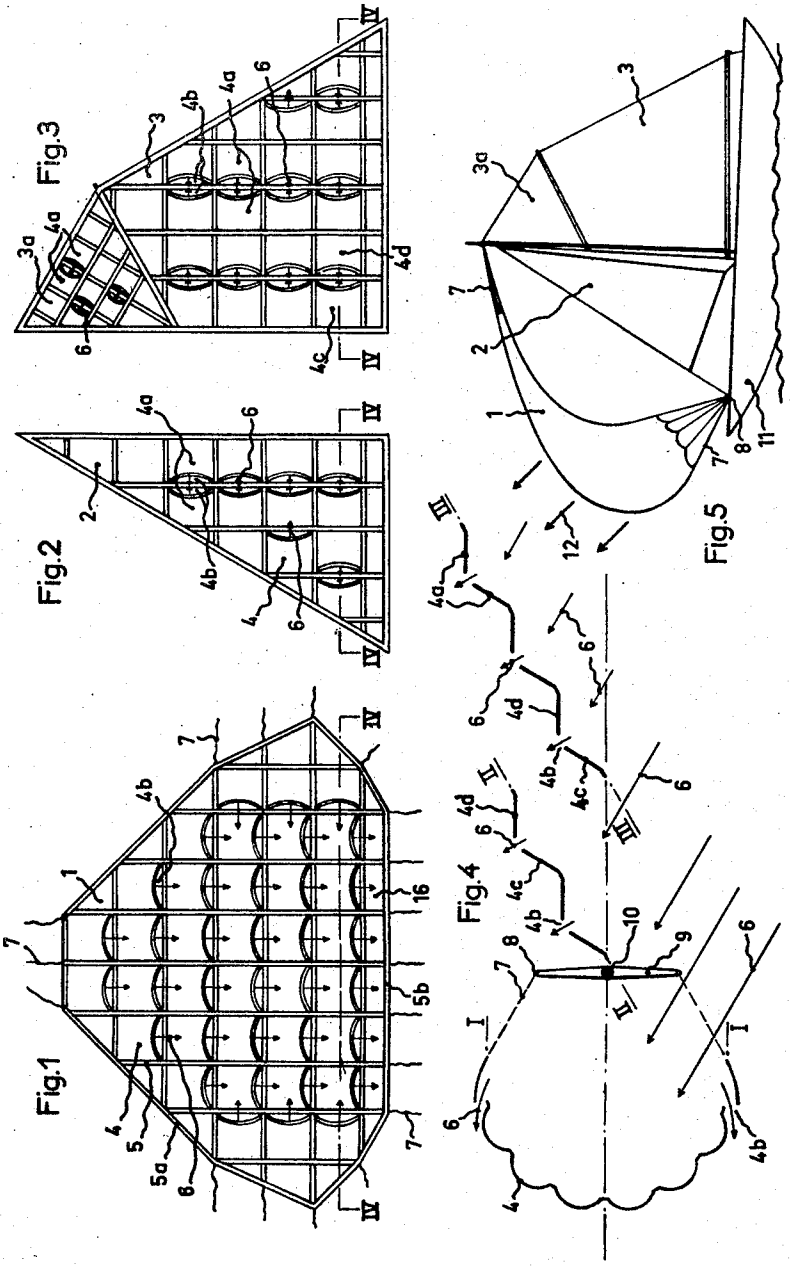
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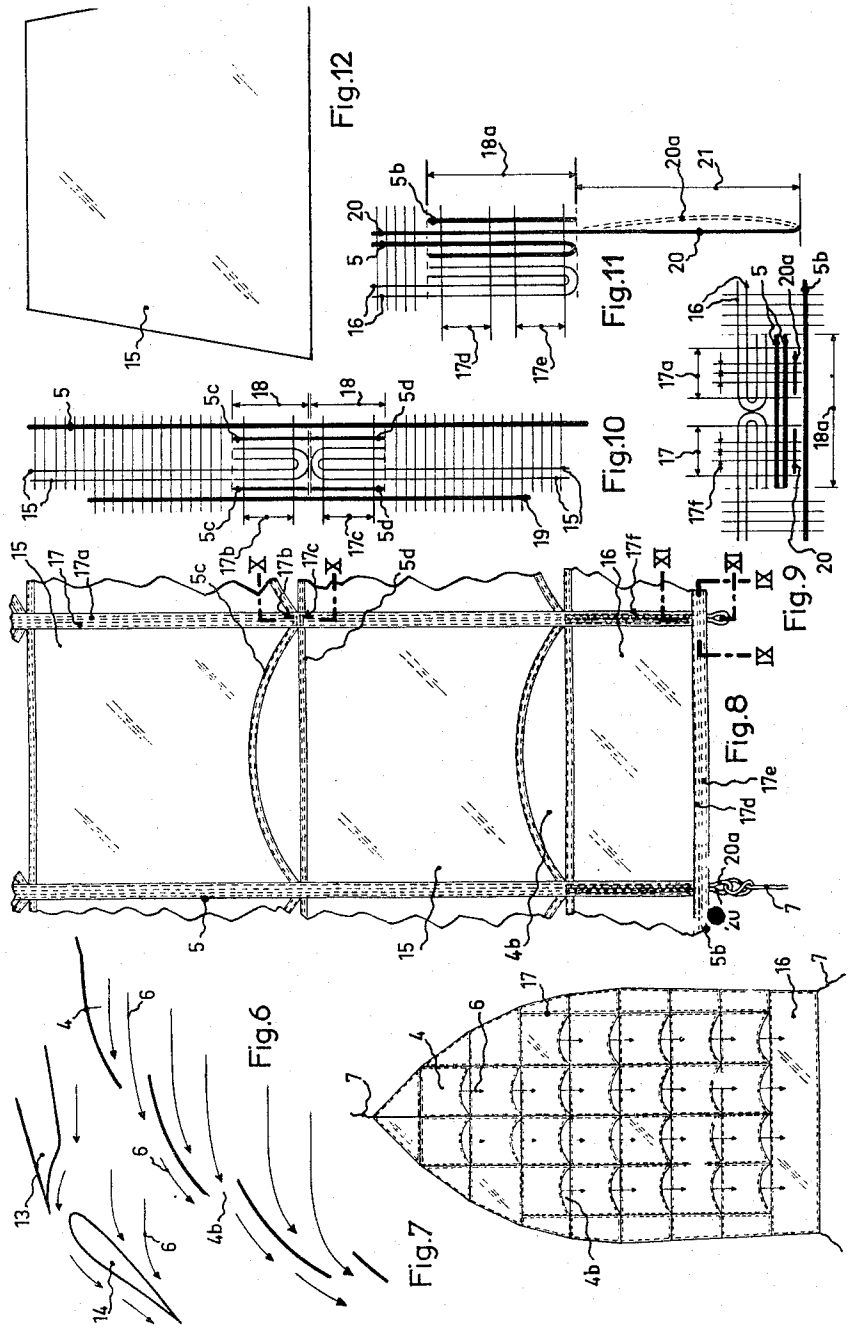
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The present invention relates to improvements applied to sails more particularly for boats and has for its object a better utilisation of the force of the wind than that obtained hitherto with conventional sails of equal area.

It is known that the propulsion effect supplied by a sail is produced, to a certain extent, by the pressure created on the surface exposed to the wind (surface which will hereinafter be designated by the term "inner surface") and for the major part by the vacuum which is set-up on the opposite surface of the sail ("outer surface").

As regards conventional sails having a certain area or even more so as regards very hollow sails such as spinnakers or balloon jibs, only a very small part of this pressure-vacuuum effect is utilised, because detachment zones for the air streams, turbulent zones, dead zones and the like are produced on the inner surface and even more so on the outer surface, all these being disturbances which harm the efficiency of an appreciable part of the area of the spread sail. Moreover, when several sails are used at the same time, interactions are produced between them; certain of the sails can be partially or completely deprived of wind, which reduces or cancels out their propulsive effect and can even produce a braking effect on the movement of the boat.

A conventional sail as well as a sail according to the invention has two sides or surfaces, one of which is convex and the other concave when the sail is inflated by the wind, and thus the sail may be defined as concavo-convex, and the sail of this invention is so arranged as to cause a directed circulation of the air on and between its two surfaces, the said circulation improving the aerodynamic capacity of the profile formed by the sail and having also the effect that the resultant force produced by the action of the wind on the sail or sails is directed in a direction different from that of the resultant force acting on the conventional sails.

This different orientation is chosen in such a way as to assist the movement of the boat, and thus if the resultant of the forces comprises a vertical component turned upwardly, there is obtained a lightening effect or even a lifting effect which is favourable to an increase in the speed of the boat.

The invention also covers a process for the manufacture of sails according to the invention and more generally of all structures made of fabric adapted to be exposed to the action of a true or relative wind and comprising the improvements which are the subject of the present invention.

According to one feature of the invention, at least a part of the surface of the sail comprises panels having a free margin, the said panels being capable, when the sail is filled with the wind, of assuming the form of a nozzle providing communication between the outer and inner surfaces of the sail so as to create a circulation and an acceleration of the air speed between these two surfaces.

According to another feature of the invention, the orientation of the fabric nozzles formed by the said panels is so chosen that the air streams at high velocity escaping from the nozzles are applied to the outer surface of the sail at a predetermined angle which improves the functioning of the sail formed with the nozzles and/or that

of adjacent sails, which may or may not also comprise nozzles.

Thus, in the simplest case, it is possible to provide at various zones of the surface of each sail a certain number of fabric nozzles orientated so as to blow substantially tangential air currents on the surface referred to as the outer surface in order to avoid any detachment or turbulence of the air streams on this surface and thus to increase the aerodynamic capacity.

While being orientated so as to produce the aforesaid favourable tangential air currents, certain or all of the nozzles of a single sail may also be disposed, for example because of a general orientation of the said nozzles towards the base of the sail, so as to cause a "thrust" effect comparable to that acting on an aircraft wing, the sail thus also transmitting an appreciable lift to the boat. This thrust effect may be considered as originating from the reaction on the sail of air streams deviated by the nozzle, as well as to a certain degree of the air current directed downwardly at the outlet from the nozzle and reacting on the air which is on the outer surface of the sail.

This arrangement, which is part of the invention, is of particular interest when it is applied to the forward sails of the boat, such as the jibs, storm-jibs and even more so to the balloon sails known as spinnakers which are able, on account of this thrust force, to cause the lifting or even a hydroplaning of the boat, if the form of the hull is suitable for this purpose, thereby introducing very large increases in speed.

In one constructional form of the invention, a single sail has arranged thereon pairs of nozzles made of fabric, of which the escape edges, that is to say, the free margins, face one another and produce in pairs, when the sail is filled, a resultant air current directed substantially normally with respect to the outer surface of the sail. This air current causes a suction effect on the ambient air, and this increases the vacuum on the outer surface while regulating the flow of air on this face of the sail. At the same time, the high velocity air escaping from these nozzles can supply the inner surface of another sail situated to leeward of the first, this making it possible to employ sails having very large overlaps without danger of being mutually masked.

A nozzle for a sail according to the invention may be formed by a simple slot, suitably reinforced, formed in the sail. According to the preferred embodiment, the nozzle is formed by a fabric panel sewn by all its edges except one to the sail, the free edge being sufficiently long to be able to fill out above the general surface of the sail, the latter naturally comprising, opposite the piece of fabric constituting the nozzle, a nozzle supply orifice of more or less large dimensions. This orifice may occupy all the surface of the nozzle panel, this having the advantage that the nozzle can be formed equally well on one surface or the other of the sail, depending on which side the sail receives the wind.

The invention will be better understood from reading the detailed description which follows and from a study of the accompanying drawings, which show by way of non-limitative examples various embodiments of the invention.

In these drawings:

FIG. 1 shows diagrammatically a sail of the spinnaker type formed according to the invention.

FIG. 2 represents a sail of the storm-jib type and

FIG. 3 represents a main sail and also a top sail compristing panels in the form of nozzles.

FIG. 4 is a sectional view showing the general flow of the streams of air on the sails in FIGS. 1, 2 and 3.

FIG. 5 is a side view of a boat equipped with the sails in FIGS. 1, 2 and 3.

FIG. 6 shows the flow of streams of air in a sail comprising nozzles according to the invention as well as, for comparison purposes, in a high-lift device for an aircraft wing.

FIG. 7 represents another constructional form of a spinnaker according to the invention.

FIG. 8 shows a method of manufacturing a sail formed with nozzles, in which assembly tapes are used.

FIG. 9 is a sectional view of the assembly of the sail according to FIG. 8, on the line IX—IX.

FIGS. 10 and 11 are respectively views of the same assembly on the lines X—X and XI—XI of FIG. 8.

FIG. 12 represents a cutting template of a nozzle used in a sail according to the invention.

The spinnaker **1** shown in FIG. 1 is formed by a certain number of panels which are connected together by means of assembly tapes **5**, certain of these panels bearing the reference **4** comprising a free edge, which, under the effect of the wind, can assume a rounded form in order to constitute the escape edge of a nozzle. The air striking the inner surface of the sail escapes through the slots **4***b* formed between the free edges of the panels and the adjacent face of the outer surface of the sail, in the direction indicated by the arrow **6**.

As is usual, the sail comprises lateral and lower boltropes or reinforcing bands **5***a* and **5***b* respectively, as well as halyards and sheets **7** permitting the hoisting of the sail and the maneuvering thereof.

FIG. 6 shows in a substantially vertical plane the circulation of the streams of air on the sail, for example in the upper range of the nozzles shown in FIG. 1. It would be seen that the air escapes at high velocity through the orifices **4***b* and is directed tangentially to the surface of the sail on the outside of the latter, in the same way as the air is directed along a high-lift flap **14** situated at the trailing edge of an aircraft wing **13**. This nozzle effect illustrated by FIG. 6 not only has the result of avoiding detachment of air or turbulent zones on the outside of the sail, this considerably improving the action of the sail and thereby increasing the propulsive power, but due to the action of the incident air on the convergent portion of the nozzles, it also causes a lifting thrust force, which can be completed to a certain degree by the reaction of the downwardly directed air streams, which flow along the outer surface.

The spinnaker thus produces a resultant force **12** (FIG. 5), presenting an appreciable component in an upward direction capable of causing the boat **11** to lift and even hydroplane.

In FIG. 1, the majority of the nozzles are shown directed downwardly so as to obtain the maximum lift effect. It is however quite understood that certain of the nozzles can be directed in different directions so as to obtain the most favourable air circulation on the outer surface of the sail. Thus, it is possible to provide one or two nozzles laterally (three on each side, in the case shown in FIG. 1), which fill up towards the front, as will be seen in FIG. 4. The best orientation of the sail with respect to the direction **6** of the wind can be achieved by means of a rocker bar **9** which can swivel about a spindle **10**, the sheets of the spinnaker being made fast to the ends **8** of said bar. A more or less large portion of the area of the sail may be formed of panels without nozzles, in the conventional manner, like the lower strip **16** of the sail shown in FIG. 1.

The panels in the form of nozzles are shown in detail in FIGS. 8 and 12. They are preferably formed by a trapezoidal surface sewn to adjacent surfaces of the sail on three sides and left free on the side of the base of the trapezium, which constitutes the escape edge. Under the effect of the wind, the nozzle swells along the rounded surface **15** and allows the air to escape through the orifice of sector form **4***b*. The particular method of assembling these panels in the form of nozzles will be described in greater detail below, but it will be seen at this stage

that this constructional form permits the nozzles to extend arbitrarily on one face or the other of the sail, depending on the direction of the wind.

Obviously, the shape of the panels forming nozzles can be different from the trapezium shown in FIG. 12 and it is for example possible to use triangular panels, which then assume a conical form under the effect of the wind. The invention is of particular interest in the case of spinnakers, because of the lifting effect which can be obtained. On the other hand, the sails of this type being practically always used when sailing free, they always work in the same direction, that is to say, it is always the same surface of the sail which serves as the inner surface and thus particular arrangements of the nozzles can be envisaged.

However, the arrangement according to the invention can also be used with advantage on sails such as those in FIGS. 2 and 3, but keeping in view in this case mainly the improvement in the aerodynamic effect of these sails. These figures show sails equipped with double nozzles **4***a* that is to say, nozzles with the orifices **4***b* directly facing one another. It is obvious that these opposed nozzles could also be separated by a cloth surface without nozzles. It will be seen from FIG. 4, that these conjugated nozzles formed by the walls **4***c* and **4***d* cause an air current from the inner surface towards the outer surface, directed substantially perpendicularly of the mean surface of the sail, this producing an aspiration phenomenon on the air which is on the outside.

The intense and directed circulation caused on the outside by these air currents makes it possible for sails having a large overlap to be used; thus, the jib II—II shown in FIG. 4 could have a much larger surface without any danger of being deprived of wind by the main sail III—III, due to the fact that it would be supplied by the air at high velocity escaping from the nozzles **4***a* of the main sail. One advantageous arrangement may also consist in arranging, on sails such as jibs or main sails, a series of parallel nozzles to the luff of the sails, i.e. parallel to the escape edge of the sail, and in proximity to this escape edge. The assembly of these nozzles, filling towards the rear, is equivalent to a high-lift flap of an aircraft wing extending substantially over the entire span of the wing. The air streams are thus guided on the two surfaces of the sail and, moreover, the air escaping from the jib nozzles can be supplied at high velocity to the main sail which is in the vicinity thereof.

According to another embodiment of the invention, simple nozzles can be arranged on one part of the sail and double nozzles on another part of the same sail this making it possible for certain sails to be used under sailing conditions and under certain directions of the wind with which they would not be able to operate satisfactorily if they were of conventional manufacture.

FIG. 7 shows another spinnaker, the major part of the area thereof being formed by nozzles which are all directed downwardly so as to obtain the highest possible lifting effect from this sail.

FIGS. 8 to 12 show in detail one preferred method of manufacturing the cloth structures according to the invention, which are capable of being subjected to a true or relative wind. A plurality of trapezoidal panels **15** are assembled together at three of their sides by means of assembly tapes **5**. The free margins of the trapezoidal panels constituting the escape edge of the nozzles are reinforced by tapes **5***c* while the leading edge of said nozzles is reinforced by tapes **5***d*. In order to effect the connection of the four adjacent panels at the point X—X, the edges folded as hems with a width **18** of the panels **15**—**15** (FIG. 10) are brought together, they are covered with reinforcing tapes **5***c* and **5***d* of a corresponding width, and then by the assembly tape **5** and an internal assembly reinforcing tape **19** is arranged on the opposite face. These various parts are united by means of stitching **17***a*, *b*, *c*. As reinforcement, it is possible with ad-

vantage to use tapes of synthetic textile material, such as woven tapes of superpolyamide sold under the commercial name of "Nylon," it being possible for such tapes to have a resistance of 150 kg. for a width of 15 mm. and of 400 kg. for a width of 30 mm. FIGURES 9 and 11 show a similar method of assembly between adjacent panels of the sail, for example the lower panels **16** of the spinnaker shown in FIG. 7, these assembly points also serving for fixing to the stays **20–20***a* for the sheets **7**. The two parts **20** and **20***a* of the stays can be fixed by double stitching **17***a, d, e,* between the assembly tape **5** and the lower reinforcing tape **5***b* of the sail, the assembly being completed by a zig-zag stitching **17***f*.

It will be seen that in accordance with this method of making-up, two adjacent pieces of cloth are joined without it being necessary to overlap hems (securing means) formed in their margins, but only by bringing two hems edge to edge and uniting by means of assembly tapes having a sufficient width and rigidity.

It is obvious that the invention is not in any way limited to the examples which have been described and illustrated and that it is capable of numerous modifications available to the person skilled in the art, depending on the proposed applications, without thereby departing from the scope of the invention.

I claim:

1. A sail comprising a fabric surface, said surface having a slot therein defining two lips, said lips, slot and the adjacent surfaces deforming and bulging under the effect of the wind to define two nozzles having escape edges facing one another, and said nozzles allowing a resultant stream of rapidly flowing air to escape from the side of the sail which is not exposed to the wind.

2. A balloon sail presenting when inflated by the wind opposite concavo-convex surfaces and comprising a plurality of panel sections forming each an air nozzle means adapted to deflect the air entering the nozzle means from the windward side of the sail to the other side thereof in a downward direction substantially tangentially of the convex surface of the inflated sail so as to produce a reacting lift component as well as a power increasing suction effect by imparting velocity to the air at said other side of the sail.

3. In a balloon sail presenting, when inflated by the wind, a concavo-convex sheet portion, a plurality of first air nozzle means adapted to deflect the air entering said first nozzle means to the convex side of said sheet portion in a downward direction tangentially of the convex surface of the inflated sail, and second air nozzle means arranged along two opposite vertical margins of said sheet portion and adapted to deflect the air entering said second nozzle means to the convex side of said sheet portion in a horizontal direction tangential to said convex side.

4. In a sail boat having a hull, a vertical mast and a horizontal boom adjacent the lower end of said mast, a balloon sail attached to said mast adjacent the upper end thereof and to said hull adjacent the front end thereof and presenting when inflated by the wind opposite concavo-convex surface portions, a main sail attached along one edge to said mast and along its bottom edge to said boom, a jib sail positioned between said balloon sail and said main sail, a plurality of first air nozzle means in said balloon sail for deflecting the air entering said first nozzle means from the windward side of the balloon sail to the other side thereof in a direction substantially tangentially of the convex surface portions of the inflated sail, and a plurality of second air nozzle means in said main sail and in said jib sail for producing horizontal air streams therethrough whereby to increase the area of negative pressure at the side of said main sail and of said jib sail opposite the windward side thereof.

5. In a balloon sail having top, bottom and lateral edges, a plurality of expansible trapezoidal panel sections united to each other in vertical alined relationship along their convergent lateral sides so as to form, when the sail is expanded by the wind, a concavo-convex sheet extending between said edges of the sail, the lower longer side of each expanded panel section forming with the upper shorter side of the adjacent panel section a substantially horizontal nozzle outlet adapted to direct the air from the concave side of said sheet downwardly to the convex side thereof in a direction substantially tangentially of the convex side.

6. In a balloon sail having top, bottom and lateral edges, a plurality of expansible trapezoidal panels the lower side of which is longer than the upper side, said panels being united in vertical alined relationship along their lateral sides only to form, when the sail is expanded by the wind, a concavo-convex sail portion between said edges of the sail, the lower side of each expanded panel forming with the upper side of an adjacent panel a downwardly opening mouth.

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