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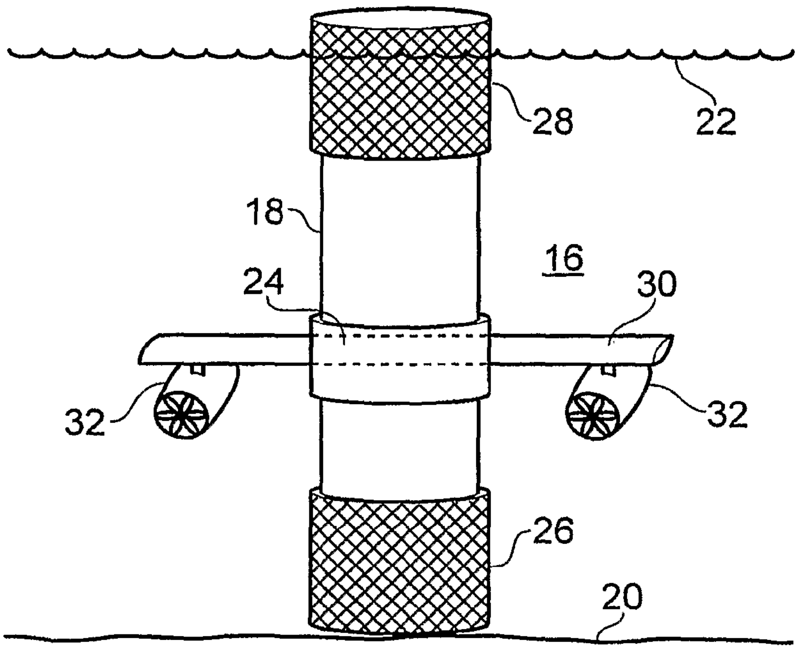
FIG. 3



(57) Abstract: A turbine (2) having a cowling (6) and a rotor (4) mounted within the cowling (6), for rotation about a central axis X-X of the cowling (6) which axis extends in an axial direction of the cowling, the cowling (6) having a radially outer surface (12) and a radially inner surface (10), the length of the inner surface (10) when measured in the said axial direction of the turbine (2) being greater than the length of the outer surface (12).

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A TURBINE HAVING A MODIFIED COWLING

Introduction

This invention relates to fluid turbines and particularly but not exclusively relates to a water turbine with a specially shaped cowling which increases the flow of water through the turbine.

Background

Energy can be generated from water by harnessing its natural movements, such as in waves, tides and river flow. One way of harnessing this energy is through the use of a turbine. A turbine converts the linear motion of water through the turbine to rotational motion which can be used to generate electricity. Because water is about 800 times denser than air, water turbines can produce much more energy than a wind turbine, for a given flow rate of fluid entering the turbine.

Tidal turbines generally utilise tidal currents that are moving with velocities of between 2 and 3 m/s. A current with a lower velocity than this is generally regarded to provide insufficient power to be economically viable.

The current velocity varies greatly with depth from the surface of the water. Close to the seabed frictional effects reduce the velocity of the current. Existing turbines are placed at a suitable depth where maximum velocity is predicted. The maximum velocity is not at a constant depth and therefore turbines are positioned away from the maximum velocity most of the time. Also turbines are restricted from being placed too close to the surface due to tidal ranges, wave action and the risk of being struck by a vessel.

Accordingly the present invention seeks to address the problems mentioned above by providing a turbine which is economically viable when operated in slower currents and/or which can be varied in depth to achieve maximum current flow at all times.

Statement of the Invention

According to the present invention, there is provided a turbine having a cowling and a rotor mounted within the cowling, for rotation about a central axis of the cowling which axis extends in an axial direction of the cowling, the cowling having a radially outer surface and a radially inner surface, the length of the inner surface when measured in the said axial direction of the turbine being greater than the length of the outer surface.

In use, the outer surface and inner surface define respective flow paths over and within the cowling, the flow path adjacent the inner surface being longer than the flow path adjacent the outer surface.

The inner and/or the outer surface of the cowling may be convex, when viewed in a plane passing through the central axis of the turbine.

Only a portion of the inner surface of the cowling may be convex and another portion may be concave, the convex portion and the concave portion meeting at a line of inflection.

The inner surface and/or outer surface may be provided with spiral grooves.

The outer surface, when viewed in a plane passing through the central axis of the turbine, defines a line which may have a stationary point.

The inner surface, when viewed in a plane passing through the central axis of the turbine, defines a line which may have a stationary point and a point of inflexion. This line may further comprise a second stationary point.

The portion of the inner surface between the first and second stationary points may define a throat, with the portion of the inner surface upstream of the throat defining an inlet and the portion of the inner surface downstream of the throat defining an outlet.

A central portion of the inner surface may define a throat, with the portion of the inner surface upstream of the throat defining an inlet and the portion of the inner surface downstream of the throat defining an outlet.

The cross sectional area of the outlet may be greater than the cross sectional area of the inlet.

The ratio of the cross sectional area of the throat to the cross sectional area of the inlet may be between 1:1.1 and 1:3.55.

The ratio of the cross sectional area of the inlet to the cross sectional area of the outlet may be between 1:1.1 and 1:2.2.

The angle subtended by the inlet and/or outlet to the throat may be between 20° and 40°.

A portion of the cowling adjacent a leading and/or trailing edge of the cowling may be substantially cylindrical. A length of parallel tubing may be fixedly attached to the front and/or back of the turbine where the inner and outer surfaces converge to form the substantially cylindrical portion.

The outer surface may comprise one or more fins extending from the outer surface in a radial direction. In use, the one or more fins may extend in a substantially vertical plane.

According to another aspect of the present invention there is provided a turbine supporting structure comprising a turbine supporting member which is connected to at least one turbine, said turbine supporting member being substantially hydrofoil shaped in cross section and, in use, extending from the turbine in a substantially horizontal plane.

The turbine supporting member may be slideably mounted to a column. The turbine supporting member may be rotatable about the column.

At least one turbine may be mounted at each end of the turbine supporting member.

In use, the at least one turbine may be connected to the turbine supporting member at a position which is downstream from where the turbine supporting member is mounted to the column.

In use, the turbine supporting member is mounted near one end of a substantially horizontally extending shaft which is mounted to the column near its other end.

The turbine supporting member may be swept back in the direction of flow.

The turbine supporting member may be delta-wing shaped.

The turbine supporting member may be mounted to the column near one of its corners and at least one turbine may be connected to a position near each of the other two corners.

The at least one turbine and/or turbine supporting member may comprise one or more fins which extend substantially vertically in an upward and/or downward direction.

Brief Description of the Drawings

For a better understanding of the present invention, and to show more clearly how it may be carried into effect, reference will now be made by way of example, to the following drawings, in which:

Figure 1 is a perspective view of a turbine in accordance with the present invention.

Figure 2 is a horizontal sectional view through plane A-A shown in Fig. 1.

Figure 3 is a perspective view of a turbine mounting apparatus.

Figure 4 is a vertical cross section through plane B-B shown in Fig. 3.

Figure 5 is a plan view of a another embodiment of a turbine mounting apparatus.

Detailed Description of Preferred Embodiments

Referring to Figure 1, a turbine is indicated generally at 2. The turbine 2 comprises a rotor 4 axially mounted within a cowling 6. The cowling 6 is open at both ends defining an entry aperture 8 and an exit aperture 7.

Figure 2 shows a cross-section of the cowling 6 through plane A-A of Figure 1. The cowling 6 has an inner surface 10 and an outer surface 12. The outer surface 12 and inner surface 10 define respective flow paths over and within the cowling, the flow path adjacent the inner surface 10 being longer than the flow path adjacent the outer surface 12.

At the entry aperture 8 the inner surface 10 and outer surface 12 meet to form a rounded leading edge 9. The inner surface 10 diverges away from the outer surface 12 and converges towards the rotational axis X–X of the turbine 2, with the rate of change of curvature decreasing to zero (a stationary point) at a mid-point between the entry aperture 8 and the exit aperture 7. After this mid-point, the inner surface 10 diverges away from the rotational axis X–X with the rate of change of curvature increasing initially and then reducing at a point of inflexion as the inner and outer surfaces 10, 12 converge to form an acute angle at a trailing edge 13 of the cowling 6. The rate of change of curvature of the inner surface 10 may be zero when the inner and outer surfaces 10, 12 meet at the exit aperture 7. The outer surface 12 may be convex, curving away from the rotational axis X–X and then back towards the rotational axis X–X as it extends from the entry aperture 8 to the exit aperture 7.

Both the leading and trailing ends 14, 15 of the cowling 6 may be cylindrical, and may, for example each be formed using a length of thin walled parallel tubing. This enhances porting into and out of the cowling 6.

The inner surface 10 and/or outer surface 12 of the cowling may be rifled. For example, helical tracks or grooves (not shown) may be formed in the inner surface 10 and/or outer surface 12. Furthermore the outer surface 12 may comprise one or more fins which project in a radial direction which is substantially perpendicular to the tangent of the outer surface 12 and which are aligned parallel to the length of the turbine. Preferably a fin is provided which extends vertically upwards towards the surface and/or vertically downwards towards the sea or river bed. The one or more fins may be streamlined.

The rotor 4 is axially mounted at substantially the smallest diameter part of the inner surface 10 of the cowling 6. However, it is to be understood that the rotor 4 could be mounted at any position within the cowling 6 to produce a turbine with the desired characteristics.

In operation, fluid flow into the entry aperture 8 drives the rotor 4 to rotate. This rotation can be converted into another form of energy, i.e. electrical energy, by means known in the art. For example, the rotor 4 may be coupled mechanically to an electrical generator (not shown).

The difference in the relative length of the inner and outer surfaces 10, 12 causes water flowing over the cowling 6 to travel a shorter distance than water driving the turbine 2. This creates a pressure difference outside the cowling 6 relative to the interior of the cowling 6 and creates a reaction force having a component towards the central, rotational axis X-X of the turbine 2. Another component of this force acts in the direction of fluid flow, increasing the speed of the fluid through the turbine 2.

The acute trailing edge 13 enhances the acceleration of the split flow rejoining the main stream created when the flow driving the turbine 2 (the inner flow) recombines with the flow over the cowling 6 (the outer flow), and thus increases the speed of the flow driving the turbine 2. By including this cylindrical portion the flow within the turbine is separated from flow around the turbine with minimal disruption and pressure change which reduces turbulence and therefore cavitation.

The flow which has been split away from the main current and passes through the turbine 2 adjacent the inner surface 10 of the cowling 6 takes a longer but smooth path, thereby causing an acceleration at the boundary of the inner flow where it joins the outer flow. This effect causes the inner flow to be pulled through the turbine 2 at an increased flow rate.

Helical tracks or grooves (not shown) along the inner surface of the cowling 6, which may take the form of rifling, cause the flow adjacent the inner surface 10 to spin. This increases efficiency and reduces the probability of cavitation occurring. The outer surface may also be provided with spiral grooves or fins (not shown). Helical fins over the outer surface of the cowling 6 cause the flow over the cowling to spin and help to speed up the rejoining flow from the turbine 2. Furthermore the one or more fins extending vertically upwards towards the surface and/or vertically downwards towards the sea or river bed which may be provided on the outer surface 12, are operable to steer the turbine so as to align it with the direction of flow. A configuration for enabling the turbine to be rotatable is described in detail below.

The inner surface 10 of the cowling 6 defines three distinct sections of the turbine 2, namely: the inlet (the entry aperture 8), throat (the smallest internal diameter portion of the turbine) and outlet (the exit aperture 7). Experimental trials have shown favourable results when the cross sectional area of the outlet is larger than that of the inlet and particularly when the ratio of the cross sectional area of the outlet to the cross sectional area of the inlet is between 1.1 and 3.5. Also by utilising an inlet and/or outlet which subtends at an angle of between 20° and 40° it is possible to reduce eddies and maintain the velocity of flow at the outlet.

Referring now to Figure 3, a turbine supporting structure 16 comprises a substantially vertical supporting structure 18. The supporting structure 18 extends from the sea or river bed 20 towards the surface of the water 22. It is to be understood that the supporting structure 18 could be a piled structure, a floating structure or any other type of structure which may be new or may be known in the art.

The supporting structure 18 comprises a movable collar 24 which at least partially encloses a section of the supporting structure 18 and is free to rotate around the supporting structure 18. The movable collar 24 is slidably mounted on the supporting structure 18 and can move along the longitudinal axis of the supporting structure 18 from a lower depth limit to an upper depth limit. The lower and upper depth limits are defined by buffer collars 26 and 28, which are fixed at specified depths. The depths of the buffer collars are adjusted to achieve the desired range over which the movable collar 24 can slide. This range may be chosen dependent on factors such as sea/river bed characteristics, tidal ranges, vessel safety zones, etc.

A turbine support member 30 is fixed to the movable collar 24 and extends in a substantially horizontal plane. At least one turbine 32 is fixed to the turbine support member 30. The turbine 32 may be fixed to the turbine support member 30 by any means known in the art and could be at a different depth from the movable collar 24. The turbine 32 may be fixed either above or below the turbine support member 30.

The turbine 32 may be rotatably connected to the turbine support member 30. The turbine 32 may then rotate to align with the direction of flow. A fin may be provided which extends vertically upwards towards the surface and/or vertically downwards towards the sea or river bed which is operable to align the turbine with the direction of flow.

In another embodiment, two turbines are fixed at opposite ends of the turbine support member 30. This configuration allows the turbines to align with the direction of flow. If the turbines are not aligned with the direction of flow there will be an imbalance of force on the turbines causing the movable collar 24 to rotate about the vertical support structure 18 until the turbine support member 30 is perpendicular to the direction of flow and the turbines are aligned with the direction of flow.

Referring now to Figure 4, the turbine support member 30 is substantially wing or hydrofoil shaped, and has a curved upper surface 34 and a less curved lower surface 36. The upper surface 34 and lower surface 36 define respective flow paths over and under the turbine support 30. The flow path adjacent the lower surface 36 is shorter than the flow path adjacent the upper surface 34.

In accordance with another embodiment, the turbine support member 30 may utilise a triangular configuration, as shown in Figure 5, in which the turbine support member 30 pivots about the vertical support structure 18 at a location in front of the turbines in the direction of flow. The turbine support member 30 is offset from the vertical support structure 18 by a shaft 40 extending from the movable collar 24 and connected to the turbine support member 30. The shaft 40 may be connected substantially in the centre of the turbine support member 30. The turbine support member 30 may be offset from the pivot by other means. For example the turbine support member 30 may be swept back or otherwise arranged so that the turbines are located at a position behind the pivot of the turbine support member 30 in the direction of flow. Alternatively a solid triangular turbine support member may be used as denoted by the dashed lines in figure 5. This forms a "delta-wing" shaped structure which provides lift for the turbine support member as is described in more detail below. Preferably the pivot is toward one corner of the "delta-wing" shaped turbine support member 30 and turbines are mounted at the other two corners of the "delta-wing" shaped turbine support member 30. By positioning the turbines behind the pivot in the direction of the flow the turbine support member exhibits a caster action so that the turbines more easily align with the direction of flow. This may be enhanced by providing the turbines and/or the turbine support member 30 with vertically extending fins, as previously described, to aid the alignment of the turbines with the direction of flow.

The weight of the water displaced by the turbine support member 30, movable collar 24 and turbine(s) 2 is approximately equal to the weight of these components at a specific depth. Therefore, there is a buoyancy force acting on the turbine support member 30 which is equal to its weight, i.e. neutral buoyancy, and thus in a non-flowing body of water, the turbine support member 30 will stay at a constant depth. This neutral buoyancy may be achieved using additional floatation aids which may be adjusted to keep the turbine 2 at a predetermined depth.

When there is water flowing past the turbine support member 30, the difference in path length creates a larger force against the fluid flowing over the turbine support member 30 than the fluid flowing below the turbine support member 30, resulting in an upward lift force 38. This upward force 38 will cause the turbine support member 30 and turbine 2 to move upwardly. At this shallower depth the turbine support member 30 is no longer neutrally buoyant and will return to the predetermined depth unless sufficient flow is maintained. The turbine support member will reside at a depth where the flow is larger below the turbine support member than above. Appropriate adjustment of the position of the turbine support member above the turbine ensures that the turbine is maintained at or very close to the depth of maximum flow.

To avoid unnecessary duplication of effort and repetition of text in the specification, certain features are described in relation to only one or several aspects or embodiments of the invention. However, it is to be understood that, where it is technically possible, features described in relation to any aspect or embodiment of the invention may also be used with any other aspect or embodiment of the invention.

CLAIMS:

1. A turbine having a cowling and a rotor mounted within the cowling, for rotation about a central axis of the cowling which axis extends in an axial direction of the cowling, the cowling having a radially outer surface and a radially inner surface, the length of the inner surface when measured in the said axial direction of the turbine being greater than the length of the outer surface.

2. The turbine of claim 1, wherein the inner surface of the cowling is convex, when viewed in a plane passing through the central axis of the turbine.

3. The turbine of claim 1 or 2, wherein the outer surface of the cowling is convex, when viewed in a plane passing through the central axis of the turbine.

4. The turbine of claim 2 or 3, wherein a portion of the inner surface of the cowling is convex and another portion is concave, the convex portion and the concave portion meeting at a line of inflexion.

5. The turbine of any preceding claim, wherein the inner surface is provided with spiral grooves.

6. The turbine of any preceding claim, wherein the outer surface is provided with spiral grooves or fins.

7. The turbine of any preceding claim, wherein the outer surface, when viewed in a plane passing through the central axis of the turbine, defines a line having a stationary point.

8. The turbine of any preceding claim, wherein the inner surface, when viewed in a plane passing through the central axis of the turbine, defines a line having a stationary point and a point of inflexion.

9. The turbine of claim 7 or 8, wherein the line further comprises a second stationary point.

10. The turbine of claim 9, wherein the portion of the inner surface between the first and second stationary points defines a throat, and wherein the portion of the inner surface upstream of the throat defines an inlet and the portion of the inner surface downstream of the throat defines an outlet.

11. The turbine of any one of claims 1 to 9, wherein a central portion of the inner surface defines a throat, and wherein the portion of the inner surface upstream of the throat defines an inlet and the portion of the inner surface downstream of the throat defines an outlet.

12. The turbine of claim 10 or 11, wherein the cross sectional area of the outlet is greater than the cross sectional area of the inlet.

13. The turbine of any one of claims 10 to 12, wherein the ratio of the cross sectional area of the throat to the cross sectional area of the inlet is between 1:1.1 and 1:3.55.

14. The turbine of any one of claims 10 to 13, wherein the ratio of the cross sectional area of the inlet to the cross sectional area of the outlet is between 1:1.1 and 1:2.2.

15. The turbine of any of claims 11 to 14, wherein the angle subtended by the inlet to the throat is between 20° and 40°.

16. The turbine of any of claims 11 to 15, wherein the angle subtended by the outlet to the throat is between 20° and 40°.

17. The turbine of any proceeding claim, wherein a portion of the cowling adjacent a leading and/or trailing edge of the cowling is substantially cylindrical.

18. The turbine of claim 17, wherein the substantially cylindrical portion is formed from a length of parallel tubing.

19. The turbine of any preceding claim, wherein the outer surface comprises one or more fins extending from the outer surface in a radial direction.

20. The turbine of claim 19, wherein, in use, the one or more fins extend in a substantially vertical plane.

21. A turbine supporting structure comprising a turbine supporting member which is connected to at least one turbine, said turbine supporting member being substantially hydrofoil shaped in cross section and, in use, extending from the turbine in a substantially horizontal plane.

22. The apparatus of claim 21, wherein said turbine supporting member is slideably mounted to a column.

23. The apparatus of claim 22, wherein said turbine supporting member is also rotatable about the column.

24. The apparatus of any of claims 21 to 23, wherein at least one turbine is mounted at each end of the turbine supporting member.

25. The apparatus of any of claims 22 to 24, wherein, in use, the at least one turbine is connected to the turbine supporting member at a position which is downstream from where the turbine supporting member is mounted to the column.

26. The apparatus of any of claims 22 to 25, wherein, in use, the turbine supporting member is mounted near one end of a substantially horizontally extending shaft which is mounted to the column near its other end.

27. The apparatus of any of claims 21 to 26, wherein the turbine supporting member is swept back in the direction of flow.

28. The apparatus of any of claims 21 to 26, wherein the turbine supporting member is delta-wing shaped.

29. The apparatus of claim 28, wherein the turbine supporting member is mounted to the column near one of its corners and at least one turbine is connected to a position near each of the other two corners.

30. The apparatus of any of claims 21 to 29, wherein said at least one turbine and/or turbine supporting member comprises one or more fins which extend substantially vertically in an upward and/or downward direction.

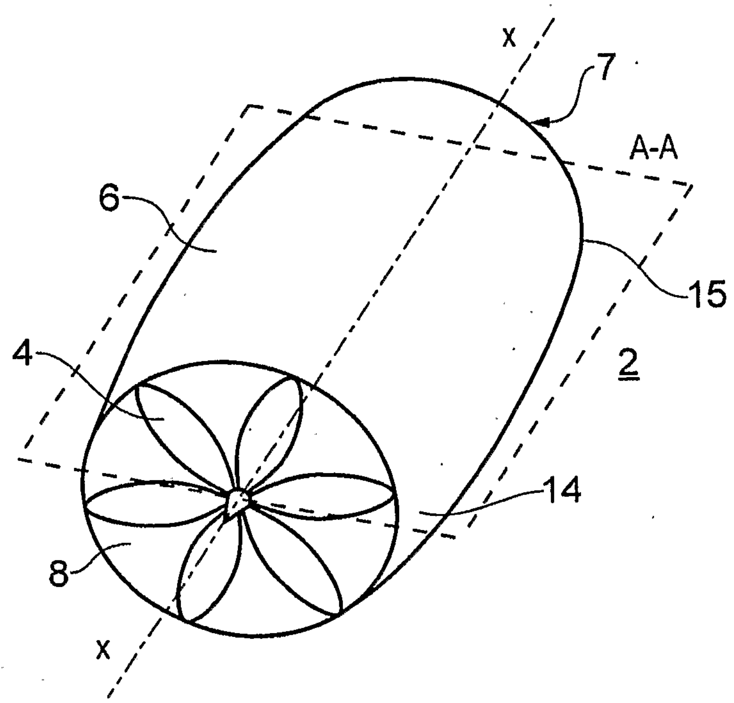

FIG. 1

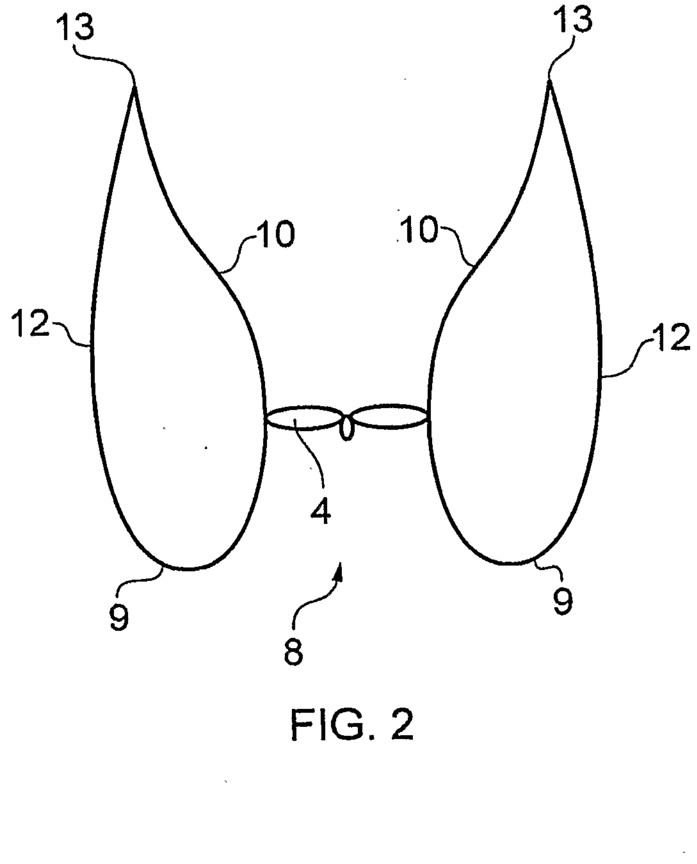

FIG. 2

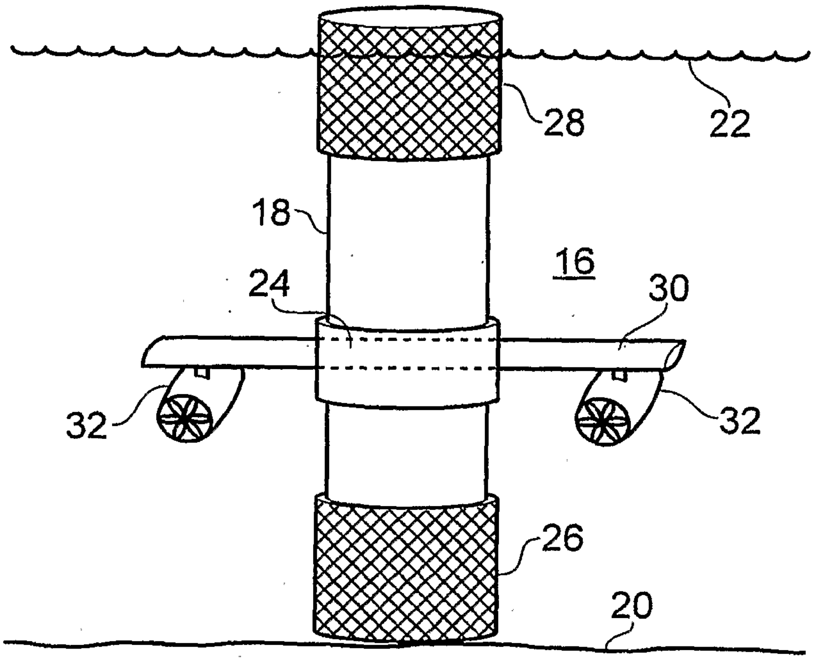

FIG. 3

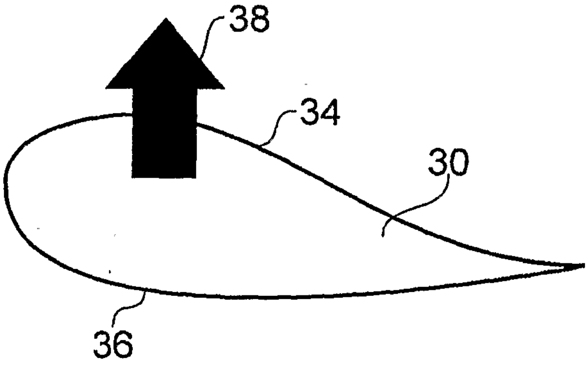

FIG. 4

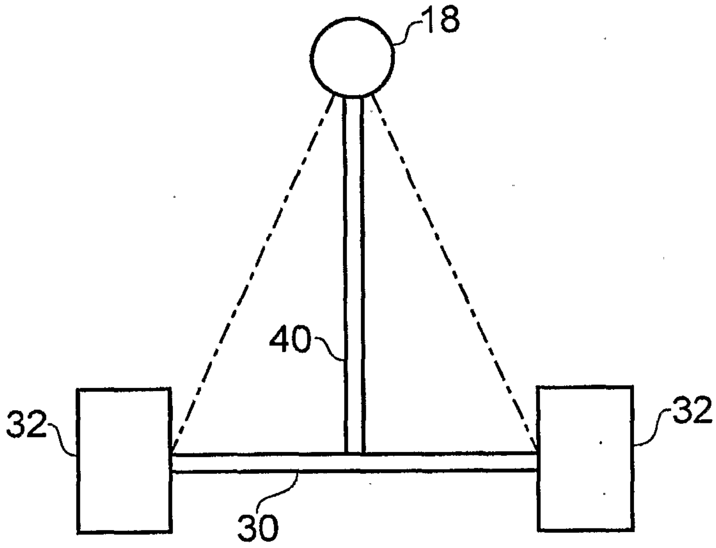

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2009/000216

A. CLASSIFICATION OF SUBJECT MATTER
INV. F03B13/26 F03B17/06

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)
F03B

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
29 June 2009	07/07/2009

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Giorgini, Gabriele

INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

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