIG. 2, where the linking organ 7 provides the T-frame 22 with two orthogonal axis of rotation, is an illustration of many technical options, including the use of a plurality of joints and supports, to attach the rigid frame 22 to a boat with at least two degrees of freedom.

[0069] In a similar manner, the blocking and orientation actions of the stabilization mechanism, not represented in FIG. 2, may be obtained by specific mechanisms incorporated in the linking organ or by means of action ropes.

[0070] It appears from FIG. 2 that the kite suspension lines 10, 12 are connected to the frame 22 through pulleys 26, 27. More precisely, each pre-line 16 or 17 has an end attached to one of the pulleys 26 or 27.

[0071] Two pulleys 26 and 27 attached to a pair of front and steering pre-lines located on the same side of the power-kite are mechanically connected to each other by means of another set of two pulleys 28, 29, rigid with the frame 22, and a stabilization organ 30, here a line. The pulleys 28, 29 thus define connection points of the wing suspension lines on the stabilization mechanism frame, each suspension line having several connection points on the frame in the present non-limiting embodiment.

[0072] Additional stabilizer front or tightening lines 31 may be provided which may pass through the linking organ 7 and the arm 6 to be attached on the boat in a security blocker or tightening device 32. These stabilizer front lines 31 may provide the pilot with some liberty to eventually modify their length and thereby the incidence angle of the kite (pitch). The tightening device 32 can be released to land the kite by lengthening the stabilizer front lines, increasing the incidence angle and making the kite land backward.

[0073] In the views of FIG. 3 and FIG. 4, showing details of the control device described above in connection with FIG. 2, a main or long beam 34 of the T-frame 22 is positioned horizontally and the power kite 1 self aligns relative to the stabilizer frame, the small beam 33 being eventually inclined with respect to vertical. The elliptic lateral trajectories of pulleys

26, 27 guided by the stabilization lines 30, 31 contribute to stabilize the kite.

[0074] The long equivalent radiuses of the pulleys trajectories at their working point reduce the natural oscillation frequency of the system, especially with short lines, i.e. when the kite is close to the frame. This reduction of the oscillation frequency provides more time for the rotation stabilization to take effect.

[0075] While the lengths of the stabilizer front lines 31 are fixed, beside the adjustments that can be made, the back stabilization lines 30 form loops each with only one attachment point at the corresponding stabilizer front line pulley 26, where both extremities of the stabilization line 30 meet. As previously mentioned, in this non-limiting technical solution, the stabilizer front lines 31 meet in the center of the T-frame long beam and pass through the linking organ 7 and arm 6.

[0076] This ropes and pulleys configuration best observed on FIG. 5 contributes to produce a rotation stabilization feedback on the steering lines 12 dependant on the elevation of the front pulleys 26. To better understand the mechanics of the stabilizer, for instance when the elevation increases due to kite perturbation (arrow 36), the distance 37 increases as well as the pulling back on the back line pulley 27 bringing the latter closer to the frame in the 38 direction. Difference of elevation between the two front lines/kite attachment points corresponds to a rotation of the kite that tends to be compensated by the stabilization unit.

[0077] In another stabilizer embodiment shown in FIG. 6, the stabilizer contains in addition to a rigid frame 60, rigid mobile elements or beams 61, 62 that guide the kite lines. In this embodiment as well, the orientation of the front lines 66 influences the length of the steering lines 67. The front lines 66 passing through guiding elements 68 orient the beams 61 that can freely rotate at the joints 69. The rigid beam 61 that essentially follows the orientation of the front lines 66 imposes a variable length to the portion of the back lines 67, redirected by pulleys 70, that link the beam 61 and the beam 62, the latter rotating only around the axis 71.

[0078] This link between the steering lines and front lines provides a stabilization effect on the steering lines. This embodiment allows redirecting all lines down to the little arm or mast 72 and boat platform to eventually vary their length with a winch 74.

[0079] The stabilizer being more efficient in short lines, if lines are extended, the kite can be directly steered with direction actions on the steering lines, represented by pulling actions 75 on the steering lines.

[0080] In another embodiment, the example of FIG. 7 illustrates, in connection with FIG. 9, the orientation unit functionalities that are intended to position and maintain the stabilizer in various positions best suited in this case for a boat. For this purpose, three types of ropes are used: two for controlling the yaw of the kite, 76a and 76b, two ropes for controlling the horizontal position of the kite, 77a and 77b, and one or two ropes 78 for essentially controlling the pitch of the kite when navigating essentially crosswind (beam reach).

[0081] The pilot may use manual traction to pull and orient the stabilizer and the kite. Depending on the direction relative to the wind (point of sailing, see FIG. 9), only some ropes are used, further simplifying the operations to conduct the boat. When the boat is traveling “broad reach” (FIG. 9b) or is “running” (FIG. 9a, back wind), only the twin ropes 77a and 77b are used. When the boat is going “beam reach” (FIG. 9c, crosswind) or “close hauled” (FIG. 9d, up wind), ropes 76a and 76b are tensed, adjustment of the pitch of the kite coming from rope 78.

[0082] According to this illustrative and non limiting embodiment, ropes 76a, 76b, 77a, 77b and 78 linking the frame 22 to the boat, pulleys 79 and rope blockers 80 control the orientation of the stabilization mechanism that can be modified when cruising, if needed. Other type of embodiment of the control units can result in variable control efficiency, especially when the number of lines of the kite is lower.

[0083] In another embodiment illustrated in FIG. 8, a long pole 82 extends above the small arm or mast 6 that supports the stabilizer. An additional security line 83 is attached to the kite, preferably leading edge 11 or extrados, and is redirected by a pulley 85 or ring at the top of the pole down to the little mast or to the boat platform and finally passes into a rope blocker 86. When the wind is not strong enough, this additional line is used to assist the kite in flying and prevent it from falling into the water. When the wind is strong enough for the kite to fly by itself all the time, the security line is relaxed. Therefore, the long pole may be useful in light wind situations and may be removed or retracted in other situations to reduce wind drag. In consistent wind, a navigation option is to keep the security line while removing the long pole.

[0084] FIG. 9 shows the typical points of sailing when the control system of this invention is mounted on a boat. When the pilot positions the kite stabilizer in orientation well suited for desired boat trajectory, a well-balanced boat tends to self orient itself, further reducing the need to operate the rudder 90 during changes of direction. The boat rudder being used to make fine adjustment of the trajectory or to compensate for poor boat equilibrium. A boat presents a good equilibrium when typically moving “beam reach” FIG. 9c (crosswind); no important rudder adjustment is required. This essentially corresponds to a vertical alignment of the resulting traction force of the kite, and the anti-drift force of the boat. To enable the boat to pursue an efficient upwind trajectory “close hauled”, FIG. 9d, it is important that the boat produces a strong anti-drift force with low drag.

[0085] The above description corresponds to a preferred embodiment of the invention described by way of non limiting example. In particular, the forms shown and described for the various component parts of the orientation unit and the stabilization mechanism are not limiting.

[0086] For instance, a person skilled in the art will encounter no particular problem in implementing alternative means to the control organs described for orienting the stabilizer, without departing from the scope of the present invention.

[0087] Obviously, the control device according to the present invention may also be implemented in connection with vehicles other than boats which may be propelled by a power kite, such as carts for instance, or even in connection with installations for producing electric energy.

[0088] It should further be noted that the control device according to the present invention may be implemented in connection with stacked wings without going beyond the scope of the invention. In such a case, the respective similarly located attachment points of the wings may be attached to each other, or the attachment points of the suspension lines on a first wing may be attached to the corresponding free attachment points of a second wing, for instance.

Claims

1. Stabilization mechanism (2), for automatically providing flight stability in variable winds to a wing (1) or to a power kite including a wing (1), the wing having a group of suspension front lines (10, 66) and a group of suspension steering lines (12, 67) each of which has a front attachment point (14), respectively, a steering attachment point (15), said stabilization mechanism having a frame (22) wherein at least three connection points are provided on said frame for connecting the kite attachment points in order to connect the wing to the stabilization mechanism,

   characterized in that said connection points are distributed on said frame along at least two distinct lines.
2. Stabilization mechanism (2) according to claim 1, characterized in that it comprises stabilization organs (30) arranged to mechanically connect each steering attachment point (15) to at least one of said front attachment points (14), such that each steering attachment point presents a distance to the stabilization mechanism that is a function of the characteristics of the tension incurred by at least one of said front lines (10, 66).
3. Stabilization mechanism (2) according to claim 2, characterized in that said front and steering attachment points (14, 15) are mechanically connected to each other by means of guiding organs (26, 27, 28, 29, 70).
4. Stabilization mechanism according to claim 3, characterized in that said front and steering attachment points (14, 15) are mechanically connected to each other through pre-lines (16, 17) to which they are attached.
5. Stabilization mechanism according to claim 3 or 4, characterized in that said guiding organs include pulleys (26, 27, 28, 29, 70).
6. Stabilization mechanism (2) according to any of the preceding claim, wherein said front and steering attachment points (14, 15) are mechanically connected to each other by means of guiding organs or pulleys (26, 27, 28, 29), characterized

   in that said frame (22) bears at least a first pair and a second pair of pulleys (28, 29), said front lines (10) or front pre-lines (16) bearing at least a third pair of pulleys (26), said steering lines (12) or steering pre-lines (17) bearing at least a fourth pair of pulleys (27), and in that a first stabilization line (30) and a second stabilization line (30) are mechanically connected to a first, respectively a second, pulley of each of said first, second, third and fourth pairs of pulleys.

7. Stabilization mechanism (2) according to claim 6, characterized in that at least one of said stabilization lines (30) is arranged as a closed loop to provide a feedback on said steering lines (12) to compensate for rotation or elevation perturbations of said wing (1).
8. Stabilization mechanism (2) according to claim 6 or 7, characterized in that it further comprises a line tightening device (32) arranged to have a still position with respect to said frame (22), and wherein at least some of said attachment points (14) are at least indirectly linked to said line tightening device such that a distance between said attachment points (14) and said tightening device can be adjusted and thus a distance between said frame and said wing can be adjusted.
9. Stabilization mechanism (2) according to claim 8, characterized in that it comprises a tightening line (31) connecting each pulley (26) borne by said front lines (10) or front pre-lines (16) to said tightening device (32) such that a distance between each pulley (26) and said frame (22) can be adjusted.
10. Stabilization mechanism (2) according to any of claims 6 to 9, characterized in that said frame (22) has a substantially T shape having a small beam (33) and a large beam (34) which are substantially perpendicular to each other.
11. Control device (2, 3), for controlling the orientation of and automatically providing flight stability in variable winds to a wing (1) or to a power kite including a wing (1), comprising a stabilization mechanism (2) according to any of the preceding claims and an orientation unit (3) including

    a base (4),

    a linking organ (7) arranged to mechanically link said base (4) to said stabilization mechanism (2) such that the latter is provided with at least one, preferably two, degrees of rotation freedom with respect to said base, and

    at least one control organ (8, 76a, 76b, 77a, 77b, 78, 80) to release or lock said stabilization mechanism.
12. Control device (2, 3) according to claim 11, characterized in that said control organs (8, 76a, 76b, 77a, 77b, 78, 80) are further arranged to act on said

linking organ (7) such as to control the orientation of said stabilization mechanism (2).

13. Control device (2, 3) according to claim 12, characterized in that said control organs (8, 76a, 76b, 77a, 77b, 78, 80) include ropes or cables the length of which can be adjusted by means of blockers or winches.

14. A vehicle (20) propelled by means of a wing (1) or of a power kite including a wing (1), comprising a stabilization mechanism (2) according to any of claims 1 to 9.

15. A vehicle (20) propelled by means of a wing (1) or of a power kite including a wing (1), comprising a control device according to any of claims 10 to 13.

Fig. 1

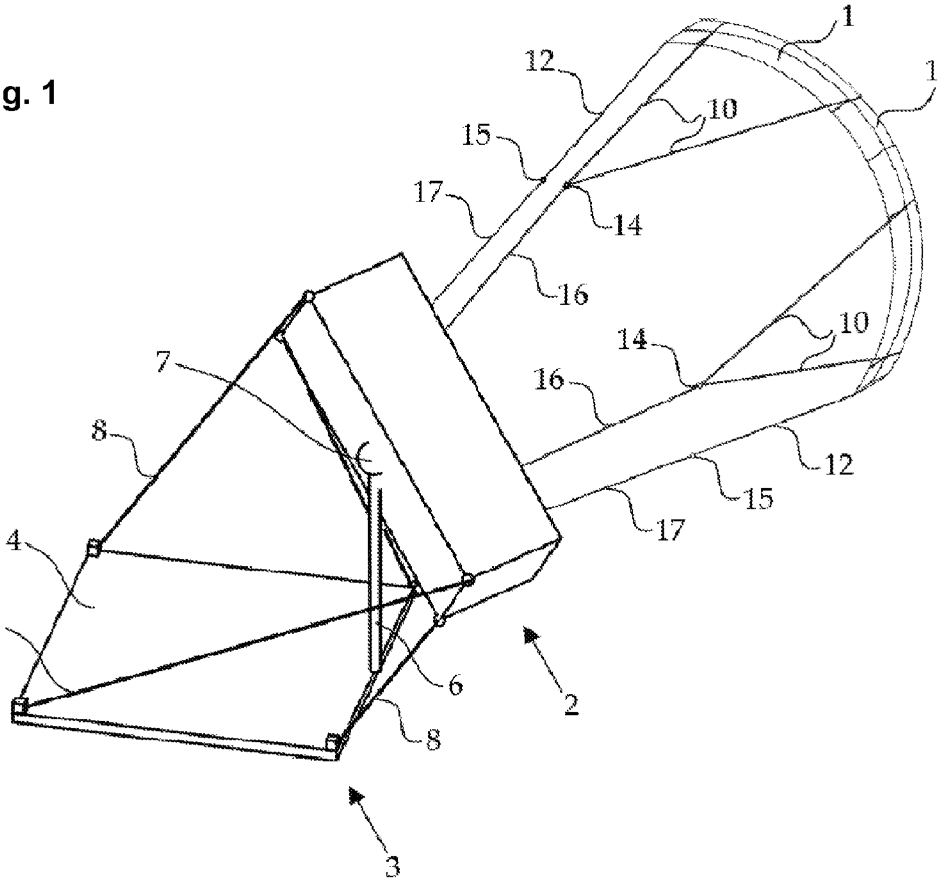


Fig. 2

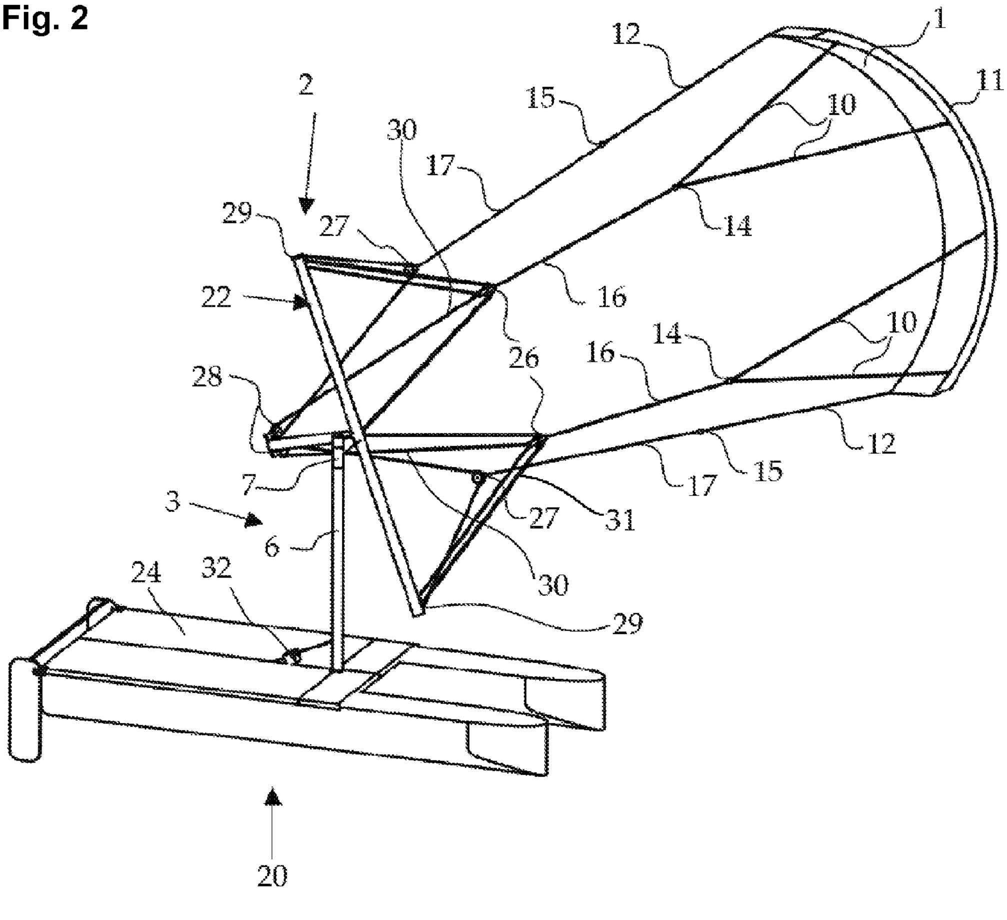

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Fig. 3

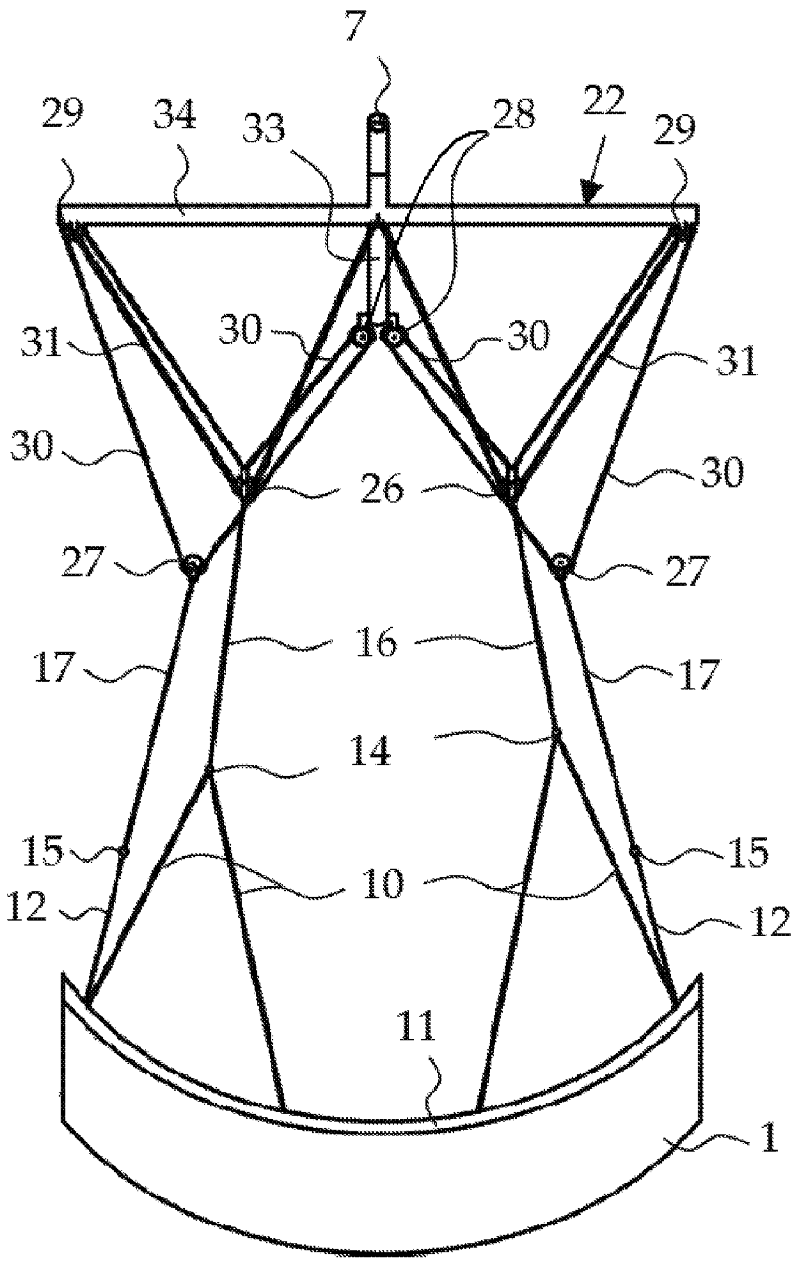
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Fig. 4

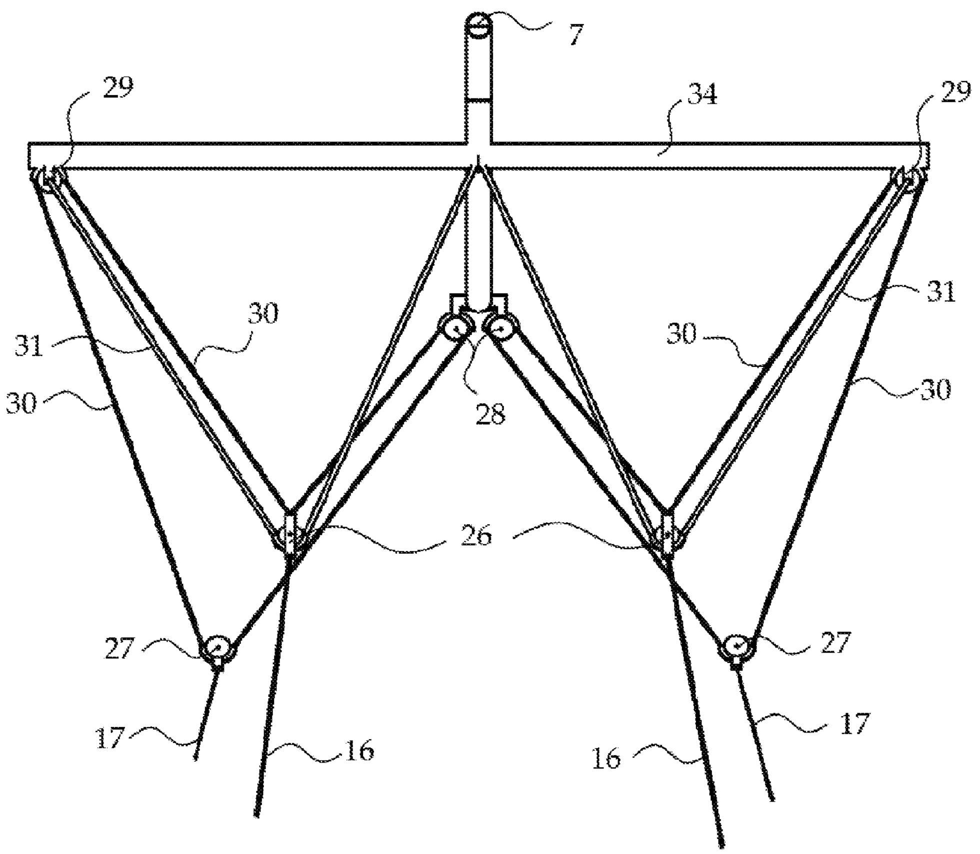


Fig. 5

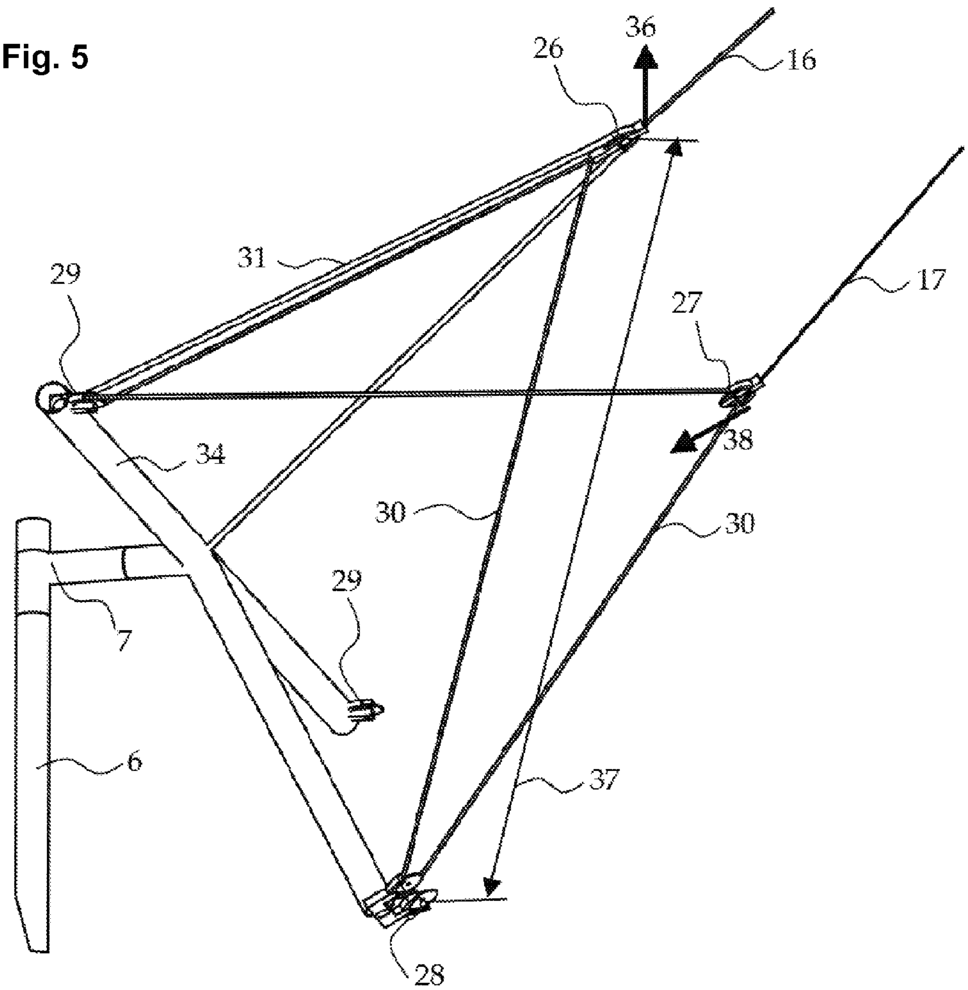


Fig. 6

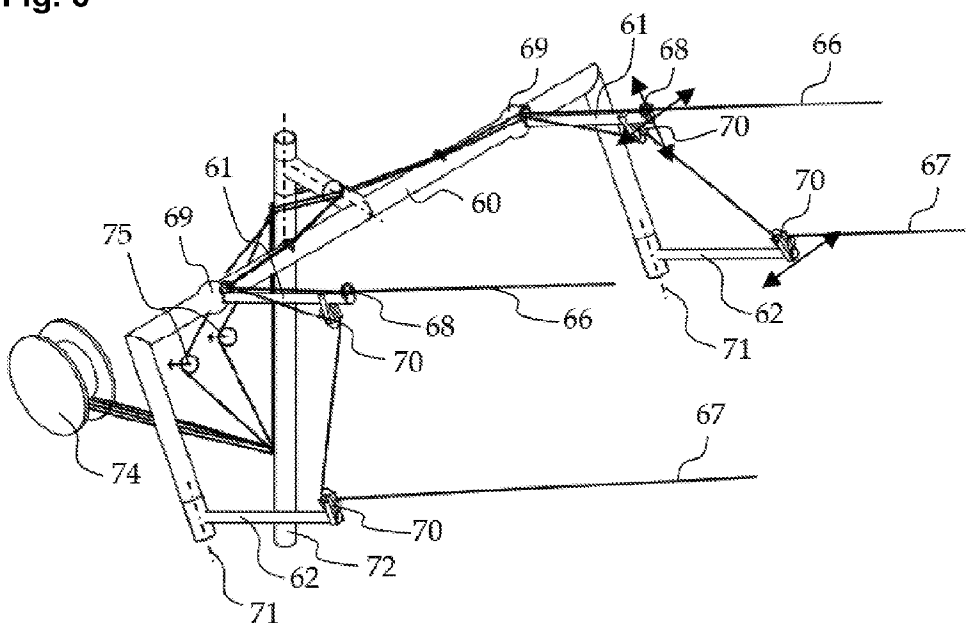


Fig. 7

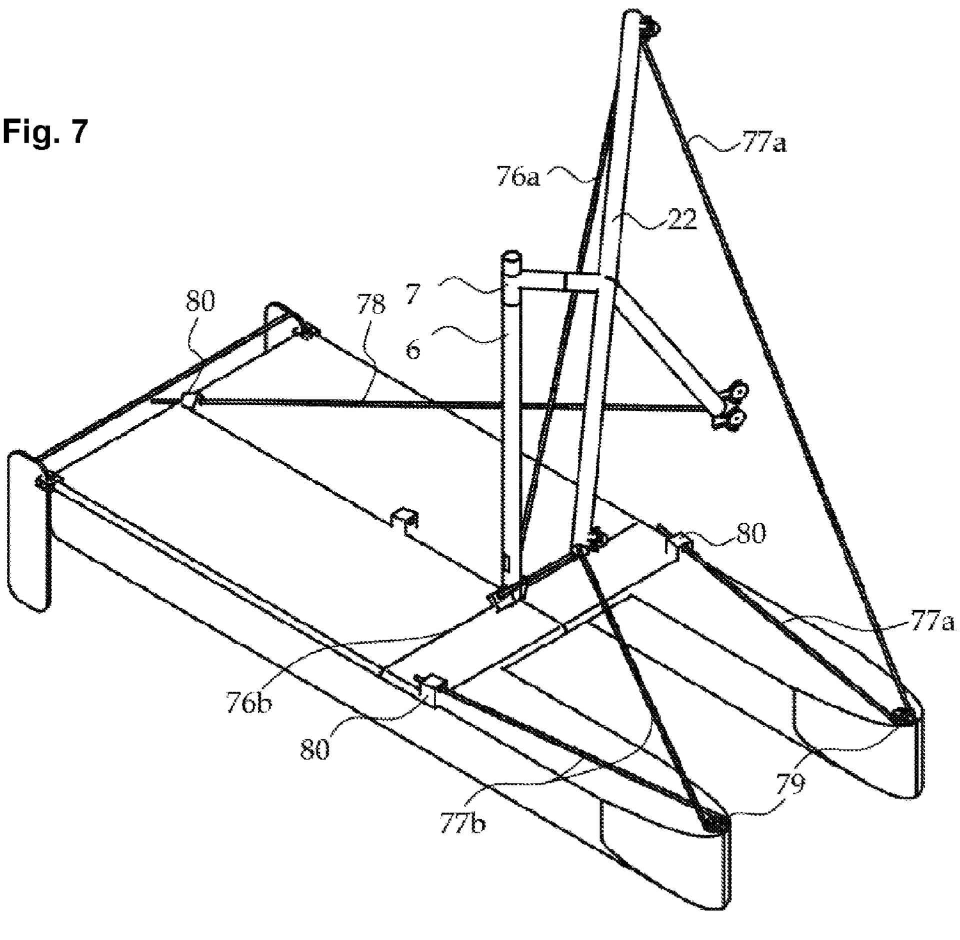
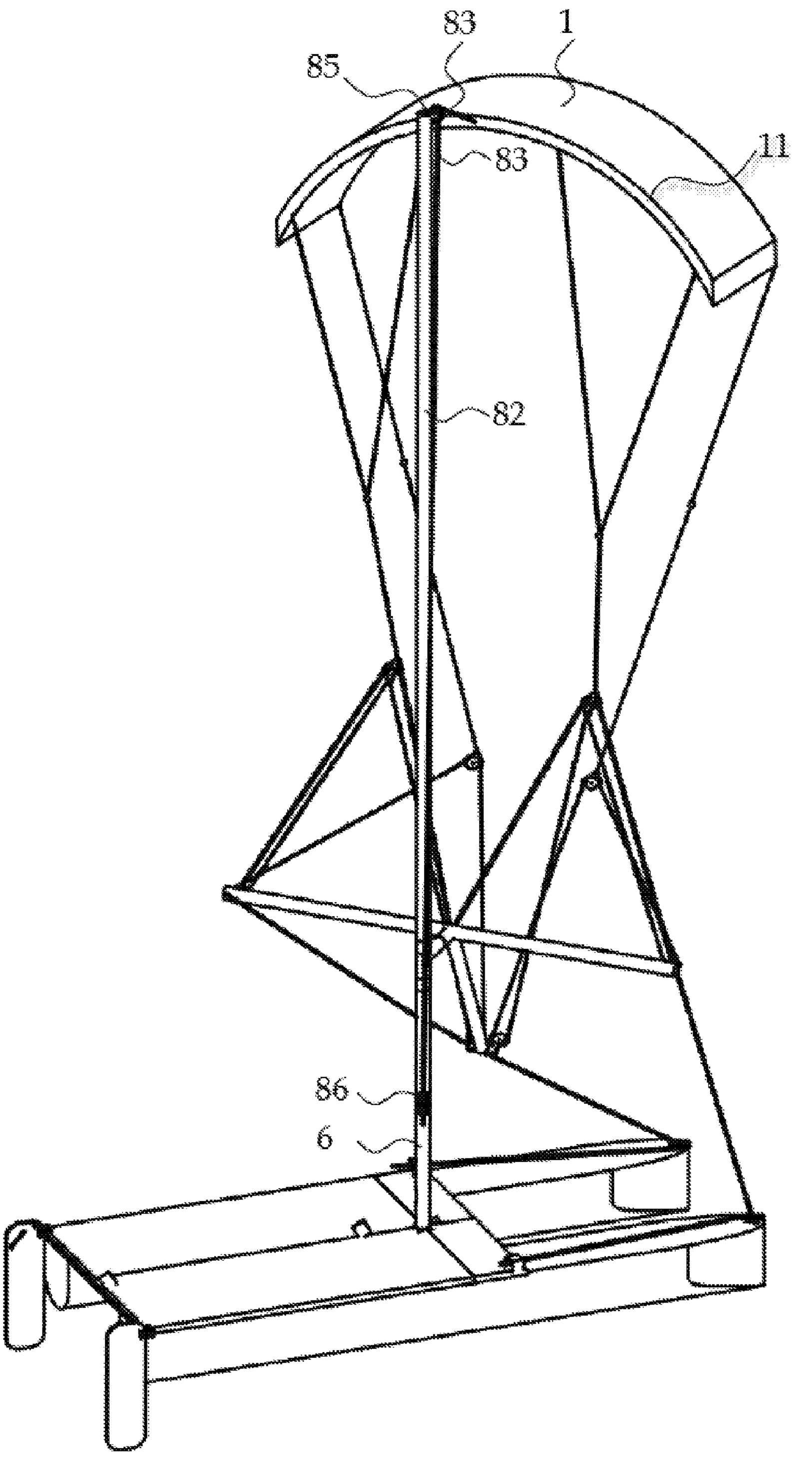


Fig. 8



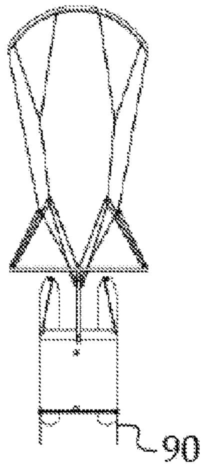


Fig. 9a

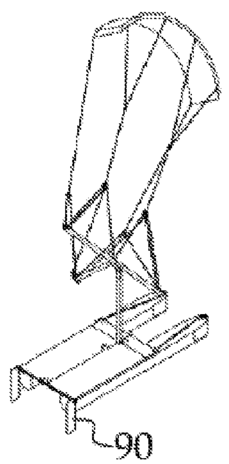


Fig. 9b

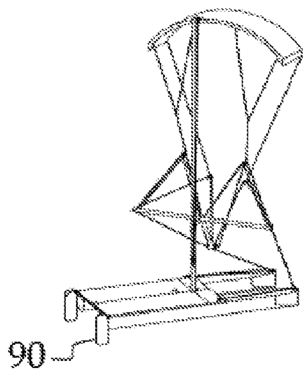


Fig. 9c

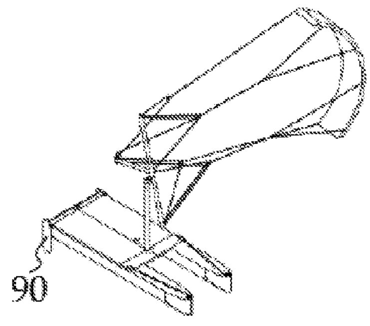
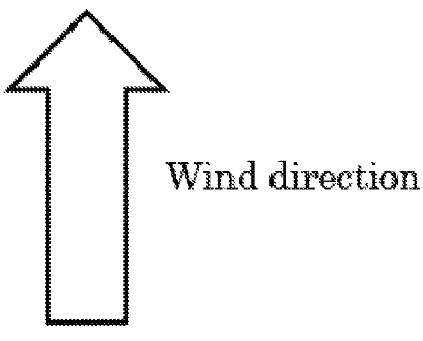


Fig. 9d



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/067807

A. CLASSIFICATION OF SUBJECT MATTER
INV. B63B35/79
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B63B B63H B64C A63H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2008/223989 A1 (MUTZENBERG FRANK WALTER [US]) 18 September 2008 (2008-09-18) paragraph [0073] - paragraph [0096]; figures 1-5	1-9,14, 15 10-13
Y	US 3 086 739 A (BARBER THEODORE C) 23 April 1963 (1963-04-23) column 1, lines 16-40; figure 1	10
Y	US 2009/151614 A1 (HANCHAR DALE WILLIAM [CA]) 18 June 2009 (2009-06-18) paragraph [0042] - paragraph [00656]; figures 1-12	11-13
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 September 2010	16/09/2010

Name and mailing address of the ISA/	Authorized officer
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International application No
PCT/EP2009/067807

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 20 2005 000478 U1 (REISENAUER MONIKA [DE]; REISENAUER ANDREAS [DE]) 17 March 2005 (2005-03-17) paragraph [0026] - paragraph [0046]; figures 1-5	1-8
X	DE 202 20 025 U1 (SKYWALK GMBH & CO KG [DE]) 10 April 2003 (2003-04-10) page 5, line 20 - page 9, line 5; figures 1,2	1-5
A	US 7 287 481 B1 (WRAGE STEPHAN [DE] ET AL) 30 October 2007 (2007-10-30) column 11, lines 20-63; figures 3,6	1,11

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2009/067807

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 2008223989	A1	18-09-2008	NONE			
US 3086739	A	23-04-1963	NONE			
US 2009151614	A1	18-06-2009	AU	2007249085	A1	02-07-2009
DE 202005000478	U1	17-03-2005	NONE			
DE 20220025	U1	10-04-2003	NONE			
US 7287481	B1	30-10-2007	AT	465940	T	15-05-2010
			AU	2006347219	A1	21-02-2008
			CN	101511671	A	19-08-2009
			DK	2054295	T3	26-07-2010
			EP	2054295	A1	06-05-2009
			EP	2213568	A1	04-08-2010
			WO	2008019700	A1	21-02-2008
			JP	2010500221	T	07-01-2010
			PT	2054295	E	11-06-2010