on the trailing edge and fixedly attached to the leading edge, and the guide line is positioned along the headboard such as to be able to move over at least one pulley between the trailing edge and the leading edge.

[0026]As a preference, when a guide line is present, it is formed as two parts, the first part on the side of the trailing edge is fixed or else able to be moved with a pulley on the headboard and able to be moved by a roller on the sail receptacle; the second part on the side of the leading edge is fixed or else able to be moved with a pulley on the headboard and able to be moved by a roller on the sail receptacle.

[0027]Another subject matter of the present invention is a vehicle with sail propulsion or hybrid propulsion comprising at least one sail-propulsion element as mentioned hereinabove, a hull and a mast secured to said hull while still maintaining a degree of freedom to rotate. This vehicle is characterized in that most of the mast is positioned inside the cavity of the above-mentioned inflatable sail.

[0028]As a preference, the mast is positioned inside the cavity of said inflatable sail.

[0029]As a preference, the sail is oriented according to the wind direction and according to the direction of travel of the vehicle either manually or automatically.

[0030]What is meant by a hybrid-propulsion vehicle according to the invention is sail propulsion coupled with another source of propulsion such as, for example, propulsion by means of a propeller driven by an electric motor or a combustion engine, having, as energy store, batteries, hydrogen (with fuel cell), natural gas or fuel oil.

[0031]What is meant by a vehicle is any craft which may or may not have wheels, moving on land or on water.

Description of the drawings

[0032]The invention will be described with the aid of the following figures, which are schematic and not necessarily drawn to scale, and in which:

- Figure 1 provides a reminder of the various physical forces that are applied to a ship, for example of the motor sailboat type, and notably the projection of the resultant aerodynamic force;

- Figure 2 is a schematic front view of the sail-propulsion element according to the invention, fully hoisted;
- Figure 3 is a schematic front view of the sail-propulsion element partially comprising ribs;
- Figure 4 is an enlarged schematic view of the rib-comprising portion of the sail-propulsion element according to the invention;
- Figure 5 is a schematic front view of the sail-propulsion element according to the invention, fully furled;
- Figure 6 is a schematic perspective view of a rib.

[0033]Before the sail-propulsion element that forms the subject matter of the present invention is explained in greater detail, with the aid of the above-mentioned figures, a reminder of a few hydrodynamic and aerodynamic definitions is given below.

[0034]A sail-propulsion vehicle, hereinafter referred to as sailboat or ship, is in contact with the air and with the water. From a physical standpoint, the predominant factors are the hydrodynamic and aerodynamic forces that are applied to the hull, the sails and the appendages (centreboards, keel, rudder, propeller).

[0035]As shown in **Figure 1**, the **aerodynamic** force (or sail thrust) is the result of the air being deflected by at least one sail. The aerodynamic force is relative to the position and surface area of the sail and to the position and strength of the relative wind. The drag force is in the direction of the relative wind, the lift force is in the direction perpendicular to the relative wind, and is not always perpendicular to the sail. For example, at 0°, a symmetrical profile creates no lift because the air covers strictly the same distance over the extrados surface and the intrados surface. At that point, it generates only drag.

[0036]The aerodynamic force generated by the sail may also be broken down in the frame of reference of the boat, rather than that of the sail, into a sail-propulsion force (along the axis of travel of the boat) and a drift force (perpendicular to the axis of the boat) which may cause a boat to heel (heeling being the transverse inclination of a boat as caused by an external phenomenon such as the wind).

such as PVC. This type of 3-D weaving ensures correct passage of air even when the sail is furled, in the dropped mode.

[0044]This first material which may be a woven material is attached to the sail by an adhesive means, by stitching or by fusion bonding or by any other means that allows secure attachment. No subsequent coating is performed because this would block the pores of the material and prevent the air from circulating correctly.

[0045]It is even possible to use by way of first woven material a fabric that effects a progressive transition between the material constituting the external layer of the sail 1 and the first woven material of the rib 8. It is also possible to use filament membrane.

[0046]As shown in **Figure 4**, each of the cells 5 are separated by a rib 8. During hoisting/dropping, the air, generated by the fans, or any other means of inflation, and located for example in the sail receptacle, is blown or sucked into the cavity of the sail. The air passes through the ribs 8 (arrows 9) from the top down or from the bottom up (depending on whether the sail is being inflated or deflated), thus allowing a substantially uniform distribution of the internal pressure in the sail 1, whether the case is that of a sail that is fully deployed, that of a sail that has had the sail area reduced by reefing, or that at the start of inflation while the ribs are stacked.

[0047]The make-up of the ribs 8 also makes it possible to react load associated with the internal pressure of the sail 1 as well as making it possible to transmit to the mast 3 the aerodynamic pressure applied to the profile of the sail 1. Indeed the ribs react the internal pressure of the sail, and are also able to transmit aerodynamic forces.

[0048]As symbolized (arrow 10), the internal pressure of the sail is exerted against the wall of the sail.

[0049]The particular choice of the first woven material according to the invention for the ribs 8, and notably the orientation of the yarns of which this material is made, allows the aerodynamic forces to be transmitted correctly from the sail to the mast 3. A limited passage of air around the mast 3 is not disadvantageous. What is of greatest importance is for the air to be allowed to pass over the front part of the rib (towards the leading edge) and over the rear part of the rib (towards the trailing edge). In other words, the rib is not fixed to the mast but “floating”. This nevertheless allows aerodynamic forces to be transmitted while at the same time making it possible to distribute the air uniformly throughout the entire volume of the sail.

[0050]The first benefit of using the first material that allows the air to pass and that reacts load according to the invention, unlike discrete orifices distributed over the surface of the sail, is that it avoids partial or complete obstruction of one or more orifices, which would have a far greater detrimental effect on the correct circulation of the air in the cavity of the sail 1.

[0051]The second benefit is that it makes it possible to appreciably reduce the pressure drops while at the same time maintaining sufficient strength for transmitting load, thus reducing the power and, therefore, energy consumption of the inflation devices.

[0052]A final benefit of this first material is the possibility to dispense with fans in the leading edge. With the solution of the invention, the fans positioned in the sail receptacle will suffice for most manoeuvres entailing blowing air in or withdrawing air.

[0053]As shown by **Figure 5**, the cells 5 allow the air (arrow 9) to pass upwards over the completely furled element according to the invention, so as to hoist the sail 1.

[0054]The schematic depiction in **Figure 6** shows a reinforced zone 11, delimited around the mast 3, in the lower part of the sail. This zone has a surface area of around 7.5 m^2. It is made from a second material different from the first material, which may for example be produced using the same material but with a different angle, for example the first material having a weave angle of 0 and 90° and the second material having an angle of +/- 45° with respect to the first material. In an alternative form, this reinforcement may be achieved by using the same woven fabric as that of the rib and by superposing two layers of fabric at 45° relative to one another.

[0055]This second material is defined by a mesh opening of around 3 mm in size.

[0056]Figure 5 further shows the presence of a band 12 made of a reinforcing material. This band 12 has a width around 80 mm.

[0057]Its function is to distribute force and limit abrasive wearing at the points through which the various line cordage, such as the reefing lines or the guide line, pass.

[0058]Discrete reinforcers (not depicted) may be positioned evenly along the leading edge and/or the trailing edge at the ribs 8.

[0059]<u>**Example**</u>