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(56) Documents Cited:

GB 2033019 A	**GB 0180001 A**
WO 2003/029646 A	**JP 600013987 A**
JP 580057082 A	**SU 001820025 A**
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UK CL (Edition V) **F1S, F1T**
INT CL^7 **F03B, F03D**
Other: **EPODOC, JAPIO, WPI, OPTICS**

(54) Abstract Title: **Wind or water currect turbine**

(57) The turbine machine generates renewable energy from stream currents, either wind, hydro or tidal stream currents. A rotor assembly 7 is mounted in a static guide structure 3 which may be mounted on a swivelling base plate (4, fig. 1), eg in a wind turbine installation on the brow of a hill. The guide structure may include side guides 11, top guides 12, bottom guide 13, deflector guides 14 and guide bars 15 to channel the flow for maximum effect. The rotor may have four straight blades which may be arranged in an axial or helical configuration (fig.4). The blades may have wing plates (9, fig.2). The turbine may be bi-directional, eg for tidal flow, and may be mounted on the seabed, in mid-water or underneath a barge. Several turbine units may stacked in a vertical tower mounted on seabed, some below water, some above water. The rotor may be arranged at any angle between horizontal and vertical.

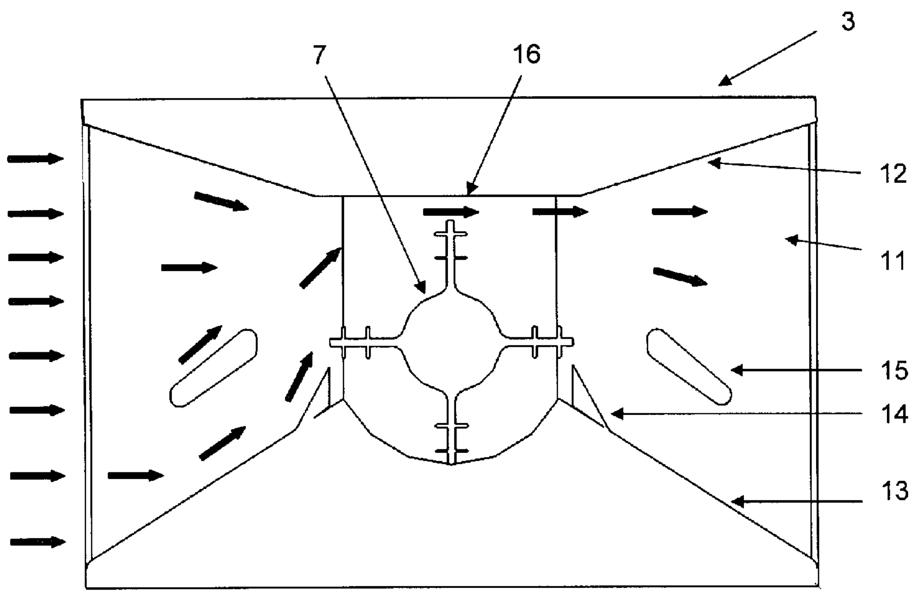

FIG 3 Side Elevation of Turbine Assembly showing current stream flow path

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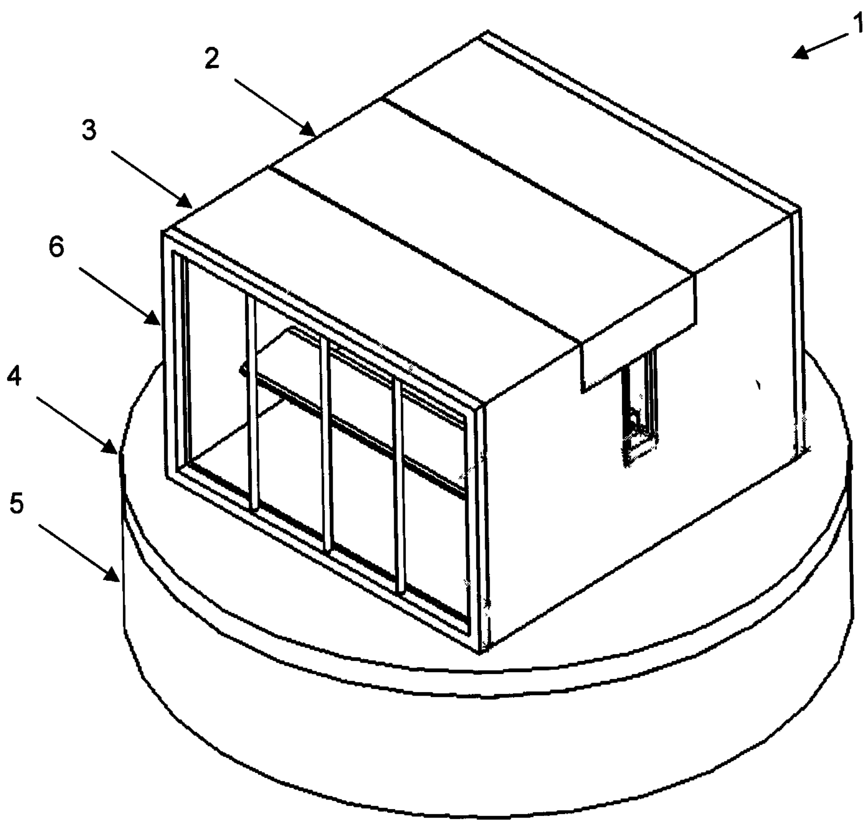

FIG 1 Isometric view of Turbine Assembly

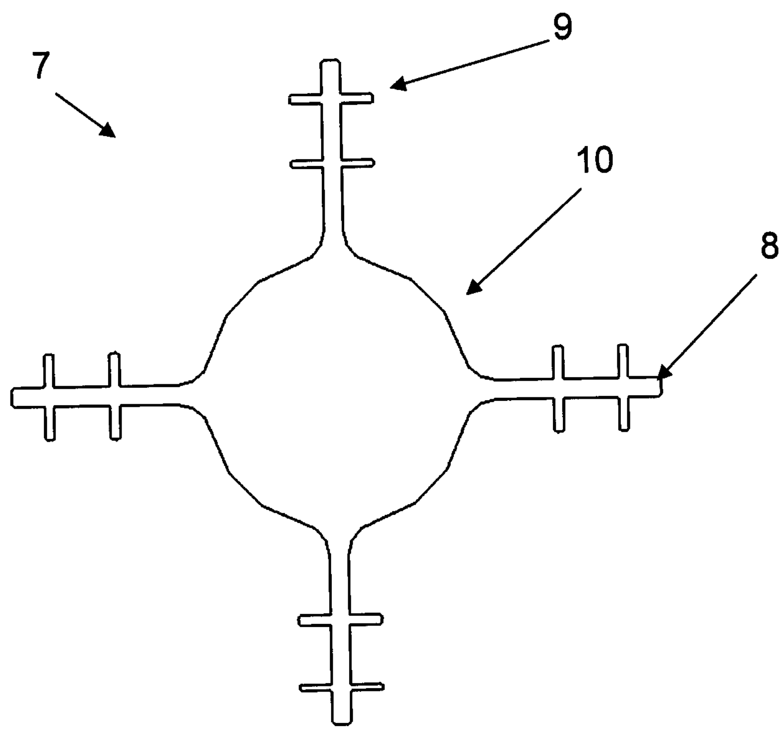

FIG 2 Side View of Rotor Assembly

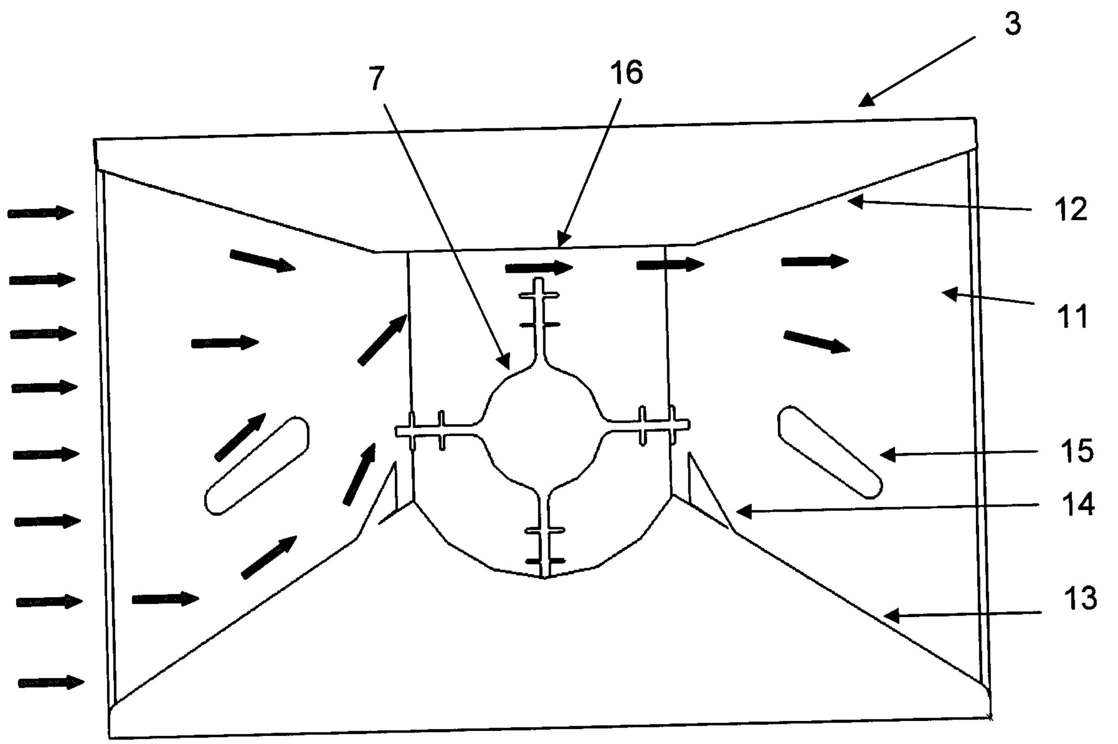

FIG 3 Side Elevation of Turbine Assembly showing current stream flow path

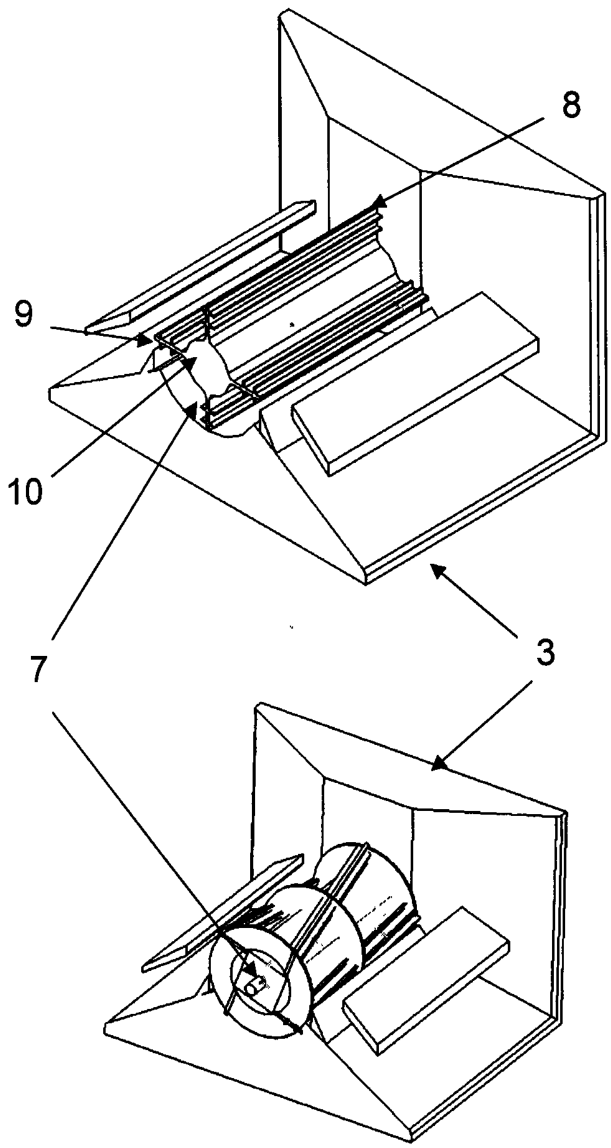

FIG 4 Isometric Sectional View of Rotor Assembly and Flow Guide Profiles

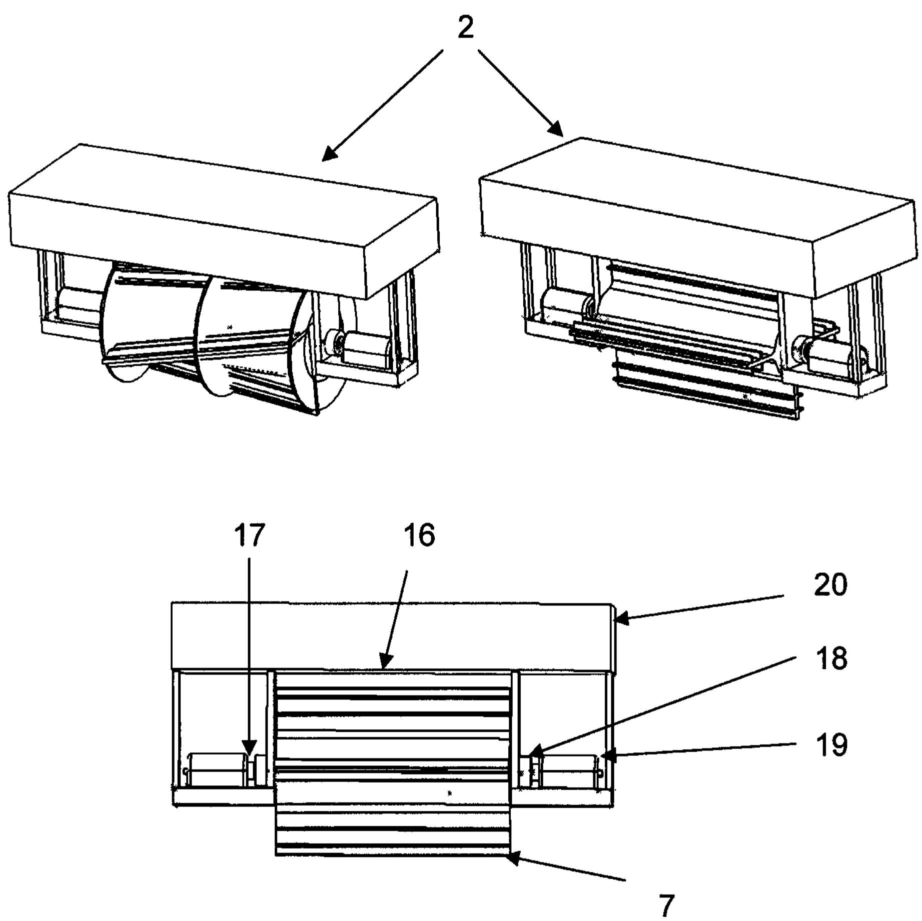

FIG 5 Isometric and Side Elevation View of the Removable Rotor Assembly

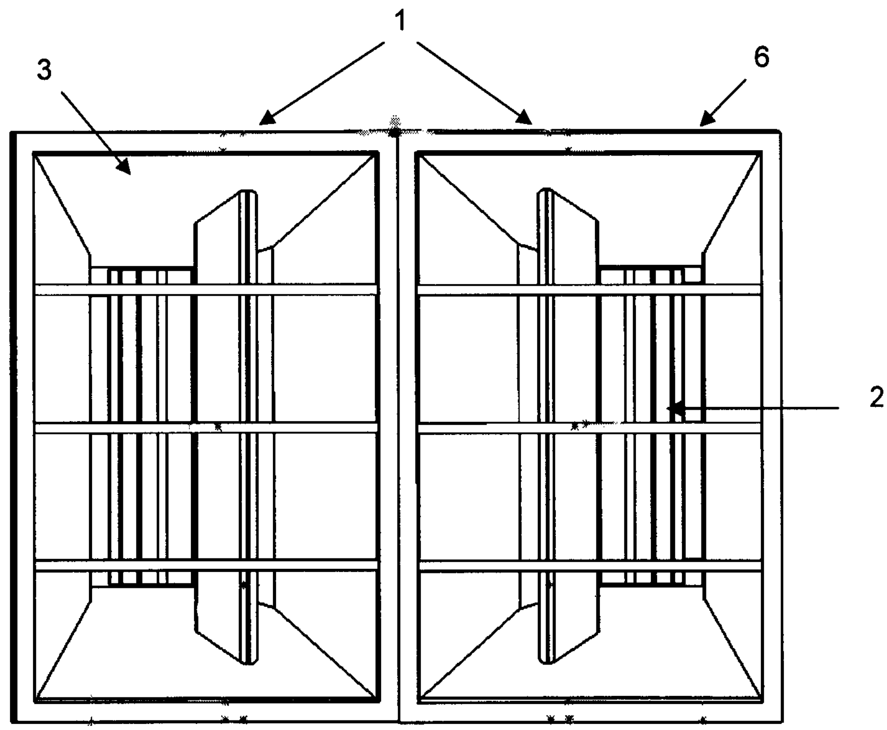

FIG 6 Front View of dual vertical axis turbines

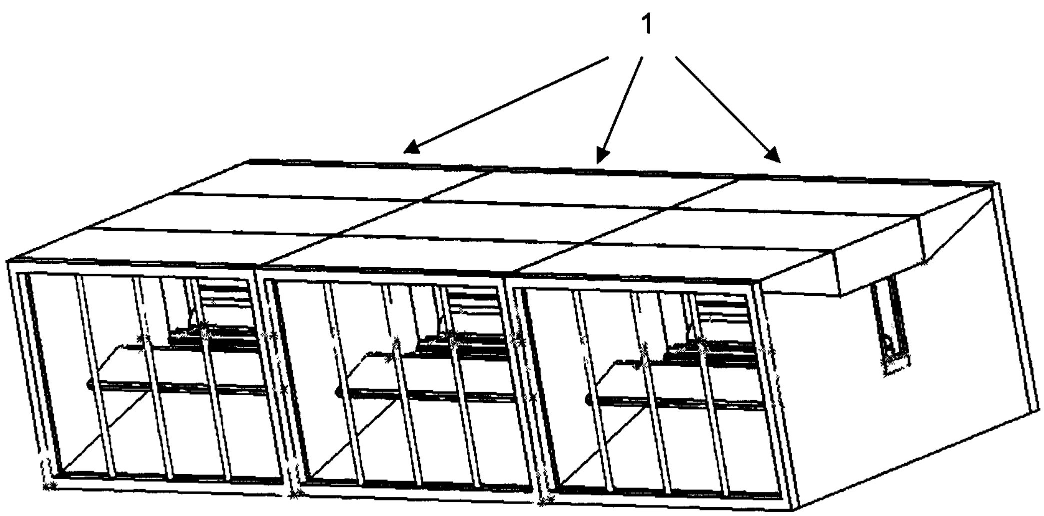

FIG 7 Isometric view of triple bank of horizontal axis turbines

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CURRENT STREAM TURBINE

Background of the Invention

Field of the Invention

The invention relates to the field of systems for generation of renewable energy using current streams i.e. wind, hydro or tidal current streams. More particularly, the invention relates to a device having a rotor that is mounted onto a static guide structure. The rotor is driven by the current stream and this energy is then converted into electrical power.

Background of the Invention

Natural renewable energy resources have the potential to provide enormous amounts of clean and sustainable energy i.e. Wind, Solar, Biomass, Hydro, Wave, Tidal Energy etc.

This Patent relates to a turbine device which be used to convert current stream energy into electrical power. The turbine can be used to harness the power of wind energy or alternatively could be mounted in a river to harness hydro power. One of the main applications for the device is to produce energy from tidal current streams by using the kinetic energy of free flowing underwater current streams to generate electricity.

Tidal current streams present an enormous, and as yet untapped, source of natural energy. As the sea falls and rises due to the influence of the earth, moon and the sun, it gives rise to enormous bodies of moving water. On most coasts, the tidal fluctuation consists of two floods and two ebbs with a semidiurnal period of about

12 hrs and 25 minutes. The magnitude of the tides change during each lunar month. The highest tides are called spring tides and the lowest tides are called neap tides. Tidal movements are well understood and are entirely predictable. Tidal energy therefore is a very constant source of energy. It is not constrained by weather condition, as is the case with Wind, Solar and Wave energy.

Most of these tidal flows of seawater move at low velocities, however, where the movements are channelled through constrained topography, such as straits between islands, high current velocities can occur. As the body of water approaches the strait the water velocity is low. As the same body of water started to pass through the width and depth restriction caused by the strait it has to speed up to ensure that the same volume of water moves through the narrowest part of the strait. When the body of water exits the strait, the water velocity reduces again.

The characteristic "channelling" of the tidal flow through a constrained strait between two land masses will result in higher current stream velocities, typical current velocities can range from 2 knots (1 m/s) up to 12 knots (6 m/s)

Tidal Streams are a relatively condensed form of renewable energy, for example, it has been estimated that the power available from an 8 Knot stream is in the order of 35.9 Kw/m^2.

The ideal site for a tidal stream turbine is in shallow water (25m–50m) with a tidal current speed above 3 Knots (1.5 m/s).

Tidal Current Stream machines use the kinetic energy of the water flow. Existing designs of current stream machines have traditionally been derived from comparable

Wind Energy Machines and been based on propeller type devices in either the horizontal or vertical configuration. As the water flow past the blades the reaction causes them to rotate and this rotation is then converted into electrical energy. Typical examples of horizontal propeller types are the Tyson and Garman Turbines, examples of vertical propellers are the Darrieus and Gorlov Turbines.

This Patent considers a Turbine which uses a horizontal waterwheel type device, as opposed to a propeller type device. The design is based on an inverted Undershot and High Breast Wheel configuration. These wheel configurations have been used onshore for centuries, this design presents their particular application in an underwater application. In this design, the water wheel rotor blades are of a large cross section to capture a large body of the flowing current stream. The configuration can be compared with a stern paddle wheel vessel where the engine rotates the paddle wheel to react against the water and thus propel the vessel. The turbine operates in the opposite manner where the current stream reacts against the large rotor blades and forces them to rotate. This rotation is then converted into electrical energy using a shaft mounted Generator or hydraulic pump unit.

One of the main issues with tidal stream machines is the difficulties associated with installation and maintenance of the structures and components involved. The design of the turbine unit and support equipment incorporates a method of transportation and installation which uses buoyancy chambers. This will enable the unit to be floated to the site and then lowered onto the seabed in a controlled manner. In addition, the main rotor and drive assembly can be recovered independently from the guide structure, for maintenance and repair. The system will be designed to allow intervention on all of the components using a Remotely Operated Vehicle (ROV) to reduce the cost of intervention.

Summary of the Invention

The basis for the design of the Turbine is an inverted traditional Waterwheel.

The waterwheel rotor is mounted onto a static guide structure on the seabed. As the water flows over the rotor blades, it causes the rotor to rotate. The rotating motion of the rotor can then be converted into electricity.

The main characteristic of the machine is the way the water flow and speed is controlled as it passes through the guide structure and over the rotor. It does this in a similar way to the "channelling" of a tidal flow through a constrained strait. In the first instance, the guides act to capture a large area of the flowing current stream. This body of water is then guided through the machine, as it does so the space available is gradually reduced. This forces the water velocity to increase as the same body of water passes through the constrained space. This channelling effect is designed to ensure that the water velocity increases so that the maximum speed is attained as the water contacts with the rotor blades.

The channelling effect occurs in two principle locations on the rotor.

In the first location, at the Breast of the wheel or Breastshot, as the water approaches the base of the Guide Structure it is forced upwards by the bottom guide plate. A guide bar acts to channel the water flow along the bottom guide plate while increasing its velocity. The end of the base guide plate has a diverter plate which is designed to guide the water flow into a generally vertical direction. This also increases the water velocity and guides the water flow to contact the rotor blades at the optimised angle of impact. The separation distance between the tip of the rotor blade and the inboard edge of the guide bar acts to constrain the space available for the water, again optimising the "channelling" effect of the water flow.

In the second location, at the top of the waterwheel rotor, or Overshot section, the water is constrained to flow through the gap between the tip of the rotor and the underside of the roof guide. The water flow is guided into this location by the side guides, top guide and the top surface of the guide bar. The design of the roof guide curvature and the separation distance above the rotor can be adjusted to ensure that the current velocity is maximised at this section and so maximise the energy impacted on the rotor wheel.

The Guide Structure is therefore designed, by incorporating a combination of a Breastshot section and an Overshot section, to optimise the bi-directional water flow routing over the rotor to maximise the amount of energy obtained from the current stream.

To fully optimise the performance of the unit in a constantly varying current stream, a number of the guide or control surfaces will be actuated. As the current stream changes direction and then changes speed the control surfaces in the machine can be trimmed to ensure the machine operates in a safe and efficient manner.

The design of the rotor can incorporate either a straight blade configuration or a helical blade configuration to suit different site conditions. The number of blades used on the rotor could also be specified to suit the operating conditions. The rotor blades incorporate wing plates to react the current flow. For underwater applications the rotor central shaft could incorporate a buoyancy chamber in order to reduce the in water weight of the rotor assembly. The design of the rotor enables bi-directional flow to optimise the functionality of the turbine unit.

The turbine is designed to be bi-directional i.e. the current can enter from either of two opposing directions. This would enable the structure to be permanently positioned on the seabed and operate in both an ebbing and a flooding current without the need to rotate the structure.

The main rotor assembly would be designed so that it could be recovered to surface for maintenance and repair and then reinstalled. Individual components, such as the Generator or hydraulic unit could be designed to be individually recoverable and replaced using ROV's.

The electrical or hydraulic connection between the turbine unit and the onshore grid could also be maintained using an ROV.

The Guide Base Structure could be manufactured from Concrete for ease of construction and to reduce corrosion problems.

The Guide Base Structure and the Rotor Assembly would be designed so that they could be floated, towed to site and then sunk to the seabed in a controlled manner. This would reduce the installation and maintenance cost of the system.

The system would be designed so that it would minimise the impact on fishing activity i.e. it would be designed to be overtrawlable and resist snag loading. The unit could be fitted with screen panels to prevent large mammals or large items of debris from entering the unit. The screens would also be self cleaning as the following change in tide direction would push the debris away from the screen.

The turbine units can be mounted on the seabed in vertical or horizontal “banks” to minimise the space required. The turbine units can be mounted with the rotor assembly at any angle ranging from horizontal to vertical orientation. The turbine units can be mounted on the seabed, mid water or underneath a barge.

The description above considers a turbine that is mounted under the sea to capture the energy from tidal stream currents. The same system could be mounted on the bed of a river to capture the energy from a free flowing river, in this application it would not require to be bi-directional.

The turbine could also be used to capture wind to drive the rotor. In this instance the turbine could be mounted on a swivel base and positioned on the brow of a hill. To reduce the visual impact of the system, it could be profiled and camouflaged to match the surrounding countryside.

As a possible example, the turbine units could be stacked in a vertical tower that was mounted on the seabed and protruding above the sea surface. The turbine units below the surface could generate energy from tidal current stream power, the section above the water could generate energy from wind power.

The main characteristics of the machine are;

- Matched combination of Breastshot and Overshot current flow routings
- Field adjustable control surfaces
- Bi-Directional flow capability

- Installation by Float out and controlled sinking
- ROV Intervention interfaces with major sub assemblies being recoverable
- Applicable for Wind, Hydro or Tidal Current Streams

Brief Description of the Drawings

The invention is pointed out with particularity in the appended claims. The above and further advantages of this invention may be better understood by referring to the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is an isometric view of the turbine assembly.

FIG. 2 is a side view of the rotor assembly

FIG 3 is a side elevation of the turbine assembly showing the current stream flow path.

FIG. 4 is an isometric view of the rotor assembly and flow guide profiles.

FIG. 5 is an isometric and side elevation view of the removable rotor assembly.

FIG. 6 is a front view of the dual vertical axis turbines.

FIG. 7 is an isometric view of a triple bank of horizontal axis turbines.

Detailed Description

Referring to FIG. 1 of the drawings, the presently preferred embodiment of the invention features a turbine unit 1 which comprises a removable rotor assembly 2 mounted in the static guide structure 3. This in turn is mounted onto a swivelling base plate 4. The swivelling base plate 4 is then mounted on a foundation structure 5. The swivel feature enables the turbine unit to be rotated to face the optimised current direction.

The foundation structure 5 would be specified to ensure that the height of the static guide structure 3 was optimised for the current stream conditions.

The turbine unit is optionally fitted with protective screen panels 6 which act to prevent large items of debris etc from entering the structure.

Referring to FIG 2 of the drawings, the side elevation of the rotor 7 shows a typical arrangement of four straight blades 8 mounted on the central shaft 10. Also shown are a number of wing plates 9 positioned on the blades 8. The arrangement of the blades 8 and wing plates 9 could also be arranged in a helical configuration on the central shaft 10. The arrangement of the rotor 7 facilitates bi-directional flow.

Referring to FIG. 3 of the drawings, the side elevation presents the nominal flow path of the current stream as it passes through the static guide structure 3 and over the rotor assembly 7. The guide elements of the structure are shown, namely the side guides 11 the top guides 12 and the bottom guide 13. These guides act to capture the current stream as it enters the structure and guides it towards the rotor assembly 7. On the upper section of the bottom guide element 13, a deflector guide 14 is fitted. The purpose of this guide is to divert the current stream vertically to provide the optimised impact angle on the rotor assembly.

The guide bar 15 has two purposes. In the first instance, Breastshot, it acts to channel the flow between the guide bar 15 and the bottom guide 13, as this flow of water is directed vertically by the deflector guide 14 the guide bar 15 constrains the opening space available between the tip of the rotor blade 8 and the inboards face of the guide bar 15. This restriction in the space available forces the water velocity to increase through the gap and therefore maximises the impact velocity on the turbine rotor.

In the second instance, Overshot, the guide bar 15 acts to deflect the flow path upwards towards the gap between the top of the rotor assembly 7 and the roof guide 16. This again acts to increase the water velocity as it passes over the rotor blades. The profile of the roof guide 16 and the separation distance between the roof guide 16 and the tip of the rotor blade 8 can be adjustable to optimise the flow characteristics of the machine.

Referring to FIG.4 of the drawings, the isometric view presents a cut away view of the rotor assembly 7 and the static guide base 3. The position of the rotor blades 8 on the central shaft 10 is shown. The wing plates 9 on the rotor blades 8 act to constrain and react the impact generated by the water flow contacting the rotor assembly 7. The option of either a straight or helical blade configuration is presented in this view.

Referring to FIG.5 of the drawings, presents the removable rotor assembly 2. The rotor assembly 7 is mounted on stub axle shafts 17 that are supported on bearing assemblies 18. A third bearing could optionally be mounted on the centre of the rotor to provide additional support. The shafts are connected to Generators/hydraulic units 19 these convert the rotation of the shafts into usable energy. This assembly also incorporates the adjustable roof guide 16 These assemblies are all mounted on a structural interface frame 20 which can be deployed into and recovered from the static guide base 3. The structural interface frame 20 would incorporate docking interfaces to facilitate the removal/installation operations using ROV intervention. This facility enables all of the major mechanical components to be removed from the operating site for maintenance or repair. Again, the option for either a straight or helical blade configuration is presented.

Referring to FIG. 6 of the drawings, this shows an arrangement of the turbine unit 1 where the assemblies, comprising the static guide base 3, the removable rotor assembly 2 and the protective screen panels 6, are mounted with the vertical shaft orientation.

Referring to FIG. 7 of the drawings, this shows an arrangement of the turbine units 1 where a bank of three units are mounted adjacent to each other, the shafts being maintained in a horizontal orientation.

CLAIMS

What is claimed is:

1 A turbine machine for generating energy from current streams, said machine comprising;

a static guide base structure having bi-directional guide and control surfaces;

a bi-directional rotor assembly mounted on said static guide base

2. The machine as recited in claim 1, wherein the machine can be used to produce energy from subsea tidal stream currents.

3. The machine as recited in claim 1, wherein the machine can be used to produce energy from river (hydro) flow.

4 The machine as recited in claim 1, wherein the machine can be used to produce energy from wind flow

5 The machine as recited in claim 1, wherein the machine can facilitate bi-directional flow through it without the requirement to rotate the guide base structure

6 The machine as recited in claim 1, wherein the machine can be used with the rotor assembly orientation horizontally, vertically or in any angle in between.

7. The machine as recited in claim 1, wherein the machine can be mounted in banks in an orientation ranging from horizontal through to vertical.

8. The machine as recited in claim 1, wherein the static guide base structure incorporates a plurality of internal guide surfaces which function to guide the bi-directional current stream.

9. The guide base structure in claim 8, which incorporates a plurality of guide bar profiles which act to control the bi-directional current flow through the structure.

10. The guide base structure as recited in claim 8, which incorporates a plurality of deflector guide profiles which act to control the bi-directional current flow through the structure.

11. The guide base structure as recited in claim 8, which incorporates an interface docking arrangement which facilitates the removal and re-installation of the rotor assembly.

12. The guide base structure as recited in claim 8, which incorporates a plurality of internal buoyancy chambers.

13. The machine as recited in claim 1, wherein the rotor assembly and associated

mechanical drive components can be removed from the guide structure for repair or maintenance and then replaced into the guide structure.

14. The machine as recited in claim 13, wherein the removable rotor assembly incorporates an interface docking arrangement which facilitates the removal and re-installation of the rotor assembly within the guide base structure.

15. The removable rotor assembly as recited in claim 13, wherein the assembly incorporates a plurality of bearing assemblies mounted on the rotor shaft.

16. The removable rotor assembly as recited in claim 13, wherein the assembly incorporates a plurality of power conversion devices mounted on the rotor shaft.

17. The removable rotor assembly as recited in claim 13, wherein the assembly incorporates an adjustable roof guide profile; the vertical position and the curvature of the guide profile being adjustable.

18. The removable rotor assembly as recited in claim 1, wherein the rotor incorporates the facility to operate bi-directionally.

19. The rotor as recited in claim 18, wherein the rotor incorporates a plurality of reaction blades attached to the central shaft in either a straight pattern or in a helical pattern.

20. The rotor as recited in claim 18, wherein the rotor blades incorporate a plurality of wing plates which act to react the current flow.

21. The rotor as recited in claim 18, wherein the rotor shaft incorporates a buoyancy chamber.

22. The machine as recited in claim 1, wherein the machine can be optionally mounted on a swivel base and or a foundation base.

23. The machine as recited in claim 1, wherein the static guide base structure incorporates a plurality of screen panels to prevent debris entering the structure.

24. The machine as recited in claim 1, wherein the machine can be mounted on the seabed or on the bed of a river.

25. The machine as recited in claim 1, wherein the machine can be mounted on the underside of a floating structure which can operate at sea or in a river.

26. The machine as recited in claim 1, wherein the machine can be mounted mid water between the water surface and the bed of the river or sea.

27. The machine as recited in claim 1, wherein the machine can be designed, when

used under the sea, to be overtrawlable and to resist snag loadings; to minimise the impact on fishing activities.

28. The machine as recited in claim 1, wherein the machine can be mounted on the brow of a hill to provide energy from wind flow, said guide base structure being profiled and camouflaged to match the surrounding landscape.

29. The machine as recited in claim 1, wherein the guide bars function to split the current stream flow into two routings, namely;

the breastshot channel which is routed below the guide bar and impacts the breast of the rotor;

the overshot channel which is routed above the guide bar and impacts the top of the rotor.

30. The machine as recited in claim 1, wherein the guide bars are adjustable in terms of;

the separation between the tip of the rotor blades and the inboard face of the guide bar;

the thickness of the guide bar;

the profile on the upper and lower surfaces of the guide bar;

the angle of the guide bar and the length of the guide bar.

Amendments to the claims have been filed as follows

CLAIMS

What is claimed is:

1. A turbine machine for generating energy from current streams, said machine comprising;

a static guide base structure having bi-directional guides, guide bars and control surfaces;

a bi-directional rotor assembly mounted on said static guide base

2. The machine as recited in claim 1, wherein the machine can be used to produce energy from subsea tidal stream currents.

3. Deleted

4. Deleted

5. The machine as recited in claim 1, wherein the machine can facilitate bi-directional flow through it without the requirement to rotate the guide base structure by 180 degrees.

6. The machine as recited in claim 1, wherein the machine can be used with the rotor assembly orientation horizontally, vertically or in any angle in between.

7. The machine as recited in claim 1, wherein the machine can be mounted in banks in an orientation ranging from horizontal through to vertical.

8. The machine as recited in claim 1, wherein the static guide base structure incorporates a plurality of internal guide surfaces which function to guide the bi-directional current stream.

9. The guide base structure in claim 8, which incorporates a plurality of guide bar profiles which act to control the bi-directional current flow through the structure.

10. The guide base structure as recited in claim 8, which incorporates a plurality of deflector guide profiles which act to control the bi-directional current flow through the structure.

11. The guide base structure as recited in claim 8, which incorporates an interface docking arrangement which facilitates the removal and re-installation of the rotor assembly.

12. The guide base structure as recited in claim 8, which incorporates a plurality of internal buoyancy chambers.

13. The machine as recited in claim 1, wherein the rotor assembly and associated

mechanical drive components can be removed from the guide structure for repair or maintenance and then replaced into the guide structure.

14. The machine as recited in claim 13, wherein the removable rotor assembly incorporates an interface docking arrangement which facilitates the removal and re-installation of the rotor assembly within the guide base structure.

15. The removable rotor assembly as recited in claim 13, wherein the assembly incorporates a plurality of bearing assemblies mounted on the rotor shaft.

16. The removable rotor assembly as recited in claim 13, wherein the assembly incorporates a plurality of power conversion devices mounted on the rotor shaft.

17. The removable rotor assembly as recited in claim 13, wherein the assembly incorporates an adjustable roof guide profile; the vertical position and the curvature of the guide profile being adjustable.

18. Deleted

19. The rotor as recited in claim 1, wherein the rotor incorporates a plurality of reaction blades attached to the central shaft in either a straight pattern or in a helical pattern.

20. The rotor as recited in claim 1, wherein the rotor blades incorporate a plurality of wing plates which act to react the current flow.

21. The rotor as recited in claim 1, wherein the rotor shaft incorporates a buoyancy chamber.

22. The machine as recited in claim 1, wherein the machine can be optionally mounted on a swivel base and or a foundation base.

23. The machine as recited in claim 1, wherein the static guide base structure incorporates a plurality of screen panels to prevent debris entering the structure.

24. The machine as recited in claim 1, wherein the machine can be mounted on the seabed.

25. The machine as recited in claim 1, wherein the machine can be mounted on the underside of a floating structure which can operate at sea.

26. The machine as recited in claim 1, wherein the machine can be mounted mid water between the water surface and the bed of the sea.

27. The machine as recited in claim 1, wherein the machine can be designed, when used under the sea, to be overtrawlable and to resist snag loadings; to minimise the

impact on fishing activities.

28. Deleted.

29. The machine as recited in claim 1, wherein the guide bars function to split the current stream flow into two routings, namely;

the breastshot channel which is routed below the guide bar and impacts the breast of the rotor;

the overshot channel which is routed above the guide bar and impacts the top of the rotor.

30. The machine as recited in claim 1, wherein the guide bars are adjustable in terms of;

the separation between the tip of the rotor blades and the inboard face of the guide bar;

the thickness of the guide bar;

the profile on the upper and lower surfaces of the guide bar;

the angle of the guide bar and the length of the guide bar.

The Patent Office

INVESTOR IN PEOPLE

Application No: GB 0312059.9
Claims searched: 1 to 30

Examiner: John Twin
Date of search: 4 November 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X	1 at least	JP 58-057082 A	(Mori Shigefumi) - see eg drawings (especially fig.4) and PAJ abstract
X	1 at least	WO 03/029646 A1	(Hilleke.com)
X	1 at least	SU 1820025 A	(Shcherbakov) - see eg WPI abstract accession no.1994-331431
X	1 at least	JP 60-13987 A	(Riyokuseishiya) - see eg drawings and PAJ abstract
X	1 at least	GB 2033019 A	(Goodridge)
X	1 at least	GB 0180001	(Goudie)
X	1 at least	US 4857753	(Mewburn Crook)
X	1 at least	US 6139255	(Vauthier)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art
Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{V}:

F1S, F1T

Worldwide search of patent documents classified in the following areas of the IPC^{7} :

F03B, F03D

The following online and other databases have been used in the preparation of this search report :

EPODOC, JAPIO, WPI, OPTICS