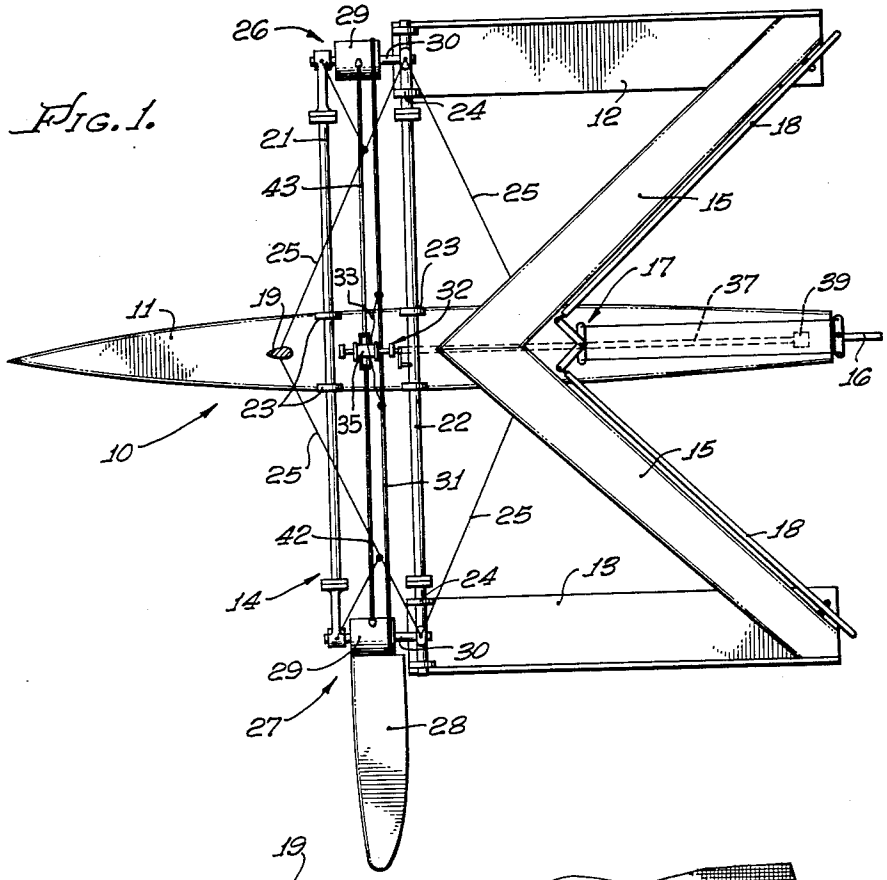
April 20, 1965 J. R. POPKIN 3,179,078

DUAL HYDROFOIL MECHANISM FOR SAILBOATS

Filed Dec. 4, 1962 3 Sheets-Sheet 1

FIG. 1.



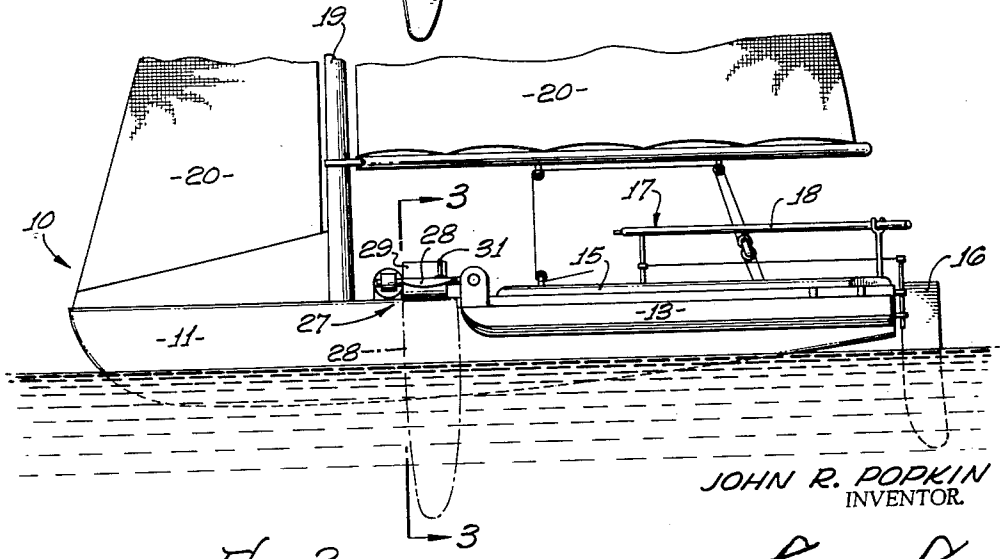


FIG. 2.

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DUAL HYDROFOIL MECHANISM FOR SAILBOATS

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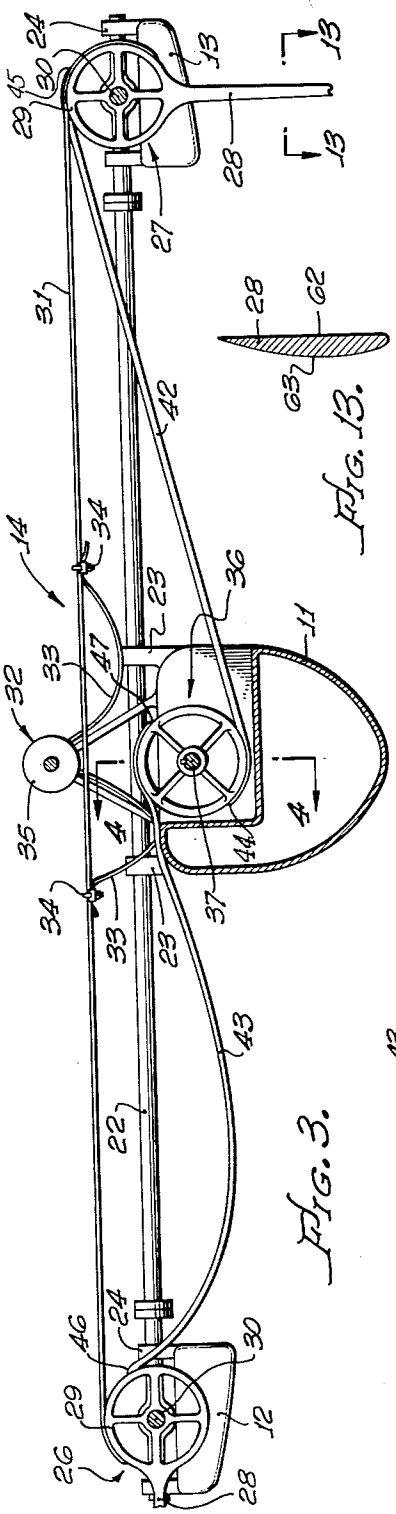


FIG. 3.

FIG. 13.

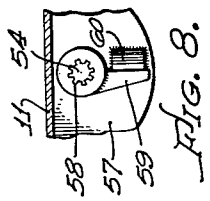


FIG. 8.

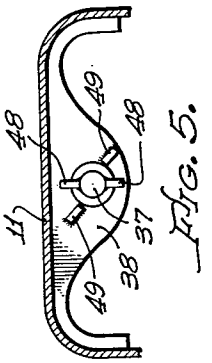


FIG. 5.

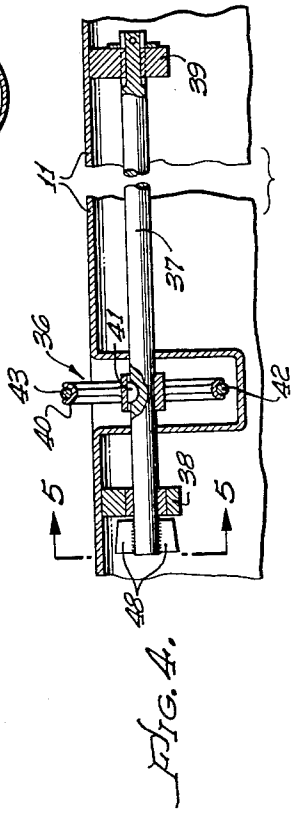


FIG. 4.

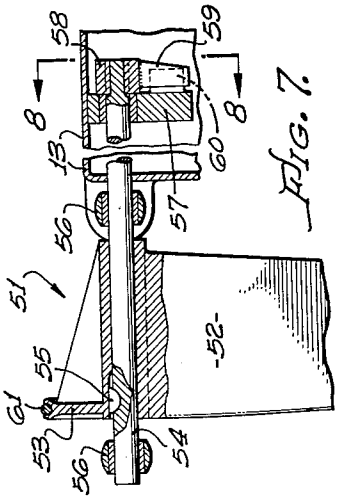


FIG. 7.

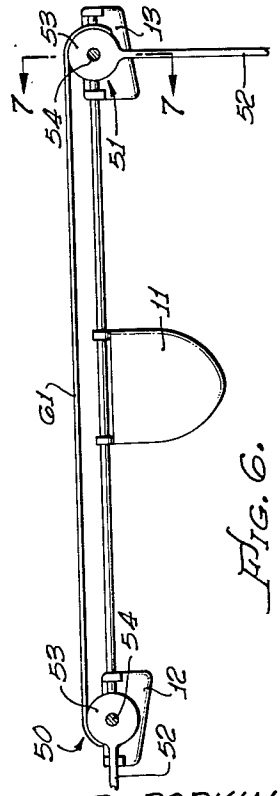


FIG. 6.

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DUAL HYDROFOIL MECHANISM FOR SAILBOATS

Filed Dec. 4, 1962 3 Sheets-Sheet 3

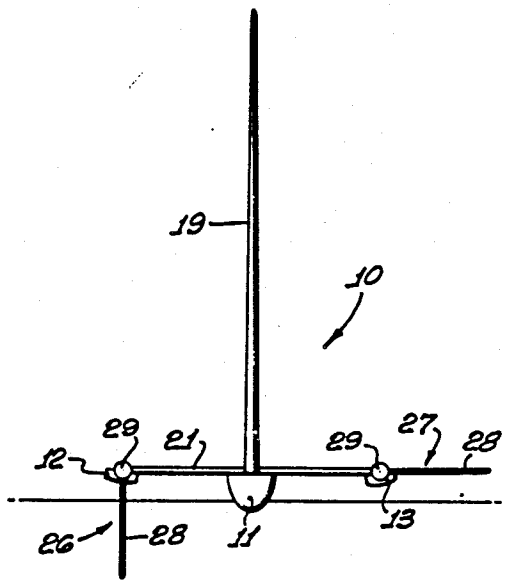


FIG. 9.

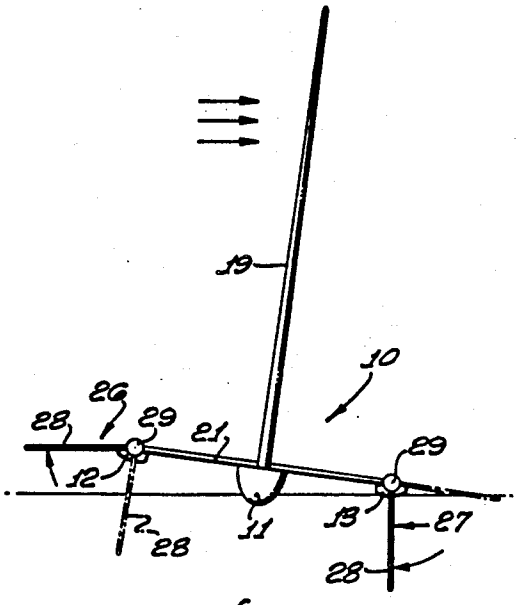


FIG. 10.

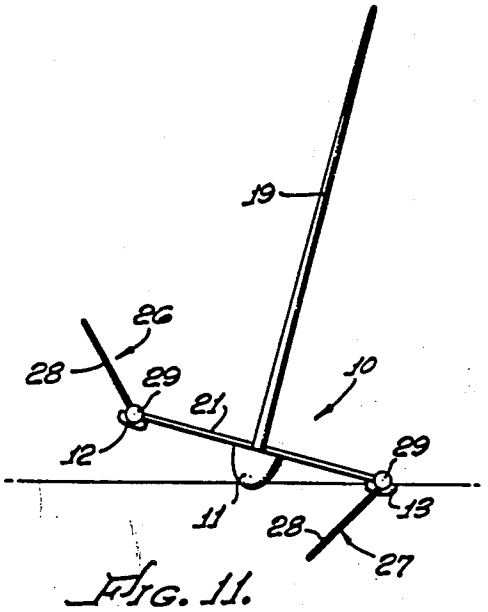


FIG. 11.

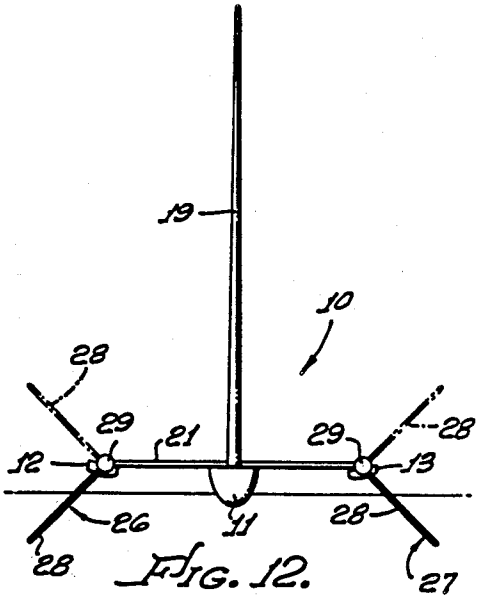


FIG. 12.

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United States Patent Office 3,179,078 Patented Apr. 20, 1965

3,179,078
DUAL HYDROFOIL MECHANISM FOR SAILBOATS

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Filed Dec. 4, 1962, Ser. No. 242,180
9 Claims. (Cl. 114—126)

This invention relates to a hydrofoil mechanism for sailboats to resist sideways slipping motion of the sailboat due to lateral wind forces and to produce a lifting force on the sailboat to improve performance characteristics and counteract the overturning forces of the wind on the sailboat. In particular, this invention relates to a dual hydrofoil mechanism which operates unattended to appropriately and properly position one of the hydrofoils in the water as needed for proper operation of the sailboat.

Conventionally sailboats are provided with center boards or other means which serve to resist lateral motion of the sailboat due to the wind producing lateral forces on the sails and sailboat. The center board serves this useful and necessary purpose, but also acts as a resistance to the forward motion of the sailboat and does not produce any forces, other than merely weight, tending to prevent overturning of the sailboat. As is well known, it is advantageous to shift the center of gravity of the weight of the boat and its contents toward the windward such as by positioning the occupants so that righting force is produced to combat the overturning force caused by the wind impinging upon the sail. Conversely, a similar righting force to produce stability may be induced by using a pair of hulls, as in a catamaran, or an outrigger hull to the leeward side whereby the sailboat is at least partially supported at a lateral distance toward leeward from the center of gravity of a sailboat thereby producing a righting moment force. However, such an outrigger hull also acts as a resistance to the motion of the sailboat through the water.

The overturning force applied to a sailboat by wind impinging upon the sails and the force tending to cause lateral motion of the sailboat will depend upon numerous factors such as wind velocity, sail area, direction of movement of the sailboat with respect to the direction of the wind, etc. Thus for example, when running with the wind, i.e., the sailboat moving in the same direction as the wind, there is very little need for a center board since the overturning forces and the lateral forces are relatively nominal. Although certain smaller sailboats have center boards which are removable or retractable for conditions where they are not needed, there are no conventional sailboats that are provided with a center board or center boards that can be adjusted to produce righting forces and forces resisting lateral movement which are proportional to the overturning and lateral movement forces produced by the wind.

It is well known that a properly shaped hydrofoil can cause resultant forces in a lateral direction as the hydrofoil passes through the water. If such a hydrofoil were properly positioned and moved for various conditions the hydrofoil could produce the necessary forces to prevent lateral movement of the sailboat and overturning of the sailboat. Moreover, a hydrofoil offers very little resistance to passage through the water as compared to a hull and can serve to stabilize the forward motion. However, to be practical, the positioning of such a hydrofoil must be essentially automatic in response to the various force conditions encountered so that erroneous positioning of the hydrofoil by an operator does not result in overturning of the sail boat or unsatisfactory handling conditions.

Accordingly, it is a principal object of this invention to provide a novel form of hydrofoil mechanism for a sailboat that will function automatically in response to wind conditions for improving the operating characteristics of the sailboat.

Another object of this invention is to provide a dual hydrofoil mechanism for sailboats employing asymmetrical hydrofoils wherein only one of the two hydrofoils is positioned in the water at one time and the asymmetrical shape of that hydrofoil produces forces tending to resist lateral slipping and overturning of the sailboat.

A further object of this invention is to provide a hydrofoil mechanism for sailboats wherein a hydrofoil is positioned on either side of the center line of the boat at a substantial distance from the center line, and only the leeward side hydrofoil is positioned in the water during normal operation.

Still another object of this invention is to provide a hydrofoil mechanism for sailboats wherein an asymmetrically shaped hydrofoil is automatically positioned in the water at an appropriate angle in response to the lateral forces on the sailboat whereby the hydrofoil produces appropriate resistive lateral forces and lifting forces to improve the operational characteristics and stability of the sailboat.

A still further object of this invention is to provide a dual hydrofoil mechanism wherein the positions of the two hydrofoils are synchronized and the operational position of each is resiliently resisted in response to particular force conditions imposed upon the sailboat.

A further and more detailed object of this invention is to provide a novel form of dual hydrofoil mechanism particularly adaptable to a trimaran sailboat wherein a hydrofoil is pivotally mounted on each of the outriggers and the leeward side hydrofoil only is positioned in the water at any one time with its angular position automatically adjusted by resilient means to continually maintain the most ideal position for the particular conditions at that moment. Moreover, it is an object of this invention to provide asymmetrically shaped hydrofoils for such mechanisms whereby the leeward side hydrofoil provides a lifting force so that the outrigger may function as a planing surface rather than a merely buoyant supporting member.

Further and more detailed objects and advantages of this invention will appear from the following description and the accompanying drawings.

In the drawings:

FIGURE 1 is a plan view of a trimaran sailboat employing a particular preferred embodiment of the dual hydrofoil mechanism of this invention with the sails, mast and boom removed for clarity of illustration.

FIGURE 2 is an elevation of the trimaran of FIGURE 1 with the sails and masts partially broken away.

FIGURE 3 is a sectional elevation of the mechanism of this invention taken substantially on the line 3—3 as shown in FIGURE 2 with the hydrofoils in a different position than shown in FIGURE 2.

FIGURE 4 is a fragmentary sectional elevation of the torsion bar mechanism used in this preferred embodiment taken substantially on the line 4—4 as shown in FIGURE 3.

FIGURE 5 is a sectional elevation illustrating the stop mechanism and taken substantially on the line 5—5 as shown in FIGURE 4.

FIGURE 6 is a schematic elevation view similar to FIGURE 3 illustrating a modified form of apparatus for the dual hydrofoil mechanism of this invention.

FIGURE 7 is a fragmentary sectional elevation view of the hydrofoil mounting taken substantially on the line 7—7 as shown in FIGURE 6.

FIGURE 8 is a fragmentary sectional view taken sub-

stantially on the line 8—8 as shown in FIGURE 7 and illustrating the stop mechanism for this modified form of the apparatus.

FIGURE 9 is a schematic illustration of a trimaran employing the dual hydrofoil mechanism of this invention and is a head-on view illustrating the positions of the hydrofoils when there is a very light wind from the right side as viewed in FIGURE 9.

FIGURE 10 is a schematic illustration of a trimaran similar to FIGURE 9 illustrating a change in the wind or a tacking maneuver when the wind is shifted to the left side as viewed in FIGURE 10.

FIGURE 11 is a schematic illustration similar to FIGURES 9 and 10 with a relatively stiff wind from the left side as viewed in FIGURE 11.

FIGURE 12 is a schematic illustration similar to FIGURES 9, 10 and 11 showing the trimaran either becalmed or running with the wind such that little or no lateral forces are applied to the trimaran by the wind.

FIGURE 13 is a sectional plan view taken substantially on the line 13—13 as shown in FIGURE 3 and diagrammatically illustrates the asymmetrical shape of the hydrofoil and the orientation with respect to the center hull of the trimaran sailboat.

Although the drawings illustrate the dual hydrofoil mechanism of this invention as installed on the outriggers of a trimaran sailboat, it is to be understood and will readily appear to those skilled in the art that the dual hydrofoil mechanism may also be used on single or double hull sailboats. When the dual hydrofoil mechanism of this invention is used on a single hull sailboat an appropriate structure may be provided and extend outwardly from the hull to support the hydrofoils in a manner similar to the hereinafter described structure. When the dual hydrofoil mechanism of this invention is used on a dual hull or catamaran sailboat, the hydrofoils may be mounted on each of the hulls or on structures extending therefrom. Moreover, although the hydrofoils are shown in the drawings as mounted on the front portions of the outriggers of the catamaran, it will be apparent from the following description that the hydrofoils could be spaced inwardly or outwardly from the outriggers by appropriately modifying the structure without departing from the invention.

Referring now to the drawings, the trimaran, generally designated **10**, has a center hull **11** and a pair of outrigger hulls **12** and **13** laterally spaced from and substantially parallel to center hull **11**. The starboard and port outriggers **12** and **13**, respectively, are supported from the center hull **11** by any convenient means such as by struts **15** and certain of the structural members of the hydrofoil mechanism, designated **14**, as hereinafter described. Struts **15** may also serve as seating regions. A rudder **16** is pivotally mounted on the stern of hull **11** and a tiller mechanism **17** is provided having extensions **18** for appropriately operating the rudder **15** from either of the seating regions on the struts **16** as is conventional. A mast **19** is provided for supporting sails **20** in a conventional manner.

The frame of the hydrofoil mechanism **14** may include a pair of support tubes **21** and **22** extending laterally across hull **11** with each being mounted on hull **11** by a pair of brackets **23**. Brackets **24** may also be provided on the extremities of support tube **22** for supporting the front end of the outriggers **12** and **13**. Appropriately located guy wires, such as guy wires **25**, extend from the outer ends of support tubes **21** and **22** to the hull **11** and mast **19** for aiding in the support and rigidity of the hydrofoil mechanism **14** and outriggers **12** and **13**. It will be obvious to those skilled in the art that the frame and guy wires shown and described may be appropriately modified to adapt the hydrofoil mechanism **14** to the particular type and style of sailboat employing the invention.

Two hydrofoil assemblies, generally designated **26** and **27**, are provided and mounted on the extremities of the support tubes **21** and **22** with hydrofoil assembly **26** positioned in front of outrigger **12** and hydrofoil assembly **27** positioned in front of outrigger **13**. The hydrofoil assemblies **26** and **27** are each comprised of a hydrofoil **28** projecting from and secured to a drum **29** which is in turn rotatably mounted on a shaft **30** extending between and secured to support tubes **21** and **22**. Although drum **29** is shown as a complete cylinder and such would probably be the easiest form to manufacture, it will readily appear from the following description that drum **29** does not necessarily have to be a complete cylinder and moreover could be oval in cross-section rather than cylindrical. A line or cable **31** extends between the hydrofoil assemblies **26** and **27** and is secured to the drum portion **29** of each by any convenient means in approximately the locations shown. The cable **31** is of a particular length and the ends are appropriately secured to drums **29** such that when cable **31** is stretched tautly between the hydrofoil assemblies **26** and **27** the hydrofoil **28** of each assembly is positioned at substantially 90° to the hydrofoil **28** of the other assembly when viewed from the front or rear. That is to say that when hydrofoil **28** of assembly **27** extends vertically downward then hydrofoil **28** of assembly **26** extends horizontally outward as shown in FIGURE 3 and vice versa. Line **31** wraps around each drum **29** a sufficient distance before attachment to the drum so that this 90° relationship may be maintained for all normal positions of operation.

A hand-operated winch assembly **32** is provided and mounted on the hull **11** for raising both of the hydrofoils **28** out of the water when desired such as for docking or for running with the wind. The winch assembly **32** is provided with a pair of cords **33** secured by clamps **34** to cable **31** at spaced locations as shown. Upon winding the cords **33** onto the drum **35** of the winch assembly **32** the cords **33** will pull the two clamps **34** toward each other thereby shortening the effective length of cable **31** and changing the 90° relationship between the two hydrofoils **28**. By foreshortening cable **31** a sufficient amount both hydrofoil members **28** may be raised out of the water.

In order to maintain the hydrofoil **28** which is in the water in the proper position depending on the particular wind and force conditions, means are provided for resiliently resisting movement of either hydrofoil member **28** in an inward direction from the vertically downwardly extending position such as that shown for hydrofoil **28** of assembly **27** in FIGURE 3. These means may comprise any convenient type of resilient resisting apparatus although I prefer to use and describe a torsion mechanism, generally designated **36**, mounted in hull **11**. Torsion mechanism **36** includes a torsion bar **37** rotatably mounted at one end by a bearing support **38** and fixedly mounted at the other end by support **39**. Torsion bar **37** may be affixed to support **39** by any convenient means. A sheave **40** is mounted on torsion bar **37** and secured thereto by any convenient means such as key **41**. Sheave **40** is substantially spaced from the end of torsion bar **37** which is affixed in support **39** and is preferably near the bearing support **38**. A cable **42** extends from the lower portion of sheave **40** to the upper portion of drum **29** of the hydrofoil assembly **27** and a similar cable **43** extends from the upper portion of sheave **40** to the drum **29** of hydrofoil assembly **26**. In the relative positions of the various components shown in FIGURES 3, 4 and 5, the torsion bar **37** is in an unstressed condition, i.e., the torsion bar and sheave are in their neutral position. The cable **42** is attached at one end to drum **29** at a location **44** approximately diametrically spaced from the attachment of hydrofoil **28**. The other end of cable **42** is attached to sheave **40** on the side of the sheave opposite the side of hydrofoil assembly **27** such as at location **45**. Similarly, cable **43** is attached at location **46** on drum **29** approximately diametrically spaced from hydrofoil **28** of assembly **26** and the other end of cable **43** is attached at

point 47 on sheave 40 on the opposite side of the sheave. Cable 42 will be taut when hydrofoil 28 of assembly 27 is extending vertically downward but torsion bar 37 will not be stressed, as shown in FIGURE 3. Likewise, cable 43 will be taut and torsion bar 37 unstressed when hydrofoil 28 of assembly 26 is extending vertically downward.

The specific functions served by the hydrofoils 28 will be more fully described hereinafter but at this point for purposes of description it will be assumed that during operation the leeward side hydrofoil assembly 26 or 27 will be positioned with the hydrofoil 28 projecting downwardly into the water and the various wind and water forces will tend to force that hydrofoil assembly to rotate about shaft 30 such that that hydrofoil 28 tends to pivot inwardly toward hull 11. In order for the hydrofoil mechanism of this invention to perform the functions desired this inward movement must be resisted. Referring specifically to FIGURE 3, it will be assumed that outrigger 13 and hydrofoil assembly 27 are on the leeward side and since the wind is coming from the left the hydrofoil 28 of that assembly is being urged toward the left or inwardly thus tending to rotate the drum 29 of that assembly in a clockwise direction. Any clockwise rotation of drum 29 of assembly 27 will tend to wrap additional cable 42 onto that drum and since cable 42 is taut when hydrofoil 28 of assembly 27 is projecting vertically downward, the wrapping of cable 42 on the drum will tend to pull the cable off sheave 40 thereby causing sheave 40 to rotate in a counterclockwise direction as viewed in FIGURE 3. Since sheave 40 is secured to torsion bar 37 which is in turn secured to support 39, this rotation of sheave 40 will be resiliently resisted by the torsion stresses induced in the torsion bar 37. The greater the inward angular displacement from vertical of hydrofoil 28 the greater will be the resilient torsion resistance by torsion bar 37. It is also to be noted that this inward movement of hydrofoil 28 of assembly 27 causes raising of hydrofoil 28 of assembly 26 above the horizontal due to the interconnection by cable 31.

Similarly, it may be seen that when hydrofoil assembly 26 is on the leeward side and that hydrofoil 28 is in a vertically downward projecting position cable 43 will be taut and inward movement of hydrofoil 28 from that position causes counterclockwise rotation of the drum 29 of that assembly thereby wrapping cable 43 onto that drum and unwrapping some of that cable from sheave 40. This causes sheave 40 to rotate in a counterclockwise direction. As previously described, this counterclockwise rotation of sheave 40 is resiliently resisted by torsion bar 37. It is to be noted that sheave 40 is rotated in a counterclockwise direction by the movement of hydrofoil 28 of either of the hydrofoil assemblies 26 or 27 inwardly from the vertical downwardly extending position. For reasons that will hereinafter become apparent it may be desirable to limit the extent of inward angular displacement from the vertically downward position of the hydrofoil 28 which may be permitted regardless of the wind and water forces and such may be accomplished by providing a stop means on torsion bar 37. This stop means may include stops 48 on torsion bar 37 near sheave 40 projecting radially outwardly and adapted to engage similar stops 49 secured to the bearing support 38. Thus, as shown in FIGURE 5, the angular displacement of torsion bar 37 and sheave 40 is limited to approximately 45° and if sheave 40 and drums 29 are approximately the same diameter as shown, the angular displacement of either of the hydrofoil members 28 will be limited to 45° from the downward vertical position. This limitation of 45° is meant only as illustrative and in actual practice may be varied for various types and styles of sailboats and to obtain various operating characteristics.

Referring now more particularly to FIGURES 6, 7 and 8, a modified form of apparatus is shown for the dual hydrofoil mechanism of this invention. In this form, the need for the torsion mechanism 36 installed in hull 11 and cables 42 and 43, as previously described, is eliminated. Hydrofoil assemblies, generally designated 50 and 51, are provided similar to the provision of hydrofoil assemblies 26 and 27. The frame work structure for supporting the outrigger hulls 12 and 13 and the hydrofoil assemblies 50 and 51 from the center hull 11 may be substantially the same or similar to that previously described. The hydrofoil assemblies 50 and 51 are each comprised of a hydrofoil 52 mounted on a sheave 53 similar respectively to hydrofoil 28 and drum 29 previously described. Sheave 53 and hydrofoil 52 are affixedly mounted to a torsion shaft 54 by any convenient means such as key 55. Torsion shaft 54 is rotatably mounted and supported by bearings 56 on either side of the hydrofoil 52. Torsion shaft 54 is relatively long and extends rearwardly into the associated outrigger hull being rotatably supported near the rearward end by bearing support 57 mounted in the outrigger hull. A splined stop member 58 is mounted on the end of torsion shaft 54 and has a stop arm 59. Stop arm 59 is adapted to engage a stop 60 secured to the bearing support 57, such that inward movement of hydrofoil 52 from the vertically downward projecting position is prevented unless sufficient force is applied to twist the torsion shaft 54. Thus, it may be seen that the separate torsion shafts 54 of this modified form serve the same function as the torsion assembly 36 and connecting cables 42 and 43 heretofore described since inward movement of either hydrofoil member 52 beyond the downward vertical position is resiliently resisted by a torsion bar. The outward and upward movement of each hydrofoil member 52 from the downward vertical position is unimpeded since stop arm 59 only engages one side of stop 60 and is free to move in the other direction. A cable 61 is provided similar to cable 31 and is appropriately connected to the sheaves 53 of the hydrofoil assemblies 50 and 51 so that the hydrofoils 52 of those two assemblies are maintained at 90° with respect to each other at all times in the same manner as heretofore described.

Each of the hydrofoil members 28 or 52 are relatively long and have an asymmetrical shape as may be seen by the cross-section shown in FIGURE 13. One side 62 is relatively flat while the other side 63 is curved outwardly and tapered to form a relatively conventional hydrofoil shape. When the particular hydrofoil member extends downwardly in the vertical position the flat side 62 faces outwardly from the center of the boat and the curved side 63 faces inwardly. As is well known in the art, a hydrofoil of such configuration passing through the water with the flat side 52 coinciding with the direction of movement will produce a force on the hydrofoil tending to move the hydrofoil in the direction of the curved side 63. Thus, whatever the hydrofoil is attached to would tend to move with the hydrofoil in the direction of the curved side. Moreover, if a hydrofoil is positioned horizontally with the curved side facing upwardly, the hydrofoil will produce a lifting force.

Referring now more particularly to FIGURES 9 through 12, the operation of the dual hydrofoil mechanism of this invention may be described in relation to the response of the mechanism to various wind conditions. As heretofore described, FIGURES 9, 10, 11 and 12 will be assumed to be headon views of the trimaran 10 previously described and, therefore, port will be to the right and starboard to the left as viewed in these figures. The dual hydrofoil mechanism may be either the type shown in FIGURES 1 through 5 or the type shown in FIGURES 6 through 8 and the operation will be identical although for purposes of description here it will be assumed that the mechanism of FIGURES 1 through 5 is being used. If the sailboat is completely becalmed and motionless the hydrofoils 28 would probably be in a position shown by the solid lines in FIGURE 12 where each hydrofoil projects downwardly and outwardly into the water at approximately 45° to the water line. It is again to be noted that the hydrofoils are maintained at approximately 90° with

respect to each other by connecting cable 31. If a light wind impinges from the port side the sailboat would tend to move toward leeward, i.e., starboard and the relative movement between the sailboat and the water would cause the starboard hydrofoil 28 to be pulled downwardly to the vertical position shown in FIGURE 9 thereby raising the port or windward side hydrofoil 28 out of the water. This position is also shown by the dashed lines in FIGURE 10. However, a shift in the wind or tacking so that the wind impinges on the starboard side, as shown in FIGURE 10, will cause the trimaran 10 to move to port relative to the water and this motion will not be resisted by the starboard hydrofoil 28 since outward pivoting motion is unimpeded. As soon as starboard hydrofoil 28 moves outwardly and upwardly the port hydrofoil 28 drops into the water and further port movement of the sailboat causes that hydrofoil to assume the vertical downwardly projecting position shown by the solid lines in FIGURE 10. Increased wind from starboard such as changes in wind conditions or changes in direction with respect to the direction of the wind will cause increased overturning forces on the sailboat and increased forces tending to make the sailboat slip laterally rather than proceeding directly ahead as controlled by rudder 16. The lateral forces from starboard will be resisted by the port hydrofoil member 28 since that hydrofoil is extending downwardly into the water and the lateral forces will cause that hydrofoil to pivot inwardly toward the central hull 11 thereby assuming a condition which may be represented by FIGURE 11. The angular portion of the hydrofoil will depend upon the intensity of the lateral forces being resisted, and it may readily be seen that the greater the lateral force the more the hydrofoil will extend inwardly rather than downwardly.

Turning now to the function of the asymmetrical shape of the hydrofoils, it may be seen that if the sailboat is moving straight through the water with the leeward side hydrofoil extending vertically downwardly that there will be a resultant force produced by the hydrofoil tending to move the sailboat toward windward since the curved side will be facing windward. As the hydrofoil assumes an angular position such as that shown for the port hydrofoil member in FIGURE 11, the force produced by the hydrofoil passing through the water will have both a horizontal component and a vertical component. The horizontal component is still directed toward windward to resist side slipping of the sailboat and the vertical force component is upwardly to, in effect, support some of the weight of the sailboat. Since this vertical lifting component of force is laterally spaced from the center of gravity of the sailboat a force moment is produced in opposition to the overturning force moment produced by the wind impinging on the sails. As is well known, a hydrofoil depends upon its shape for producing lifting forces and the lifting forces produced when the hydrofoil is passing through the water greatly exceeds the buoyancy of the hydrofoil. Thus, as shown in FIGURE 11, a large portion of the weight of the sailboat may be supported by the leeward side hydrofoil member 28 and as a consequence the center hull 11 may lift nearly free of the water or at least to a position where it is planing along the surface of the water. Under such conditions, the resistive drag of the center hull is greatly reduced and performance characteristics are greatly improved. Moreover, it may be seen that the greater the lateral wind forces the greater will be the lifting force produced by the leeward hydrofoil member since the increased lateral force causes the hydrofoil member to more closely approach a horizontal position than the vertical position.

It is preferred in the particular embodiment of this invention in a trimaran that the outrigger hulls 12 and 13 be positioned above the water when in a level position and that the entire weight be supported by hull 11. Further, the bottom surfaces of outrigger hulls 12 and 13 are relatively flat and towed outwardly, i.e., positioned at an angle to the horizontal such that when the wind causes the trimaran 10 to heel over, as shown in FIGURES 10 and 11, the outrigger hull will serve as a planing surface rather than merely as a buoyant support. When it is desired to run the sailboat before the wind such that, as in conventional sailboats, no center board is necessary or when approaching a dock both of the hydrofoil members 28 may be raised above water level to any position such as the position shown by dashed lines in FIGURE 12 by merely operating winch mechanism 32, heretofore described, to foreshorten cable 31.

Thus, it may be seen that by this invention there is provided a hydrofoil mechanism for sailboats which functions without attention to position a hydrofoil in the water always on the leeward side of the sailboat with the angular position of the hydrofoil being automatically adjusted in response to the conditions of lateral force imposed upon the sailboat. Moreover, by employing dual asymmetrically shaped hydrofoils which are automatically and properly oriented a highly desirable lifting force is produced on the leeward side of the sailboat to resist overturning and improve operating characteristics. Further, this lifting force results in a portion or all of the hull being lifted out of the water to thereby minimize the water drag produced by the hull. Each of these unusual functions are accomplished automatically by the apparatus of this invention and such apparatus does not require attention during normal sailing for compensating for changes in wind conditions, direction of movement, tacking, etc.

Having fully described my invention it is to be understood that I do not wish to be limited to the details herein set forth or to the details illustrated in the drawings, but my invention is of the full scope of the appended claims.

I claim:

1. An apparatus for a sailboat, comprising, a pair of hydrofoils pivotally mounted on the sailboat at laterally spaced locations on either side of the longitudinal center line of the sailboat, said hydrofoils having an asymmetrical shape for producing a lateral force when passing through the water, means for automatically pivoting each of said hydrofoils solely in response to wind impinging on the sailboat to raise the windward side hydrofoil out of the water and to lower the leeward side hydrofoil into the water, means for further pivoting said leeward side hydrofoil in response to wind forces to angularly position that hydrofoil in the water such that the said lateral force produced by said asymmetrical shape resists both sideways slipping and overturning forces imposed on the sailboat by the wind.

2. An apparatus for a sailboat comprising, a pair of hydrofoils, each hydrofoil being asymmetrical with one side curved and the other side relatively flat, one of said hydrofoils positioned on either side of and laterally spaced a substantial distance from the longitudinal center line of said boat, each said hydrofoil pivotally mounted by one end on the sailboat on an axis relatively parallel to the longitudinal center line of the sailboat and located above the normal water line of the sailboat for said hydrofoil to engage the water when extending downwardly, each of said hydrofoils oriented such that said flat side faces outwardly from the sailboat when that hydrofoil extends downwardly from the pivotal mounting thereof, means operably connecting the two said hydrofoils for synchronous movement of said hydrofoils for pivoting one hydrofoil out of the water when the other hydrofoil is in the water in downwardly and downwardly-inwardly extending positions, means resisting pivoting of either said hydrofoil in an inwardly direction from the vertically downward extending position of such hydrofoil, both hydrofoils extending into the water when the sailboat is stopped or moving with the wind, means for automatically pivoting said hydrofoils solely in response to wind impinging on the sailboat with the leeward side hy-

drofoil assuming a downward and relatively vertical position to resist the lateral motion of the sailboat.

3. An apparatus for a sailboat comprising, a pair of hydrofoils, each hydrofoil being asymmetrical with one side curved and the other side relatively flat, one of said hydrofoils positioned on either side of and laterally spaced a substantial distance from the longitudinal center line of the said boat, each said hydrofoil pivotally mounted by one end on the sailboat on an axis relatively parallel to the longitudinal center line of the sailboat and located above the normal water line of the sailboat for said hydrofoil to engage the water when extending downwardly, each of said hydrofoils oriented such that said flat side faces outwardly from the sailboat when that hydrofoil extends downwardly from the pivotal mounting thereof, means operably connecting the two said hydrofoils for synchronous movement of said hydrofoils for pivoting one hydrofoil out of the water when one other hydrofoil is in the water in downwardly and downwardly-inwardly extending positions, means resiliently and increasingly resisting pivoting of either said hydrofoil in an inwardly direction toward the center line of the sailboat from the vertically downward extending position of such hydrofoil; both hydrofoils extending into the water when the sailboat is stopped or moving straight forward, upon wind impinging on the sailboat to produce lateral forces urging lateral motion the leeward side hydrofoil assuming a downward and relatively vertical position to resist the lateral motion, and increasing lateral force causing said leeward side hydrofoil to pivot inwardly in opposition to said resisting means for producing an upward lifting force by that hydrofoil due to the asymmetrical shape.

4. An apparatus for a sailboat comprising, a pair of hydrofoils, each hydrofoil being asymmetrical with one side curved and the other side relatively flat, one of said hydrofoils positioned on either side of and laterally spaced a substantial distance from the longitudinal center line of the said boat, a sheave means connected to each hydrofoil at one end, each said hydrofoil and sheave means pivotally mounted on the sailboat by said sheave means on an axis relatively parallel to the longitudinal center line of the sailboat and located above the normal water line of the sailboat for said hydrofoil to engage the water when extending downwardly, each of said hydrofoils oriented such that said flat side faces outwardly from the sailboat when the hydrofoil extends downwardly from the pivotal mounting thereof, cable means extending between the two said sheaves and connecting thereto for causing synchronous movement of said hydrofoils for pivoting one hydrofoil out of the water when the other hydrofoil is in the water in downwardly and downwardly-inwardly extending positions, means resiliently and increasingly resisting pivoting of either said hydrofoil in an inwardly direction toward the center line of the sailboat from the vertically downward extending position of such hydrofoil; both hydrofoils extending into the water when the sailboat is stopped or moving straight forward, upon wind impinging on the sailboat to produce lateral forces urging lateral motion the leeward side hydrofoil assuming a downward and relatively vertical position to resist the lateral motion and increasing lateral force causing said leeward side hydrofoil to pivot inwardly in opposition to said resisting means for producing an upward lifting force by that hydrofoil due to the asymmetrical shape.

5. An apparatus for a sailboat comprising, a pair of hydrofoils, each hydrofoil being asymmetrical with one side curved and the other side relatively flat, one of said hydrofoils positioned on either side of and laterally spaced a substantial distance from the longitudinal center line of the said boat, each said hydrofoil pivotally mounted by one end on the sailboat on an axis relatively parallel to the longitudinal center line of the sailboat and located above the normal water line of the sailboat for said hydrofoil to engage the water when extending downwardly, each of said hydrofoils oriented such that said flat side faces outwardly from the sailboat when that hydrofoil extends downwardly from the pivotal mounting thereof, means operably connecting the two said hydrofoils for synchronous movement of said hydrofoils for pivoting one hydrofoil out of the water when the other hydrofoils is in the water in downwardly and downwardly-inwardly extending positions, torsion bar means mounted in the sail boat and operatively connected to both said hydrofoils for resisting pivoting of said hydrofoils inwardly from the vertically downward extending position and permitting pivoting of said hydrofoils outwardly from the vertically downward extending position; both hydrofoils extending into the water when the sailboat is stopped or moving straight forward, upon wind impinging on the sailboat to produce lateral forces urging lateral motion the leeward side hydrofoil assuming a downward and relatively vertical position to resist the lateral motion and increasing lateral force causing said leeward side hydrofoil to pivot inwardly in opposition to said torsion bar means for producing an upward lifting force by that hydrofoil due to the asymmetrical shape.

6. An apparatus for a sailboat comprising, a pair of hydrofoils, each hydrofoil being asymmetrical with one side curved and the other side relatively flat, one of said hydrofoils positioned on either side of and laterally spaced a substantial distance from the longitudinal center line of the said boat, each said hydrofoil pivotally mounted by one end on the sailboat on an axis relatively parallel to the longitudinal center line of the sailboat and located above the normal water line of the sailboat for said hydrofoil to engage the water when extending downwardly, each of said hydrofoils oriented such that said flat side faces outwardly from the sailboat when that hydrofoil extends downwardly from the pivotal mounting thereof, means operably connecting the two said hydrofoils for synchronous movement of said hydrofoils for pivoting one hydrofoil out of the water when the other hydrofoil is in the water in downwardly and downwardly-inwardly extending positions, a torsion bar mounted in the sailboat, a sheave mounted on said torsion bar, cable means connecting said sheave to each said hydrofoil for causing turning of said sheave upon pivoting of either said hydrofoil in an inwardly direction toward the center line of the sailboat from the vertically downward extending position of such hydrofoil, said turning of the sheave being resiliently resisted by said torsion bar, and the magnitude of such resilient resistance by said torsion bar being proportional to the magnitude of the inward angular displacement of a hydrofoil from the vertical downwardly extending position.

7. An apparatus for a sailboat comprising, a pair of torsion shafts mounted on the sailboat relatively parallel to the longitudinal center line of the sailboat and laterally spaced from such center line, one torsion shaft on either side of such center line and above the normal water line of the sailboat, each torsion shaft having one end freely rotatably supported and the other end turnably supported with means for stopping the turning at a predetermined location, a hydrofoil mounted on each said torsion shaft near the first-mentioned end and extending outwardly from said torsion shaft, each hydrofoil being asymmetrical with one side curved and the other side relatively flat, each of said hydrofoils oriented such that said flat side faces outwardly from the sailboat when that hydrofoil extends downwardly from said torsion shaft, means operably connecting the two said hydrofoils from synchronous movement of said hydrofoils for pivoting one hydrofoil out of the water when the other hydrofoil is in the water in downwardly and downwardly-inwardly extending positions, the said means for stopping turning of each said torsion shaft permitting free outwardly and upwardly movement of that said hydrofoil from the vertical downwardly extending position and stopping said torsion shaft for resiliently resisting inward movement

of said hydrofoil toward the sailboat from the vertical downwardly extending position.

8. The apparatus of claim 6 wherein means are provided for affirmatively and rigidly limiting the inward movement of said hydrofoil toward the sailboat center line to a predetermined amount.

9. The apparatus of claim 7 wherein means are provided for affirmatively and rigidly limiting the inward movement of said hydrofoil toward the sailboat center line to a predetermined amount.

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