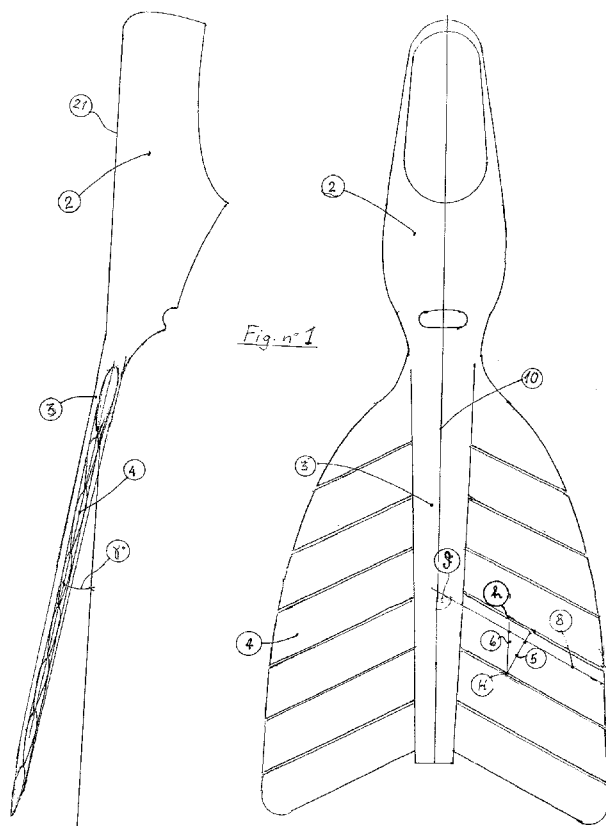




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- (71) Applicant: **RIBI, Leon** [—/CH]; Route De Morgins 6, 1872 Troistorrents (CH).
- (72) Inventors: **RIBI, Leon**; Route De Morgins 6, 1872 Troistorrents (CH). **RIBI, Guido**; CH. de Perreaz 9, 1008 Prilly (CH).
- (74) Agent: **KARAGHIOSOFF, Giorgio A.**; c/o Studio Karaghiosoff e Frizzi, Via F. Baracca 1/r, 17100 Savona (IT).
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[Continued on next page]

(54) Title: SWIM FINS



(57) Abstract: The present invention relates to swim fins and particularly to fins having each at least one single-piece longitudinal member attached to the front of the foot pocket, with a blade part attached to such longitudinal member and consisting of one or more flap elements.



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Swim fins

5

PREAMBLE

The present invention relates to swim fins and particularly to fins having each at least one single-piece longitudinal member attached to the front of the foot pocket, with a blade part attached to such longitudinal member and consisting of one or more flap elements.

15 In the state of the art, certain modern fins have also been formed with a number of vanes with rigid or semi-rigid hydrofoils articulated about two axes at their ends and spaced at a distance of less than 25% the chords thereof from the edge of attachment of such foils. These two axes are in turn perpendicularly incorporated in the two conventional rigid longitudinal members of the fin, which are linked and rigidly connected to the two sides of the foot pocket. The rotation of these foils is limited

20 by the rigid connection of their two inserts fitting in the two longitudinal members. In other cases, the foils, which are also rigid, also rotate about two axes, inserted in the two longitudinal members, also rigid, and their rotation is limited both by locks

25 integral with the longitudinal members and by webs made of rubberized fabric which are connected both to the longitudinal members and to the ends of the rigid foils. In both cases, the rotational movement is

30

obviously caused by the airflow generated by kicking strokes, but the orientation of the foils cannot be controlled throughout the kicking stroke to be at the best angle of attack α° .

5 The invention has the object of providing improved swim fins that can provide, with the same physical effort, a greater transformation of the force exerted by the forward-propelling body.

10 The invention fulfills the above object by the provision of swim fins as defined in the main claim 1.

The dependent claims relate to advantageous improvements of the teachings of claim 1.

15 The characteristics of the invention and the advantages derived therefrom will appear more clearly from the following description of a few exemplary embodiments as shown in the accompanying figures, in which:

20 Fig. 1 shows a plan view and a side view of a first embodiment, relating to a fin with constant-chord flaps.

Fig. 2 shows the plan view and the side view of a further embodiment, relating to a fin with tapered flaps and the detail of the bent and twisted flap.

25 Fig. 3 shows the plan view and the side view of a further embodiment, relating to a fin with two longitudinal members and arrow-shaped flaps.

Fig. 4 is a detail view of a constant-chord flap embedded in the longitudinal member.

30 Fig. 5 shows the bent longitudinal member with the flap embedded therein and aligned with the longitudinal axis of the longitudinal member to form an angle Φ° .

Fig. 6 shows the constant-chord flap with a diagram D, with the projection of the deformed shape of the bent flap.

Fig. 7 is an axonometric view of the detail of
5 the deformed shape of the flap with the diagram D.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

The fins 1 of the present invention are composed of a closed or open foot pocket 2 having a string or an adjustable strap. The front of the aforementioned
10 foot pocket 2 has the root of a longitudinal member 3 permanently attached to its end, such member being adapted to bend about axes 11 perpendicular to the axis 9 and perpendicular to the plane of symmetry 10
15 where the orientation of the orthogonal foil section of the longitudinal member 3 opposes the lowest resistance. Furthermore, the foil sections are so designed as to provide a programmed cylindrical deformed shape 20 for the longitudinal member 3. A
20 series of sheet-like flaps 4 are attached to each of the two lateral surfaces of the aforementioned longitudinal member 3, and may be parallel although independent of each other. Their apexes are free, whereby they are able to move vertically up or down
25 relative to the axis 9 of the longitudinal member 3.

The section of the flaps may have any foil profile.

In a non-limiting embodiment, these sheet-like flaps 4 have sections with orthogonal airfoils 17 and
30 efficient airfoils 18, whose foci 7 on their chords 5 or 6 are obviously situated on their longitudinal axis 8.

Nevertheless, as discussed above, in certain alternative variant embodiments, the flaps may also have different foil profiles, particularly other than airfoils.

5 These foils 17 and 18 may be either symmetric or asymmetric. The flaps 4 may also have different foil profiles along the same flap 4 and generally have a tapering thickness toward their apex.

10 In the illustrated embodiment, the aforementioned flaps 4 are attached at their root to the two sides of the longitudinal member 3 and form a supplementary acute angle θ° with their own longitudinal axis 8 and with the longitudinal axis 9 of the longitudinal member, which opens away from the
15 foot pocket 2.

 Alternatively, the longitudinal axes 8 of the flaps 4 may also not be straight, with a different angle θ° being formed for each point of the longitudinal axis 8 between the tangent on the
20 curvilinear longitudinal axis 8 of the flap 4 and the straight longitudinal axis 9 of the longitudinal member 3.

 Once again, all the foci 7 on the chords of the foils 17 and 18 are situated at about 25% of the
25 chords 5 and 6 from the leading edge of these foils 17 and 18.

 The above listed parts, i.e. the foot pocket 2, the longitudinal member 3 and the flaps 4 generally form a one-piece unit manufactured by a single
30 molding step.

 In a variant of the fins 1 in which the assembly of the longitudinal member 3 and the flaps 4 are interchangeable, the fins 1 are composed of foot

pockets 2, which can receive therein, by means of suitable quick connectors 21, assemblies of the longitudinal member 3 and the flaps 4 having different hydrodynamic properties to best fit the needs of scuba diver.

A further embodiment of the fins 1 consists of a foot pocket 2, two longitudinal members 22 attached to each side of the foot pocket 2 and a series of flaps 23 which have a peculiar arrow shape, whose distal ends of their branches are elastically joined to the inner walls of the two longitudinal members 22. Here, the branches of the flaps 23 will bend about axes perpendicular to the axis of symmetry 10 of the foot pocket 2 under moments MP equal to the summation of their lifts dP times their respective distances l, i.e.: $P \times l \times \cos (1/2 \text{ interior angle of the arrow})$, with l being equal to the distance between the dPs and the tip of the arrow level 25 with the common focus 7 of the two branches.

In a further embodiment, the flaps may be also designed to be independent of the longitudinal member/s and connected thereto by means of elastic articulations, characterized by having one or more degrees of freedom.

Hydrodynamic bending and torsional moments on the structure of the fins 1 to optimize the angle of attack α°

The present invention is not only based on the fact that each fin 1 is equipped with a hydrodynamic assembly consisting of a single straight and elastic longitudinal member 3 with sheet-like flaps 4 attached at its sides and free at their ends, whose sections are airfoils 17 orthogonal to the

longitudinal axis 8 or efficient airfoils 18 having the same axis 8, which forms a supplementary acute angle θ° with the longitudinal axis 9 of the longitudinal member 3, but also on the synergistic hydrodynamic behavior of the longitudinal member 3 and the flaps 4 attached thereto.

During the kicking strokes, an air flow impacts and bends the flaps 4, which in turn drag along and bend the longitudinal member 3.

This flow may be essentially deemed to consist of two flows:

the flow that is generally caused by the moving fins 1 and

the flow induced by the speed of water movement relative to the diver or swimmer.

The flow generated by the fins 1 may be in turn divided, to simplify calculations, into two components: a horizontal component and a vertical component which reverses its direction at each half kicking cycle. The resultant of these components of the three flows deforms by reaction the flaps 4 and hence the longitudinal member 3 such that the flow thereby generated may impact the flaps 4 with the best possible angle of attack α° .

In short, the simultaneous deformations of the longitudinal member 3 and the flaps 4 caused by the kicking strokes are those that correspond to the deformation of the programmed synergistic hydrodynamic attitude of the longitudinal member 3 providing the best possible angle of attack α° of all the flaps 4. Such optimization is only limited by the areas close to the embedment of the flaps 4 in the longitudinal member 3, where deformations are

necessarily limited and there is an excessive angle of attack α° .

A further important feature is the provision of a supplementary acute angle θ° between the longitudinal axis 8 of the flaps 4 and the longitudinal axis 9 of the longitudinal member 3.

Under hydrodynamic loads the flap 4 bends perpendicularly along the vertical plane containing the longitudinal axis 8, which is perpendicular to the chords 5 of the sections of the airfoils 17, which oppose minimum resistance to bending, to obtain a deformed cylindrical surface 20 whose generatrices are by definition parallel.

For improved understanding of the following discussion, we will assume a diagram D for each flap 4, whose plane is coplanar with the plane of any flap 4, and whose y axis corresponds to the longitudinal axis 8, whereas the origin coincides with the incidence of such axis 8 with the embedment of the flap 4, and the x axis is perpendicular to the axis 8 at the embedment of the flap 4. We will draw on the diagram D the curve of the projection of the deformed surface 20 of the bent flap 4 and will indicate on such curve the distances as taken on the plane of the flap 4 from a line orthogonal to the axis 8 and passing through the origin, a perspective center H and a leading point h of any efficient airfoil 18 of the flap 4. We will soon note that the point H is on a higher x axis than the point h, on the curve of said diagram D.

Therefore, the chords 6 of the efficient airfoils 18 have a slope δ° of $\arcsin((1/2 \cdot \text{chord } 6 \cdot \cos \theta^\circ \cdot \text{tg } \delta^\circ) / \text{chord } 6)$, if the curve falling between

the point H and the point h has the same radius. This slope necessarily affects, i.e. reduces, the angle of attack α° .

Another important feature relates to the angle
5 of torsion τ° about the longitudinal axis 8 of the flap 4 embedded in the longitudinal member 3, with an angle θ° being significantly formed between the axis 8 and the axis 9, such angle providing a torsional moment component, orthogonal to the longitudinal axis
10 8, which progressively reflects, along the axis 8, into a decrease τ° of the angle of attack α° .

Furthermore, in order to obtain the best possible angle of attack α° , the moments of some of the airfoils 18 might be usefully used, due to their
15 coefficients C_m , whether different foils are used for the various flaps 4 or different values are taken relative to the angles of attack of the lift.

This will obviously imply the use of asymmetric foils, having a curved centerline. In general, the
20 moment coefficient C_m is negative and the effect on the foil 18 will be a pitching moment which will consequently decrease the angle of attack α° .

In this case, to improve the kicking efficiency, the foils 18 will advantageously have an orientation
25 that will allow proper utilization thereof during the downward kicking stroke. If the velocity vector of the flow is known, then the moment will be easily determined with the known relationship, and hence the corresponding angular deflection ε° which will cause
30 a torsion of τ° degrees according to the resistance opposed by the sections of the foils.

This will provide the local deflection angle ε° generated by the C_m and the torsion angle τ° along

the flap 4 and hence the local changes of the local angle of attack α° generated by ε° and τ° , with the local angle of the slope ξ° of the chords 6 of the efficient airfoils 18, as well as the angle of the local slope ϕ° of the deformed shape 20 of the longitudinal member 3.

Finally, with all the resultants of α° , i.e. the CLs (α°) of all the flaps 4, all the total instantaneous lifts P may be calculated, and hence the instantaneous thrust of the fin 1 may be thus determined.

With the above in mind, the most industrially interesting embodiment consists in a fin 1 having a foot pocket 1 with the root of a flexible longitudinal member 3 incorporated at its front, such member being able to bend up and down and having sheet-like flaps incorporated at its sides and shaped with airfoil sections 17, 18. These flaps 4 are only stably fixed by their roots on the two sides of the longitudinal member 3, whereas their longitudinal axis 8 forms a supplementary acute angle θ° with the longitudinal axis 9 of the longitudinal member 3.

Thus, they can freely bend up and down and twist about their longitudinal axis 8. All these parts, which form a single structure in this embodiment, are simultaneously cast from one material in a mold.

Key:

- 1) Fins
- 2) Foot pocket
- 5 3) Longitudinal member
- 4) Flap
- 5) Minimum orthogonal chord of the orthogonal foil 17
- 6) Chord of the efficient foil 18
- 7) Foci of the chords 5 and 6
- 10 8) Longitudinal axis of the flaps 4
- 9) Longitudinal axis of the longitudinal member 3
- 10) Median plane of the foot pocket 2 of the fin 1
- 11) Transverse axes orthogonal to the axes 8 and 9
- 12) Sole of the foot pocket 2
- 15 13) General airfoils
- 14) Components of the lift P
- 15) Perspective center H of the foil 13
- 16) Leading point h of the foil 13
- 17) Orthogonal foils
- 20 18) Efficient foils
- 19) Sections of the airfoils 14
- 20) Deformed line or surface
- 21) Quick connectors of the hydrodynamic assembly
- 22) Longitudinal members of the fin
- 25 23) Arrow-shaped flaps
- 24) Airfoils of the flaps 23
- 25) Part of the foil 23 that is not connected to the longitudinal members 22
- α°) Angle of attack
- 30 θ°) Arrow angle of the flap 4 between the axes 8 and 9
- γ°) Angle between the axis of the longitudinal member 9, and the plane of the sole of the foot pocket 21

- δ°) Angle between two tangents on the curve of the diagram D
- ϕ°) Angle between two tangents on the deformed shape of the axis 9 of the longitudinal member 3
- 5 ϵ°) Slope of the chord 6 of the foil 18
- τ°) Torsion angle of the flap 4
- ϵ°) Angle generated by the negative moment of the foil 18
- μ°) Complementary lift angle
- 10 D) Auxiliary angle of the deformed shape 20 of the flap 4
- L) Length of the longitudinal axis of the flap 8
- P) Lift
- MP) Lift moment

CLAIMS

1) Fins having each a one-piece longitudinal member, attached to the front of their foot pockets, with flaps being attached at its sides to project
5 outwards, and being free at their ends.

2) Fins (2) as claimed in claim 1, that can be worn to swim and are made of elastomers and/or plastomers or other equivalent materials, characterized in that they each consist of a foot
10 pocket (2), possibly open with a rear strap closure, with a single one-piece elastic longitudinal member (3), attached by its root at its front, said member being preferably straight and lying orthogonally in the vertical median plane (10) of said foot pocket
15 (2), said longitudinal member (3) being further adapted to deflect about its horizontal transverse axes (11), parallel to the plane of the sole (12) of the foot pocket (2) and perpendicular to said vertical median plane (10), whereas sheet-like flaps
20 (4) are stably attached by their roots at both its sides, horizontally project outwards and are totally free at their ends, whose longitudinal axes (8) form a supplementary outwardly opening rear acute angle θ° with the longitudinal axis (9) of the longitudinal
25 member (3), said flaps (4) having sections with airfoils (17) whose minimum chords (5), preferably parallel to one another, are orthogonal to the longitudinal axis (8) of the flaps (4), whereas the chords (6) of the efficient airfoils (18) form an
30 angle θ° with the longitudinal axis (8) of the flaps (4) when all the chords (5) and (6) lie on one plane containing the longitudinal axis (9) of the longitudinal member (3), said one axis forming a

downward acute angle γ° with the plane of the sole (12) of the foot pocket (2) when said foils (4) and longitudinal member (3) are at rest, i.e. are not subjected to bending or torsional stresses.

5 3) Fins (1) as claimed in claim 1 or 2, characterized in that the longitudinal member (3) and the flaps (4) are simultaneously cast and incorporated in the foot pocket (2) within the mold of the entire fin (1) and for an integral part
10 thereof.

 4) Fins as claimed in one or more of the preceding claims, characterized in that the free ends of the flaps (4) may be also bent upwards, i.e. away from the sole (21) of the foot pocket (2) to improve
15 the downward kicking efficiency of the kicking strokes.

 5) Fins as claimed in one or more of the preceding claims, characterized in that the assembly of the one-piece longitudinal member and its flaps
20 (4) may not be permanently attached to the foot pocket (2), and may be removable by the provision of a quick-connection fastener (21), for replacement with another assembly having a different size and/or different airfoils (6) of the flaps (4) to better fit
25 the power and mission of the diver.

 6) Fins as claimed in one or more of the preceding claims, characterized in that the alignment of the foci (7) of the orthogonal airfoils (17) of the flaps (4), i.e. their longitudinal axes (8),
30 coinciding with those of the efficient airfoils (18) of the same flaps (4), may also lie along the curved lines.

 7) Fins (1) as claimed in one or more of the

preceding claims, characterized in that the lines tangent to the curved alignment of the foci (7) of the airfoils (17) or (18), i.e. the longitudinal axes (8) of the flaps (4), which are preferably but not
5 necessarily straight, may form different supplementary acute angles θ° with the longitudinal axis (9) of the longitudinal member, opening toward the tip of the fin (1).

8) Fins (1) as claimed in claim 7, characterized
10 in that the angles θ° between the lines tangent to the curved alignment of the foci (7) of the airfoils (17) or (18) of the flaps (4), and the longitudinal axis (9) of the longitudinal member may be different for each flap (4).

15 9) Fins as claimed in one or more of the preceding claims, characterized in that, with flaps having orthogonal chords (5) of constant length, the chords (6) of the flaps (4) of the functional, i.e. efficient foils (18), have the same length as the
20 chords (5) of the foils (17) orthogonal to the longitudinal axes (8) of the flaps (4) divided by the sines of the angles θ° .

10) Fins as claimed in one or more of the preceding claims, characterized in that the
25 longitudinal members (3) bend with their axes (9) in the vertical median plane (10) of the fin (1) and about axes (11) perpendicular to their longitudinal axes (9) and are pushed by the flaps (4) which in turn bend due to the moments (MP) of the lifts (P)
30 about other axes (11) parallel to the chords (5) of the foils (17) and perpendicular to their longitudinal axes (8), when they are impacted by the oriented water flow during the kicking strokes.

11) Fins as claimed in claim 10, characterized in that the bending movements of their longitudinal members (3), as well as the bending and torsional movement of their flaps (4), i.e. all of their
5 deformations, coincide with the deformations required to obtain the best possible angles of attack α° of the oriented water flow relative to the chords (6) of the efficient foils (18) of the flaps (4), during the kicking strokes.

10 12) Fins (1) as claimed in claim 11, characterized in that the chords (6) of the efficient foils (8) in the flaps (4), level with their foci (7) at the embedment, are always tangent to the deformed shape (20) of the axis (9) of the longitudinal
15 members (3), with a polar orientation angle (ϕ°) that varies relative to the unbent, i.e. undeformed axis (9), said angle ϕ° corresponding to the prevailing part of the angle of attack α° during the variable action of the hydrodynamic forces of the oriented
20 water flow during the kicking strokes.

13) Fins as claimed in one or more of the preceding claims, characterized in that, considering that asymmetric foils have the property of having a negative and pitching torsion coefficient C_m , they
25 can be used to optimize the angle of attack α° .

14) Fins as claimed in one or more of the preceding claims, characterized in that, when indicating the distances of the points H and h, corresponding to the perspective edge and to the
30 leading edge of any efficient foil (18) of a flap (4), from a line coplanar to the plane of said flap (4), perpendicular to its axis (8) and passing through its focus (7) at the embedment of the same

flap (4) in the longitudinal member (3), over a constant-radius curve of the orthogonal projection of the deformed shape (20) of the plane of said bent flap (4) of a diagram (D) whose y axis is the axis (8), and whose origin is its focus (7) at the embedment, the point H is found to be on a higher x axis of said curve than the point h: then the chords (6) of the efficient foils (18), whose planes are locally perpendicular to the surface of the deformed shape of the plane of the bend flap (4), will have a slope angle ϵ° of $\arcsin(\frac{1}{2} \cdot \text{chord6} \cdot \cos \theta^\circ \cdot \text{tg} \delta^\circ) / \text{chord6}$, where δ° is the angle between the tangent lines at the points h and H on the curve of the diagram D, which will reduce the value of the angle of attack α° .

15) Fins as claimed in one or more of the preceding claims, characterized in that the airfoils (17) and (18) of the flaps (4) may not be symmetric with respect to their chords (5) and (6), and may be thus asymmetric, i.e. with the upper surface line different from and longer than the lower surface line, i.e. with a curved centerline.

16) Fins as claimed in claim 15, characterized in that the flaps (4) may be made from a material whose mechanical characteristics differ from those of the rest of the fins.

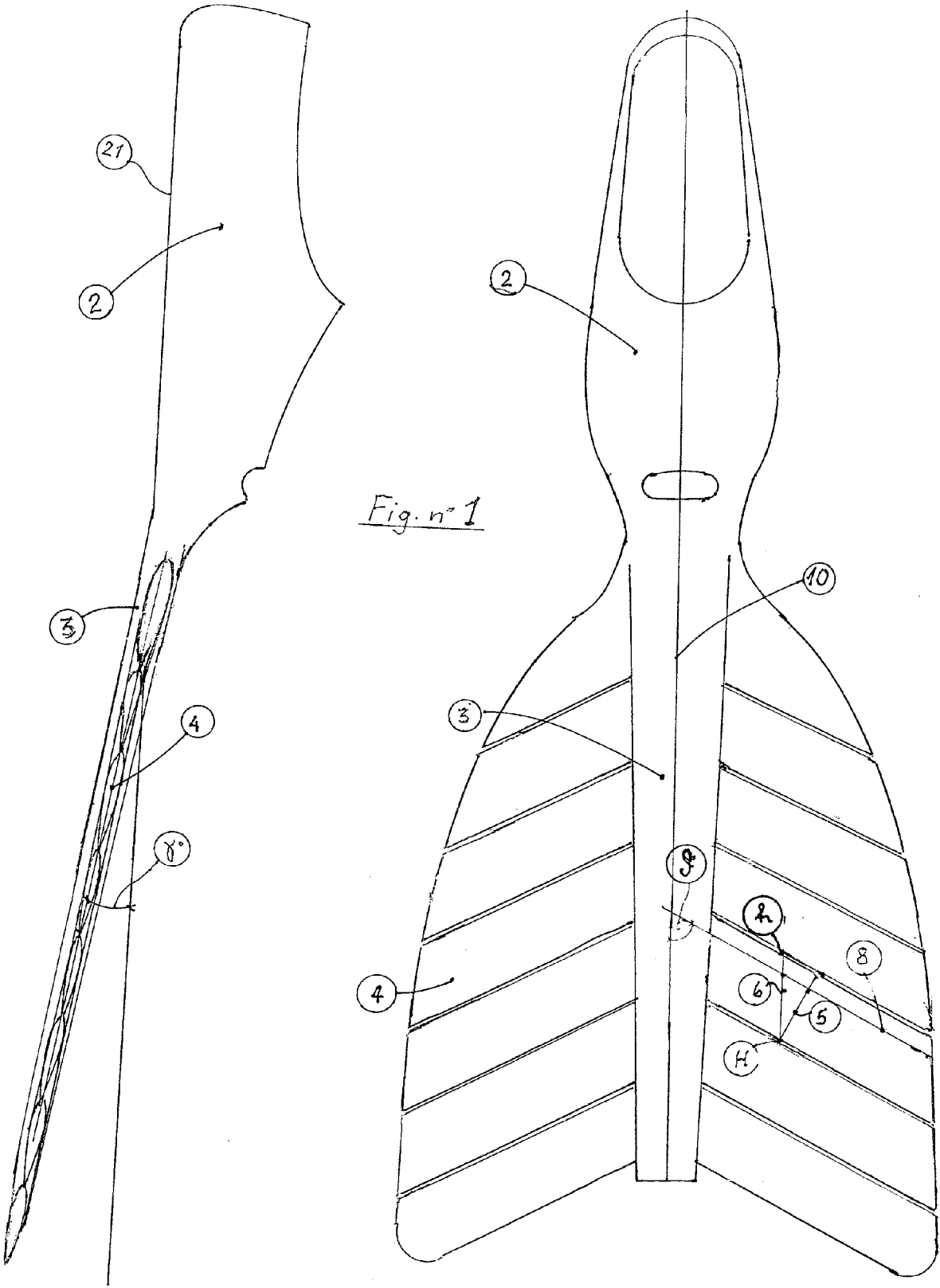
17) Fins (1) consisting of a foot pocket (2) with two divergent elastic longitudinal members (22) attached at its front and lateral sides, and with a series of adjacent flaps (23), which are also elastic, incorporated on each side therebetween, and having an arrow shape with the tip facing the rear outer side of the fin (1), and controllably movable

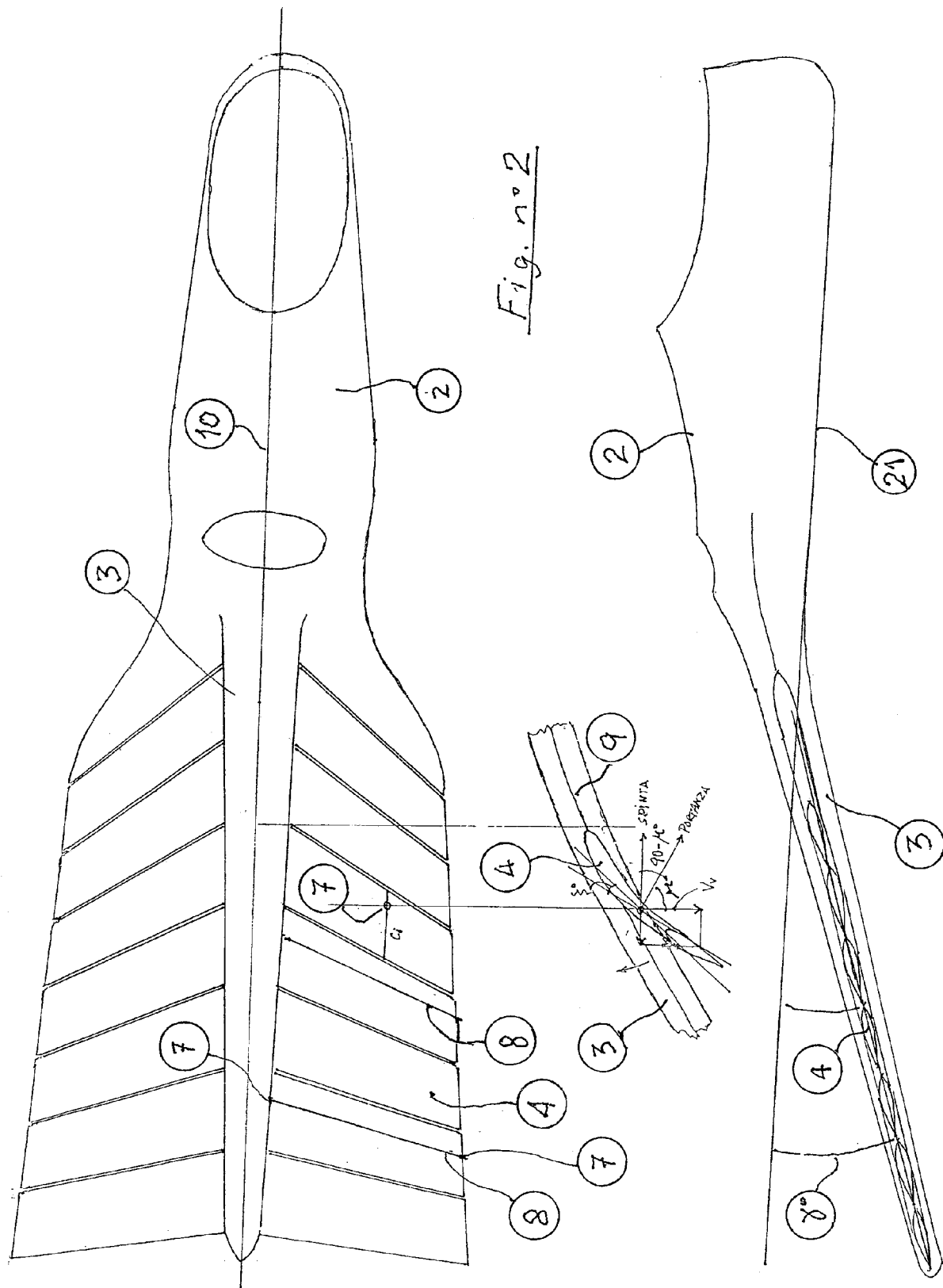
up and down whereas the sections (19) of their airfoils (24), due to their elastic mobility, change their angle of attack α° relative to the water flow, under the hydrodynamic stresses generated by the
5 kicking strokes.

18) Fins as claimed in claim 17, characterized in that the connection of the arrow-shaped flaps (23) to the two longitudinal members (22) is limited to about 3/5 of the length of the foil from the leading
10 point (h), whereas the unconnected part 25 is free to float during the kicking strokes.

19) Fins as claimed in one or more of the preceding claims, characterized in that all or some of the flaps do not have an airfoil profile.

15 20) Fins as claimed in one or more of the preceding claims, characterized in that the flaps are designed to be independent of the longitudinal member/s and connected thereto by means of elastic articulations, characterized by having one or more
20 degrees of freedom.





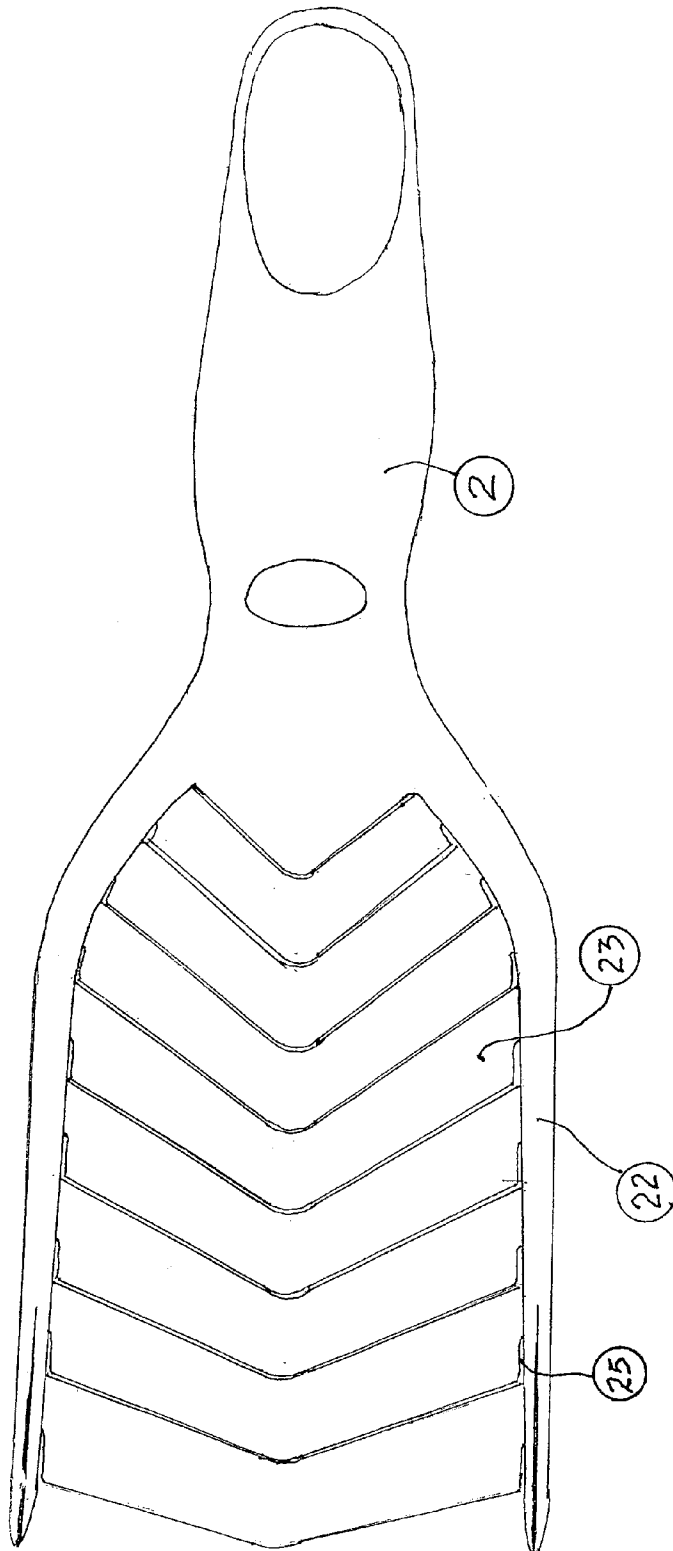
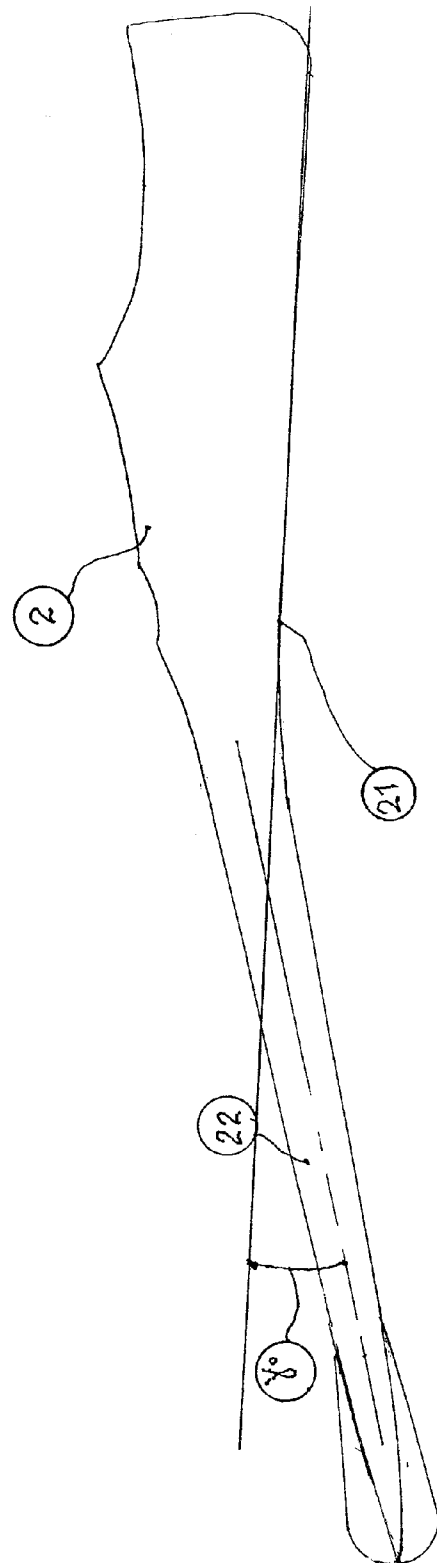


Fig. n-3



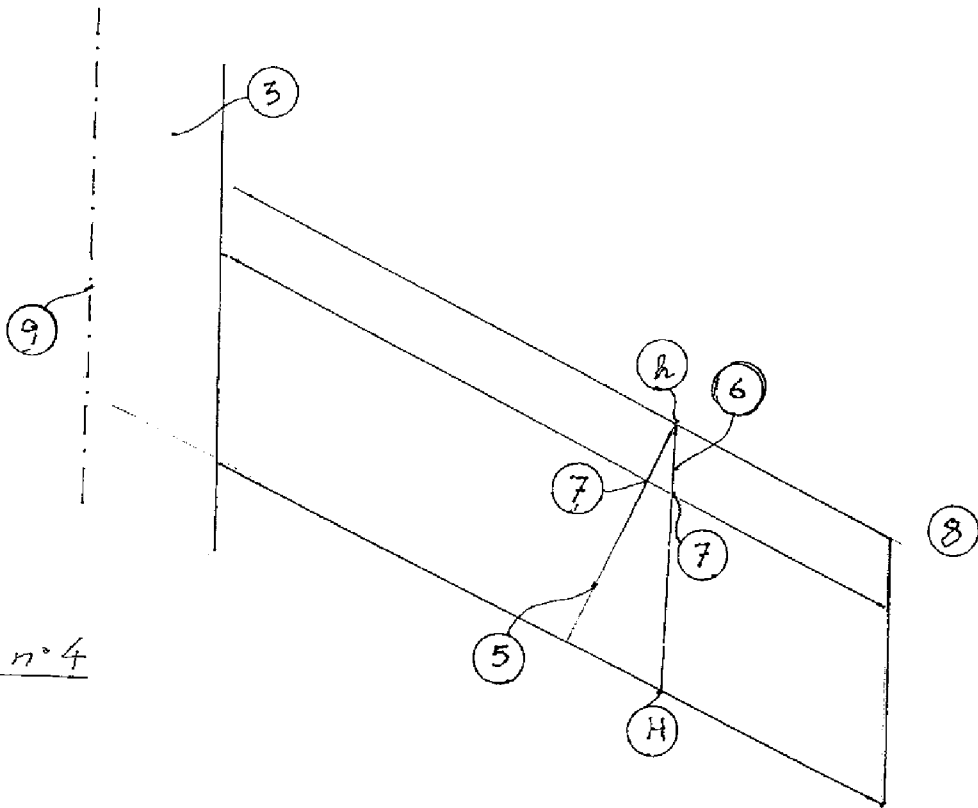


Fig n° 4

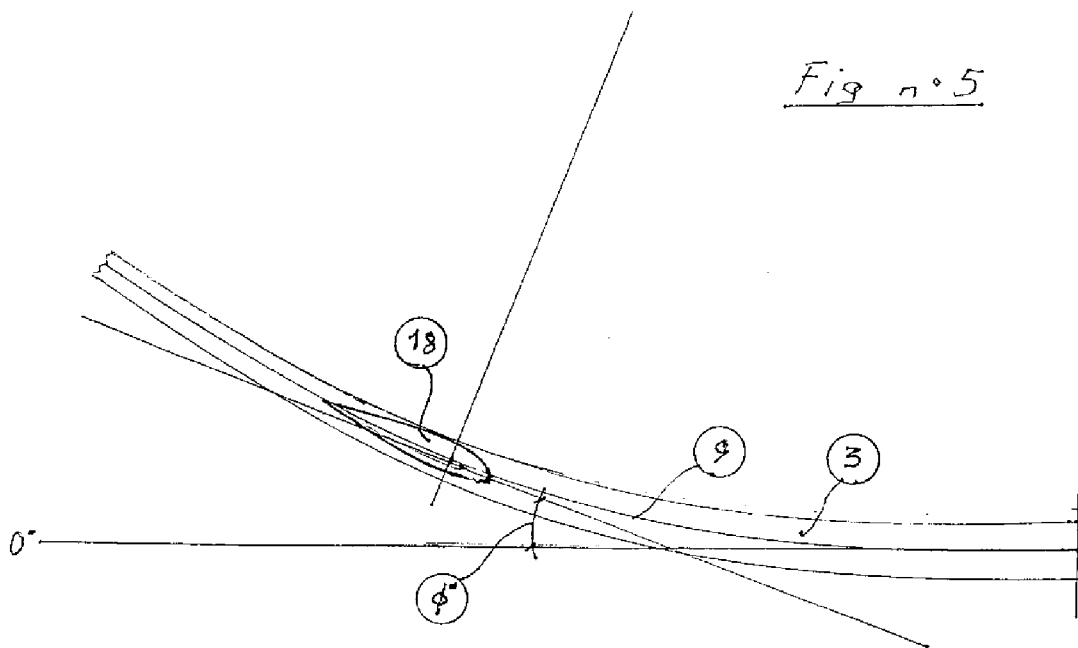


Fig n° 5

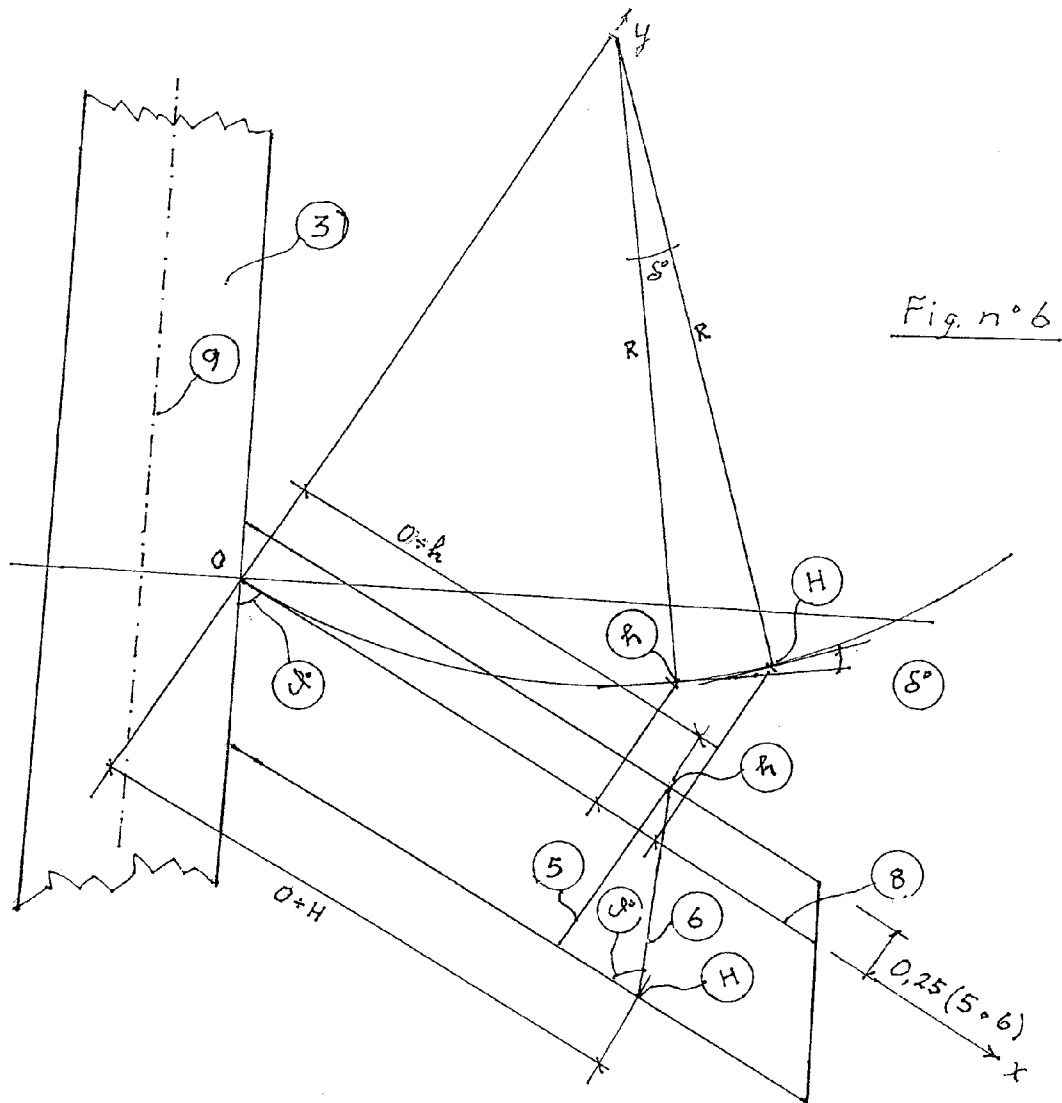
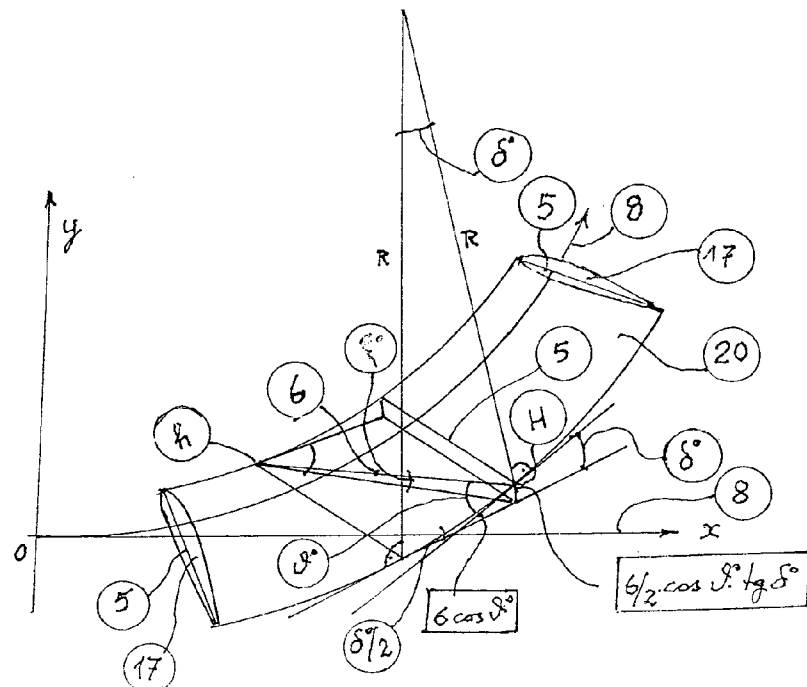


Fig. n° 7



INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/051954

A. CLASSIFICATION OF SUBJECT MATTER
INV. A63B31/11 A63B31/14
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010/140965 A1 (WALLMARK ANDREAS [SE]) 9 December 2010 (2010-12-09)	1,4,5
Y	figures 8a, 8b -----	2,3,6-16
Y	EP 1 257 329 A1 (SALVAS SUB SPA [IT]) 20 November 2002 (2002-11-20) paragraph [0044] - paragraph [0051] -----	2,3,6-16



Further documents are listed in the continuation of Box C.



See patent family annex.

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European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Tejada Biarge, Diego

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2017/051954

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2017/051954

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-16

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-16

Fins having each a one-piece longitudinal member attached to the front of their foot pockets, with flaps having sections with airfoils and being attached at its sides to project outwards and being free at their ends, whereby the longitudinal axes of the flaps form an outwardly opening rear acute angle with the longitudinal axis of the longitudinal member.

2. claims: 17, 18

Fins consisting of a foot pocket with two divergent elastic longitudinal members attached at its front and lateral sides.

3. claim: 19

Fins with flaps which do not have an airfoil profile.

4. claim: 20

Fins with flaps which are designed to be independent of a longitudinal member and connected thereto by means of elastic articulations so that they have one or more degrees of freedom.
