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(54) **HYDROFOIL**

(57) A hydrofoil for a watercraft comprises a mast (3) as well as a front wing (5) and a rear wing (6), which are arranged, based on the forward travel direction, one behind the other at a free end portion of the mast (3). The rear wing (6) is designed as an annular wing and, in ad-

dition, includes at least one tubular portion (12), which is oriented to the forward travel direction in such a way that water is able to flow through said tubular portion counter to the forward direction of travel.

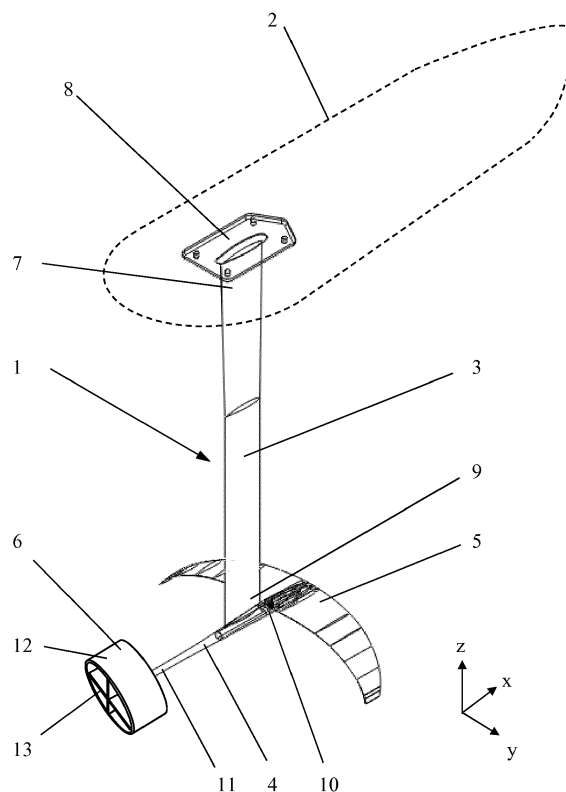


FIG. 1

Description

[0001] The invention relates to a hydrofoil comprising a mast, a front wing and a rear wing, which are arranged, based on a forward travel direction, one behind the other at a free end portion of the mast. The invention also relates to a board, which is equipped with such a hydrofoil.

[0002] Hydrofoils make it possible to lift a board out of the water when travelling, for example, when kite surfing or jet skiing, in order to thereby reduce the flow resistance. The hydrofoil generally includes a mast on which at least one wing is mounted. The mast is also attached to the board. In travel mode, only a portion of the mast and of the wing or wings remains submerged in the water. One example of such a hydrofoil board is found in EP 2 907 737 B2.

[0003] The object of the invention is to improve the travel stability of a hydrofoil board in order, for example, to make it easier for beginners in learning to travel with such a board.

[0004] This object is achieved by a hydrofoil according to patent claim 1. The hydrofoil according to the invention comprises a mast having a first end portion and a second end portion, a front wing and a rear wing intended for generating lift and arranged at the second end portion of the mast, the front wing being designed as a mono-plane wing, and the rear wing being arranged behind the front wing (5) in the flow direction based on a forward travel direction, wherein the rear wing (6) is designed as an annular wing and additionally has at least one tubular portion which is oriented toward the forward travel direction in such a way that water can flow through said portion counter to the forward travel direction.

[0005] It has been shown that compared to a conventional rear wing as described in EP 2 907 737 B2, an improved travel performance can be achieved, which is dependent to a lesser degree on the inclination of the board and, as a result, offers enhanced safety.

[0006] An improved stabilization about the vertical axis is also achieved.

[0007] The tubular design also results in lower induced resistance, i.e., in a reduction of flow losses.

[0008] The hydrofoil according to the invention is further distinguished by a high robustness and lower ventilation compared to a hydrofoil that has a conventional rear wing.

[0009] Advantageous embodiments of the invention are the subject matter of additional patent claims.

[0010] Thus, the annular wing may, for example, have precisely one tubular portion, the longitudinal axis of which is oriented in the forward travel direction.

[0011] In another embodiment variant, it is provided that the annular wing has two tubular portions arranged in parallel to one another.

[0012] The tubular portions extending in parallel to one another may directly adjoin one another in a twin configuration or else may be mutually spaced apart transversely with respect to the forward travel direction and may be

interconnected by a bridge.

[0013] In the simplest case, the at least one tubular portion has a constant through-flow cross section throughout. It is also possible, however, to design merely one region with a constant through-flow cross section.

[0014] It is further possible to design the tubular portion in the form of a nozzle or of a diffuser depending on the need. For this purpose, the at least one tubular portion may have a through-flow cross section that narrows or widens in the through-flow direction or else at least one region that has a through-flow cross section that narrows or widens in the through-flow direction.

[0015] In another embodiment variant, it is provided that the at least one tubular portion in the through-flow cross section thereof and/or upstream of said cross section, has one or more struts that extend transversely with respect to the through-flow direction. In this way, an additional reinforcement of the tubular portion may be achieved. The struts may optionally also be used to influence the flow passage through the tubular portion. A connection to the rear wing may also be achieved by way of the struts.

[0016] In another embodiment variant, the annular wing and the front wing are interconnected by means of a connecting rod, which is in turn connected to the mast, the annular wing and the front wing being preferably spaced apart from the mast. The attachment of the wing to the mast is facilitated by the connecting rod. The connecting rod in this case may either be permanently installed on the mast or else may be attached as a detachable component to the mast, so that if required, connecting rods of varying lengths may be used.

[0017] The connecting rod, based on the vertical direction of the hydrofoil, may be level with the through-flow cross section of the at least one tubular portion.

[0018] It is also possible, however, based on the vertical direction of the hydrofoil, to arrange the connecting rods below or above the through-flow cross section of the at least one tubular portion.

[0019] In another embodiment variant, it is provided that the at least one tubular portion forms an inlet edge, which extends in a plane perpendicular to the inflow.

[0020] Alternatively, the at least one tubular portion may form an inlet edge, which extends in a plane that is inclined with respect to the inflow at an angle of more than 0° up to a maximum of 20°.

[0021] The tubular portion is preferably designed as a closed profile in the circumferential direction. It is also possible, however, to design the at least one tubular portion with a continuous longitudinal slot in the through-flow direction.

[0022] In another embodiment variant, one or more outwardly projecting outer wings may be arranged on the outer circumference of the at least one tubular portion.

[0023] A board is also proposed, which is equipped with a hydrofoil of the type explained above.

[0024] The invention is explained in greater detail below with reference to an exemplary embodiment depicted

in the drawing and with reference to additional variants. The drawing shows in:

- Figure 1 a spatial view of a hydrofoil according to an exemplary embodiment of the invention, which is mounted on a board indicated by dashed lines,
- Figure 2 a detailed view of the annular wing of the hydrofoil from Figure 1,
- Figure 3 different variants of the through-flow cross section of the annular wing,
- Figure 4 different variants of the arrangement of the annular wing in the vertical direction with respect to the connecting rod, and in
- Figure 5 different variants of the tubular portion in a side view.

[0025] The exemplary embodiment explained in greater detail below and the additional variants refer to a hydrofoil 1 for a watercraft. For the purpose of explanation, Figure 1 shows a board 2 an example of a watercraft suitable for kite surfing or jet skiing, to which a hydrofoil 1 is attached. It is possible, however, to also use corresponding hydrofoils 1 on boats, for example.

[0026] The hydrofoil 1 has a mast 3, a connecting rod 4, a front wing 5 and a rear wing 6. These components are designed as separate parts and interconnected in such a way that they can be replaced individually. In this way, it is possible to flexibly adapt the hydrofoil 1 to various intended purposes. The hydrofoil 1 can be very compactly folded for transporting. It is also possible, however, to integrate two or more components into one single part.

[0027] The mast 3 has a first end portion 7 for attachment to the board 2, as well as a second end portion 9 for connecting the connecting rod 4. The mast 3 has a height in the range of 700 to 1200 mm in the vertical direction z, a length in the range of 80 to 150 mm in the longitudinal direction or forward travel direction x, and a thickness in the range of 10 to 30 mm in the transverse direction y.

[0028] The mast 3 is fabricated preferably from a composite fiber plastic, such as carbon fiber-reinforced plastic (CFK) or glass fiber-reinforced plastic (GFK). However, it may also be manufactured from an aluminum alloy or from a multilayer composite material.

[0029] The first end portion 7 of the mast 3 may form a flange-like attachment portion 8, which is widened with respect to its remaining cross section and which provides a bearing surface for the underside of the board 2.

[0030] A second end portion 9 at the free end of the mast 3 has a holding means for the connecting rod 4, for example, in the form of a through-opening, in which the connecting rod 4 is held. Instead of a through-opening, the holding means may alternatively also be designed

as a recess open on a longitudinal side, in particular, a groove, in which the connecting rod 4 is secured.

[0031] The front wing 5 and the rear wing 6 are attached to the mast 3 via the connecting rod 4. The mast 3 is braced via the connecting rod 4 against forces occurring on the wings 5 and 6 during travel. In such case, the connecting rod 4 is secured on the mast 3 against a rotation about its longitudinal axis. This may be achieved, for example, by a corresponding profiling of the connecting rod 4 and the holding means on the mast 3 and/or with the aid of a suitable attachment means, as is explained in greater detail in EP 2 907 737 A1.

[0032] The connecting rod 4 is fabricated from metal, preferably from a steel, titanium or aluminum alloy. It has a slim diameter in the range of 10 to 25 mm, as a result of which the flow resistance in the water remains minimal. The length of the connecting rod 4 is preferably in the range of 400 to 1000 mm. With respect to a simple fabrication and mounting, the connecting rod 4 may be designed with a constant diameter. However, it is also possible for merely portions, for example, the region that is guided in the holding means, to be designed with a constant cross section.

[0033] The front wing 5 and the rear wing 6 are arranged one behind the other in the travel direction and attached to a front and rear end 10, 11 of the connecting rod 4. The front wing 5 is seated, in particular, at the front end 10 and the rear wing 6 is seated at the rear end 11 of the connecting rod 4, so that based on the forward travel direction, the front wing 5 is in front of the mast 3 and the rear wing 6 is behind the mast 3. The front wing 5 and the rear wing 6 in this configuration are preferably spaced apart from the mast 3.

[0034] Both the attachment of the connecting rod 4 to the mast 3, as well as the attachment of the wings 5 and 6 to the connecting rod may be detachably designed. In this way, connecting rods 4 of different lengths may be attached to the mast 3 in order to change the position of the wings 5 and 6. Furthermore, different front and rear wings 5 and 6 may be attached to the connecting rod 4,

[0035] The wings 5 and 6 are preferably manufactured from fiber composite plastic, in particular, carbon fiber-reinforced plastic (CFK) or glass fiber-reinforced plastic (GFK), or from a multilayer composite plastic.

[0036] The rear wing 6 is designed as an annular wing, whereas the front wing 5 is configured as a mono-plane or one deck wing panel.

[0037] An annular wing in the present case is understood to be a wing that has at least one tubular portion 12, which is oriented toward the forward travel direction x in such a way that water is able to flow through said wing counter to the forward travel direction. Its inner cross section is substantially unobstructed.

[0038] In this way, a lower induced resistance and lower ventilation are achieved, compared to a rear wing designed as a profiled wing panel.

[0039] Moreover, the annular wing enables an improved stabilization about the vertical axis z, so that a

more stable travel performance occurs, which is, in particular, essentially also independent of the angle of inclination.

[0040] Compared to a profiled wing panel, the annular wing is further distinguished by a greater robustness, i.e. greater mechanical stability.

[0041] The tubular portion 12 preferably has a minimum through-flow diameter of at least 7 cm² and further preferred of at least 12.5 cm².

[0042] The annular rear wing 6 of the hydrofoil 1 according to Figure 1 is depicted in greater detail in Figure 2. Said annular wing has precisely one tubular portion 12, the longitudinal axis A of which is oriented in the forward travel direction x.

[0043] The tubular portion 12 has a constant through-flow cross section throughout. In the present case, it is designed as a simple hollow tube having a circular cylindrical cross section.

[0044] Apparent within the through-flow cross section of the tubular portion 12 are two struts 13, which extend transversely with respect to the through-flow direction x and are arranged here merely by way of example in a cross-shaped cross-sectional profile. The tubular portion is reinforced on the inside by the struts 13. In addition, the connection of the annular wing to the connecting rod 4 may be made via the struts 13. In addition, it is also possible to optionally use the struts 13 for influencing the flow through the tubular portion 12.

[0045] The tubular portion 12 is arranged in such a way that the connecting rod 4 points in the direction of the through-flow cross section of the tubular portion 12. Thus, based on the vertical direction z, the connecting rod 4 is at the level of the through-flow cross section.

[0046] Figure 2 depicts merely one possible embodiment of an annular rear wing 6. Numerous modifications of the annular wing are possible, which are to be explained in greater detail below with reference to the Figures 3 through 5. In addition, the longitudinal extension of the struts 13 in the longitudinal direction x may be designed differently than depicted, for example, limited solely to the flow inlet side of the tubular portion 12 or optionally positioned axially upstream of the latter, as is indicated, for example, in Figure 4.

[0047] Examples a through f of possible modifications of the cross section of the annular wing in the yz-plane are depicted in Figure 3. Variant a in this case corresponds to the previously explained tubular portion 12 of the Figures 1 and 2, which has an annular through-flow cross section. Instead of an annular profile, other hollow profile shapes such as, for example, an elliptical cross section in variant b or the like (cf. variant e) may also be used.

[0048] It is further possible to provide multiple, for example, in particular, two tubular portions 12, on the annular wing, which may be arranged directly adjacent to one another in a twin configuration according to variant d or spaced apart from one another in a dual configuration by a strut 14 in transverse direction y (cf. variant f).

[0049] The two tubular portions 12 are depicted in Figure 3d next to one another in the twin configuration in the vertical direction. However, it is also possible to use such a twin configuration with tubular portions 12 situated one on top of the other in the vertical direction.

[0050] In addition, one or multiple outwardly projecting outer wings 15 may be arranged on the outer circumference 18 of the at least one tubular portion 12, as is depicted by way of example for variant c. Corresponding outer wings 15 may, however, optionally also be provided on the other profile variants.

[0051] As shown in Figure 4, the position of the tubular portion 12 relative to the connecting rod 4 may also be modified. As previously described above, the connecting rod 4 may be at the level of the through-flow cross section of the at least one tubular portion 12, based on the vertical direction z of the hydrofoil 1 (cf. Fig. 4, variant a). However, it is alternatively also possible, based on the vertical direction z of the hydrofoil 1, to arrange the connecting rod 4 below or above the through-flow cross section of the at least one tubular portion 12, as is depicted in Figure 4 for the variants b and c.

[0052] It is also possible to vary the through-flow cross section in the longitudinal direction x, i.e., instead of a tubular portion having a constant through-flow cross section throughout, for example, as shown in the Figures 1 and 2, to design merely one area in the longitudinal direction x with a constant through-flow cross section.

[0053] Further regions in the longitudinal direction x may, for example, be designed with a through-flow cross section that narrows or widens in the through-flow direction.

[0054] It is further possible to design the at least one tubular portion 12 throughout with a through-flow cross section that narrows or widens in the through-flow direction, as is depicted by way of example in Figure 5 in the variants a and d.

[0055] There is also the possibility of modifying the course of the inlet edge 16 of the at least one tubular portion 12. The inlet edge 16 of the tubular portion 12 in the variants c and d in Figure 5, and in the additional variants of Figures 3 and 4 extends in a plane perpendicular to the inflow.

[0056] It is also possible, however, to also incline this inlet edge 16 at an angle of more than 0° to a maximum of 20° relative to the inflow, as is depicted in the variants a and b of Figure 5.

[0057] The outlet edge 17 of the tubular portion 12 may optionally also be similarly angled.

[0058] The invention has been described in greater detail above with reference to an exemplary embodiment and a large number of variants. The exemplary embodiment and the additional variants serve to substantiate the feasibility of the invention. Individual technical features explained above in the context of additional individual features may also be implemented independently of the latter, as well as in combination with additional individual features, even if this is not expressly described,

as long as this is technically possible. Features from the variants, in particular, may be adopted individually or in combination in a hydrofoil according to the exemplary embodiment. The invention is therefore explicitly not the specifically described exemplary embodiment and is not limited to the variants depicted, but comprises all embodiments defined by the patent claims.

List of reference numerals

[0059]

1	hydrofoil
2	board
3	mast
4	connecting rod
5	front wing
6	rear wing
7	first end portion
8	attachment portion
9	second end portion
10	front end
11	rear end
12	tubular portion
13	strut
14	bridge
15	outer wing
16	inlet edge
17	outlet edge
18	outer circumference
x	longitudinal direction (= forward travel direction)
y	transverse direction
z	vertical direction
A	longitudinal axis

Claims

1. Hydrofoil comprising:

a mast (3) having a first end portion (7) and a second end portion (9),
 a front wing (5) and a rear wing (6) intended for generating lift and arranged at the second end portion (9) of the mast (3),
 the front wing (5) being designed as a mono-plane wing panel, and
 the rear wing (6) being arranged behind the front wing (5) in the flow direction based on a forward travel direction (x),

characterized in that

the rear wing (6) is designed as an annular wing and additionally has at least one tubular portion (12) which is oriented toward the forward travel direction (x) in such a way that water can flow through said portion counter to the forward travel direction.

2. Hydrofoil according to claim 1, **characterized in that** the annular wing has exactly one tubular portion (12), the longitudinal axis (A) of which is oriented in the forward travel direction.
3. Hydrofoil according to claim 1, **characterized in that** the annular wing has two tubular portions (12) arranged in parallel with each other.
4. Hydrofoil according to claim 3, **characterized in that** the tubular portions (12) are mutually spaced apart transversely with respect to the forward travel direction and interconnected by means of a bridge (14).
5. Hydrofoil according to any of claims 1 to 4, **characterized in that**, throughout, the at least one tubular portion (12) has a constant through-flow cross section or at least one region that has a constant through-flow cross section.
6. Hydrofoil according to any of claims 1 to 5, **characterized in that**, throughout, the at least one tubular portion (12) has a through-flow cross section that narrows or widens in the through-flow direction or at least one region that has a through-flow cross section that narrows or widens in the through-flow direction.
7. Hydrofoil according to any of claims 1 to 6, **characterized in that** the at least one tubular portion (12), in the through-flow cross section thereof and/or upstream of said cross section, has one or more struts (13) that extend transversely with respect to the through-flow direction.
8. Hydrofoil according to any of claims 1 to 7, **characterized in that** the annular wing and the front wing (5) are interconnected by means of a connecting rod (4) which is in turn connected to the mast (3), the annular wing and the front wing (5) being spaced apart from the mast (3).
9. Hydrofoil according to claim 8, **characterized in that** the connecting rod (4), based on the vertical direction of the hydrofoil (1), is level with the through-flow cross section of the at least one tubular portion (12).
10. Hydrofoil according to claim 8, **characterized in that** the connecting rod (4), based on the vertical direction of the hydrofoil (1), is arranged below or above the through-flow cross section of the at least one tubular portion (12).
11. Hydrofoil according to any of claims 1 to 10, **characterized in that** the at least one tubular portion (12) forms an inlet edge (16) which extends in a plane, perpendicular to the inflow.

12. Hydrofoil according to any of claims 1 to 10, **characterized in that** the at least one tubular portion (12) forms an inlet edge (16) which extends in a plane that is inclined with respect to the inflow at an angle of more than 0° up to a maximum of 20°.
13. Hydrofoil according to any of claims 1 to 12, **characterized in that** the at least one tubular portion (12) has a continuous longitudinal slot in the through-flow direction.
14. Hydrofoil according to any of claims 1 to 13, **characterized in that** one or more outwardly projecting outer wings (16) are arranged on the outer circumference (18) of the at least one tubular portion (12).
15. Board (2) comprising a hydrofoil (1) according to any of the preceding claims.

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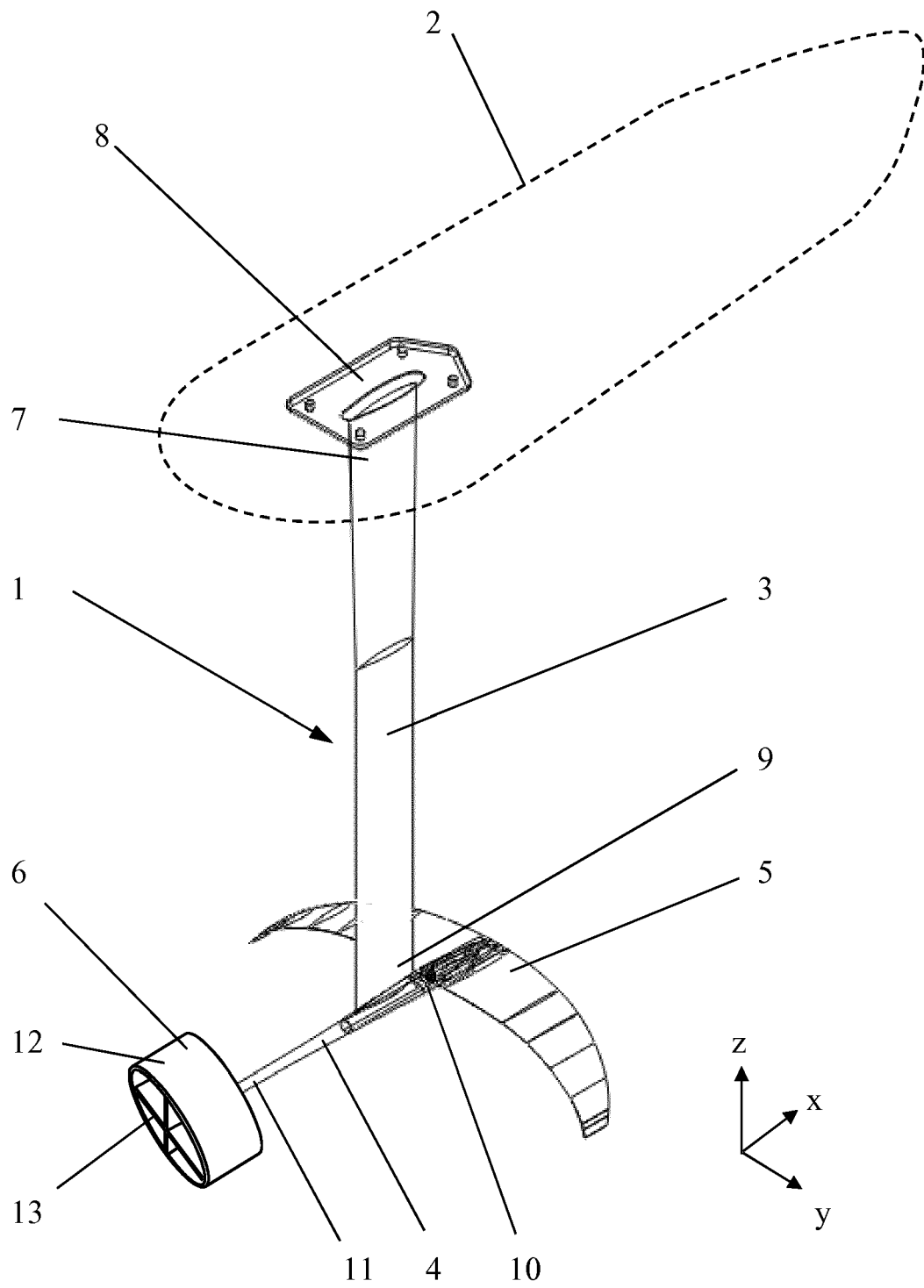


FIG. 1

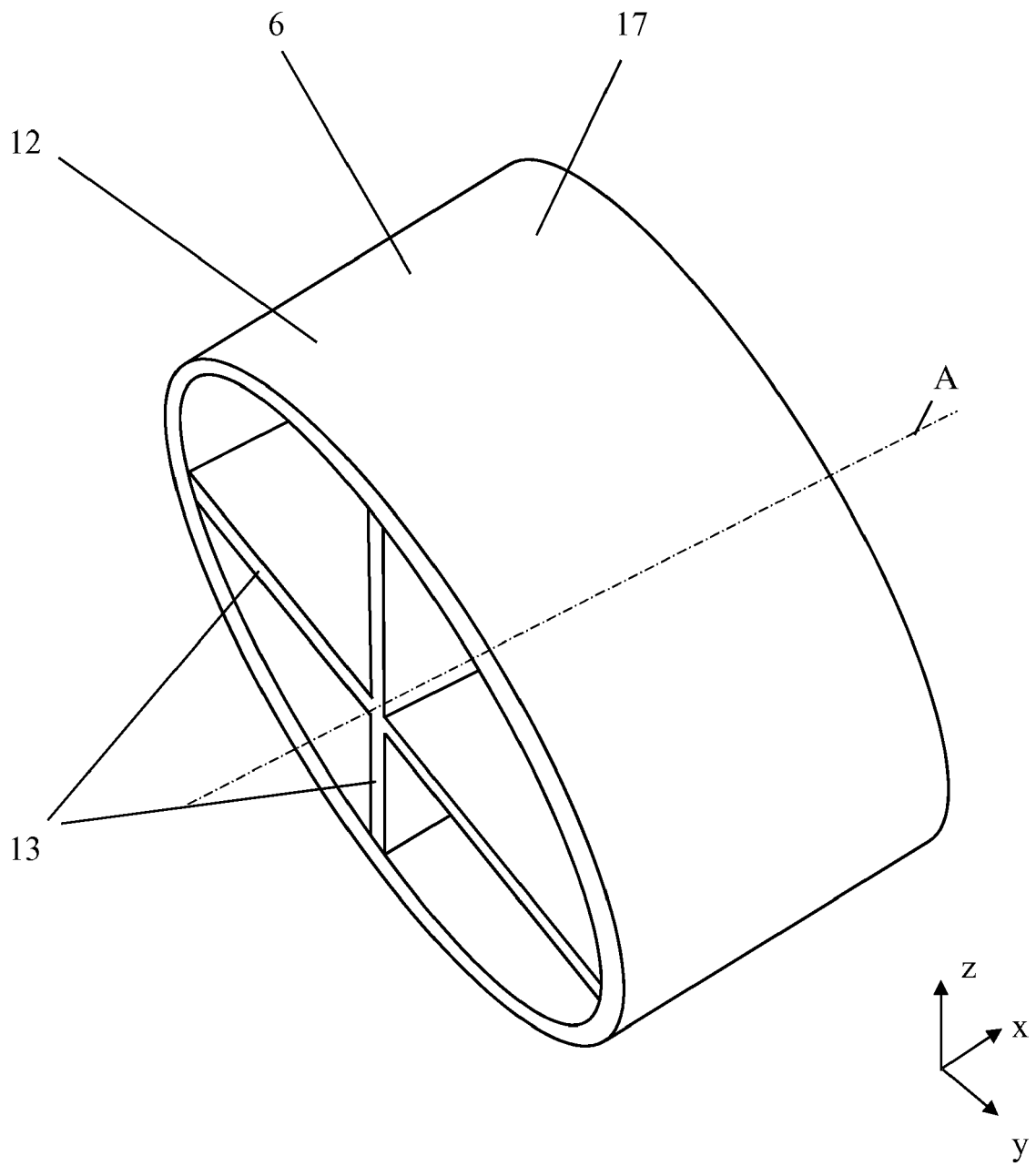


FIG. 2

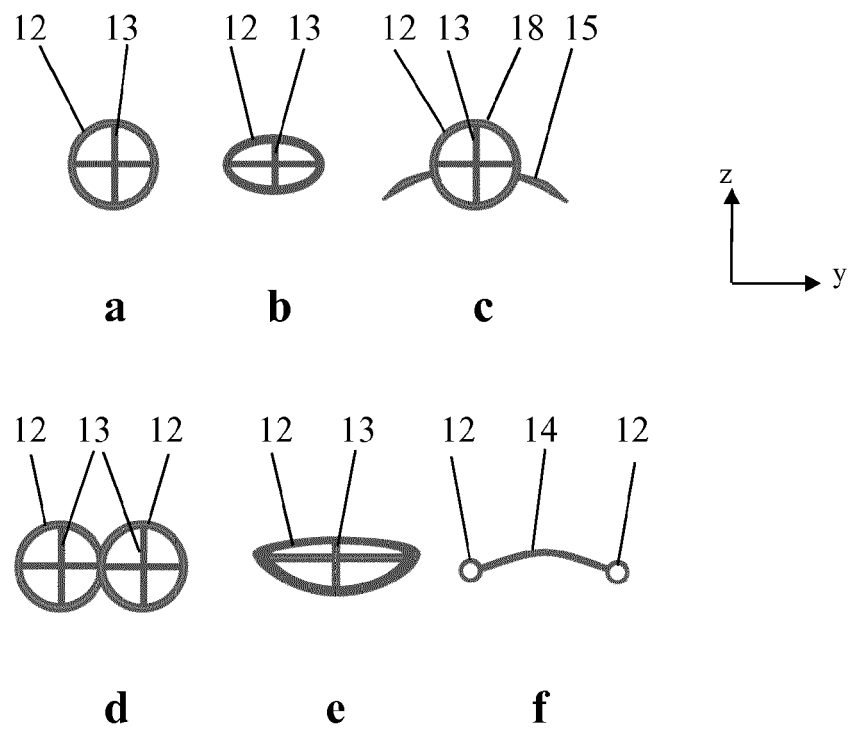


FIG. 3

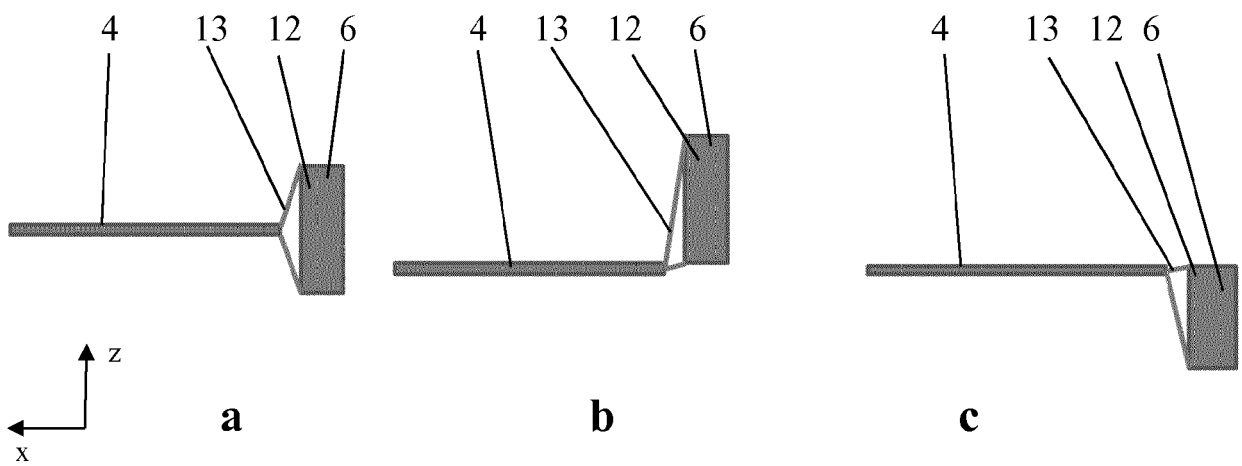


FIG. 4

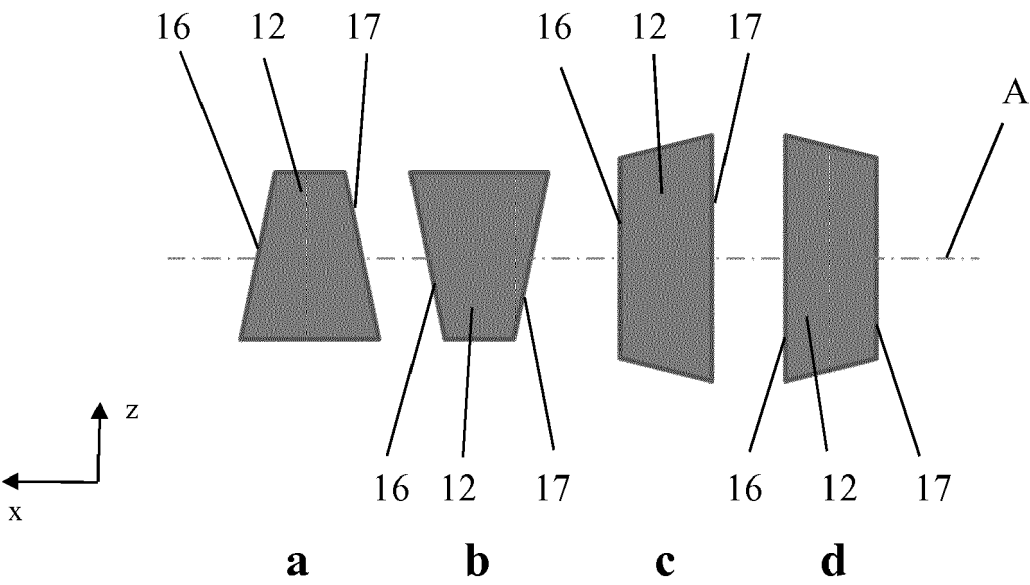


FIG. 5



EUROPEAN SEARCH REPORT

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Place of search The Hague		Date of completion of the search 16 May 2019	Examiner Freire Gomez, Jon
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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