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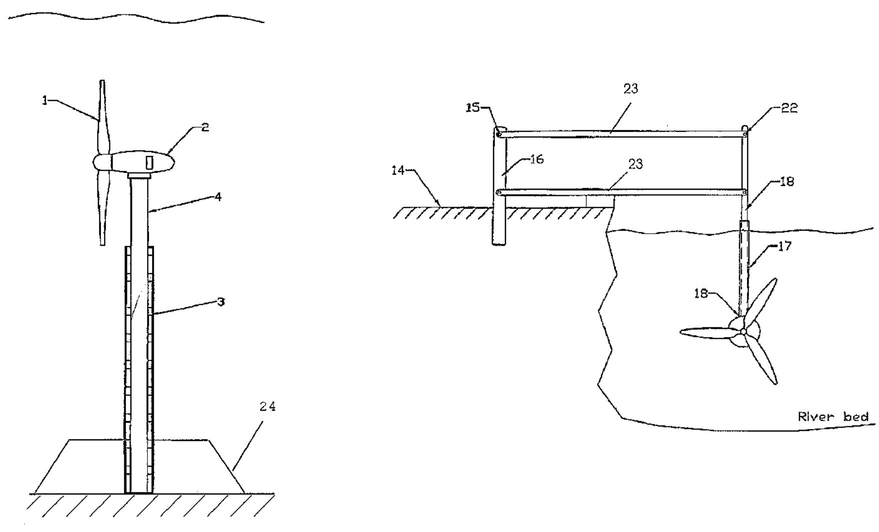
(54) Title: WATER TURBINE CAPABLE OF BEING LIFTED OUT OF THE WATER



(57) Abstract: A turbine for extracting power from flowing water, e.g. in rivers, estuaries, tidal flows etc., is submerged under the water and can be easily raised up for maintenance etc.

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WATER TURBINE CAPABLE OF BEING LIFTED OUT OF THE WATER

The present invention relates to water turbines that can utilise the kinetic energy of flowing water such as rivers, estuaries and tidal streams and can convert it to the rotational movement of an axle or the like. This rotational movement can be used to generate electricity, power pumps, etc.

Turbines to extract the kinetic energy from a fluid are well and widely used in wind power where they extract wind energy. Typically they consist of a rotor that converts the wind into a circular motion about an axis. This rotation is then transmitted by means of a shaft to a suitable load that uses the energy for a required purpose such as generating electricity.

Traditional hydro-electricity schemes require a large civil engineering structure to act as a barrage or dam, incurring problems with environmental disturbance such as the disruption of tidal patterns and related natural habitats. Also the detrimental impact of hydroelectricity schemes which flood areas of land on local populations and the environment are well documented.

A scheme which uses stand-alone turbines, which operate like wind turbines in the way that they absorb energy from the flow of the fluid without the need for a dam or similar structure, would minimise the environmental impact of water energy extraction. It would have added advantage that it can be applied in many sites where it is disadvantageous to interrupt the watercourse, like shipping channels, rivers and estuaries so that it would allow marine traffic and aquatic life to pass though the area with minimal disruption. The energy density of flowing water is considerably more than that of the wind and so it would be advantageous to use flowing water.

Wind turbines are well known and widely used. However for water, the turbine location and magnitude of forces involved differ substantially from wind turbines and hence require a different approach. This difference is especially pronounced in the installation and maintenance of turbines in a marine environment and the maintenance costs incurred by a water turbine in a marine environment would comprise a large proportion of the running costs.

Turbines for use in rivers have been disclosed in US Patent 3,986,787 and US Patent 4,7178,32. These patents disclose turbines suspended from floating platforms and can only be used in particular circumstances, especially with very large rivers and are expensive to install and maintain and susceptible to damage from surges etc.

We have now devised a system for extracting energy from flowing water which reduces these costs, reduces the effect of corrosion in a marine environment, has low environmental impact and ease of maintenance and incurs minimal costs while undertaking routine maintenance operations.

According to the invention there is provided a system for converting the kinetic energy of flowing water into rotational energy which comprises a turbine located below the surface of the water and which is supported on a support structure and in which the turbine has a rotor shaft on which blades are mounted and the flowing water acting on the blades turns the shaft.

The support structure is connected directly to the ground either beneath the flowing water, for example, the river bed or to the side, for example the river bank.

The turbine preferably uses an axial flow lift-type propeller turbine.

The energy converted by a turbine can be used for purposes that require energy input via a rotating shaft. In the case of this invention, the rotation of the shaft can be used to generate electricity or perform any other purpose.

All components of the turbine system are designed to resist the corrosive marine environment by using corrosion resistant materials, and easily accessible surfaces for ease of application of protective coatings.

The turbine blades are shaped for optimum efficiency and, can operate at fixed pitch or the pitch of the blades can be varied by a control system to increase the efficiency of the system under various flow conditions and the blades can be turned completely on a radial axis to enable the turbine to operate in reversed flow conditions. This pitching angle may be varied over the blade as a whole or over sections of the blade independently; also this pitching technique can be used to halt the turbine by angling the blades as such that no net torque is produced on the turbine axis.

Preferably there is a structure to protect the blades from marine debris and large marine life such as seals. Some marine mammals are renowned for their curious nature and it is therefore important to prevent them from reaching the installation. They can be deterred by sonic means or by a protective grid or mesh. This functions to allow the water to pass through with velocity, but prevents larger marine creatures from reaching the system components; it can also be of such design that marine debris is diverted from the blades and it can be constructed from corrosion resistant material. This grid can be used to protect an individual turbine or multiple turbines in the case of a multiple installation.

There can be a shroud fitted around the circumference of the blades to protect the tips of the blades from impact and to increase the velocity of the flow through the swept area of the blades. The blades can also be constructed in such a manner that they are able to resist the impact of marine debris should it collide with them.

Preferably the system is mounted on a support structure which enables the turbine to be raised above the water level and lowered below the water surface to facilitate the vertical displacement of the turbine and housing for the purpose of maintenance.

In one embodiment the support structure comprises a telescopic arrangement column attached to the ground below the water, e.g. the bed of a river or estuary or the sea or it can be held in place by gravity below the water.

The telescopic arrangement can be actuated by variable buoyancy of the uppermost section so that the section can have a positive buoyancy which causes the turbine to be raised up, e.g. by filling part of the section with air and lowered by filling this section with water. Optionally there can be multiple sections in which the buoyancy can be varied independently of each other; alternatively the telescopic arrangement can be actuated by a mechanical means.

In this case the telescopic arrangement can be actuated by a cable from a vessel above.

Preferably the telescopic arrangement has neutral buoyancy and, as such, can be easily displaced and can have a cross sectional profile as to be more streamlined than a cylinder.

The telescopic support is at least partially hollow and has at least one fluid inlet hole to allow for rapid pressure equalisation when the turbine is raised or lowered. In order to facilitate the raising and lowering of the turbine, preferably the telescopic arrangement incorporates low friction load carrying devices inside the telescopic overlaps.

Preferably the supporting arrangement incorporates seals to inhibit the ingress of silt and other marine debris and there can also be seals in the supporting means for the turbine.

An alternative method of supporting the turbine is by means of a hinged cantilever arrangement with one end of the cantilever arm attached to the turbine and the support for the cantilever arm attached to the ground. The support structure can be mounted to ground to the side of the flowing water or mounted onto a platform floating above the water. The cantilever arm can be hinged at the support structure and operated by a mechanical means such as a winch to actuate the hinged cantilever system.

Alternatively a variable buoyancy system can be used to assist in the operation of the hinged cantilever. Preferably the hinged cantilever arrangement is of the parallelogram type, in which the arc travelled by the turbine and housing, on displacement, follows a radius of the parallelogram length about a point directly horizontal to the operating position of the turbine.

In use, the turbine shaft transmits the produced torque, a thrust force and other vibration loadings from the turbine blades to the turbine housing. The thrust force and vibration loadings are preferably absorbed into the housing though low friction load bearing devices and the torque is absorbed through the generator. The consequence of this is that the housing must be capable of withstanding these forces, which in high flow conditions, are very large.

Preferably the turbine housing contains the load for the rotor, which can be, for example, electricity generation equipment or a pump, or a mechanical device suitable for performing other tasks can also be used. It is sealed against water ingress and includes a system to maintain a dry environment, such as a pump, to expel any leaked water, or an air or inert gas positive pressure system. The generating equipment includes a flexible coupling to a generator and electricity conditioning devices to prepare the electricity to be transmitted to the shore or for another use.

A gearbox can be employed to alter the speed of the shaft used to generate electricity. An embodiment of this design utilises a low speed electricity generator which eliminates the need for a gearbox, hence increasing the efficiency of the drive train; a low speed permanent magnet generator is suitable for this purpose.

Another embodiment of this design utilises a kinetic energy storage device such as a flywheel in such a way that it can be used to improve the operation of the system.

Performance monitoring and control systems can be contained within the sealed turbine housing, e.g. a torque measurement device, a blade pitch control system, a frequency monitor, a flow monitor, a temperature control system, a braking device and communications equipment can be located here. The flow monitor can consist of a central information processing point acting to interpret the measurements taken from one or more measurement devices that are located separately from the main structure of the turbine. In the case of a multiple installation the measurements from these devices can be interpreted individually by each turbine system or interpreted by one system to control more than one.

The turbine housing is attached to the supporting structure in order that the turbine arrangement is held in place in the water where required. Multiple rotors and housings can be supported by a common structure, hence reducing support costs.

In one embodiment of the invention, the housing is attached to the supporting structure in such a manner that it is able to rotate independently of the supporting structure to facilitate moving the rotor into or out of the direction of the oncoming fluid. Rotation out of the direction of flow can be required for maintenance etc. This rotation is facilitated by automated mechanical or electrical means, controlled using information from the flow monitoring system; this yawing mechanism is limited to 360 degrees to ensure that the electrical output cables do not twist indefinitely. In another embodiment the housing is firmly attached to the support structure and the support structure turns with the rotor independently of the foundation. Similarly the rotation is limited to 360 degrees. Alternatively, in situations where there is only one significant flow direction, such as a river, or two coaxial flow directions as in some tidal currents, the yawing mechanism is not required. The variable pitch mechanism can be used to reverse the direction of operation and the rotor can operate either upstream or downstream of the housing or both directions under different flow conditions.

An important aspect of the preferred embodiment of the invention is that the support structure provides a means of locating the housing and associated components during installation and returning them to the surface for maintenance. Access to the inside of the housing is obtained by way of a sealed entrance for maintenance, which can include mechanical routines such as replacing lubricants, the removal of biofouling from operating surfaces of the rotor and housing. This is additional to mechanisms that function to undertake automated maintenance during normal operation such as self-cleaning and self lubricating systems.

The invention is illustrated in the accompanying drawings in which
Fig. 1 shows an embodiment with the turbine in lowered and raised positions;
Fig. 2 shows a turbine raised and lowered by buoyancy;
Fig. 3 shows details of the shape of the support structure profile;
Figs. 4 and 5 show cantilever arrangements.

Referring to fig. 1, this shows an embodiment of the invention that allows the entire system to be submerged. This is advantageous in that there is no visual impact, and minimal disruption to marine traffic. There is a telescopic supporting structure (3) consisting of one or more sections that slot inside one other enabling the turbine housing to be displaced vertically during installation and maintenance. The turbine housing is attached to the uppermost section (4). The system is secured to the sea bed by some means which may be a gravity anchor (24). The arrangement is dimensioned as such that the turbine housing can be vertically displaced from the position of fig. 1a to above the surface (5) as shown in fig. 1b in order that maintenance operations can be undertaken. During these operations the turbine housing remains firmly supported by the structure to enable this position to be sustained in periods of high current flow. This is advantageous in that maintenance can be undertaken over a sustained period without requiring the housing to be lowered to avoid the forces experienced in periods of high flow. No large ship or divers are required to carry out maintenance operations so these costs are not incurred.

One fluid inlet or multiple inlets are situated in the telescopic sections to allow for pressure equalisation when the arrangement is displaced. These holes can incorporate restrictive devices such as valves to assist in control in the ascent and descent.

Low friction, load bearing, corrosion resistant devices (6) are installed between the telescopic sections to reduce the frictional loads between them and increase the operating life of the structure. It is important that these devices function to support the structure during turbine operation as the loads experienced increase dramatically.

There are seals (7) at the entrances of each telescopic section to provide protection from silt and other marine debris. These must be capable of allowing the displacement of the telescopic arrangement and be resistant to biofouling. These will be installed before the installation of the system to eliminate the need for manual intervention underwater.

The electrical cables are fed from the turbine housing to a place at the base of the telescopic arrangement enabling them to travel to shore underwater creating minimal visual impact. In use, the device is in the position of fig. 1a. When maintenance is required etc. the telescopic section is extended and the turbine raised above the water.

Referring to fig. 2 this shows the telescopic arrangement actuated by variable buoyancy. This can be one buoyancy chamber, or more likely multiple smaller chambers that allow for controlled sinking of the lower chambers to bring the arrangement vertical during installation. A buoyant system will allow the structure to be floated into position during installation and decommissioning, hence reducing the requirements of the deployment vessels.

To supply the ballast pump with air, a refillable compressed air system can be used to store air whilst the turbine is above water. Alternatively a releasable floating pipe arrangement can be used. When required, the floating pipe (8) is released from the turbine housing on a winch cable (9). This reaches the surface and then supplies the ballast pump with air. When the housing reaches the surface the pipe is winched back into the housing and can be re-packed with corrosion resistant protection (10). In use the turbine is in the operating position of fig. 1a, buoyancy chamber(s) are filled with air and the turbine rises up to the position of figs. 2b and 2c. Alternatively the air inlet pipe can be grouped with the electrical cables, as such that the inlet is located on land close to the point where the cables emerge.

Other methods of actuation include mechanical in the form of rack and pinions, worm gears or screw type methods. Hydraulics can also be utilised to similar effect, also a lifting vessel method can be used, wherein a cable is either released in a similar method to the floating pipe arrangement as described, or a diver can be used to affix it manually.

Mechanical methods of actuation can be improved by incorporating neutral buoyancy into the displaceable aspects of the system. This will reduce the forces experienced during actuation and hence the requirements of system components.

Referring to fig. 3, this shows different embodiments of shape of the cross section of the telescopic sections. A circular cross section (12) can be used, the primary disadvantage being that some additional means such as a sliding rail is required to take the torque loading about the central axis. These loads will occur in ordinary operation owing to fluctuations in flow velocity, and comprise a significant force on the system. A non-circular cross section will have the advantage that this load can be incorporated into the shape (13) and fig. 3b which shows an example of a streamlined section that will function both to eliminate torque concerns and reduce the loading on the structure through the reduction of drag forces. It is desirable that streamlined telescopic sections will turn with the rotor into the direction of flow. Hydrodynamic control surfaces can be incorporated to assist in manoeuvering and stabilising the device.

Additional streamlining can be affixed to the telescopic arrangement and the housing to reduce drag forces and minimise oscillatory forces originating in the wake.

A second embodiment of the support structure is shown in figs. 4 and 5 where the support structure is not completely submerged. It is intended for use on smaller installations where access can be gained from a platform consisting either of the land at the side of a watercourse or a floating platform. This embodiment incorporates a hinged cantilever that functions to lower the turbine housing into the water.

In this embodiment the hinged cantilever arrangement is a parallelogram type and the system consists of a structure mounted through hinge (15) on platform or bank (14) through upright supports (16). The turbine housing is suspended from an upright frame (17) which can be braced and streamlined to increase the stiffness and reduce the effects of system oscillation. The hinges (15) are low friction, high stiffness devices to prevent vibration and enable ease of lifting.

The parallelogram cantilever arrangement comprises support (16) connected to cantilever arms (23) by hinges (15). The other end of the arms (23) are connected by hinges (22) to turbine support (17) on which turbine (21) is mounted. The arc traveled by the turbine and housing on displacement follows a radius of the parallelogram length about a point directly horizontal to the operating position of the turbine (21). If dimensioned effectively this allows the turbine housing to be very easily accessible on the platform or bank (14).

A land platform installation shown in fig. 4 in a region of flow with varying direction requires a yawing mechanism (18) as described above. If the velocity is constant, for example in a river, the plane of rotation can then be fixed to suit the flow direction; the electrical output cable is run up the structure to a point on land where it can be utilised. For maintenance the turbine can be lifted out of the water and can be accessed from the platform or bank (14).

A floating platform installation shown in fig. 5 rotates about an anchoring point (19) with the flow so no yawing mechanism is required. The electrical cable is run up the structure onto the platform where it follows the anchor cable to the bed where it is transmitted under the water to the shore.

The hinged cantilever arrangement can be actuated by mechanical means including a winch or hydraulics. Buoyancy effects can be utilised to assist displacement; however this will not remove the turbine housing and rotor from the water completely.

Claims

1. A system for converting the kinetic energy of flowing water into rotational energy which comprises a turbine located below the surface of the water and which is supported on a support structure and in which the turbine has a rotor shaft on which blades are mounted and the flowing water acting on the blades turns the shaft.

2. A system as claimed in claim 1 in which the support structure is connected directly to the ground.

3. A system as claimed in claim 2 in which the support structure is supported by the ground beneath the flowing water.

4. A system as claimed in claims 2 or 3 in which the turbine is supported on a support structure which comprises a telescopic arrangement comprising a plurality of telescopic components which enables the turbine to be raised and lowered.

5. A system as claimed in claim 4 in which the telescopic arrangement is actuated by variable buoyancy of a section.

6. A system as claimed in claims 4 or 5 in which the telescopic arrangement is actuated by variable buoyancy of a plurality of its telescopic sections and in which the buoyancy of the sections can be varied independently of each other.

7. A system as claimed in claim 4 in which the telescopic arrangement is actuated by a mechanical means.

8. A system as in claim 4 wherein the telescopic arrangement is actuated by a cable from a vessel above.

9. A system claimed in any one of claims 4 to 8 in which the telescopic support has substantially neutral buoyancy.

10. A system as claimed in one of claims 1 to 9 in which the support has a streamlined cross sectional profile.

11. A system as claimed in any one of claims 1 to 10 in which there is at least one fluid inlet hole connecting the interior of the support structure to the water to allow for rapid pressure equalisation when the turbine is raised or lowered.

12. A system as claimed in any one of claims 4 to 11 in which the telescopic arrangement incorporates low friction load carrying devices on the surfaces of the telescopic components which overlap.

13. A system as claimed in any one of the preceding claims in which the supporting arrangement incorporates seals to inhibit the ingress of silt and other marine debris.

14. A system as claimed in claims 1 or 2 wherein the support structure comprises a hinged cantilever arrangement.

15. A system as claimed in claim 12 wherein the support structure is mounted on the ground to the side of the flowing water.

16. A system as claimed in claim 14 wherein the support structure is mounted onto a platform floating on the water.

17. A system as claimed in claim 14 in which mechanical means are utilized to actuate the hinged cantilever system.

18. A turbine system as claimed in claim 17 in which the mechanical means

comprises a winch mechanism to actuate the hinged cantilever system.

19. A turbine system as claimed in claim 14 in which variable buoyancy is used to assist in the actuation of the hinged cantilever.

20. A turbine system as claimed in claim 14 wherein the hinged cantilever arrangement is of the parallelogram type, and the arc travelled by the turbine and its housing on displacement follows a radius of the parallelogram length about a point directly horizontal to the operating position of the turbine.

21. A system as claimed in any of the preceding claims in which the turbine housing is able to rotate on a vertical axis about the telescopic arrangement to enable the turbine to face into and out of the direction of water flow.

22. A system as claimed in any one of the preceding claims in which the support structure is able to rotate on a vertical axis about and independent of its foundation to enable the turbine to face into the direction of water flow.

23. A system as claimed in any one of the preceding claims in which the turbine utilises a mechanism to alter the pitch of the blades.

24. A system as claimed in any one of the preceding claims in which the turbine utilises a mechanism to alter the pitch of sections of the blades independently of each other.

25. A system as claimed in any one of claims 1 to 22 in which the turbine has blades with blades that are fixed.

26. A system as claimed in any one of the preceding claims in which there is an electrical generator which can function efficiently at the rotational speed of the shaft

and is connected directly to the shaft without gearing.

27. A system as claimed in claim 26 in which the generator can run at variable speed.

28. A system as claimed in claim 26 or 27 wherein the generator is of a permanent magnet type.

29. A system as claimed in any one of the preceding claims in which the complete system is submerged in normal functioning.

30. A system as claimed in any one of the preceding claims in which there is a releasable air inlet that can float to the surface.

31. A system as claimed in any one of the preceding claims in which there is a compressed air system for the purpose of varying the buoyancy of a central section of the support structure.

32. A system as claimed in any one of the preceding claims which incorporates a system to remove any ingressed fluid from any sealed components.

33. A system containing a turbine as claimed in any one of the preceding claims and a flow monitoring system in order that the flow characteristics of the water can be ascertained without disturbance from the turbine being present in the measurements.

34. A system as claimed in any one of the preceding claims which incorporates a kinetic energy storage device to improve the operation of the system.

35. A multiple system which comprises a plurality of systems as claimed in any one of the preceding claims that act together to form one power generation unit.

36. A system as claimed in any one of the preceding claims which incorporates a sonic device for the purpose of deterring marine life from approaching the system.

37. A system as claimed in any one of the preceding claims that incorporates a structure to protect one or more turbines from marine debris and large marine life.

38. A system as claimed in claim 37 in which a structure to protect one or more turbines from marine debris and large marine life functions in such a way that marine debris is diverted away from the structure and the turbine blades.

39. A system as claimed in any one of the preceding claims which incorporates a structure positioned around the circumference of the blades of the turbine which acts to protect the tips of the blades and to increase the velocity of the flow through the blades.

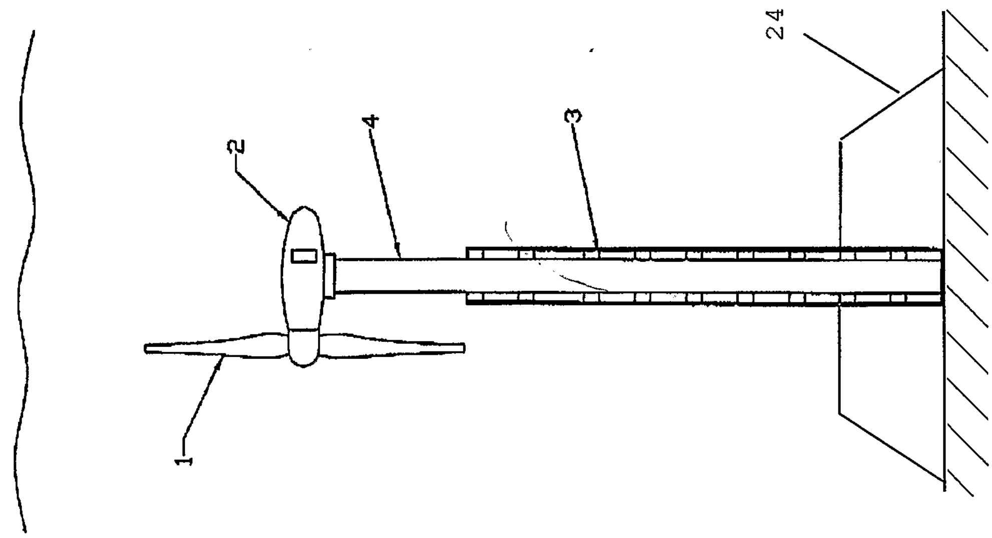

Fig. 1a

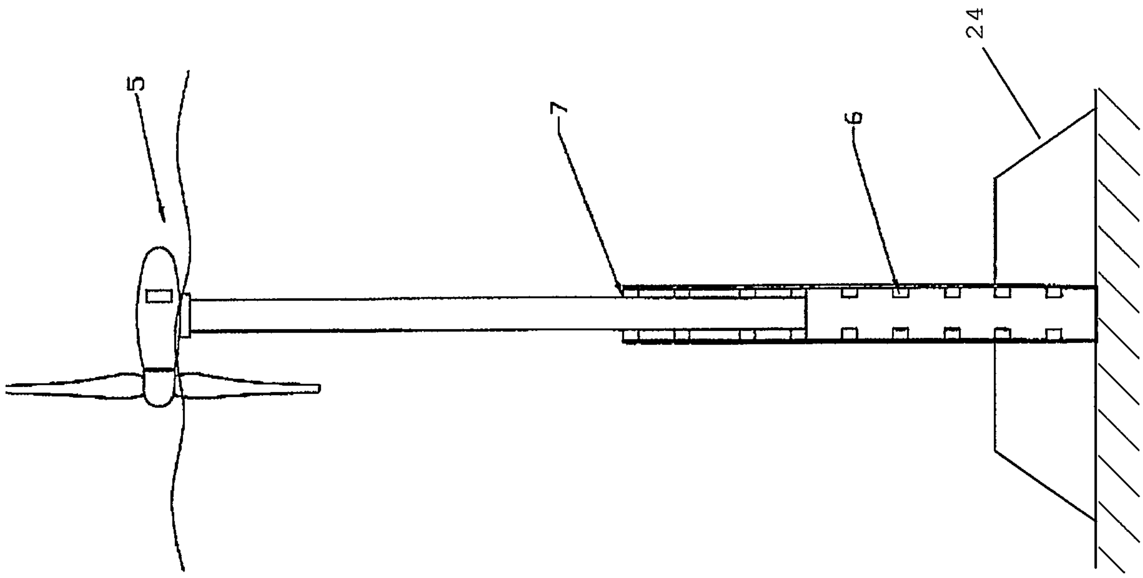

Fig. 1b

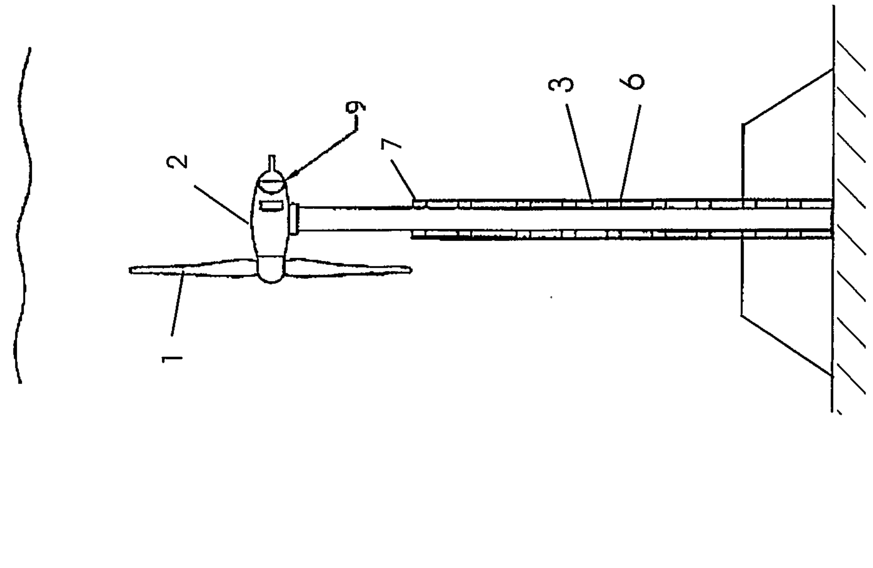

Fig. 2a

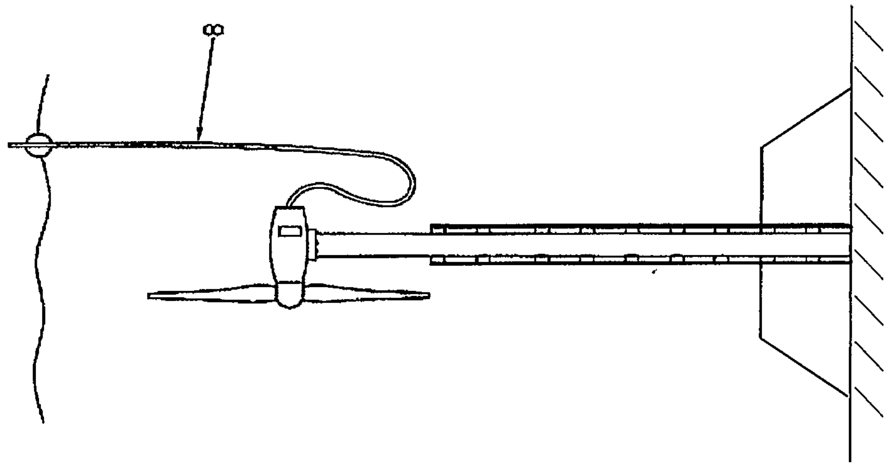

Fig. 2b

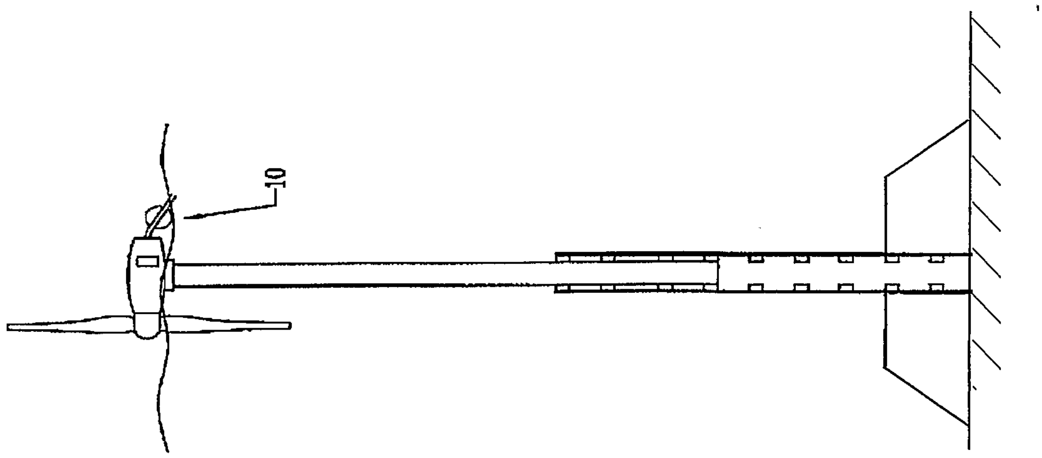

Fig. 2c

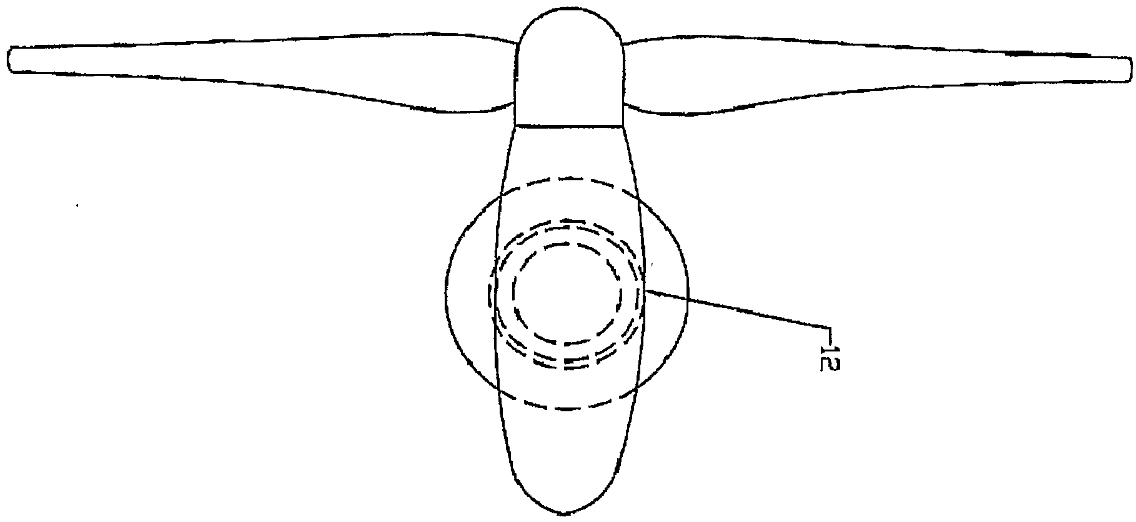

Fig. 3a

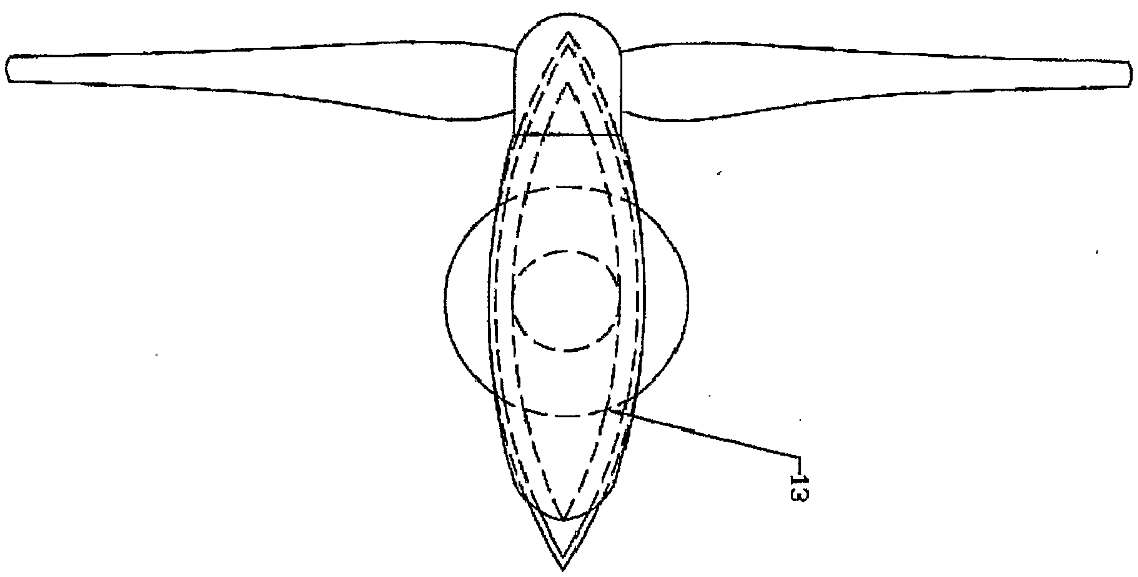

Fig. 3b

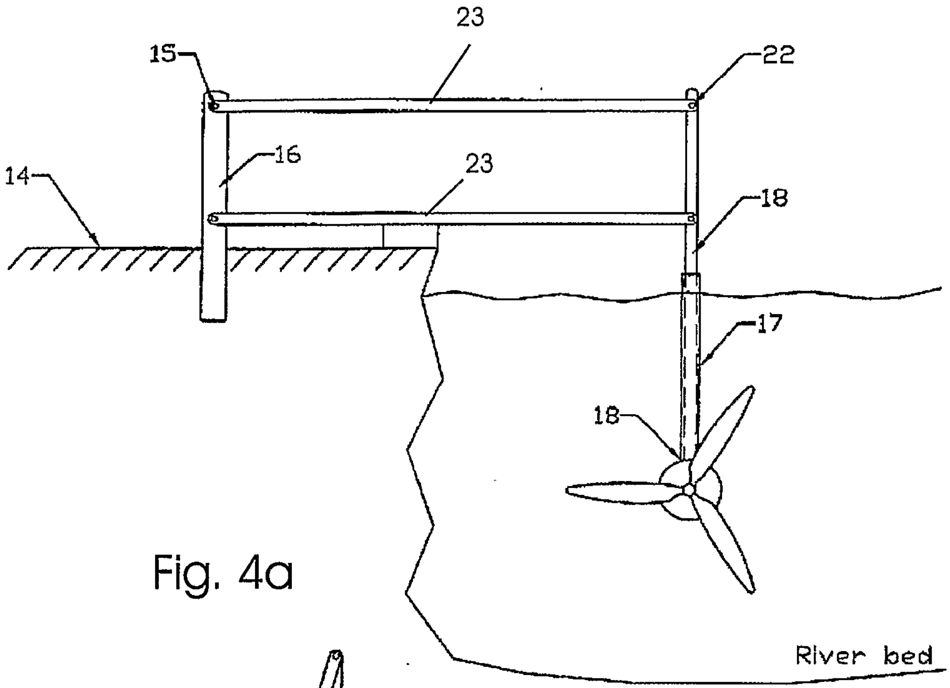

Fig. 4a

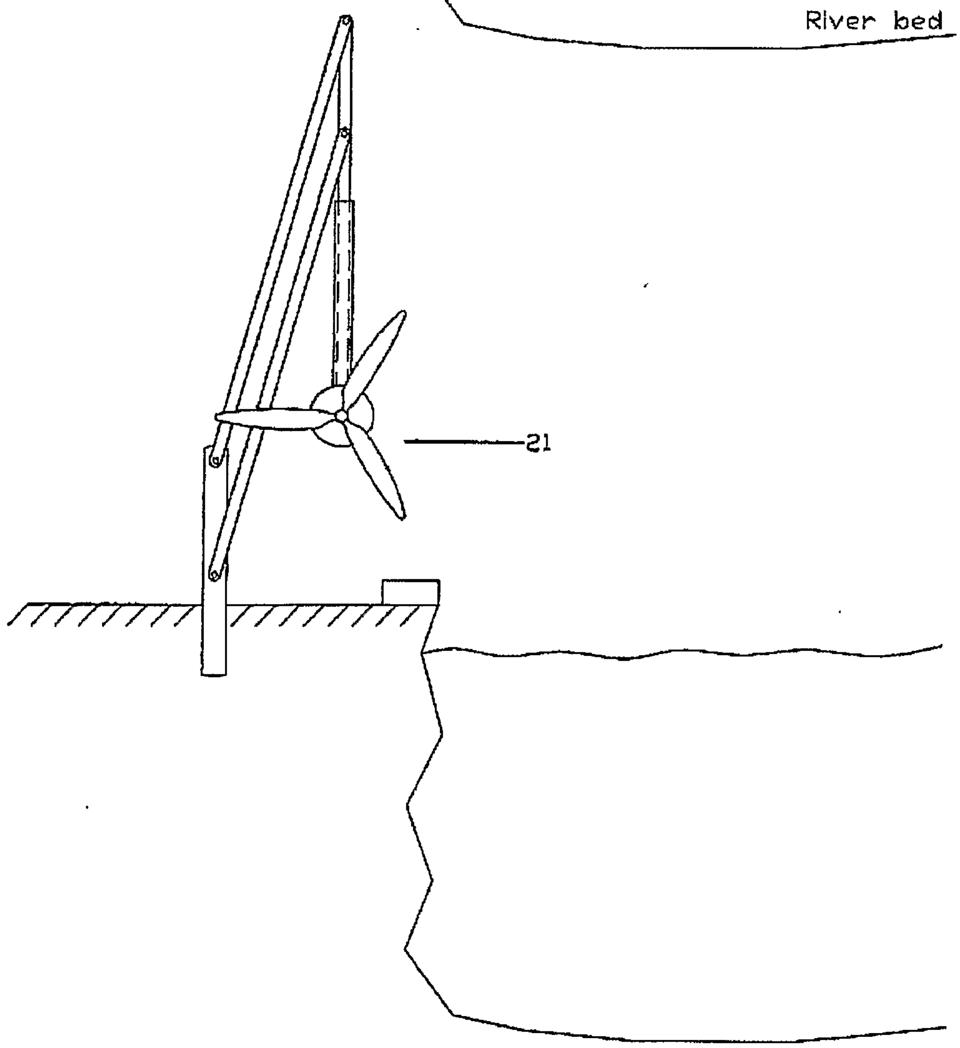

Fig. 4b

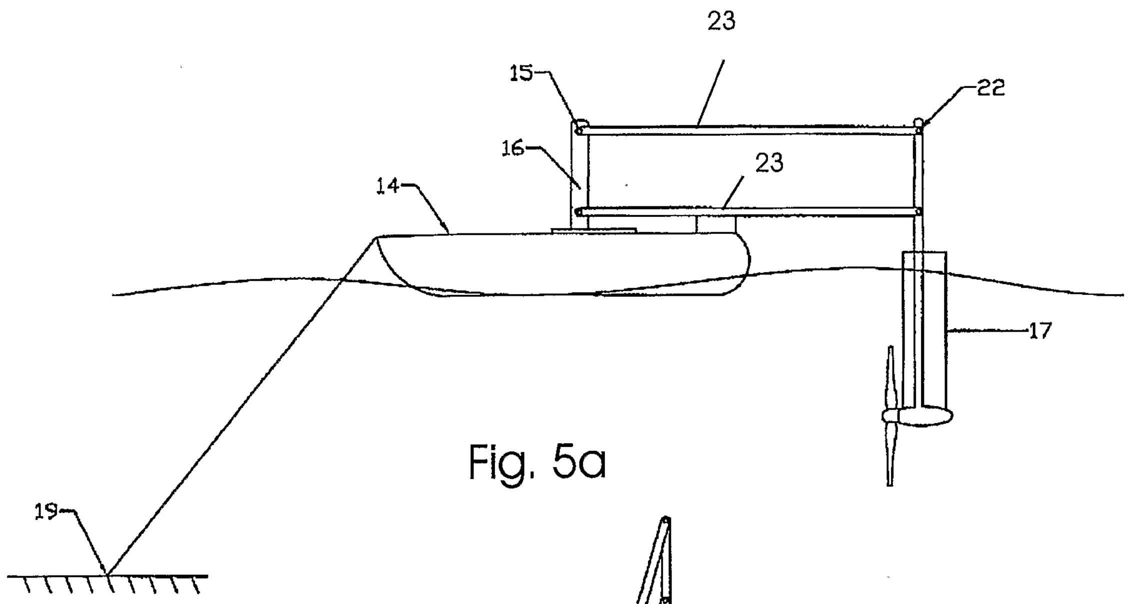

Fig. 5a

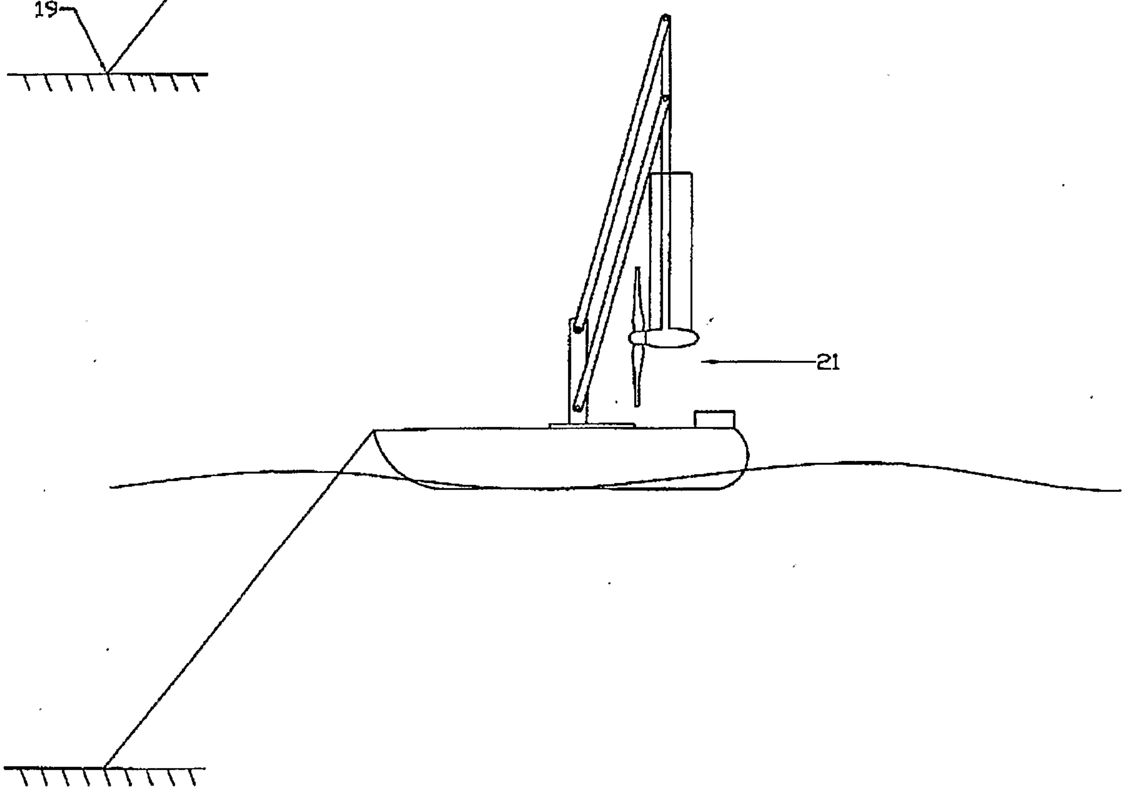

Fig. 5b

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB2004/005189

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 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)
IPC 7 F03B F03D

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

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 652 221 B1 (PRAENKEL PETER) 25 November 2003 (2003-11-25)	1-5, 7-10,12, 14, 16-19, 21-23, 25-29, 31,34,35
A	column 2, line 42 - line 53 column 3, line 36 - column 5, line 37 column 6, line 57 - column 9, line 30 abstract; figures 1-3,8-17 ----- -/--	6,11

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

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 March 2005	13/04/2005

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, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	O'Shea, G

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 348 249 A (JOHN RICHARD CAREW * ARMSTRONG) 27 September 2000 (2000-09-27)	1-5,9, 10,13, 14, 21-23, 25-29, 31-33
A	page 1 - page 3 abstract; claims 10,13; figures	6,30
X	FR 2 704 908 A (GARRIGOU JOEL) 10 November 1994 (1994-11-10) page 1, line 1 - line 4 page 1, line 31 - page 2, line 6 page 2, line 35 - page 3, line 7 abstract; figures	1,2, 14-18, 20,23-29
X	WO 03/025385 A (CLEAN CURRENT POWER SYSTEMS INC; DAVIS, BARRY, V; GRILLOS, EMMANUEL; A) 27 March 2003 (2003-03-27) page 8, line 11 - page 10, line 3 page 12, line 12 - line 26 page 15, line 11 - page 16, line 22 abstract; figures 1,9,10,17-27	1-4,8, 16, 25-29, 35,37-39
X	WO 01/16483 A (TABARASI, STELIAN) 8 March 2001 (2001-03-08) page 3 - page 5 abstract; figures	1-3, 14-18, 23,24, 26-29
X	US 4 932 007 A (SUOMALA ET AL) 5 June 1990 (1990-06-05) column 1, line 10 - line 40 column 2, line 26 - column 3, line 15 abstract; figure 1	1,36

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB2004/005189

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

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

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

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

1. claims: 1-13,21-39

   A submerged water turbine being supported on the ground, the turbine being capable of being lifted out of the water by means of a telescopic arrangement. Various actuation means are provided as well as other constructional details.

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2. claims: 1,2,14-18,22-39

   A submerged water turbine being supported on the ground, the turbine being capable of being lifted out of the water by means of a hinged cantilever arrangement. Various actuation means are provided as well as other constructional details.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB2004/005189

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 6652221	B1	25-11-2003	AT	277282	T	15-10-2004
			AU	766741	B2	23-10-2003
			AU	2681900	A	14-09-2000
			CA	2367715	A1	31-08-2000
			DE	60014071	D1	28-10-2004
			EP	1183463	A1	06-03-2002
			WO	0050768	A1	31-08-2000
			GB	2348465	A ,B	04-10-2000
			NZ	514274	A	25-06-2004
			NZ	531809	A	25-02-2005
			GB	2347976	A ,B	20-09-2000
			GB	2348250	A ,B	27-09-2000
GB 2348249	A	27-09-2000	NONE			
FR 2704908	A	10-11-1994	FR	2704908	A1	10-11-1994
WO 03025385	A	27-03-2003	WO	03025385	A2	27-03-2003
			CA	2460479	A1	27-03-2003
			EP	1430220	A2	23-06-2004
			JP	2005502821	T	27-01-2005
WO 0116483	A	08-03-2001	RO	115748	B	30-05-2000
			WO	0116483	A1	08-03-2001
US 4932007	A	05-06-1990	NONE			