SAILBOARD WITH SLOTTED WINGLETS

Applicant: John H. Keller, Newburgh, NY (US)

Inventor: John H. Keller, Newburgh, NY (US)

Appl. No.: 13/946,798

Filed: Jul. 19, 2013

Related U.S. Application Data

Continuation-in-part of application No. 12/880,360, filed on Sep. 13, 2010, which is a continuation-in-part of application No. PCT/US2009/057138, filed on Sep. 16, 2009, said application No. 12/880,360 is a continuation-in-part of application No. PCT/US2010/029785, filed on Apr. 2, 2010.

Provisional application No. 61/097,836, filed on Sep. 17, 2008, provisional application No. 61/165,472, filed on Mar. 31, 2009, provisional application No. 61/166,569, filed on Apr. 3, 2009.

ABSTRACT

A sailboard hull has at least one pair of winglets or foils beneath the top of the board. Each winglet or foil has above it a slot and allows dynamic lift from both the top and bottom surface of the winglet and reduction of drag when the board is traveling at a transition speed between displacement mode and planing mode. At high planing speed it does not normally have lift from the top surface of the winglet. There may be multiple pairs of winglets or foils. Back slots may be provided at the rear of the sailboard hull providing a higher ratio of winglet width to maximum hull width. A top slot may cover at least half the winglet area, and a winglet may have a camber/slope step on the planing surface.
SAILBOARD WITH SLOTTED WINGLETS

CROSS-REFERENCE TO RELATED APPLICATIONS


FIELD OF THE INVENTION

[0002] The present invention generally relates to a sailboard/windsurfer hull or other small watercraft hull having winglet(s) with a slot for improving the transition from displacement operation to planing operation and the transition to higher planing speeds.

BACKGROUND

[0003] U.S. patent application Ser. No. 10/157,875 teaches the use of winglets on the outer surfaces of a sailboard for increasing the lift to drag of the sailboard when transitioning from a displacement mode to a planing mode. These winglets have been found to be quite effective in reducing the amount of wind needed to cause the sailboard to plane. However, the front nose of these winglets can be above the flat undisturbed water surface thus preventing or reducing the water flow and lift from the top surface of the winglet.

[0004] When the sailboard is designed so that the water will easily pass above the front of the winglet, the board needs to be slightly concave down and slightly longer in the nose. One would also like the lift from the winglet to be nearer the back of the board. Also, the flow over the top of the front of the winglet may stop at a slower board speed than desired, while the camber of the winglet is limited by the thickness to length ratio. In addition, one would like the winglet to be a larger percentage of the back of the board to further reduce the wave and turbulent drag at transition speeds.

[0005] U.S. patent application Ser. No. 10/157,875 also teaches the use of a wing grid which is a plurality of winglets with slots between the winglets. However, each winglet has drag from the separation of the water at its nose to pass over and under the winglet, thus if the number of winglets is too large there will be increased drag from this wing grid.

[0006] On wings of many airplanes there are "Fowler-type flaps" which, when they are moved down and back from the wing, form slots in front of the flap or winglet with a surface of the main wing. At some positions of these flaps, the top part of the wing in front of the slot partially covers the nose or beginning of the flap. In this position there is a Coanda flow of energized fluid that flows through the slot and over the flap thus creating a vacuum lift on top of the flap.

[0007] PCT/US2009/057138 teaches a step design whereby at slower planing speeds the water contacts the surface close to and behind the step, producing lift. At faster planing speed it does not contact this surface, thus reducing drag.

SUMMARY

[0008] U.S. Pat. No. 3,495,563 to E. Reischmann shows in FIGS. 2 b and 2 d a winglet or part of a planing surface (31) on a planing watercraft. Above this winglet/planing surface (31) there is not a slot but rather only the side of the remaining part of the hull with a dead rise of about 45 degrees. The stated purpose is to reduce the drag.

[0009] It is therefore an object of the present invention to provide a sailboard hull to increase the dynamic lift of a winglet beneath a slot in the side of the sailboard hull.

[0010] It is another object to have an efficient winglet on a shorter or smaller sailboard.

[0011] It is a further object to move the lift further back closer to, or behind, the center of gravity of the board and sailboarder.

[0012] It is yet another object of the present invention to have the nose of a winglet covered such that water from the front of the winglet does not spray up onto the sailboarder.

[0013] Another further object of the invention is to have the top of a winglet clear of water above about 15 mph.

[0014] It is still another object of this invention to reduce the variation of the optimum position of the center of gravity of the sailboard and sailboarder.

[0015] Another further object of the invention is to prevent weeds from catching in the slot.

[0016] To achieve the foregoing and other objects and advantages of the invention, winglets with a forward slot, including a slot opening, in accordance with the invention, start at a location on the order of 130 cm, generally in the range of 110 to 210 cm, from the back of a sailboard or less. That is where, when the sailboard is transitioning from displacement mode to a planing mode, the pressure under the board is near the maximum where the slot opens in front of the winglet. This opening of the slot in front of the winglet may be on the order of 50 cm long (range of 20 to 120 cm) as measured parallel to a longitudinal axis of the board. In an exemplary embodiment, the vertical distance (height) of the slot between a top surface of the winglet and a bottom of the surface above the winglet is roughly one-half the thickness of the winglet, especially at a front opening to the slot. A surface starting before the nose of the winglet (i.e. the front/leading edge of the winglet) can extend and be integral with at least a portion of a surface above the winglet. The surface starting before the nose of the winglet may extend over the winglet from the nose of the winglet back to a point where the winglet has a thickness of about 50% the maximum thickness of the winglet.

[0017] The thickness of the winglet may vary, either or both in a transverse direction and a longitudinal direction. This can result, for example, in the nose and/or outside edge of the winglet having thicknesses which are thinner than at other points of the winglet. The nose of the winglet may, for example, have a thickness of about 50% (half) the maximum thickness of the winglet. This reduces spray off of the nose of the winglet. Meanwhile, the slot allows energized water from under the front of the board to produce a Coanda effect (lift) over the top surface of the winglet.

[0018] The winglets according to this invention may have a slot formed on the top of (that is to say, above) a portion or the entirety of the winglet, particularly near the end of the winglet such that the turbulence and wave drag at the back of the board is decreased. That is, a top slot allows the winglet to be extended under a top portion of the board (under a hull part
having a top surface on which a user stands or is situated when using the sailboard and a bottom surface forming a slot with the winglet. This also allows the top surface of the sailboard, which is above the top slot, to have a foot strap and a larger top surface area for sailing and jibing the sailboard.

[0019] The transverse end of a forward slot, i.e. the outside, can be covered or partially covered so that water and waves, particularly on the windward side do not enter the slot or strike the nose of the winglet when sailing at high planing speeds, such as over 15 mph. When partially covered by a cover or partial cover (which can be part of the hull), an opening/gap between the cover or partial cover and the winglet can be provided to allow any weeds or grass which enter the slot to escape.

[0020] While the nose of the winglet can be perpendicular, angled back, angled forward, or curved, it is preferred that it be angled or swept back. This will both allow it to shed weeds and direct the water passing on top of the winglets away from the front foot straps.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The foregoing and other objects, aspects, and advantages will be better understood from the following detailed description of a preferred embodiment of the invention with reference to the drawings, in which:

[0022] FIGS. 1A-1E show, respectively, a curved and angled cross-sectional view, top plan view, side view, bottom plan view, and a transverse cross-sectional view of a sailboard hull with slotted winglets,

[0023] FIG. 2 shows a side view of a sailboard hull with multiple slotted winglets with a camber/slope step,

[0024] FIG. 3 shows a sailboard hull with a cover over a front slot opening which extends over the top of the winglet,

[0025] FIG. 4 shows a detail of the camber/slope step in FIG. 2, and

[0026] FIGS. 5A-5E show, respectively, a top plan view, a side view, and three transverse cross-sectional views of a sailboard hull with a winglet with a top slot or channel.

DETAILED DESCRIPTION

[0027] Referring now to the drawings, and more particularly to FIGS. 1A-1E, a cross section of a side part of a sailboard hull is shown with a preferred embodiment of a winglet 2 with a front slot 3 and a top back slot 6. 'Front slot' and 'forward slot' are treated as substantially synonymous terms and may be used interchangeably herein. A ‘front slot’ or ‘forward slot’ may include an ‘opening’ or ‘forward opening’ which should also be understood as substantially synonymous. The term ‘top slot’ includes ‘back slot’ and ‘top black slot’. Hereafter a ‘winglet’ 2 may also be called a ‘slotted winglet’ 2 to emphasize the presence of a slot above the winglet. Winglet 2 has a length, in a longitudinal direction of the sailboard hull, at least 2 or 3 times its transverse width on each side of attachment to the main body. Thus it is distinguished from a fin or skeg at the side of the hull as in some racing catamaran sailboats. Winglet 2 may be integral with the sailboard hull such that the hull of the sailboard includes the winglet. The portion of the sailboard hull excluding the winglet will be referred to as the main board (or hull) body.

[0028] A slot as used herein is a narrow opening, groove, passage, or channel formed between a winglet or foil and a surface of the hull such that the height to width ratio of the slot is less than one, and the height to winglet chord ratio is much less than one (and thus less than the height to width ratio). Furthermore, a surface which forms a top or roof of the slot is substantially flat in the transverse direction. Substantially flat is defined as having a slope equal to or less than ±15° and preferably equal to or less than ±10° with respect to a horizontal. As used, the symbol "<" indicates that the top/roof of a slot slopes up and out (that is, angling up with respect to a horizontal in a transverse plane and away from a longitudinal center line of the hull). This is similar to the dead rise convention of a hull, except that the angle of a dead rise is usually larger than applicable to form a slot. The symbol "<" indicates the top/roof of a slot slopes down and out (that is, angling down with respect to a horizontal in a transverse plane and away from a longitudinal center line of the hull).

[0029] A front slot 3 starts behind a front planing or displacement section 4, which may be part of the nose or front of a sailboard. The opening/start to a front slot 3 is located in a region of an underside of the sailboard hull where water pressure is highest when the sailboard starts to plane. For a nearly flat planing surface, this maximum pressure occurs at about 1/3 to the wetted surface length back from the start of the wetted surface length. Winglets with a forward slot may start at a location on the order of 130 cm, generally in the range of 90 to 160 cm, from the back of a sailboard or less. When the sailboard is transitioning from displacement mode to a planing mode, the pressure under the board is near the maximum in the slot at its opening in front of the winglet. The slot opening in front of the winglet 2 is 20 to 120 cm, or on the order of 50 cm, in a longitudinal direction of the board.

[0030] “Planing mode” is defined as the lift being mainly hydrodynamic lift (≥90%) and when the hydrostatic lift is ≤10% of the total lift. “Displacement mode” is where the lift is mainly hydrostatic and the drag vs. speed is increasing nonlinearly with increasing speed. As used herein, “displacement mode” is used to indicate that ≥70% of the lift is hydrostatic lift and the remaining lift (≤30% or less) is hydrodynamic lift. Thus the board is in “transition mode” when the hydrostatic lift is between 70% and 10% of the total lift and the hydrodynamic lift is most of the remaining lift, that is 30% to 90%. In “transition mode”, the drag vs. speed normally goes through a hump or peak, but this is not always the case if the weight is small or the wave drag is sufficiently reduced.

[0031] In transition mode, the high water pressure forces water through a front slot 3 and over the top surface of a winglet 2. This causes a Coua da effect/vacuum lift on the winglet.

[0032] The main drag forces acting on a hull in planing mode are dynamic drag, which is the dynamic force in the backward direction, and skin friction. The main drag force acting on a hull in displacement mode is wave drag, which is the difference of pressure on forward facing surfaces and backward facing surfaces. In transition mode, all three—that is to say wave drag, dynamic drag, and skin friction—are significant, with wave drag and dynamic drag being the most significant.

[0033] The lift of the water going through front slot 3 and top slot 6 (or slot 10 of FIGS. 3 and 5A-5E) is not large and is less than the planing lift on the winglet. This is due to the fact that the depth and mass of this water is small and not like the depth and mass of the fluid over a normal wing on an airplane or a deep hydrofoil on a watercraft.

[0034] It should be noted that the cross section of the board shown in FIG. 1A is angled/curved, as shown by section A-A in FIG. 1B. The cross section is slightly angled/curved to
approximate more closely the path of the water at a transition speed. Dynamic lift can be provided from both the top and bottom surface of the winglet when the board is traveling at a transition speed between displacement mode and planing mode.

At high planing speed the board does not normally experience lift from the top surface of the winglet, as water may not enter the slot at high angles of attack. When the board is planing at a high speed, water leaving the front planing or displacement section 4 may go below the nose of the winglet. At high speeds, the front slot 3 and the nose of the winglet 2 may be above the water and thus only the bottom surface of the winglet is in or makes contact with the water. Front slot 3, provided with an opening in front of the winglet, allows for the winglet to start further back on the sailboard where the lift will be closer to the center of gravity. Furthermore, the sailboard can be shorter if desired. This in turn makes the front of the sailboard lighter and improves the ease by which a sailboarder or sailor can sail at an optimum planing attack angle of about 3 to 5 degrees.

In an exemplary embodiment, the bottom edge or bottom 4 of planing or displacement section 4, which is the start of the roof of the opening to slot 3, is approximately tangent (that is, less than or equal to) 10° to a tangent line to the front planing or displacement section 4, as shown in FIG. 3. Alternatively, the bottom edge or bottom 4 of section 4 can have a smooth upward curvature (roller) such that the water will remain in contact with both the top and bottom surfaces of the winglet 2 at a transition speed, but the water flow from waves will separate from the curvature and go below the nose of the winglet 2 at faster planing speeds.

The surface behind the upward curve of bottom 4 on section 4 which provides the roof of the opening to slot 3 is preferably cambered with a negative second derivative (height with respect to longitudinal distance) curvature as shown in FIG. 3. This roof surface can end at or just after covering the nose of winglet 2 as shown in FIG. 1A. In some embodiments this roof may instead be straight.

Winglets 2 with a forward slot 3 in accordance with the invention start at a location on the order of 130 cm, generally in the range of 90 to 160 cm, from the back of the sailboard. That is where the pressure under the board is the greatest when the sailboard is transitioning from displacement mode to a planing mode. The forward slot 3 opening in front of a winglet 2 may be roughly 50 cm long (range of 20 to 120 cm) as measured along the bottom of the winglet in the longitudinal direction of the board. The vertical distance (i.e., height) at the opening of a forward slot 3 between a winglet 2 and a surface which provides the top of forward slot 3 may be roughly one half the maximum thickness of the winglet or greater.

As shown in FIG. 1A, at the opening of forward slot 3, the surface that makes the top of forward slot 3 is the lower surface of section 4. This surface extends over the nose of the winglet to a point where the winglet thickness has increased to a thickness of about 50% of the maximum thickness of the winglet (prior to reaching the point of maximum thickness of the winglet). Thus any water spray from the nose of the winglet is reduced. That is to say, a portion of front planing or displacement section 4 extends over a nose or leading edge of each winglet or foil such that spray off from the nose or leading edge of the winglet or foil is reduced as compared to spray off of a nose or leading edge of a winglet or foil which does not have a portion of a front planing or displacement section extending over it. The forward slot 3 allows energized water from under the front of the board (leaving section 4) to produce a Coanda effect over the top surface of the winglet.

Referring now to FIGS. 1B to 1D, FIG. 1B shows a top view, and FIG. 1C a side view, of a sailboard and the location of the cross section shown in FIG. 1E. The transverse end of a forward slot 3 can be fully or partially covered, such as at the opening of the forward slot 3, by a cover 12 so that water and waves, particularly on the windward side of the sailboard, do not enter the forward slot 3 and strike the nose of the winglet when sailing at high planing speeds, such as over 15 mph. When partially covered by cover 12, an opening between partial cover 12 and the winglet can allow weeds going into the forward slot to escape. FIG. 1D shows a bottom view of the sailboard shown in FIGS. 1B to 10.

While a slot and winglet can be perpendicular, angled back, angled forward, or curved, it is preferred that they be swept back, preferably at angles of 20° to 80°. This amount of sweep-back can allow the shedding of weeds or other solid debris which enter the slot, and a forward slot 3 which is swept back can direct the water passing over the winglets away from the front foot straps and the board sail.

A top slot 6 can be cut into the back of the hull of the sailboard. This allows the width of the back of the winglet to be a larger percentage of the back width of the board. This provides a higher ratio of winglet width to maximum hull width at the back of the winglet as compared with a front or middle of the winglet. Thus when the board is beginning to plane, a larger percentage of the water flowing under the top section of the portion 8 of the hull can flow smoothly off the back of the winglet. The drag of the board at transition speeds is thereby reduced and the lift is increased. A top slot 6 also allows for a wider spacing of foot straps 26 and a wider top sailboard surface of the top portion 8 of the hull, which can easily be used by the sailor for sailing and jibing the sailboard. The top slot 6 can have one or more support vanes 6 inside. These vanes are preferably curved to match the typical water flow through a slot 6 at transition speed.

The board can have more than one set of slotted winglets, such as is shown in FIG. 2. FIG. 2 shows multiple slotted winglets. A main winglet 2 is shown in the back. It may have a camber 16, step 21 and slope 18, i.e. a camber/slope step, on the planing surface. (Such features may also be employed on the winglet 2 of the embodiment discussed above in connection with FIGS. 1A-1E, as shown in FIG. 3.) In front of the main winglets 2 is a pair of auxiliary winglets 5. A main winglet 2 and an auxiliary winglet 5 are positioned so as to form a slot between them. The positioning can be a partial overlap of a tail/endpoint of auxiliary winglet 5 and a start/leading edge of main winglet 2, as shown in FIG. 2. By the same token, section 4 extends over the auxiliary winglet 5 to form a further slot above auxiliary winglet 5. The slots thus formed are preferably continuous and integral with the slot above main winglet 2. Tests of wings with auxiliary airfoils are given by Fred E. Weick and Robert Sanders NACA Report 472 pp 567-584. This arrangement of winglets allows for a larger total slot height in front of the main winglet 2. Thus it allows more water to flow over the top of the winglet 2 at transition speed and a correspondingly larger lift coefficient. Both the main winglet 2 and particularly the auxiliary winglet 5 can start (i.e., have a leading edge) at a height above a center rocker line (i.e., centerline) 27 of the sailboard. This arrangement also allows the camber 16 of the camber/slope step to be the whole length from near the start (i.e., leading edge) of the
main winglet 2 to the step 21. The camber 16 depth relative to the adjacent surface 24 can also be large, on the order of 0.65 cm (range 0.02 to 2 cm), thus increasing the planing lift at high planing speed as well as total lift of the winglet 2 at transition speed. Part of the camber 16 can be above the hull depth at centerline 27 of the hull and part can be below the hull depth at centerline 27, near the step. The vertical dimension of the step 21 is preferably about 2 to 3 mm (range of 1 to 9 mm), as shown in FIGS. 2, 3 and 4 and in the enlarged detail shown in FIG. 6. The step 21 has a radius of curvature on the order of 1 cm. Behind the step is a slope 18 which slopes upward. This allows smooth flow of water over the step at transition speeds, and at roughly 15 mph or greater the flow of water behind the step devets from slope 18. To insure this ventilation and de-wetting of slope 18 the outside edge of the winglet can also be stepped with a horizontal displacement of about 1 cm relative to the rail of the winglet 2 at the step 21. This is shown as edge step 41 in FIG. 1D, which for purposes of illustrating alternative embodiments shows one side of the board with edge step 41 and one side without. In practice, both sides of the board may have an edge step 41.

FIG. 2 shows the hull at a typical planing angle of attack of 3.5 degrees (as measured with respect to a line tangent to the back 40% of the centerline 27 of the board body). If desired, the auxiliary winglet 5 can be changed from a winglet and made part of planing or displacement section 4. In such a case, a long slot/slot opening is produced. The resulting single slot is advantageously stronger and easier to fabricate. This is what is shown in FIG. 3.

Referring now to FIG. 3, the length of a slot 10 over and on top of (i.e. above) a winglet 2 can be extended to the back of the board such that it would include slot 6 of FIGS. 1A-2. That is, a forward slot 3 (of FIGS. 1A-2) can be integral and continuous with a back slot 6 so as to form a slot 10 extending to the back of the board. This configuration allows foot straps 26 on the top surface 8 of the sailboard to be placed further to the outside as in a Formula sailboard or other sailboards in which it is desired to use a longer fin.

As shown in FIGS. 1B-3, the back planing surface 23 of the winglet and sailboard bottom is outside of the planing region 24 near and in front of a fin 9. The fin 9 is fixedly connected to the sailboard hull in planing region 24. Back planing surface 23 includes slope 18. Slope 18 can have a positive rocker on the order of a 50 meter (3000 cm) radius or a positive second derivative of 3x10^{-4} cm^{-2} (range of 0 to 8x10^{-4} cm^{-2}). Alternatively, it can have a negative rocker. In addition, camber 16 and planing surface 23 (which may further include a camber 25) produce lift at transition speed but dewet planing surface 23 behind the step 21 at faster planing speeds. The bottom view of FIG. 1D shows two planing surfaces 23 and steps 21, each surface 23 being to either side of back planing region 24.

The hull body may comprise planing regions 23 and 24. Alternatively, planing region 23 may be a planing region of a winglet, the winglet being integral with or fixedly attached to the hull body.

The depth of camber 16 can be small (about 2-6 mm) and consists of a downward curved section of about 10 cm length with a maximum angle on the order of 7 degrees, as shown, for example, in FIG. 2 behind arrow 28. This angle is formed between a first line tangent to camber 16 at the end of camber 16 and centerline 27 at the same longitudinal position of the board. The camber can also be larger, on the order of 0.65 cm (range 0.2-2 cm) as shown in FIG. 2. This camber is followed by a smooth upward curve with a radius on the order of 1 cm (range of 0.3 to 4 cm). These camber/slope steps allow the sailboard to be sailed at an optimum attack angle (3° to 5°) from transitional speeds to speeds greater than 20 mph.

As disclosed in the above-incorporated PCT/US2009/057138 there should be an increased attack angle or cusp at least on the fin side of the intersection of the planing surface region 24 and the planing region 23. Planing surface region 24 is shown with dotted lines in the side view of FIG. 1C to distinguish it from the rocker of surface region 23.

The bottom of the sailboard can be essentially flat near the fin, except for a cusp 221 at the intersection between surface 23 and region 24. Since the purpose of cusp 221 is to keep the outflow of water from planing region 24 from wetting surface 23 in planing mode, its depth depends on the transverse width of surface 23 and the vertical displacement of surface 23 above planing region 24. In some embodiments, the depth of step 21 relative to region 24 is small, and cusp 221 protrudes down below both 23 and 24. This results in a downward cusp on both surfaces 23 as well as region 24. The radius of curvature between these two cusps can be on the order of 1 cm.

There can be multiple concave shapes or a slight "Vee" shape in region 24 with variation of about 5 mm or less. Cusp 221 is also shown in the embodiment of FIG. 5E.

Since steps 21 are small, the region of the camber 16 and rocker/slope 18 is shown in more detail in FIG. 4. The camber 16, step 21, slope 18 and cusp are easy to fabricate into the bottom planing surface(s) of the sailboard. For example, they can be constructed from an additional piece of Divinycell under the fiberglass or carbon skin of the sailboard.

If one wishes a particular sailboard to plane at lower speed, another camber 25 can be added at the end of the region 23 and slope 18. Camber 25 preferably has a cup angle of 7 degrees or less, as shown in FIG. 4. In FIGS. 3 and 4, the hull is shown with a planing attack angle of zero degrees.

Referring now to the front of the hull in FIGS. 1a-3, the nose 30 of the hull of the sailboard is preferably shaped like an upside down or inverted wing, asymmetric from bottom to top with more transverse curvature on the bottom than on the top as shown in FIG. 1E. This inverted wing shape can be symmetric from the top side to the right side (i.e. symmetric about a longitudinal section of the sailboard). In this way the top area shown as 31 can have less positive (e.g. convex) curvature or, preferably, a negative (e.g. concave) curvature as also shown in the exemplary cross-section of FIG. 1E, while the bottom area 32 of the nose 30 will have greater curvature. A purpose of this nose shape is to reduce or counteract the lift of the true wind on the nose of the board, which can cause the sailboard to be unstable and the nose to fly up into the air. This effect is often referred to as board "tail-walking". Thus, by employing an inverted wing nose shape, one can use a larger sailboard and take advantage of the greater lift to drag of this invention.

FIGS. 5A-5E show an alternative winglet configuration 33. A winglet 33 may have any desired aspect ratio of length to width and may be provided as a set of winglets. This set of winglets, a left winglet and a right winglet, have top slots 10 (channels 10) above winglets 33. Top slots 10 cover at least half of the winglets 33. That is to say, a top/roof of a slot 10 covers at least half of the winglet surface which
provides a bottom/floor of the slot. FIG. 5A clearly shows a top portion 8 of the sailboard/hull, an underside of which provides the top/roof of slot 10, covering more than half of the top surface of winglet 33.

[0058] It is preferred that these winglets be swept back both to shed weeds and for better directional stability. In FIG. 5A the front edge of each winglet 33 of the pair of winglets is swept back with respect to a longitudinal center line of the hull. The bottom of the end of winglet 33 (i.e. the outside edge of the winglet, the part of the winglet furthest from a longitudinal center of the hull), is below the bottom surface of the rest of the hull, as shown in FIG. 5B. Winglet 33, more specifically the bottom of the end of winglet 33, may be the lowest part or portion of the sailboard/sailboat hull, at that longitudinal position.

[0059] With reference to FIGS. 5C and 5D, cross sections of two preferred embodiments of a sailboard hull with winglets 33 are shown. The top/side surface of a top slot 10 preferably roughly follows the shape of the top of the winglets so there is no pressure increase in the channel due to a changing height in the slot/channel 10. At high planing speeds, only winglet 33 and the back section of the sailboard, preferably with camber/slope steps as discussed above, are in or in contact with the water. Thus the winglets 33 with slots aid in the stability of the sailboard and maintaining the planing attack angle at high planing speed. The cross sections in FIGS. 5C and 5D also show slot 10 covering over half of a winglet 33. That is, the figures show the sides of the top portion 8 of the sailboard covering over half of the top surfaces of the winglet pair. In addition, the shape of a winglet 33 in the transverse direction may be straight (such as in FIG. 5C) or bent or curved (such as in FIG. 5D). In the latter case, the angle of the winglet in the transverse direction may be greater where the winglet attaches to the remainder of the hull as compared to the end/tip of the winglet. The end of the winglet may also slope up slightly. Note that in FIG. 5C, only the structural elements through which the cross-section is taken are shown for purposes of clarity. In FIG. 5D, however, some portions of the sailboard which are behind where the cross-section is taken are shown.

[0060] FIG. 5E shows a cross-sectional view taken near the rear of the sailboard. Rear slots 6 are present on either side of the sailboard. Support veins 6, which appear behind the plane of the cross-section, are also shown. A small cusp 221 is present where each planing surface 23 meets planing region 24.

[0061] Those skilled in the art will appreciate that two or more applications of winglets with a front slot or top slot can be used in a row in accordance with the invention and that slotted winglets 2 can be used with known hydrofoils nearer the front or middle of a hull to better maintain an optimum planing angle at even faster planing speeds.

[0062] While the invention has been described in terms of a preferred embodiment and variations thereon, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the appended claims.

[0063] Furthermore, while the embodiments described herein are primarily directed to sailboard hulls, those skilled in the art will recognize that the invention pertains to other watercraft hulls, particularly small watercraft hulls, especially those with a length of 12 feet or less.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is as follows:

1. A board hull of a sailboard or watercraft less than or equal to 12 feet long, comprising: a top portion which has a top surface and a bottom surface, at least one pair of winglets or foils at least a portion of which are beneath said bottom surface of said top portion, and a slot above each winglet or foil of said at least one pair of winglets or foils, wherein at least a portion of said bottom surface of said top portion is a roof of said slot and at least a portion of an upper surface of said each winglet or foil is a floor of said slot, wherein said slot has an opening in front of or above said each winglet or foil, and wherein water passing through said slot reduces wave drag of said each winglet or foil.

2. The board hull as recited in claim 1, wherein said slot has a height to width ratio which is less than one and a height to winglet chord ratio which is less than said height to width ratio.

3. The board hull as recited in claim 1, wherein said roof of said slot has a slope in a transverse direction equal to or less than ±15° with respect to a horizontal.

4. The board hull as recited in claim 1, further comprising: one or more front foot straps attached to said board top surface of said top portion, and wherein said slot and said each winglet or foil are swept back at angles of 20° to 80° to allow shedding of weeds which enter said slot and/or to direct water passing over said each winglet or foil away from said one or more front foot straps attached to said board top surface of said top portion.

5. The board hull as recited in claim 1, wherein said at least one pair of winglets or foils starts 90 to 160 cm from a back/rear of said board hull.

6. The board hull as recited in claim 1, further comprising: a pair of back slots cut into a back/rear of said board hull which are above at least a portion of said at least one pair of winglets or foils, said pair of back slots being configured such that a ratio of slot width to maximum hull width at a point at said back/rear of said board hull is equal to or greater than said ratio at a point further from said back/rear of said board hull.

7. The board hull as recited in claim 1, wherein each back slot of said pair of back slots has a support vane positioned therein.

8. The board hull as recited in claim 6, wherein said slot extends to said back/rear of said board hull such that said back slots produce a streamline effect in displacement and transition modes while said top portion forming a roof of said back slots allows the back foot straps to be spread wider apart and still remain out of a water flow than without said back slots.

9. The board hull as recited in claim 1, further comprising at least two back foot straps, wherein said pair of back slots are configured to allow said at least two back foot straps to be laterally spaced a distance equal to or less than a width of said board top surface of said top portion above said back slots.

10. The board hull as recited in claim 1, wherein a bottom surface of said each winglet or foil has at least one camber/step having a camber with a depth of 0.2 to 2 cm and a step with a height of 1 to 9 mm and a curvature of radius 0.3 to 4 cm.
11. The board hull as recited in claim 1, further comprising: a back planing region near and in front of a fin at an underside of said board hull; and a back planing surface to either side of said back planing region having a camber/slope step, an intersection of said back planing region and said back planing surface, said intersection having a cusp, wherein said camber/slope step allows said board hull to maintain an attack angle of 3° to 5° for transitional speeds to speeds greater than 20 mph, and wherein said cusp keeps an outflow of water off said back planing region from said back planing surface in planing mode.

12. The board hull as recited in claim 11, wherein said back planing surface has an additional camber with a cup angle of 7 degrees or less.

13. The board hull as recited in claim 1, wherein said opening of said slot is 20 to 120 cm long in a longitudinal direction of said top portion.

14. The board hull as recited in claim 13, further comprising a front planing or displacement surface at a front bottom of said top portion, wherein a roof of said opening of said slot comprises i) a first part which is approximately tangent said front planing or displacement surface, ii) a second part having a rocker, and iii) a third part having a camber toward and/or over a nose of said at least one pair of winglets or foils.

15. The board hull as recited in claim 1, wherein said roof of said slot covers at least half of said upper surface of said each winglet or foil which is said floor of said slot.

16. The board hull as recited in claim 15, wherein said each winglet or foil is straight or bent/curved in a transverse direction.

17. A watercraft hull, comprising: a top portion which has a top surface and a bottom surface; a winglet at least a portion of which is beneath said top portion; and a slot above said winglet formed by said bottom surface of said top portion and a top surface of said winglet, wherein said slot has a height to width ratio which is less than one and a height to winglet chord ratio which is less than said height to width ratio.

18. The watercraft hull as recited in claim 17, wherein said winglet is configured as a pair of winglets.

* * * * *