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(71) Applicant(s):
Anthony Thomas Morse
Ashbank, Lucklawhill, Balmullo,
ST ANDREWS, Fife, KY16 0BQ,
United Kingdom

(72) Inventor(s):
Anthony Thomas Morse

(74) Agent and/or Address for Service:
Marks & Clerk
19 Royal Exchange Square, GLASGOW,
G1 3AE, United Kingdom

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(54) Abstract Title: **Subsea turbine energy generation apparatus**

(57) An apparatus for generating energy from flowing water comprises a turbine rotor portion 12, to be driven by the flowing water, and operably connected to an energy generator portion 14, and a support portion 30 connected to either the generator 14 or the turbine 12. The support portion 30 is engaged with a guidebase assembly or similar structure 18, to anchor the apparatus in position. The guidebase assembly 18 may form part of a subsea wellhead assembly.

Also disclosed is an energy generation apparatus where at least two of the turbine portion, the generating portion and the support portion are releasably connected to one another, so that they may be deployed separately from an underwater location.

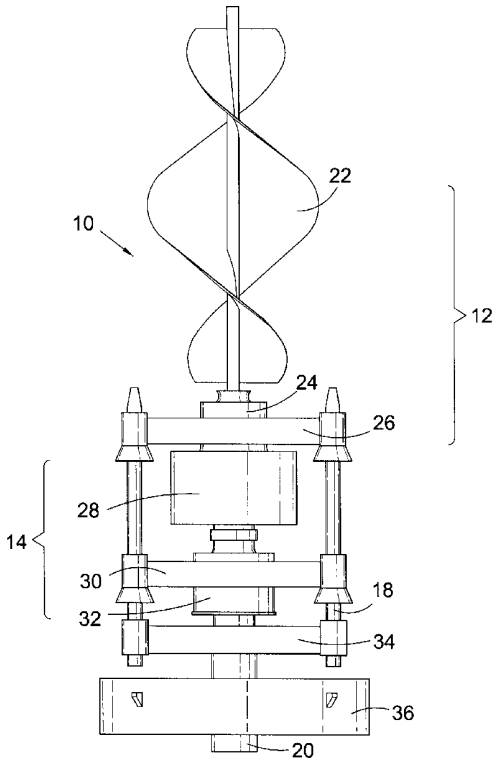

Fig. 1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

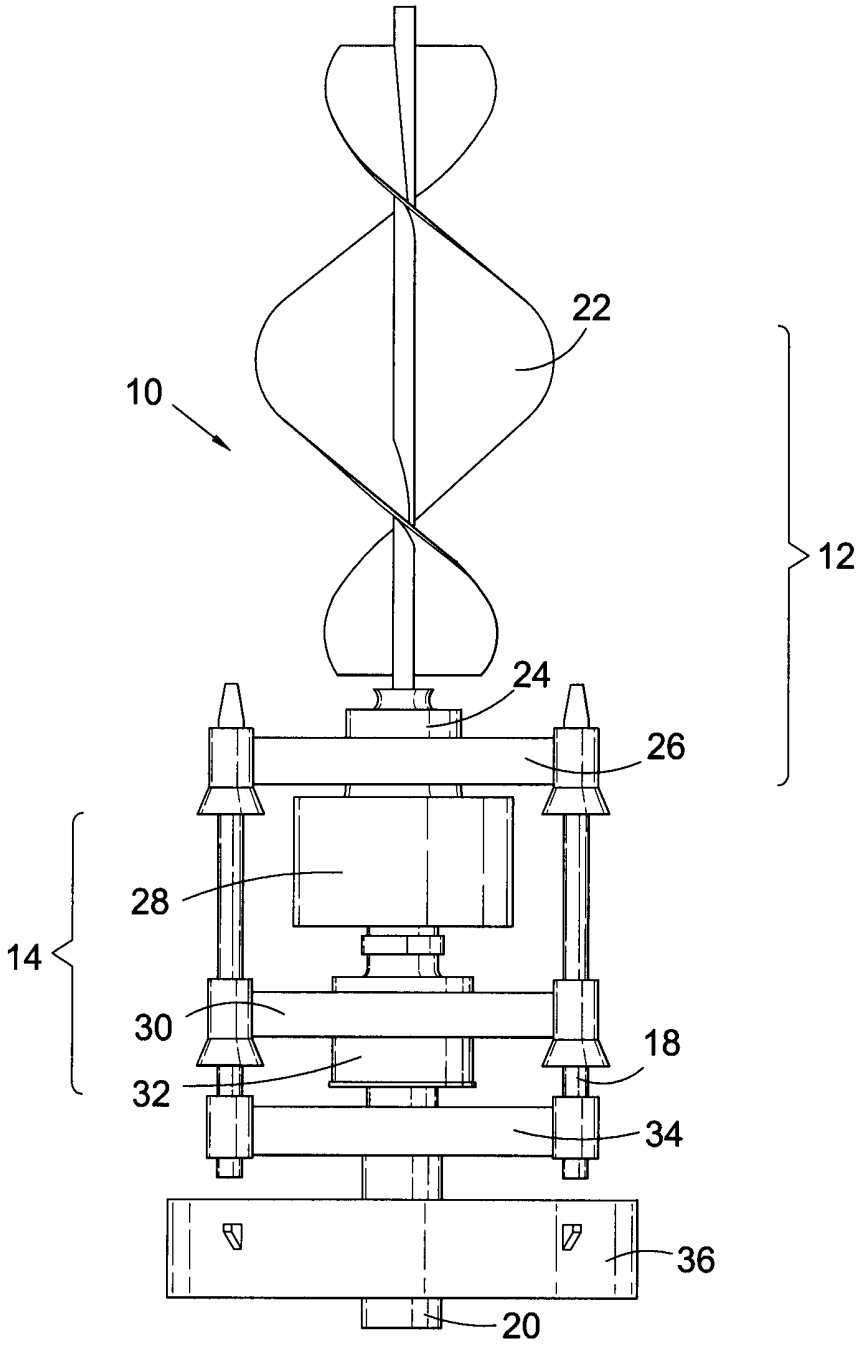

Fig. 1

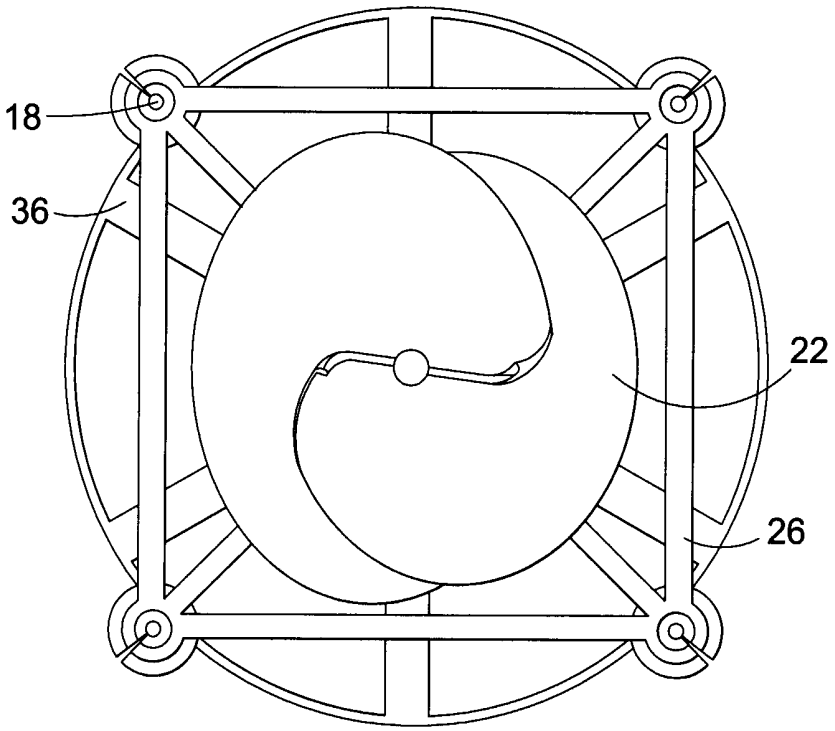

Fig. 2

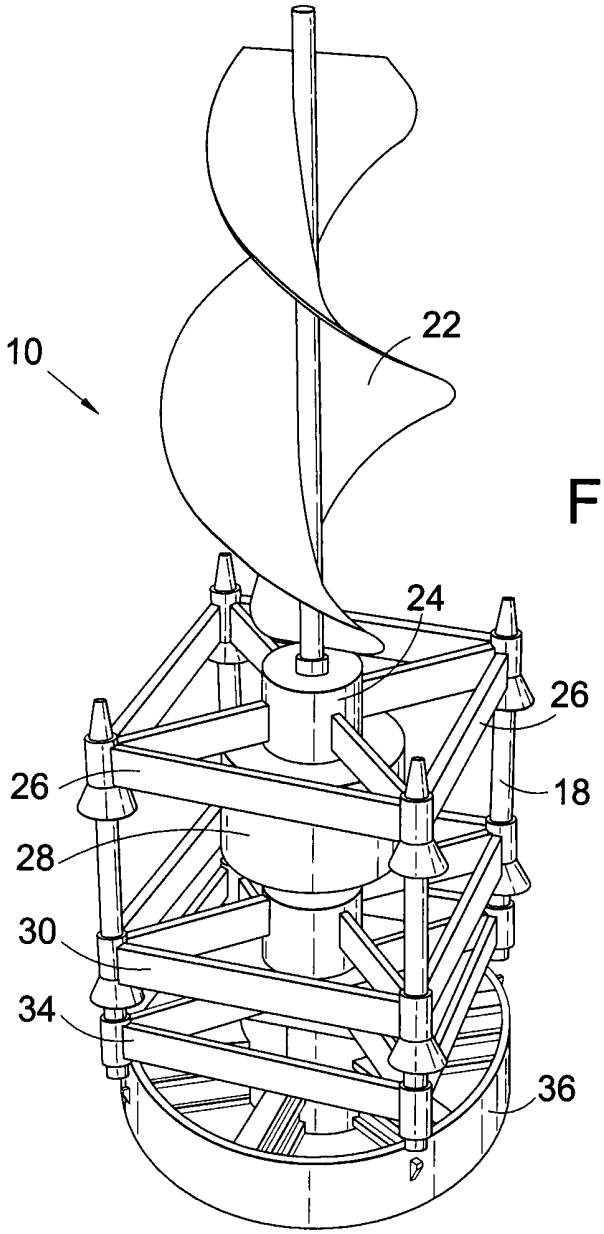

Fig. 3

SUBSEA ENERGY GENERATION

The present invention relates to an apparatus for generating energy from flowing water. The invention is primarily, although not exclusively, intended for subsea use; and is particularly suited for use in the offshore oil and gas exploration and production industries. Particular embodiments of the invention may be used to generate electricity; however, alternative energy may be generated.

There are numerous different devices and systems for generating energy from flowing water; for example, wave power systems, tidal power systems, hydroelectric generators, and the like. However, these suffer from a number of disadvantages.

Common wave and tidal barrage systems both typically require a number of generating units to be installed in order to provide sufficient power to be commercially useful. This can lead to unsightly installations and unwanted environmental impact. Further, it is often necessary to construct large, heavy structures to hold generating systems in place against fast current flow. It is often difficult to deploy and install generating systems, particularly in deep or fast-flowing water; for this reason the majority of practical systems are often limited to installation at less than 50 metres in depth. This in turn leads to further problems as the relatively shallow location of the generators can result either in the

generators obstructing other use of the water, or even protruding from the surface of the water, and so being unsightly.

An additional problem with certain electricity generating systems is the need to create dams or tidal barrages to obtain sufficient water flow to allow for economical generation of electricity. Clearly such systems have an additional environmental impact beyond that of simply installing the generators themselves.

It is among the objects of embodiments of the present invention to obviate or alleviate, at least in part, certain of the disadvantages of prior art energy generating devices.

One potential user of energy generated by subsea systems is the offshore oil and gas exploration and production industry. Drilling rigs and similar structures require an energy supply to assist in powering the operation of subsea equipment. Further, downhole tools as used in the drilling / completion industry may also require an energy supply for their operation. At present this energy supply is provided by conventional fossil-fuel electricity generators located on the drilling rig; such generators must be regularly supplied with fuel. It would be more convenient to provide electricity generated locally which does not require a fuel supply; such as that generated from water power. It would further be beneficial

to generate energy used downhole at the subsea well itself.

Furthermore, the offshore oil and gas industry often faces the relatively high cost of abandoning or decommissioning exhausted wells and wellheads. Embodiments of the present invention allow such wells and wellheads to be used as locations (anchors) for equipment to generate energy; this is particularly advantageous when combined with an existing distribution network, such as the pipelines which will already be present near a well and which may thus be used to distribute generated energy.

These and other objects of the invention are achieved in part in certain embodiments of the invention by the use of a modular generator system which is arranged to engage with what is generally known as a wellhead guidebase assembly located (anchored) in a subsea location. Wellhead guidebase assemblies are generally cemented in place to the top of a well bore, and hence provide a convenient anchor point for attachment of tools and the like. The assembly may typically be used for the attachment of 'Christmas trees', which are structures used during oil and gas production operations to allow control of fluid flow from a well, and to provide means whereby downhole tools and the like may be attached to the well. Wellhead guidebase assemblies are generally of a standard form, as will be described, and so provide a convenient means for attaching a generator system and apparatus of the present invention.

According to a first aspect of the present invention, there is provided an apparatus for generating energy from flowing water, the apparatus comprising a turbine rotor portion for being driven by flowing water, the turbine rotor portion being operably connected to a generator portion; and a support portion connected to one of the turbine rotor portion and the generator portion; wherein at least two of said portions are releasably connected to one another, such that said two of said portions may be deployed or retrieved separately from an underwater location.

Thus, the present invention allows for a modular construction of the apparatus, such that, for example, the support portion may be deployed in a subsea location first, followed by separate deployment of the generator and turbine portions. This allows for the apparatus to be deployed using smaller, less powerful means than prior art systems, so making it less costly to deploy. For example, the apparatus may be deployed by means of a drilling industry running tool (typically used to deploy or 'run in' downhole tools and the like), or by means of cables or the like running from surface. The modular nature of the apparatus also allows for relatively straightforward replacement or retrieval of separate portions for maintenance, as well as the substitution of variant portions for others, for example to adapt the apparatus to

different subsea conditions. Of course, despite the modular nature of the apparatus, the complete apparatus may be deployed as a single unit, rather than modularly, if desired.

References herein to 'subsea', 'seabed' and the like will be understood by the skilled person to include other underwater locations, such as lakebeds, riverbeds, and the like, including coastal locations such as a foreshore.

Preferably the generator portion is an electrical generator portion; the apparatus may conveniently be used to generate electricity from water movement. However, alternative forms of energy may be generated if desired; in particular a hydraulic generator may be used, or the apparatus may include a device for separating hydrogen from water which may be powered directly from water movement or indirectly via an electricity generator. The generation of hydrogen may be particularly convenient where the hydrogen is able to be transferred along existing pipelines such as those leading from oil and gas wells. Suitable electrical, hydraulic, or hydrogen generators are known, and may be readily used by the skilled person.

Preferably all three of the portions are releasably connected together; in a preferred arrangement, the turbine portion is connected to the generator portion, and the generator portion is connected to the support portion.

Preferably the apparatus comprises connectors, for

releasably connecting the portions together and for connecting the support portion to a well head guide base assembly. The connectors may be hydraulic connectors; alternatively or in addition mechanical connectors may be used. Suitable connectors will be known to those of skill in the art.

Preferably the support portion is adapted to engage with a subsea wellhead guidebase assembly. For example, a typical guidebase assembly includes a number of upwardly extending members; the support portion may comprise members arranged to engage with such upwardly extending members; the members may be in the form of openings located on a supporting frame of the support portion. Wellhead guidebase assemblies are also generally of a standardised form, which allows the present invention and in particular the support portion thereof to be produced in a corresponding standard form which will be suitable for engaging with such guidebase assemblies. In use, the support portion may engage with an existing guidebase assembly previously mounted on the sea floor or to the head of a drill bore. This allows the present invention, in certain embodiments, to be retrofitted to an existing guidebase assembly, which may be of particular benefit for the use of the invention in providing electricity to downhole tools and similar devices, or to drilling rigs and platforms.

Alternatively, the apparatus may further comprise a

wellhead guidebase assembly for engaging with the support portion. In this case, the guidebase assembly (and optionally the support portion) may be deployed first of all, by for example drilling or piling and cementing the guidebase assembly into a suitable seabed location, with the remaining portions being deployed subsequently. It will be appreciated that this may require more work than retrofitting the apparatus to an existing guidebase assembly, but may be the preferred option in the event that suitably-located guidebase assemblies do not exist in the desired location. In still further embodiments, the apparatus may comprise one or more vertically oriented members for engaging with the support portion; these members are preferably of the same size and arrangement as the members provided on a conventional guidebase assembly. Conveniently four of these members are provided, arranged in the corners of a quadrilateral. The members may be comprised in the support portion, or may be separate from the support portion. Two and four post wellhead assemblies will be known to those of skill in the art, and either form may be used in the present invention.

In those embodiments in which the support portion is adapted to engage with a guidebase assembly, or with one or more vertically oriented members, preferably one or both of the remaining portions are also adapted to engage with a guidebase assembly, or with said members. This provides a

convenient means whereby the various portions may be aligned and engaged during deployment.

The support portion may further comprise a ballast to assist in retaining the apparatus on the seabed. The ballast may comprise a concrete weight or the like.

The apparatus may still further comprise additional portions for interposing between the generator portion and the turbine portion. The additional portions may include spacer portions, for raising the effective height of the turbine portion to allow for variations in location of water flow and local conditions; or may include additional turbine portions, for improving the area over which water flow is intercepted. In further embodiments of the invention, the additional portions may comprise buoyancy members, such as buoyancy chambers, for adjusting the buoyancy of the apparatus or of parts thereof.

The turbine portion may include a turbine rotor of any suitable form, and may be selected depending on the expected conditions where the apparatus is to be deployed. The person skilled in the art of energy generation will be aware of suitable forms of rotor which may be used. For example, helical vertical rotors, or multiple-bladed horizontal rotors may be used, as may numerous alternative forms. In certain embodiments of the invention, the apparatus may be provided with a plurality of interchangeable turbine portions, to allow selection of an

appropriate form.

The generator portion may include a generator of any suitable form; again the skilled person will be aware of numerous suitable types of generator. Examples of suitable electrical generators include permanent magnet alternators, and induction generators. Alternatively, hydraulic generators or hydrogen generators may be used. Again, the generator may be selected depending on expected conditions in the location where the apparatus is to be deployed.

Preferably the apparatus further comprises means for distributing generated energy; preferably the device is for distributing generated electricity. This may conveniently take the form of a conducting device leading from the apparatus. In certain embodiments, the conducting device may communicate with a manifold for communicating with a plurality of similar apparatuses; the manifold allows electricity from multiple apparatuses to be combined and transmitted onwardly. Alternatively, or in addition, the conducting device may communicate with an offshore drilling platform; or with an electricity storage device for example capacitors or batteries; or with an onshore electricity distribution network. The apparatus may further comprise a transformer. Where the apparatus generates energy that is not electricity, the apparatus may comprise an alternative appropriate form of energy distribution means; for example, hydrogen pipelines, storage containers, or the like.

According to a further aspect of the present invention, there is provided an apparatus for generating energy from flowing water, the apparatus comprising a turbine rotor portion for being driven by flowing water and for connecting to an energy generator portion; and a support portion for connecting to one of the turbine rotor portion and the energy generator portion; wherein at least two of said portions are adapted to be releasably connected to one another, such that said two of said portions may be deployed or retrieved separately from an underwater location.

According to a further aspect of the present invention, there is provided a system for generating energy from flowing water, the system comprising:

a plurality of apparatuses, each apparatus comprising a turbine rotor portion for being driven by flowing water, the turbine rotor portion being operably connected to an energy generator portion; and asupport portion connected to one of the turbine rotor portion and the energy generator portion; wherein at least two of said portions are releasably connected to one another, such that said two of said portions may be deployed or retrieved separately from an underwater location;

a manifold for collecting and onwardly distributing energy generated by the apparatuses; wherein

each apparatus is in communication with the manifold

to allow transmission of generated energy.

According to a yet further aspect of the present invention, there is provided a method of deploying an apparatus for generating energy, the method comprising the steps of:

deploying asupport portion on the seabed;

deploying a generating portion on the support portion, and releasably connecting the generating portion thereto; and

deploying a turbine rotor portion on the generating portion, and releasably connecting the generating portion thereto.

The deployment preferably takes place from surface, and may be effected by means of cables, running tools or the like.

Preferably the support portion is deployed so as to anchor and engage with a portion of a guidebase assembly or similar structure. The method may further comprise the step of deploying a guidebase assembly and securing the assembly to the seabed prior to deploying the support portion, although it may be that the support portion is instead deployed to engage with an existing guidebase assembly. The generator portion and turbine rotor portions may also be deployed so as to engage with a portion of a guidebase assembly; in alternative embodiments, the apparatus may engage with a portion of a Christmas tree which is itself

engaged with a guidebase assembly.

The various portions are preferably connected by means of hydraulic and/or mechanical connectors.

The method may yet further comprise the step of connecting the apparatus to energy conducting means.

According to a still further aspect of the present invention, there is provided an apparatus for generating energy from flowing water, the apparatus comprising a turbine rotor portion for being driven by flowing water, the turbine rotor portion being operably connected to an energy generator portion; and asupport portion connected to one of the turbine rotor portion and the energy generator portion; wherein the support portion is adapted to be engaged with a portion of a guidebase assembly or similar structure so as to retain and anchor the apparatus in position.

These and other aspects of the present invention will now be described by way of example only and with reference to the accompanying Figures, in which:

Figure 1 shows a side view of an apparatus for generating energy in accordance with an embodiment of the present invention;

Figure 2 shows a top view of the apparatus of Figure 1; and

Figure 3 shows a perspective view of the apparatus of Figure 1.

Referring to the Figures, these show an apparatus 10 for generating energy from flowing water in accordance with an embodiment of the present invention. In this example, the apparatus generates electricity from flowing water, although it will be apparent to the skilled person that alternative forms of energy may be generated using the present invention. The apparatus 10 includes three distinct portions : a turbine rotor portion 12, an electrical generator portion 14, and a support portion.

Also shown in the Figures is a wellhead guidebase assembly 18/34, which in this example comprises four vertically-extending guideposts which are attached to the sea floor by virtue of being anchored 36 to a subsea well head 20. The design of guidebase assemblies and their anchoring to well heads is well-known in the oil and gas industry, and will not be described in detail here.

The turbine rotor module 12 includes a helical rotor blade 22 having at its base a hydraulic connector 24 of known design, and a square steel frame 26 which includes corner openings arranged to allow the frame 26 to engage with the guideposts of the guidebase assembly 18. The hydraulic connector 24 includes integral bearings (not shown) which allow the rotor 22 to turn, and is also used to allow the turbine rotor module 12 to releasably connect to the electrical generator module 14. In certain embodiments of the invention, the hydraulic connectors may

be replaced with mechanical connectors.

The electrical generator module 14 includes a generator 28 which is driven by rotation of the rotor 22, a further square steel frame 30 for engaging with the guidebase assembly 18, and a further hydraulic connector 32. The square steel frame 30 comprises an upper and a lower square portion connected by upwardly extending corner opening posts; in effect this makes the frame 30 resemble two single frames connected by the posts and this frame comprises the support portion.

The further connector 32 allows the generator module 14 to connect to a well-head base 36. The further connector 32 hydraulically locks onto the well head 20, which is of known design (typically an 18 3/4 inch housing) and includes a profile to which the connector attaches. The frame and base 36 cooperate with the well head 20, and by this means are connected to the electrical generator module 14.

Deployment of the apparatus proceeds as follows. Firstly the wellhead guidebase assembly 18 is deployed in an appropriate sea floor location. The guidebase assembly may be deployed using conventional oil and gas industry devices, and may be attached to the sea floor by means of a conductor pipe drilled and cemented or piled into position, with the well head 20 being hydraulically locked into this conductor by use of a hydraulic set packer device or

similar. Alternatively, and preferably a previously-deployed guidebase assembly may be utilised, for example an assembly forming part of an oil or gas well.

The generator module 14 and associated support frame is then lowered over the guidebase assembly 18. The module 14 is lowered from the surface, and the frame 30 is run over the cables, which extend through the corner openings of the frame 30. These corner openings are received on the guidebase assembly to align the module 14 in the correct position.

The hydraulic connector 32 is operated (for example, from an umbilical to surface, or by interface with a remotely operated vehicle (ROV), or by divers) to connect the modules together. The generator 28 may be connected to an export cable, transformer, capacitor, or battery arrangement (not shown). This may be by any convenient connector arrangement, and may be operated for example, by a ROV or by divers.

Finally, the turbine rotor module 12 is lowered on the cables and connected in the same manner. The apparatus 10 is then ready to generate electricity.

It will be noted that the present invention allows for a modular deployment of the apparatus; this is simpler than deploying a complete structure at once. Equally, retrieval of the apparatus or individual modules may proceed in a similar manner, with the hydraulic connectors 24, 32 being

disengaged remotely or locally.

The modular nature of the apparatus also allows for a deal of flexibility in its use. The form of the rotor blade 22 used will depend on the current velocity and depth; the style may range from a helical type blade to a multi-bladed horizontal propeller type blade system. Due to the modular nature of the apparatus, it is possible to stack multiple vertical blades together or to raise the position of the blades by means or a 'riser system' to allow optimum location in a current.

The generator type may be a permanent magnet alternator or an induction generator. Depending on the type used, a hydrostatic housing may be included to protect the generator. A gearing system may be included to increase rotation rate from the rotor to the generator. Alternatively, the apparatus may be used to generate non-electrical forms of energy; for example, using a hydraulic generator or using a hydrogen generator to split water into hydrogen and oxygen. Suitable energy export devices will of course be necessary, and will be readily apparent to the skilled person; for example, gas export pipelines or the like.

Further, an array of individual apparatuses may be connected together at a central manifold. An electrical power cable may connect the manifold to the appropriate end user (onshore grid, storage batteries, transformer,

drilling rig, and so forth). The manifold may contain a transformer to increase voltage for export over long distances.

The apparatus may generally be installed at any location with sufficient water velocity to drive the rotor. Typically this would be at flow rates above 2 metres / second. It is expected that a suitable array of devices may be used to produce from 0.5 to 2 megawatts of electricity. The environmental impact will be limited, and since the devices may be located entirely subsea, there will be no visual impact from land. Further, with suitable depth, there will also be no or limited disruption to surface currents or shipping movements.

CLAIMS

1. An apparatus for generating energy from flowing water, the apparatus comprising a turbine rotor portion for being driven by flowing water, the turbine rotor portion being operably connected to an energy generator portion; and a support portion connected to one of the turbine rotor portion and the energy generator portion; wherein the support portion is adapted to be engaged with a portion of a guidebase assembly or similar structure so as to retain and anchor the apparatus in position.

2. An apparatus according to claim 1, wherein the guidebase assembly or similar structure comprises a subsea wellhead guidebase assembly.

3. An apparatus according to claim 2, wherein the support portion comprises a plurality of members arranged to engage with a plurality of upwardly extending members of the guidebase assembly.

4. An apparatus according to claim 3, wherein said members of the support portion are in the form of openings located on a supporting frame of the support portion.

5. An apparatus according to any preceding claim, wherein

at least one of the generator portion and the turbine portion are also adapted to be engaged with a portion of said guidebase assembly or similar structure.

6. An apparatus for generating energy from flowing water, the apparatus comprising a turbine rotor portion for being driven by flowing water, the turbine rotor portion being operably connected to a generator portion; and a support portion connected to one of the turbine rotor portion and the generator portion; wherein at least two of said portions are releasably connected to one another, such that said two of said portions may be deployed or retrieved separately from an underwater location.

7. An apparatus according to claim 6, wherein all three of the portions are releasably connected together.

8. An apparatus according to claim 7, wherein the turbine portion is connected to the generator portion, and the generator portion is connected to the support portion.

9. An apparatus according to claim 6 or claim 7, further comprising connectors for releasably connecting the portions together and for connecting the support portion to a wellhead guidebase assembly.

10. An apparatus according to any preceding claim, further comprising a wellhead guidebase assembly for engaging with the support portion.

11. An apparatus according to any of claims 1 to 9, further comprising at least one vertically oriented member for engaging with the support portion.

12. An apparatus according to claim 11, wherein four said vertically oriented members are provided, arranged in the corners of a quadrilateral.

13. An apparatus according to any preceding claim, wherein the support portion includes a ballast to assist in retaining the apparatus on the seabed.

14. An apparatus for generating energy from flowing water, the apparatus comprising a turbine rotor portion for being driven by flowing water and for connecting to an energy generator portion; and a support portion for connecting to one of the turbine rotor portion and the energy generator portion; wherein at least two of said portions are adapted to be releasably connected to one another, such that said two of said portions may be deployed or retrieved separately from an underwater location.

15. An apparatus according to any preceding claim, wherein the generator portion is an electrical generator portion.

16. An apparatus according to any preceding claim, further comprising additional portions for interposing between the generator portion and the turbine portion.

17. An apparatus according to claim 16, wherein the additional portions comprise spacer portions for raising the effective height of the turbine portion.

18. An apparatus according to claim 16, wherein the additional portions comprise buoyancy members.

19. An apparatus according to any preceding claim, wherein the turbine portion comprises a helical vertical rotor.

20. An apparatus according to any preceding claim, further comprising means for distributing the generated energy.

21. A system for generating energy from flowing water, the system comprising:

a plurality of apparatuses, each apparatus comprising a turbine rotor portion for being driven by flowing water, the turbine rotor portion being operably connected to an energy generator portion; and a support portion connected

to one of the turbine rotor portion and the energy generator portion;

wherein at least two of said portions are releasably connected to one another, such that said two of said portions may be deployed or retrieved separately from an underwater location;

a manifold for collecting and onwardly distributing energy generated by the apparatuses;

wherein each apparatus is in communication with the manifold to allow transmission of generated energy.

22. A system for generating energy from flowing water, the system comprising:

a plurality of apparatuses, each apparatus comprising a turbine rotor portion for being driven by flowing water, the turbine rotor portion being operably connected to an energy generator portion; and a support portion connected to one of the turbine rotor portion and the energy generator portion;

each said support portion being adapted to be engaged with a portion of a respective wellhead guidebase assembly so as to retain and anchor the apparatuses in position; and

a manifold for collecting and onwardly distributing energy generated by the apparatuses;

wherein each apparatus is in communication with the manifold to allow transmission of generated energy.

23. A method of deploying an apparatus for generating energy, the method comprising the steps of:

deploying a support portion on the seabed;

deploying a generating portion on the support portion, and releasably connecting the generating portion thereto; and

deploying a turbine rotor portion on the generating portion, and releasably connecting the generating portion thereto.

24. A method according to claim 23, wherein the support portion is deployed so as to anchor and engage with a portion of a guidebase assembly secured to the seabed.

25. A method according to claim 23, further comprising the step of deploying a guidebase assembly and securing the assembly to the seabed prior to deploying the support portion.

26. A method according to claim 23, wherein the support portion is deployed so as to anchor and engage with a portion of a Christmas tree which is itself engaged with a guidebase assembly secured to the seabed.

27. An apparatus for generating energy from flowing water as described herein and with reference to Figs. 1 to 3.

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Application No:	GB0408513.0	**Examiner:**	Catherine Allen
Claims searched:	1-5 & 22	**Date of search:**	10 August 2004

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 & 5	GB2348249 A ARMSTRONG et al
X	1 & 5	US4383182 A BOWLEY
X	1 & 5	JP2003269310 A TOSHIBA ENGINEERING CO
X	1 & 5	US2003/0146628 A SANCHEZ
X	1 & 5	WO2002/070890 A1 LIPP
X	1 & 5	WO2000/68567 A1 WORMS
X	1 & 5	WO2004/020821 A1 JOO
X	1 & 5	DE4325122 A WELSCH

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[W] :

F1S; F1T

Worldwide search of patent documents classified in the following areas of the IPC[07]

F03B

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

Online: EPODOC, JAPIO, WPI