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AERODYNAMIC SAIL, BOOM AND JAW FOR BOATS

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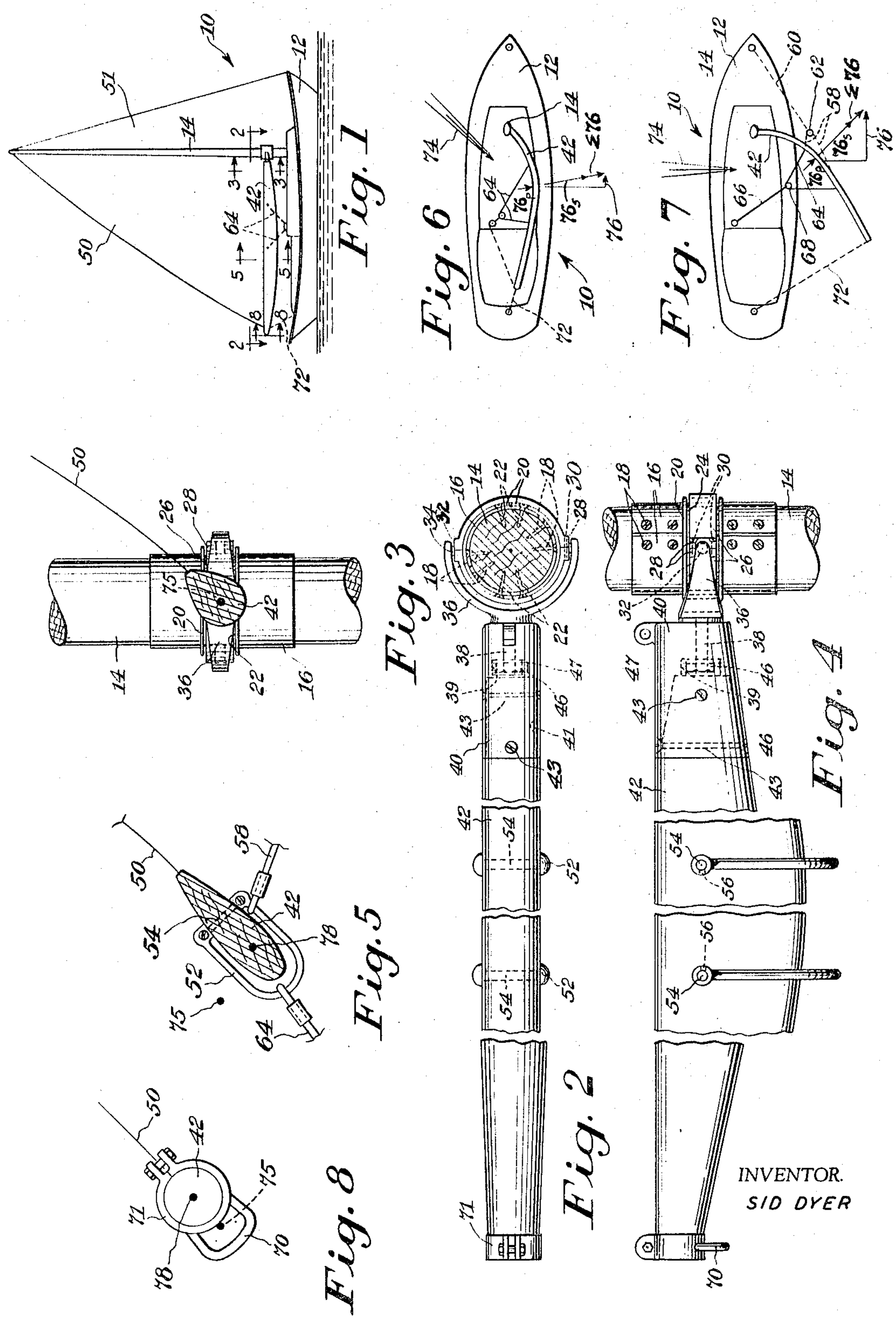

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AERODYNAMIC SAIL, BOOM AND JAW FOR BOATS

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This invention relates to a mast, boom, boom-end fitting, sail and rig such as used in sailboats, iceboats, windmills, and other objects propelled by wind, and in particular to their sails, the attitude of said sails, the control of said sails; and more specifically to an improved and novel construction by which stress, strain, and materials are reduced on one hand while on the other, improved aerodynamic curvature, and therefore more effective negative pressure or vacuum, and therefore greater wind power are achieved.

Today's art and science of sailing is the result of centuries of painful evolution from animal skins secured to crossed sticks, through lateen sails and square rigs, to today's gaff-boomed rigs and fore and aft Bermuda Marconi rigs. History has left to the airplane the opening of new horizons.

In the design of aircraft, from 60% to 80% of the lift is obtained from the "suction" or negative pressure above the airplane wing. The aerodynamic curvature of the wing, "over and past the leading edge," establishes the air-stream and the resultant magnitude, location and direction of the suction above the wing.

It was not realized until the advent of the airplane that the suctional negative pressure on the leeward surface of a sail also causes more drive than the positive pressure on the windward surface. Until the advent of my invention, the importance of aerodynamic lateral deflection of the sail-boom was equally unrecognized as being essential to optimum curvature of the lower strata of the sail. This lower area also, as well as that aloft, should permit the air-stream to flow "by and past the leading" mast and along the boom and sail in order to cause maximum possible suction and drive along the lower strata of sail.

Similarly, until my invention, the importance of an aerodynamic cross-sectional shape of the sail-boom was equally unrecognized as essential to utilizing the existent air-stream "under and upward past the leading" boom. This air-stream from below is warm air and wind reflected off the water and deck and has a natural tendency throughout the world to rise at about 4° from the horizontal. Thus a boom of aerodynamic cross-section will permit this air-stream to flow "under and upward past the leading" boom to cause maximum horizontal suction and drive, heretofore unrealized, all along the lower area of sail.

Today's boom and gooseneck devices have several undesirable details which not only add unnecessary stress, strain and material to the boom as well as the mast, but also fail to provide desirable aerodynamic characteristics for full utilization of wind forces:

(1) The conventional axially straight boom is longitudinally not efficient aerodynamically;

(2) The conventional boom's cross-section is transversely not efficient aerodynamically;

(3) The conventional boom destroys the sail's inherent aerodynamic curvature by causing bagging all along its foot;

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(4) The conventional sail catenary unnecessarily overstresses the boom;

(5) The conventional boom and sail are horizontally not efficiently positioned aerodynamically as the wind streams past the mast;

(6) The conventional sail is vertically not efficiently positioned aerodynamically as the wind streams upward past the boom (sic);

(7) The conventional gooseneck fitting unnecessarily imparts torsional and eccentric column stresses to this already most highly stressed region of the mast;

(8) The conventional straight boom can not be modified to more and less aerodynamic curvature to suit gentle and strong winds;

(9) The conventional baggy sail area adjacent along the boom does not provide as much drive per unit area as other areas of the sail;

(10) The conventional baggy sail area adjacent along the boom does not provide as much drive per unit area as other areas of the sail higher up; thus requiring added area and structure aloft, causing increased overturning moment requiring more ballast, more beam or both, with increased wetted surface and parasite drag. In even moderate airs, the wind pressure aloft lays the boat over, buries the hull, causes an unsymmetrical underwater body, requiring corrective rudder action and consequent additional drag—while the effective projected sail driving area and lateral resistance area are reduced;

(11) The conventional baggy sail area adjacent along the boom does not provide readily attainable "lift" which not only could be readily converted to forward drive, but also could simultaneously raise the vessel and reduce her wetter surface and drag;

Other undesirable characteristics of conventional boom and gooseneck fitting devices are:

(12) Unnecessary torsional loads induced by a gooseneck mounting, etc., require additional mast material;

(13) Unnecessary torsional loads in the mast cause unnecessary stresses, in the deck partners and/or mast step and hull bottom, and require additional hull material;

(14) Present sailboats, therefore, are relatively slow on most points of sailing, uncomfortable and difficult to handle in strong breezes—and some actually dangerous.

The principal object of this invention is to provide a simple, rugged, light and readily self-positioning boom, boom-fitting, and rig, the constructions of which are such that the boom assumes (under wind action or via manually controlled braces) a *horizontal longitudinal contour* of maximum aerodynamic efficiency in the interest of power and speed.

Another principal object of this invention is to provide a simple, rugged, light and readily self-positioning boom, boom-fitting, and rig, the constructions of which are such that the boom rotates automatically (under wind action or via a manually actuated device) to a *transverse boom attitude* and angle of attack to provide heretofore unrecognized sources of power from vertically rising wind currents from under the boom, and to resolve this power to useful horizontal drive of maximum aerodynamic efficiency in the interest of power and speed.

Another principal object of this invention is to provide a simple, rugged, light and readily self-positioning boom, boom-fitting, and rig, the constructions of which are such that the same can be installed in the average type of sailboat, iceboat, etc., without reconstruction and at low cost.

Another object of this invention is to provide a simple, rugged, light and easily self-positioning boom, boom-fitting, and rig, the constructions of which are such that the same assume (under wind action or via mechanical devices) a contour which permits the adjacent area of sail to approach a shape of maximum aerodynamic curvature.

Still another object is to provide a simple and practical assemblage the construction of which will permit a sail to be adjusted (relative to its mast and boom) so that aerodynamic curvature, when underway and drawing, may be varied to suit prevailing wind velocities thus eliminating the need for changing suits of sails.

Still another object is the provision of an improved fully articulated boom-mast fitting which will permit free movements of the boom and sail not only vertically and laterally (relative to the mast), but also torsionally (relative to the boom).

Still a further object of this invention is to provide a simple, rugged, light and readily self-positioning boom, boom-fitting, and rig, the constructions of which will eliminate the foregoing undesirable characteristics, defects and faults.

Yet another object of this invention is to provide a simple, rugged, light and easily self-positioning boom, boom-fitting, and rig for controlling camber and attitude of the sail so that the sail will trim most efficiently on any point of sailing and any wind velocity.

In addition, a boat equipped in accordance with this invention not only sails on a more even keel, but also the lifting effect on the boom and sail causes a cushioning effect on the sea. The boat is not only faster, but also more comfortable and safer than boats which can not effectively exploit their lower sail areas.

To the accomplishment of the foregoing objects, capabilities and advantages, and such other objects, capabilities, advantages and features as may become apparent, this invention consists in the novel construction and arrangement of parts hereinafter described in detail and then defined in the appended claims. Reference is had to the accompanying drawings forming a part hereof which show, as an example merely for the purpose of illustration and not of limitation, preferred embodiments of this invention which is in no way a limitation upon the scope of the appended claims viewed in the light of the prior art. It is expressly understood that changes, variations and modifications may be made in practice within the scope of said claims when found expedient.

In the accompanying drawings, in which similar reference characters denote corresponding parts:

FIGURE 1 is a side view in elevation of a vessel, ship, boat, iceboat, land vehicle (windmill, fan), or the like, equipped with a mast, main sail, boom and jaw made in accordance with this invention;

FIGURE 2 is an enlarged fragmented sectional plan view of mast and boom taken along line **2—2** of FIGURE 1;

FIGURE 3 is an enlarged transverse cross-sectional view of boom taken along line **3—3** of FIGURE 1;

FIGURE 4 is a fragmented side elevational view of the parts shown in FIGURE 2;

FIGURE 5 is an enlarged transverse cross-sectional view of boom taken along line **5—5** of FIGURE 1;

FIGURE 6 is a plan view of the vessel and parts shown in FIGURE 1, close hauled and rigged for strong winds;

FIGURE 7 is a plan view of the vessel and parts shown in FIGURE 1, on a beam roach rigged for both strong winds and gentle breezes;

FIGURE 8 is an enlarged aft end elevational view of the boom taken along line **8—8** of FIGURE 1.

Referring now more particularly to the drawings, a sailboat **10** of conventional rig and construction is shown which includes features of the present invention, which features can be readily applied to other types of vessels, iceboats, vehicles, or the like.

The sailboat illustrated is shown to include a hull **12** and a mast **14**, which mast may be of any cross-sectional shape, mounted thereupon in any conventional manner. Secured to a lower portion of the mast **14**, such as by screws **18**, are a pair of mast sleeve segments **16**. Secured centrally, upon the sleeve segments **16**, are a pair of semi-circular split channels **20**, secured such as by screws **22**, which rotatably receive a pair of semi-circular split collars **26**, each of which has readily outwardly extending bosses **28**. Bolts **30** secure the adjacent bosses **28** together, thus securing the split collars together in the form of an annular ring within the annular groove **24** of the split channels **20**.

The bosses **28** contain a pair of axially aligned, outwardly open, and diametrically opposed sockets **32** which pivotally receive a pair of inwardly directed pintles **34** of a jaw member **36**.

The jaw member **36**, which includes a threaded shaft portion **38** at its free end, is received within a recess **39** formed in the outer end of an aerodynamic boom and fitting **40**, and has a socket **41** at its opposite end into which is fitted the tapered end of boom **42**. Elongated bolts **43** secure the end of the boom in assembled relationship with the boom-end fitting **40**. A nut **46** within the recess **39** cooperates with a washer **47** to secure the shaft **38** in rotatable assembled relationship with the boom-end fitting **40** to allow for free rotation of the boom **42** about a longitudinal axis of rotation.

The main sail **50** may be attached along its foot to boom **42** in any conventional manner, and attached along its luff to the mast **14**, in any conventional manner. The head of said sail and the forestay **51** are also conventionally secured to the head of mast **14**.

Wishbones **52** are swung upon transversely extending pins **54** which extend through spaced apart portions of the boom **42**, and are secured by means such as set screws **56**. Tackle **58** of the forward brace line **60** extends around sheave **62** and is made fast to the wishbones **52**, as is tackle **64** of the after brace line **66** which extends around sheave **68**. As will be explained later, either or both of such brace line tackles may be eliminated or used, depending upon the direction and velocity of the wind.

A bail member **70** is secured to the free end of boom **42** upon fitting **71** for engagement by sheet line **72**. In FIGURES 6 and 7, for reference purposes the wind direction is identified by numeral **74**, and the useful forward component of the propulsive force produced by the wind on the assemblage is identified by numeral **76**. This useful force **76** is a component of $\Sigma 76$; the latter being the sum of pressure of 76_p plus suction 76_s. In FIGURES 3, 5 and 8, the virtual chord of rotation of boom **42** is identified by reference numeral **75**, whereas the torsion and shear centers are identified by reference numeral **78**.

As stated hereinbefore, while the present invention is illustrated and described specifically with respect to a sailing vessel, it is obvious that the invention may be similarly applied to other vessels and vehicles. Also, while being described particularly with reference to a mainsail, the features of this invention may be similarly applied to gaffs and to other sails, such as jibs, and the like.

The sail **50** is hoisted on the mast **14** and is also affixed along its foot to boom **42**. Boom **42** is supported and reacted at its inboard end by the aerodynamic boom-end fitting **40**, which terminates in the jaw **36** and collars **26**, all free to rotate in groove **24** of channels **20** carried upon the sleeve segments **16** and mast **14**; and at its outboard end by the sail **50** and sheet line or lines **72**. Said sheet lines, of rope or wire, etc., serve to sheet home the sail and boom on the port or starboard sides of the boat.

Boom **42**, which may be of any material and either solid or hollow, is of such *cross sectional shape* as to offer the least aerodynamic resistance to *transverse wind* currents while said shape also harnesses said currents for maximum drive in a useful forward direction; and is of such a cross-sectional area and section modulus as to be readily capable of lateral deflection to provide the most efficient aerodynamic *longitudinal curvature to longitudinal wind* currents in order to convert said currents to maximum drive in a useful forward direction. The cross sectional shape of boom 42 is the usual streamlined teardrop: the variable cross section section-modulus, however, is calculated in the invention so as to permit the boom to deflect laterally under a moderate breeze; as the wind force increases, said deflection may become aerodynamically undesirable (sails in strong winds are sheeted flatter than those in gentle breezes) and the afterbraces 64 are then made up to cause the boom to deflect less; as the wind dies, the limited deflection and limited aerodynamic curvature are also undesirable and thus the forward braces 60 are hauled on to cause the boom more aerodynamic curvature. Forward and after braces 64 and 60 may be used individually or simultaneously, and on either the port or starboard tacks. Obviously the use of the after-braces 64 in high winds reduces the overall span of the boom on one hand (thereby allowing a decrease of weight and material), while permitting the adjustment of the entire lower area of the sail for maximum aerodynamic efficiency. Conversely, the use of the forebraces 60 (which may be the same lines rearranged on small boats) in a whispering breeze permits the entire lower area of the sail and boom to be bellied longitudinally for maximum aerodynamic drive.

Boom 42 is so mounted in boom-end fitting 40 as to be capable of axial rotation to suit not only the port and starboard tacks, but also so as to provide a leading edge and the least resistance to the *wind currents rising* from the water, ice, deck, etc. Boom-end fitting 40 may be either a simple pin device (with fixed or spring stops at about 45° + and − rotation) allowing rotation by the wind, or same may be more developed with roller-bearings and mechanical devices for more sophisticated angular changes. Obviously the use of the axially rotating boom-end fitting 40 not only *reduces the torsional stresses in the boom to zero,* since the catenary of the sail will always pass through the boom's geometric shear center (thus allowing a decrease of weight and material), but also permits the entire lower area of the sail and boom to be bellied transversely for maximum aerodynamic drive.

Similarly, jaw 36 is so mounted in collars 26 as to permit the boom not only to rotate about its longitudinal axis, and vertically in the plane of the mast, but also so as to permit the entire boom, sail, etc., to rotate about the vertical axis of the mast. Thus, on every heading, the mast provides a leading edge, symmetrically disposed and with the least wind resistance, to the entire lower area of sail and boom for the most efficient use of longitudinal wind currents in order to convert said currents to maximum drive in useful forward direction. Obviously the use of the collar-mounted jaw 26–36 not only *reduces the trosional stresses in the mast to zero* on all headings, since the boom-end reaction will always pass through the mast's torison center, but also said jaw and collar reduce the otherwise eccentric mast column load to a simple symmetrical bearing—thus allowing a decrease in weight and material of mast.

Sleeve 16 is simply and symmetrically mounted to the mast (via clamps, bolts, screws, welds, etc.) in order to receive the end reactions of the boom and to transfer same to the mast. Whereas my invention already permits less weight and material in the mast, this sleeve now offers a simple and inexpensive means of local reinforcement of the mast (either solid or hollow, wood or metal) at this most important juncture of mast and boom. In lieu of expensive secreted interior mast blocking, difficult of securing and impossible of inspection, this sleeve also serves to increase the local net area of mast at no additional cost of weight, material nor labor. Said sleeve may also be developed for use as a pin rail, winch foundation, etc.

The invention thus described provides:

(1) A boom of light weight.

(2) A boom capable of imparting *longitudinal* aerodynamic curvature to the lower strata of sail and thus to make available heretofore unused horizontal wind forces for forward drive.

(3) A boom capable of imparting *vertical* aerodynamic curvature to the lower area of sail and thus to make available heretofore unused vertically rising wind forces for forward drive.

(4) A boom capable of preserving and improving the sail's inherent aerodynamic curvature all along its foot.

(5) A sail catenary vector which reduces the boom stresses to a minimum.

(6) A boom-sail-mast relationship of maximum efficiency as the wind streams past the mast.

(7) A boom-sail relationship of maximum efficiency as the wind streams across the boom (sic).

(8) A boom-mast mounting which imparts no torsional stresses to the mast.

(9) A boom-mast mounting which imparts no torsional stresses to the boom (sic).

(10) A boom-mast mounting which imparts no eccentric column stresses to the mast.

(11) A boom and sail capable of varying aerodynamic curvature to suit gentle and strong winds for maximum power and speed.

(12) A boom-sail relationship which increases the drive per unit area along the foot of the sail.

(13) A boom-sail relationship which permits reductions of areas and structures aloft.

(14) A boom-sail relationship which permits reductions of ballast and beam of hull.

(15) A boom-sail relationship which permits reductions of wetted surface and parasite drag.

(16) A boom-sail relationship which permits reductions of corrective rudder action and paraside drag.

(17) A boom-sail relationship which permits greater use of projected sail area and lateral resistance area.

(18) A boom and lower area of sail which are so arranged as the permit the wind to raise the boat and thus reduce the underwater resistance.

(19) A boom and lower area of sail of heretofore unattainable aerodynamic efficiency thus permitting less area and structure aloft, thus reducing overturning moment, thus reducing dangerous condition, thus reducing required ballast or beam, thus reducing wetted surface and drag.

(20) A boom and lower area of sail of higher areodynamic efficiency thus permitting less area and structure aloft, thus increasing speed.

(21) A boom-mast mounting for maximum aerodynamic efficiency and for minimum stress of boom, mast and boat.

Thus it is obvious that my invention is susceptible to various embodiments and is not limited to the particular constructions shown. The predominant principles of the illustrations shown are the construction of the mast, boom, boom-fitting, and the sail such that the same offers the minimum of aerodynamic resistance from all directions—while developing maximum aerodynamic power. It is further obvious that features shown only in certain of the figures are applicable to other constructions, and that all of the constructions are merely indicative of the principles which underlie this invention. It is to be understood that in the following claims, I use the word "hull" to denote in general a body structure as distinguished from the sail, spars and rigging, and that the body structure may be of any nature—e.g., one, two or more hulls and related keels and center boards; iceboat frames, land vehicle bodies or chassis, windmill structures, etc. Similarly, the word "sailing" or "sail" boat, or the like, includes power boats, model or toy boats, iceboats, sailing land or beach wagons, bicycles, etc., to all of which, and to others, this invention is applicable.

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

1. The combination of a sail, mast and variable control camber inducing boom interconnected to each other having a propulsive area for assuming a horizontal contour of aerodynamic advantage comprising brace means for adjusting the camber of said boom to obtain a horizontal aerodynamic advantage for maximum forward drive.

2. The combination of a sail, mast and variable control camber inducing boom having a propulsive area for assuming a vertical contour of aerodynamic advantage wherein said boom has a variable angle of attack leading airfoil edge extending along the lower area of said sail, said edge being adjustable to vary the angle of attack to vertically rising wind currents to obtain a horizontal aerodynamic advantage for maximum forward drive.

3. A sailing vessel comprising
a hull;
a mast supported on said hull;
a boom means, said boom means including an elongated structural member having a substantially straight upper edge and a variably arched lower edge of greatest depth intermediate the ends thereof, said structural member having sides of greatest width intermediate said upper and lower edges to define exterior aerodynamic surfaces responsive to a flow of air upon said boom means;
means securing said boom means to said mast, said means including an annular ring rotatably mounted on said mast, a jaw pivotally mounted at one end to said annular ring for movement in a vertical plane and rotatably secured at the other end to said boom means for rotatably mounting said boom means thereon; and
a sail connected between said mast and boom means; whereby said boom is pivotally movable horizontally with respect to said mast and deflectable with respect to the longitudinal axis of said boom means to assume a horizontal contour of aerodynamic advantage relative to the lower strata of said sail secured adjacent said upper edge of said structural member in order to increase the forward propulsive force transmitted by said boom means and said sail in said hull.

4. A sailing vessel comprising
a hull;
a mast supported on said hull;
a boom means, said boom means including an elongated structural member having a substantially straight upper element and a variably arched lower element of greatest cross sectional area intermediate the ends thereof, and having gradually curved sections intermediate said upper and lower elements to define transverse exterior aerodynamic surfaces responsive to a flow of air upon said boom means;
means securing said boom means to said mast, said means including an annular ring rotatably mounted on said mast, a jaw pivotally mounted at one end to said annular ring for movement in a vertical plane and rotatably secured at the other end to said boom means for rotatably mounting said boom means thereon; and
a sail connected between said mast and boom means; whereby said boom is pivotally movable vertically with respect to said mast and rotatable with respect to the longitudinal axis of said boom means to assume a vertical attitude and angle of attack to vertically rising heat and wind currents for an areodynamic advantage relative to the lower areas of said sail secured adjacent said upper element thereof to transpose said vertical currents into horizontal forward propulsive forces for said hull.

5. A sailing vessel comprising
a hull;

a mast supported on said hull;
a boom means including an elongated structural member of a longitudinally variable cross section section-modulus for permitting lateral deflection thereof and a fitting at one end of said structural member;
means securing said boom means to said mast, said means including an annular ring rotatably mounted on said mast, a jaw pivotally mounted at one end to said annular ring for movement in a vertical plane and rotatably secured at the other end to said fitting of said boom means for rotatably mounting said boom means thereon;
a sail connected between said mast and boom means;
forward brace lines connected to one side of said structural member; and
after brace lines connected to the other side of said structural member, each of said forward and after brace lines having means for laterally deflecting said structural member whereby the deflection of said structural member is capable of being controlled and adjusted in relation to the intensity of the wind.

6. A sailing vessel comprising
a hull;
a mast supported on said hull;
a boom means including an elongated structural member of a longitudinally variable cross section section-modulus for permitting lateral deflection thereof and a fitting at one end of said structural member having means for limiting rotation of said structural member about the longitudinal axis thereof within a range of 45° clockwise and 45° counterclockwise about said axis;
means securing said boom means to said mast, said means including an annular ring rotatably mounted on said mast, a jaw pivotally mounted at one end to said annular ring for movement in a vertical plane and rotatably secured at the other end to said fitting of said boom means for rotatably mounting said boom means thereon; and
a sail connected between said mast and boom means whereby said boom means is movable horizontally and vertically with respect to said mast and rotatable with respect to the longitudinal axis of said boom means and at all times adjacent to and parallel to the shear and torsion centers of said boom.

7. A sailing vessel comprising
a hull;
a mast supported on said hull;
a boom means including an elongated structural member of longitudinally variable cross section section-modulus and a fitting on one end of said member;
means securing said boom means to said mast including an annular ring rotatably mounted on said mast having horizontally disposed means thereon, and a jaw pivotally mounted at one end to said horizontally disposed support means for limited pivotal movement in a vertical plane and rotatably secured at the other end to said fitting freely rotatably mounting said boom means thereon; and
a sail connected between and to said mast and boom means whereby said boom means is movable horizontally and vertically with respect to said mast and freely rotatable with respect to the longitudinal axis of said boom means in response to horizontal wind forces and vertically rising heat and air forces on said boom and sail.

8. In a sailing vessel as set forth in claim 3, wherein said surfaces of said structural member are further responsive to a flow of air to exert lifting forces upon said boom means and sail which are transmitted to the hull through the mast to partially raise the hull from the water.

9. A sailing vessel as set forth in claim 7 wherein said boom means and said sail are in continuous aerodynamic relationship therebetween.

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