

[54] **MAST FOR SAILING YACHTS AND METHOD**

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[51] Int. Cl. **B63b 15/00**

[58] Field of Search 114/89, 90, 102-104, 114/108, 112; 244/41, 130

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[57]

ABSTRACT

Reduction of drag and wind resistance offered by a mast coupled with increased sail efficiency is achieved in a mast having a non-circular cross-sectional shape and a plurality of rows of projections on the surface on opposite sides thereof and on the front side thereof and extending substantially throughout the length of the mast. Air flow passing around the mast undergoes turbulence and separates from the mast as a turbulent boundary layer and reattaches to the sail in a manner whereby the detached air flow between the mast and the sail is significantly less than that achieved by conventional mast constructions. Reattachment of air flow on the mast is enhanced by forming the rear side of the mast with a wedge-shaped enlarged slot for receiving the luff edge of the sail permitting the sail greater movement to either side of the mast to permit the air to reattach to the sail at a point closer to the mast than has been accomplished with conventional mast constructions. Preferably, the projections are integrally formed on an adhesive tape of metal, cloth or plastic which, in turn, is adhered to the opposite sides and the front of the mast. Additionally, a T-shaped slot is formed in the front side of the mast for accommodating fittings for a spinnaker pole or sails.

21 Claims, 6 Drawing Figures

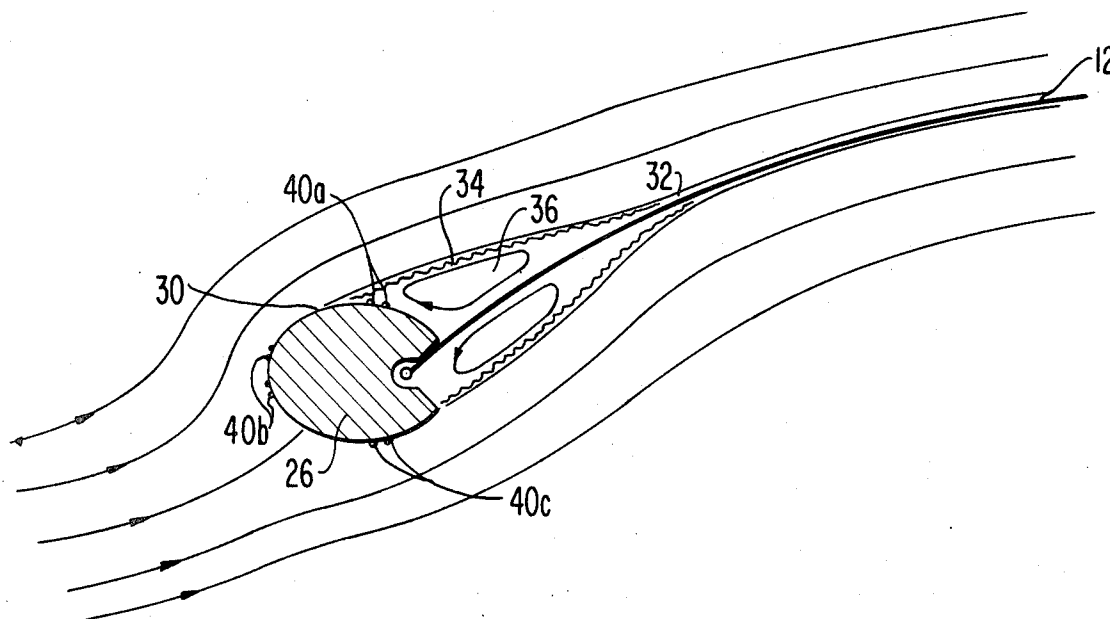


FIG. 1
PRIOR ART

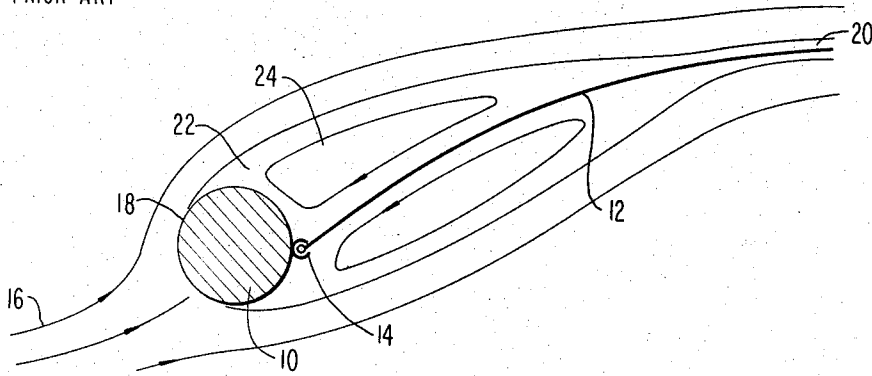


FIG. 2

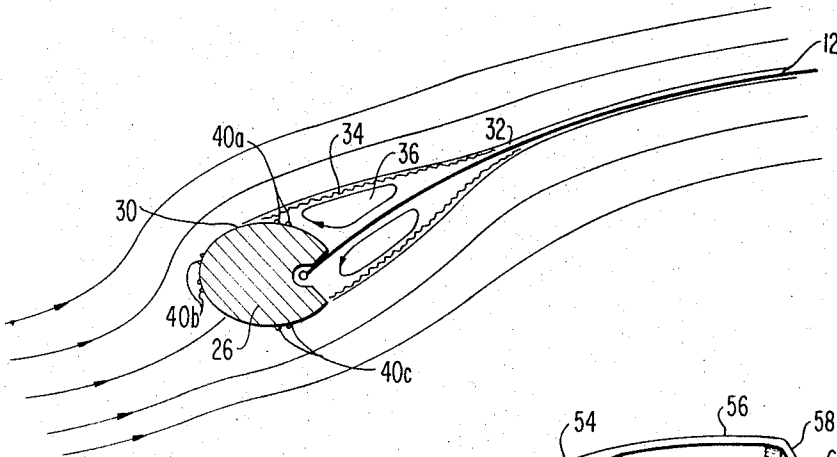


FIG. 3

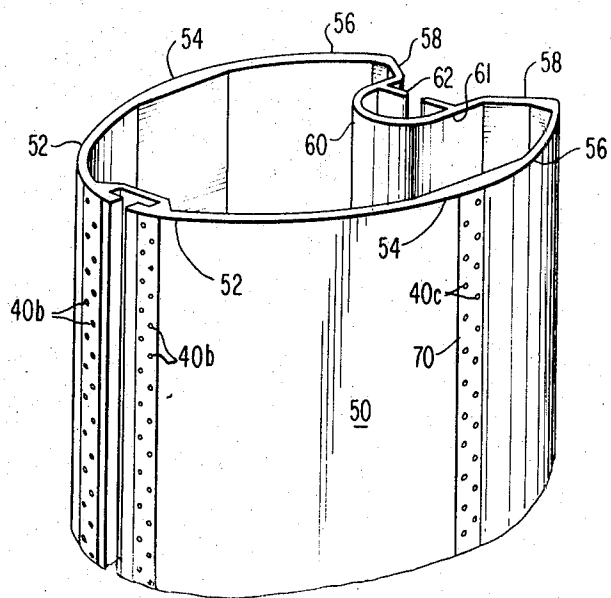


FIG. 4

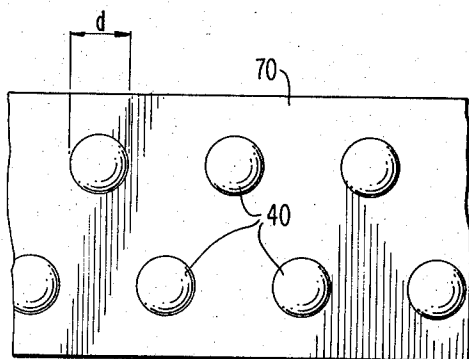
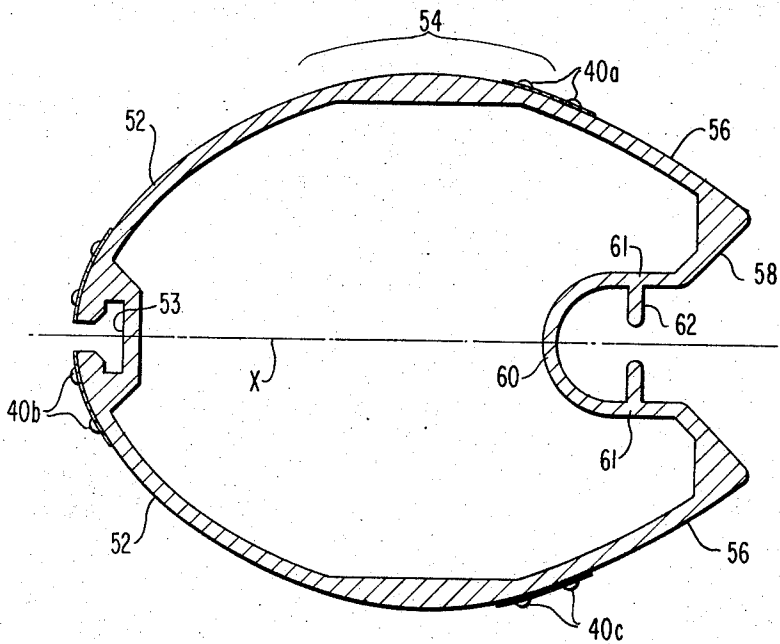
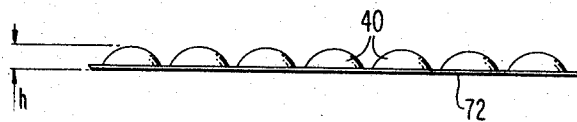


FIG. 5

FIG. 6



MAST FOR SAILING YACHTS AND METHOD

BACKGROUND OF INVENTION

In the design of sailing yachts or similar watercraft, very little attention has heretofore been given to the design of the mast from the standpoint of reducing drag and resistance to the air flow about the mast and increasing efficiency of the sail. One conventional attempt in this direction has been to form the mast with a streamlined shape, however, the resulting improvement in air flow has been limited. Furthermore, this method is not satisfactory where the mast is rotatable.

INVENTION AND OBJECTS

The present invention relates to an improved mast for a sailing yacht or similar wind propelled craft or vehicle and also to a novel method of forming the same.

One of the primary objects of the present invention is to reduce drag and resistance to air flow provided by a mast and also to improve efficiency of the sails of a sailing yacht or similar wind propelled craft. Included herein is the provision of a novel and improved mast for a sailing yacht which will offer significantly less resistance to air flow and moreover will aid in increasing the efficiency of the associated sail.

Another and more specific object of the present invention is to provide a mast for a sailing yacht having a novel cross-sectional configuration which helps to achieve the above stated objects.

A further object of the present invention is to provide such a mast for a sailing yacht having novel means for mounting a sail thereto while permitting the sail at its luff edge to undergo increased movement to either side of the mast depending on the wind direction to allow air flow to attach to the sail at a location closer to the mast than has been heretofore accomplished by conventional mast constructions. Included herein is a provision of such a mast having novel means for accommodating fittings for a spinnaker pole or sails to be attached to the front of the mast.

Yet another object of the present invention is to provide novel method and means for providing a predetermined contour on the surface of the mast for creating turbulence in the air flowing around the mast.

SUMMARY OF INVENTION

The above and other objects are achieved by forming on the leeward side of a mast surface, a configuration for creating turbulence in the air flow around the mast so that the air flow detaches from the mast in a turbulent boundary layer thereby decreasing unattached flow (or increasing attached flow) between the mast and the sail. Coupled with the latter is the formation of the mast cross section to have a generally elliptical or parabolic front surface shape, a midsection formed by opposed arcs of a circle on opposite sides of the mast and a rear surface section formed by opposed arcs of a circle having a radius of curvature greater than the arcs of the midsection.

In the preferred embodiment, the turbulence is created by forming a plurality of projections on the surface of the mast on the leeward side and distributed substantially throughout the length of the mast. It is additionally preferred that the projections be formed in a plurality of rows extending substantially the length of the mast at right angles to a diametrical plane extending

transversely of the mast. It is further preferred that the projections be formed on the front side of the mast and also on opposite sides of the mast to permit effectiveness regardless of which side of the mast the wind is coming from or for tacking purposes.

The projections may be one and one-half millimeter from the surface of the mast while having a diameter of approximately three millimeters. It is additionally preferred, for commercial purposes, that the projections be integrally formed in an elongated adhesive tape made from metal, plastic, cloth, etc., and that the tape be adhered to the mast at the locations aforesaid.

In order to further enhance attached air flow between the mast and the sail, the rear side of the mast is formed with a generally V or wedge-shaped recess for receiving the luff edge of the main sail while permitting the luff edge greater movement to either side of the mast to thereby bring the main sail closer to air flow over the mast to facilitate early attachment of air flow to the main sail. Additionally, the mast in the preferred and commercial embodiment, is formed with a T-shaped recess extending throughout its front side for receiving a fitting for a spinnaker pole or permitting additional sails to be attached to the mast at the front side thereof. The mast may have a solid or tubular body, however, in the commercial embodiment a metallic tubular extruded body is employed.

DRAWINGS

Other objects and advantages of the present invention will become apparent from the following more detailed description taken in conjunction with the drawings in which:

FIG. 1 is a diagrammatic view showing air flow around a mast of conventional construction;

FIG. 2 is a view generally similar to FIG. 1 but depicting a mast according to the present invention;

FIG. 3 is a fragmental perspective view of a mast embodying the present invention;

FIG. 4 is a cross-sectional view of the mast body shown in FIG. 3;

FIG. 5 is a fragmental plan view of a tape with projections thereon employed in accordance with the present invention; and

FIG. 6 is an elevation view of the tape shown in FIG. 5.

DETAILED DESCRIPTION

Referring now to the drawings in detail, FIG. 1 illustrates the flow of air around a conventional mast 10 of the prior art and an associated main sail 12 attached to the rear side of mast 10 by a suitable fitting attachment generally designated 14. Air flow designated 16 passes around the mast 10 and detaches at a location designated 18, and continues as a laminar boundary layer until it reattaches at location 20 to the main sail at a point sufficiently spaced from the mast 10 so as to cause wind resistance or drag symbolically illustrated by the numeral 24. This drag obviously reduces the speed and maneuverability of the sailing yacht while also reducing the efficiency of the sail.

In contrast with the conventional mast construction and air flow between the mast and the main sail as illustrated in FIG. 1 and described above, the present invention reduces unattached air flow between the mast and the sail to reduce the drag and wind resistance while also improving efficiency of the sail. FIG. 2 illus-

trates a mast 26 embodying the present invention and the air flow therearound wherein unattached air flow between locations 30 on the mast and 32 on the sail 12 is significantly reduced to decrease the drag symbolized by the numeral 36 while allowing a greater surface portion of the main sail 12 to be utilized thereby increasing the efficiency of the sail. In accordance with the present invention, this is achieved by utilizing a certain specific noncircular outline or surface shape of the mast 26 coupled with utilization of projections placed along sides of the mast to extend substantially throughout the full length of the mast. The projections generally designated 40 are placed on the leeward side of the mast in advance of the normal air flow separation point on the mast to create a turbulent boundary layer 34 thus prolonging attached air flow and causing the air flow to reattach to the sail 12 at a location 32 closer to the mast 26 than would normally be obtainable utilizing masts of conventional construction. The projections 40 are placed throughout the front side of the mast as illustrated by projections 40b in FIG. 2 to trigger transition of the air flow from laminar to a turbulent boundary layer. In addition, the projections 40 are placed throughout opposite sides of the mast 26 as indicated by the numerals 40a and 40c in FIG. 2 to ensure transition on the windward side of the mast; it being understood that the projections 40a and 40c are applied to opposite sides of the mast to alternatively be effective when tacking between port and starboard tacks.

Referring now to FIGS. 3 and 4, there is illustrated a preferred form of a mast embodying the present invention generally designated 50 having a tubular extruded body formed from a suitable light-weight metal, such as aluminum or other suitable light-weight alloys. The shape of mast 50 is specifically designed so that the front portion 52 thereof has a surface shape in the form of an ellipse or a paraboloid having a major diameter or radius of curvature at least 1.5 times larger than the minor diameter. The mid-section or opposite sides 54 of mast 50 are formed by arcs of a circle having a radius of curvature less than the radius of curvature of the major arc of the front section ellipse 52. The rear section 56 of the mast is also formed by opposed arcs of a circle, however, the radius of curvature of the arcs of the rear section 56 is greater than that of the mid-section 54. As may be seen from FIG. 4, the cross section of the mast 50 is symmetrical about the X-axis passing through the front and rear sides thereof. Additionally, in the front section 52 symmetrically disposed on opposite sides of the axis of symmetry X, there is provided an elongated T-shaped slot 53 for receiving slide fittings for a spinnaker pole or other sails to be attached to the mast at the front side section 52 thereof.

In accordance with another feature of the present invention, the rear side of the mast is formed with an enlarged V or wedge-shaped recess for receiving the luff edge of the main sail in an improved manner permitting the main sail to move further to the leeward side of the mast to enhance reattachment of the air flow thereto.

In the preferred embodiment shown in FIGS. 3 and 4, the rear side of the mast includes opposite generally V-shaped reentrant portions 58 which extend inwardly into the interior of the mast from curve sections 56, and merge into a generally semicircular section 60 through means of straight flange sections 61 which extend between reentrant portions 58 and the semicircular section 60 as clearly shown in FIGS. 3 and 4. A longitudi-

nally continuous chamber is formed within semicircular section 60 by means of flanges 62 which project inwardly from the juncture between straight sections 61 and semicircular section 60; it being understood that semicircular section 60, straight sections 61, flanges 62 and reentrant portions 58 extend continuously throughout the length of the mast, it being again noted that the mast is symmetrical about the axis. Flanges 62 at their inner free extremities are spaced from each other to define a passage through which slide fittings (not shown) for the luff edge of the main sail may be introduced into the chamber of section 60 and held therein against lateral outward movement by means of flanges 62.

The specific cross section of the mast as shown in FIG. 4, that is, the location of the various wall segments of the mast relative to the axes of the mast and the thicknesses of the various wall sections, are designed so as to provide optimum minimum dimensioning so as to make the mast slimmer without adversely effecting the strength of the mast. In the preferred embodiment shown in FIG. 4, which is a full scale drawing of the cross section of an actual commercial embodiment, the cross section is designed to have a moment of inertia about the lateral axis of the mast which is fifty percent (50%) greater than the moment of inertia around the longitudinal axis of the mast; the specific commercial embodiment shown being designed for use with a two spreader-type of rigging system. A further disclosure as to the thickness of the various wall sections of the mast and the moment of inertia may be obtained from FIG. 4 which is a full scale drawing of the commercial embodiment as indicated above.

The projections 40 provided on the mast in accordance with the invention as described above, may be formed in any suitable manner, however, it is preferred for practical purposes in the preferred and commercial embodiment, that they be integrally formed on a metallic tape 70 having an adhesive surface 72 which may be bonded along the mast at the locations aforesaid. It is preferred that the projections at each of the locations on the mast be provided in a plurality of rows which extend parallel to the mast or at right angles to a transverse plane through the mast or, in other words, at right angles to the wind direction. In the embodiment shown, two rows of projections 40 are provided at each of the locations on the mast, however, additional rows or a single row may be provided depending on the mast profile. Also, it is preferred that projections 40a and 40c be placed rearwardly of the widest width dimension of the mast as shown in FIG. 4 of the drawings where they extend into rear sections 56 of the mast. The height h of the projections from the mast surface may be approximately $1\frac{1}{2}$ millimeters while the diameter d of each of the projections may be approximately 3 millimeters; these dimensions being depicted in FIGS. 5 and 6. It is also preferred that the projections 40 in one row on each of the tapes be staggered relative to the projections in the adjacent row on the same tape as shown in FIG. 5. That is to say that the projections 40 in one row would be aligned with the spaces between the projections 40 in the adjacent row on each of the tapes as shown in FIG. 5.

In use, and referring to FIG. 2, air flow about the mast 26 will strike the projections 40b which will be positioned on the leeward side and which will cause a turbulent layer of air 34 to form and separate from the

mast 26 as a boundary layer and soon reattaching to the sail at location 32. The air flow about the windward side of the mast will strike the projections 40c and cause a similar turbulent boundary layer separation to take place. The result is that the unattached air flow between the mast and the sail is substantially reduced over prior art or conventional constructions and thus the resistance to the air flow afforded by the mast is substantially reduced while additional sail area is freed to be effective in propelling the craft. It should be noted that the shown and described embodiment of the mast of the present invention has been subjected to wind tunnel tests and it has been determined that the resistance of the mast is reduced fifty percent (50%) from that of conventional or prior art mast constructions of the type having a round cross-sectional mast of the same average diameter. Additionally, the improved efficiency of the main sails due to the reduced boundary layer thickness on the leeward side of the sail was estimated to be 10 to 15 percent of the maximum side force on the main sail. The reduction and drag afforded by the present invention should enable the associated sailing yacht to point about 2° higher to the relative wind (about 3° higher relative to the course sailed) at the same speed as would result using a mast having a circular cross section of the same average diameter.

What is claimed is:

1. A mast for a sailing yacht or similar watercraft to be propelled by the lift effect by the wind on the sail; the mast comprising an elongated body having a front end and a rear end and means for attaching a sail to the rear end, and first means including individual projections on the leeward side of the mast and raised from the surface of the mast and distributed substantially throughout the length of the mast for causing air flowing around the mast to separate as a turbulent boundary layer to ultimately reduce unattached flow of air between the mast and the sail when the mast is in use, and wherein there is further included second means including individual projections positioned on the windward side of the mast and raised from the surface of the mast and distributed substantially throughout the length of the mast and wherein there is further included third means including individual projections on the front end of the mast and raised from the surface of the mast and distributed substantially throughout the length of the mast, said second and third means also being for use in creating a turbulent boundary layer as aforesaid.

2. The mast defined in claim 1 wherein the front end of the mast has a generally elliptical surface shape.

3. The mast defined in claim 2 wherein the opposite sides of the mast are surface-shaped as opposed arcs of a circle.

4. The mast defined in claim 3 wherein the opposite sides of the mast adjacent the rear end converge towards the rear end of the mast as opposed arcs of a circle having a greater radius of curvature than the arcs on the opposite sides of the mast.

5. The mast defined in claim 4 wherein the radius of curvature of the opposite sides of the mast adjacent the rear end of the mast is less than the radius of curvature of the opposite side portions of the mast adjacent the front end of the mast.

6. The mast defined in claim 1 wherein said projections are provided in a plurality of rows extending gen-

erally at right angles to a diametrical plane taken transversely through the mast.

7. The mast defined in claim 1 wherein said projections extend approximately one to one-half millimeter from the surface of the mast.

8. The mast defined in claim 1 wherein said projections on the leeward and windward sides and on the front end of the mast are provided in a plurality of rows at each of the locations on the windward and leeward sides and on the front end of the mast.

9. The mast defined in claim 8 wherein the front end thereof has a generally elliptical shape and the opposite sides thereof at the midsection thereof are formed as opposed arcs of a circle and wherein the opposite sides thereof adjacent the rear end coverage towards the rear end thereof as opposed arcs of a circle having a greater radius of curvature than the arcs of the opposite sides of the mast at the mid-section thereof.

10. The mast defined in claim 9 wherein the rear end of the mast body has an elongated generally V-shaped slot therein for receiving the luff edge of an associated sail and for permitting the sail to move further to opposite sides of the mast to decrease unattached flow of the air between the mast and the sail when the mast is in use.

11. The mast defined in claim 10 wherein the front end of the mast has an elongated generally T-shaped slot formed therein substantially throughout for receiving fittings for attaching a spinnaker pole or other sails to the mast.

12. The mast defined in claim 11 wherein there are a plurality of tapes adhered to the opposite sides of the mast and to the front end of the mast respectively and wherein said projections are formed on the tapes.

13. A mast for a sailing yacht or similar watercraft to be propelled by the lift effect of the wind on the sail; the mast comprising an elongated body having a front end and a rear end and means for attaching a sail to the rear end, and first means on the leeward side of the mast and raised from the surface of the mast and distributed substantially throughout the length of the mast for causing air flowing around the mast to separate as a turbulent boundary layer to ultimately reduce unattached flow of air between the mast and the sail when the mast is in use, and wherein said means on the leeward side of the mast is raised from the surface of the mast and includes a plurality of projections on the surface of the mast distributed substantially throughout the leeward side of the mast and wherein there is further included an elongated tape adhered to the leeward side of the mast and extending substantially throughout the full length thereof and wherein said projections are formed on said tape.

14. A mast for a sailing yacht or similar watercraft to be propelled by the lift effect by the wind on the sail; the mast comprising an elongated body having a front end and a rear end and means for attaching a sail to the rear end, and means projecting from the leeward side of the mast for causing air flowing around the mast to separate as a turbulent boundary layer to ultimately reduce the unattached flow of air between the mast and the sail when the mast is in use, and wherein there is further included sheet material attached to the leeward side of the mast and wherein said means projecting from the mast is formed on the sheet material.

15. The mast defined in claim 14 wherein said means projecting from the mast is located rearwardly of the

mid-section of the mast measured between the opposite sides of the mast at the widest width dimension thereof.

16. The mast defined in claim 14 wherein there is further included second means projecting from the front end of the mast for use in forming the said turbulent boundary layer aforesaid.

17. A mast for a sailing yacht or similar watercraft to be propelled by the lift effect by the wind on the sail; the mast comprising an elongated body having a front end and a rear end and means for attaching a sail to the rear end, and means projecting from the leeward side of the mast for causing air flowing around the mast to separate as a turbulent boundary layer to ultimately reduce the unattached flow of air between the mast and the sail when the mast is in use, and wherein said means projecting from the mast includes at least two rows of projections distributed along the longitudinal dimension of the mast with the projections in one of the rows being staggered relative to the projections in the other row.

18. The mast defined in claim 17 wherein said projections extend from the surface of the mast a distance of approximately one and one-half millimeters.

19. The mast defined in claim 14 wherein the front

end of the mast has a generally elliptical surface shape and wherein the opposite sides of the mast are surface shaped as opposed arcs of a circle.

20. The mast defined in claim 19 wherein the rear end of the mast has an elongated generally V-shaped recess through which the luff edge of the associated sail is connected to the mast, the V-shaped recess having a sufficiently large width greater than 45° for permitting the sail to move to extreme positions on opposite sides of the mast to increase unattached flow of the air between the mast and the sail when the mast is in use.

21. A method of increasing attached air flow between a mast and a sail for a sailing yacht or similar wind propelled craft to reduce the resistance offered by the mast and to increase the sail efficiency, the step comprising providing projections along the surface of the mast at the leeward side thereof to cause air flowing about the mast to undergo turbulence and to detach from the mast as a turbulent boundary layer, and wherein said projections are provided by attaching an elongated tape-like sheet along the leeward side of the mast, the sheet having a plurality of projections distributed along its length.

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