The invention is concerned with a sail assembly having the features of the preamble of claim 1 (EP-A-0083 432).

The conventionel sail assembly according to EP-A-0083 432 is schematically illustrated in Fig. 1. The leading edge of the sail is wrapped around a cylindrical mast or profiled sleeves disposed thereon, respectively, to form a sock for the mast. The seam between sock and sail forms a concave discontinuity on each side of the sail to the rear of the mast. This discontinuity induces turbulences which reduce the efficiency of the sail by increasing drag and decreasing lift generated by the sail. "Lift" herein means a force normal to both relative wind and the mast for propelling the sailing vehicle by wind passing the sail leading edge proximate to the mast towards the sail trailing edge. "Drag" herein means a force normal to the lift and to the mast caused by resistance to relative wind passage over the mast and sail. Additional drag is produced with conventional technology because of the non-optimum shape of the leading edge.

In this specification the terms "front", "top" and "head" refer respectively to upwind and away from the vehicle directions. The directions "rear", "bottom" and "foot" are opposite to the respective "front", "top" and "head" directions.

An improvement in the prior art is the use of an airfoil-shaped mast as shown in Fig. 2. The front edge of the sail is supported by a bead engaging a slot in the rear of the mast. This design provides an efficient shape at the front of the mast, a relatively thin trailing edge at the rear of the mast and, when properly trimmed, a nearly continuously smooth shape on the top (low pressure) side of the sail at the rear of the mast.

The main disadvantage of the airfoil-shaped mast is that the concave discontinuity on the bottom (high pressure) side is greater than that formed by the conventional attachment described above when the curvature of the sail matches that of the rear top side of the mast.

Another disadvantage of the airfoil-shaped mast is that turbulence will be generated on the top side unless the sail is trimmed to match the curvature of the top side of the mast at the point of attachment. Proper trim is illustrated in Fig. 2 by position (a) of the sail. In this position the curvature of the sail matches the curvature of the rear top side of the mast. When the direction and/or the velocity of the relative wind vary it may be desirable for overall sail performance to trim the sail either to position (b) or position (c) as shown in Fig. 2. The conditions illustrated by positions (b) or (c) produce the disadvantage of increased drag caused by turbulence at the rear of the mast due to a convex (position (b)) or concave (position (c)) discontinuity on the top side.

Another disadvantage of the airfoil-shaped mast is that the conditions illustrated by positions (b) and (c) in Fig. 2 produce additional drag at the leading edge of the mast because the mast leading edge does not face properly into the relative wind.

To correct for the discontinuity at the top side between the airfoil-shaped mast and the sail, and to align the leading edge into the relative wind, the prior art adds a further adjustment, that of rotating the mast. This added adjustment is, however, costly to produce, subject to mechanical failure, and burdens a sailor with an additional function.

A further disadvantage of the prior art mast rotational adjustment is that the optimum position for matching sail curvature will not always position the leading edge directly into the relative wind.

It is the object of the present invention to provide a sail assembly of the kind described in the preamble of claim 1, that provides an efficiently shaped, properly oriented leading edge of the sail without inducing turbulences on either the top or bottom sides of the sail, and that is automatic in operation.

This object is solved by claim 1.

The present invention provides a sail assembly with an efficient leading edge that aligns properly to the relative wind and forms a smooth aerodynamic contour behind both sides of a cylindrical mast, the shape automatically adjusting for changes in trim of the sail.

Stiffening means for a sail assembly are known per se, but the shape thereof is controlled by way of a sail boom and not by way of the battens (US-A-4,064,821).

Preferably, the rib pocket pairs extend parallel to the batten pockets on each side of the main section.

The present invention can be furnished as an attachment for a sail comprising a plurality of flexible rib pairs tangent to opposide sides of the mast to be slidably clamped near one end tangent to opposite sides of the corresponding full-length battens. The battens are in engagement with anchors pivotably located by the mast. An aerodynamically shaped leading edge member in front of the mast is fastened to the rib pairs and to each anchor so that the leading edge member is free to pivot with the anchors and the rib pairs about the mast.

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A sail can be attached by forming a sock closely fitting the leading edge member so that the sock seam is aligned with desired points of tangency of the flexible rib pairs at the battens. To the sock seam is sewn a main portion of the sail including a trailing edge to the rear of the points of tangency. The sock can extend to the rear of the sock seam over each flexible rib pair to form a pair of rib pockets for slidably clamping the flexible rib pairs to the battens at the desired points of tangency. The seam is interrupted at the rib pockets to provide openings for the flexible rib pairs. The battens are located by conventional batten pockets to the rear of the seam and retained by conventional batten straps at the trailing edge. Preferably the batten pockets extend within the sock and are attached to the anchors for guiding the battens into engagement with the anchors.

The pressure of the relative wind over the sail causes the leading edge and the flexible rib members to assume an efficient aerodynamic shape without turbulence-inducing discontinuities on either side of the sail and with the leading edge properly facing into the relative wind.

Preferably the anchors have clearance to permit the flexible rib members to be inclined with respect to the mast so that the battens may also be inclined as dictated by sail design.

The leading edge member can be interrupted to provide a space within which to attach a conventional yoke to the mast.

Preferably the leading edge member is provided with a plurality of slots forming stops for locating the leading edge against the front of the mast. The leading edge member has notches opposite the slots to permit articulation con-

forming to flexing of the mast. The leading edge member can also be articulated into a coiled configuration to facilitate shipment.

Preferably the leading edge member is filled and reinforced with a low-density material such as closed-cell polyurethane foam.

Because of the pivotable aerodynamically shaped leading edge and the flexible rib members clamped between the ends of the battens for automatic control of a smooth contour on both sides of the sail, the attachment of the present invention satisfies the need for a sail attachment that provides an efficiently shaped leading edge of the mast facing into the relative wind without introducing turbulence on either the low-pressure or high-pressure sides of the sail, and that is automatic in operation.

Further details, features and advantages of the invention will become better understood with reference to the following description, appended claims, and accompanying drawings where:

Fig. 1 shows a lateral section of a conventional sail attachment to the mast;

Fig. 2 shows a lateral section of a conventional sail attachment to an airfoil-shaped mast;

Fig. 3 is an elevational view of a sail attached to the mast in accordance with the present invention, the attachment comprising a leading edge member interrupted to provide space to attach a conventional yoke (not shown) to the mast;

Fig. 4 is a lateral detailed sectional view of the attachment of Fig. 3 along the line 4-4 of Fig. 3;

Fig. 5 is a detailed fragmentary sectional view of the attachment of Fig. 3 taken on line 5-5 in Fig. 4;

Fig. 6 is a detailed fragmentary sectional view of the attachment of Fig. 3 taken on line 6-6 in Fig. 5;

Fig. 7 is a detailed fragmentary sectional view of the attachment of Fig. 3 taken on line 7-7 in Fig. 5;

Fig. 8 is a detailed fragmentary sectional view of the attachment of Fig. 3 taken within the region 8-8 in Fig. 3; and

Fig. 9 shows articulation of the leading edge member of the attachment of Fig. 3 into coil form to facilitate shipment.

With reference to Fig. 3 and 8, a cylindrical mast 10 having a tip 12 and a foot 14 is pivotably attached at the foot 14 to a sailboard 16. A sail 18 attached to the mast 10 is equipped with an out-haul 20 fastened to a conventional yoke (not shown). The sail 18 is also equipped with a conventional down-haul 21 proximate to the foot 14 for stretching the sail 18 against the tip 12. A conventional boot 22 is fastened to the sail 18 by a boot pin 23. The boot 22 engages the tip 12 when tension is applied to the down-haul 21. A sock seam 24 in the sail 18 connects a main section 25 of the sail to a sock 26 enclosing the mast 10.

With reference to Figs. 3-7, the sail 18 having a trailing edge 27 is equipped with a plurality of full-length battens 28 which are conventionally located by corresponding batten pockets 29 on the main section 25. The battens 28 extend

from corresponding conventional batten straps 30 on the trailing edge 27 to corresponding anchors 31. The batten straps 30 stretch the sail 18 over the corresponding battens 28 when a batten loop patch 32 fastened to the batten strap 30 is engaged with a batten hook patch 33 fastened to the batten pocket 29. Each batten pocket 29 and a corresponding pocket extension 34 of the main section 25 extends to a point proximate to the corresponding anchor 31 for guiding the batten 28 into engagement with the anchor 31. An anchor strap 35 fastened to the pocket extension 34 secures the batten pocket 29 with the pocket extension 34 to the anchor 31 through a strap slot 36 in the anchor 31. An anchor loop patch 37 fastened to the anchor strap 35 engages an anchor hook patch 38 fastened to the batten pocket 29.

In front of the mast 10 and within the sock 26 of the sail is located a leading edge member 39. The leading edge member 39 can be interrupted to form a head leading edge member 39a and a foot leading edge member 39b with space between for fastening a conventional yoke (not shown) to the mast 10. The head leading edge member 39a is retained axially within the sock 26 by the boot pin 23. The foot leading edge member 39b is retained axially within the sock 26 by a foot pin 43.

With reference to Figs. 4 and 5, the leading edge member 39 is equipped with a plurality of stops 40 which rest against the mast 10. A plurality of flexible rib pairs 41 co-planar with corresponding battens 28 contact opposite sides of the mast 10 and are pivotably fastened tangent to the leading edge member 39 by a pair of rib rivets 45. Each flexible rib pair 41 extends beyond the sock seam 24 of the sail 18 and is slidably clamped tangent to opposite sides of the batten 28 by a pair of rib pocket extensions 42 in the sock 26. Each anchor 31 is shaped to be pivotably located by the mast 10. Each anchor 31 has an anchor notch 44 to provide

clearance for each rib of the flexible rib pairs 41. The anchor 31 is fixedly riveted to the leading edge member 39 by a plurality of anchor rivets 47. Thus, the leading edge member 39, anchor 31 and flexible rib pairs 41 are free to pivot as a unit about the mast 10 according to the orientation of the battens 28.

Preferably the clearance for the rib pairs 41 provided by the anchor notches 44 in the anchors 31 is sufficient to permit the flexible rib pairs 41 to assume positions substantially inclined from perpendicular to the mast 10. This clearance enables the battens 28 to be positioned substantially inclined as dictated by the design of the sail 18.

Preferably the stops 40 are formed by corresponding slot bulkheads 46 moulded into the leading edge member 39. The configuration of the stops 40 and the slot bulkheads 46 permits the leading edge member 39 to be vacuum-formed from sheet material.

Preferably the leading edge member 39 is reinforced by a filler 48. This filler may, for instance, be a low-density closed-cell polyurethane foam. The filler 48 has such buoyancy that an assembly including the sail 18 will float in water.

Preferably the leading edge member 39 has slots 50 corresponding to each stop 40 so that the leading edge member 39 is segmented and can be articulated at each of the stops 40. This articulation of the leading edge members 39 permits the mast 10 to flex when in use. In addition the leading edge member 39 can be arranged into a coiled configuration more convenient for shipping as shown in Fig. 9.

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In another version of the present invention the rib pocket extensions 42 for slidably clamping the flexible rib pairs can be separate from the sock.

The attachment of the present invention can be assembled to the sail 18 in the following steps:

1. Inserting the head leading edge member 39a with the attached anchors 31 and the flexible rib pairs 41 partway into the sock 26, the flexible rib pairs 41 having been inclined to precede corresponding anchors 31 entering the sock section 26;

2. Guiding each flexible rib of the rib pairs 41 into the corresponding rib pocket extensions 42;

3. Continuing insertion of the leading edge member 39a completely into the sock 26;

4. Installing the boot 22 with the boot pin 23 engaging the boot 22, the sock 26 and the leading edge member 39a;

5. Repeating steps 1-3 for the foot leading edge member 39b;

6. Fastening the foot leading edge member 39b to the sock 26 with the foot pin 43;

7. Fastening the pocket extensions 34 with the batten pockets 29 to the anchors 31 by feeding the anchor straps 35 through the corresponding strap slots 36 in the anchors 31, then engaging the anchor loop patches 37 with the corresponding anchor hook patches 38;

8. Inserting the mast 10 between the stops 40 and the anchors 31 until the tip 12 engages the boot 22;

9. Inserting the battens 28 between the batten pockets 29 and the main section 25 at the trailing edge 27, into engagement with the anchors 31;

10. Fastening the batten straps 30 with the battens 28 in axial compression; and

11. Attaching the conventional yoke and connecting the down-haul 21 and the out-haul 20.

In operation of the described attachment, the shape and orientation of the battens is defined by the location of the mast and the yoke and the pressure of wind against the sail. One rib 41a of each flexible rib pair 41 automatically assumes a smooth convex shape while the other rib 41b of each flexible rib pair 41 automatically assumes a smooth concave shape. Simultaneously, the anchors 31 are turned by the battens 28 to face the leading edge member 39 properly into the wind. The anchor straps 35 securing the batten pockets 29 to the anchors 31 assist the turning of the anchors 31 under tension in the batten pockets 29 at the anchors 31 reacting against compression of the battens 28 by the batten straps 30.

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Claims

1. Sail assembly comprising a sail (18) including a sock (26) for enclosing the mast (10), said sail being stiffened by elastically flexible battens (28) extending from a location in the vicinity of the mast (10) in the direction towards the trailing edge (27), the front end of the battens being pivotally retained on the mast, characterized in that anchors (31) mounted on the mast retain the leading ends of the battens (28) and are pivotable about the mast (10) due to the movement of the battens, and that a plurality of stiffening means (41) for the sock (26) are arranged to extend along the leading edge within pocket extensions (42) of the sail (18) so as to be tangentially movable relative to the battens (28), said rib pairs being located by the anchor means (31) and being deformed in accordance with the flexure of the battens (28) and swivelling about the mast in accordance with the orientation of the battens (28).

2. Sail assembly as claimed in claim 1, characterized in that the stiffening means of the sock (26) comprise a flexible rib (41a; 41b) which extends from the anchor (31) along one side of the sock (26).

3. Sail assembly as claimed in claim 1, characterized in that the stiffening means for the sock (26) comprise a pair of flexible ribs (41) which extend from the anchor (31) along either side of the sock (26).

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4. Sail assembly as claimed in any one of the claims 1 to 3, characterized in that the stiffening means comprise a leading edge member (39) which assumes a smooth aerodynamic shape before the mast (10).

5. Sail assembly as claimed in any one of the claims 1 to 4, characterized in that the sail (18) includes a main section (25) with the trailing edge (27), said main section connecting with a seam (24) of the sock (26), in that batten pockets (29) for the battens (28) are provided in the main section (25) and freely extend into the sock (26) to locations in the vicinity of the mast (10), in that a plurality of pairs of rib pocket extensions (42) of the sock (26) interrupt the seam (24) between sock (26) and main section (25) of the sail (18) opposite corresponding batten pockets (29), said pairs of rib pocket extensions (42) extending in parallel to the batten pockets (29) on either side of the main section (25), in that the leading edge member (39) is formed within the sock (26) to provide an aerodynamic shape on the side opposite the sock seam (24), in that the anchors (31) are fixedly mounted on the leading edge member (39) so as to pivotably mount the leading edge member (39) on the mast (10), wherein the anchors (31) are aligned with the batten pockets (29) and fastened thereto, in that the plurality of battens (28) disposed in the corresponding batten pockets (29) are passed through the batten pockets in firm engagement with the anchors and extend to a point near the trailing edge (27), and in that a plurality of pairs of flexible ribs (41), which are co-planar with the respective battens (28) and are mounted on opposite sides of the mast (10) to engage the leading edge member (39) at a tangent, project into the corresponding pairs of rib pocket extensions (42), the pairs of flexible ribs (41) being slidably clamped by the pairs of rib pocket extensions (42) substantially tangentially to the opposite sides of

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the respective battens (28), and the leading edge member (39) being automatically positioned into relative wind and defining a smooth aerodynamic shape of the sock blending with both sides of the main section (25) as the sail (18) is variously trimmed.

6. Sail assembly as claimed in any one of the claims 1 to 5, characterized in that it comprises means by which the battens (28) may be inclined at an angle to the mast axis in accordance with the cut of the sail.

7. Sail assembly as claimed in claim 5, characterized in that the leading edge member (39) is segmented so that the segments swivel with the anchors (31) when the mast (10) flexes.

8. Sail assembly as claimed in claims 5, 6 or 7, characterized in that the leading edge member (39) is reinforced by a filler (48) clamped therein.

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