(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 June 2012 (21.06.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/080749 A1

(51) International Patent Classification:
F03B 13/18 (2006.01) *F03B 13/22* (2006.01)

(21) International Application Number:
PCT/GB2011/052502

(22) International Filing Date:
16 December 2011 (16.12.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1021471.6 17 December 2010 (17.12.2010) GB

(72) Inventor; and
(71) Applicant : **FOSTER, David** [GB/GB]; 124 Kiln Lane, St. Helens, Merseyside WA10 4RJ (GB).

(74) Agent: **FORRESTERS**; 15 Hamilton Square, Birkenhead, Merseyside CH41 6BR (GB).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

[Continued on next page]

(54) Title: WAVE POWERED ELECTRICITY GENERATOR

(57) Abstract: An electricity generating device for converting the power of waves into electricity is provided. The device has a support member (1) and a main body portion (2) mounted on the support member (1). The device also has a lever arm (4) pivotably connected to the main body portion (2), said lever arm having a buoyant member (5) secured thereto. The device also having a piston (3a) being connected to the lever arm (4), said piston being arranged to reciprocate within a cylinder (3) attached to, or within, the main body portion (B). The movement of the buoyant member (5), acting via the lever arm (4), causes the piston (3a) to reciprocate within the cylinder (3) to provide a pumping action to force water through a pipe (6) connected to an outlet of said cylinder (3) to drive an impeller (7) connected via a system of gears (8a, 8b) to an electrical generator (9).

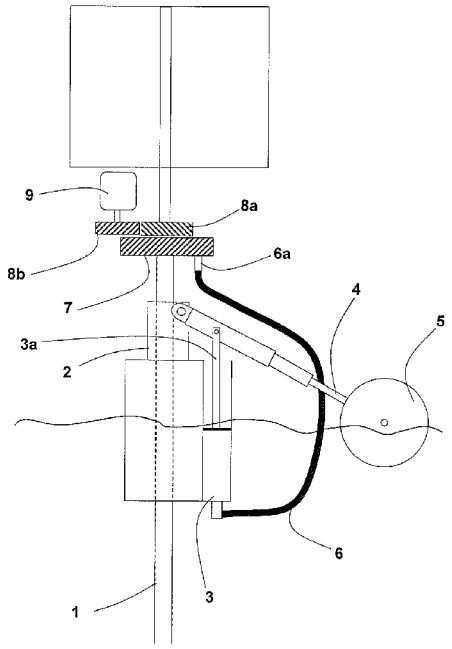

Fig. 1

WO 2012/080749 A1

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

WAVE POWERED ELECTRICITY GENERATOR

The present invention relates to an electricity generator which utilises wave action to generate electrical power.

Various attempts have been made over the years to seek to obtain power from renewable sources such as wind, solar and wave energy, resulting in the production of wind farms and solar panels for such purpose. Of the various attempts to generate electricity from wave action, one of the most famous of these is the "Salter duck", patented in the 1970's by Stephen Salter which utilised a plurality of moveable members, the surfaces of which engage an oncoming wave and are caused to rotate about a substantially horizontal axis before returning to their original position after the wave has passed. The upward and downward rotation of the moveable members is then converted into mechanical or electrical energy. However, there have been many attempts over the past 100 or more years to extract energy from wave power.

It is the object of the present invention to seek to provide an improved wave powered electricity generator.

According to the present invention there is provided an electricity generating device for converting the power of waves into electricity, comprising: a support member, a main body portion mounted on a support member, a lever arm pivotably connected to the main body portion, said lever arm having a buoyant member secured thereto, a piston being connected to the lever arm, said piston being arranged to reciprocate within a cylinder attached to, or within, the main body portion so that movement of the buoyant member, acting via the lever arm, causes the piston to reciprocate within the cylinder to provide a pumping action to force water through a pipe connected

to an outlet of said cylinder to drive an impeller connected via a system of gears to an electrical generator.

Preferably the main body portion may be displaceably mounted on the support member. In this way it is able to rise and fall with the level of the tide to ensure that the movement of the buoyant member (e.g. float), acting via the lever arm, is optimised for all tide heights. Further preferably the main body portion may be securable in position on the support member. In this way the main body portion can be prevented from moving relative to the support body when necessary, for example, for maintenance or cleaning.

Preferably the buoyant member may be secured to the distal end of the lever arm.

Alternatively the buoyant member may be secured to the distal end of a secondary arm, which is mounted perpendicular to the lever arm. Further preferably the secondary arm may be mounted on the lever arm by connecting means that permit the buoyant member, which is mounted on the secondary arm, to move relative to the lever arm in a horizontal direction, a vertical direction or both horizontally and vertically. In this way the position of the buoyant member relative to the lever arm can be varied to optimise the device for all tide heights.

Advantageously the connecting means may comprise drive means that are operable to move the buoyant member relative to the lever arm. In this way the buoyant member position can controlled remotely and/or automatically in response to changes in the wave conditions/tide heights.

Preferably the lever arm may be telescopic, so as to be adjustable for different wave heights, since generally, the higher the waves, the longer the lever-arm would need to be, and vice versa. This feature is considered

particularly useful when the buoyant member is secured to the distal end of the lever arm.

Alternatively, the lever arm could be set at an average wave height. Further, it will be appreciated that a number of the lever-arm, buoyant member (e.g. float), piston arrangements could be provided on a single main body portion, each operating in parallel.

The present invention will now be described further with reference to the accompanying drawings in which Figure 1 show a first preferred embodiment of the wave powered electricity generator of the present invention and Figure 2 shows a second preferred embodiment.

Referring first to Figure 1, in which an example of a wave powered electricity generator according to the invention is shown to comprise a support member 1, which may be secured to the seabed or to some other structure already in position e.g., a support member of a wind tower, or a leg of a pontoon or pier, or an oil rig or other such structure. Releasably mounted on the support member 1 is a main body portion 2, which is generally able to follow the height of the tide, when the generator is used in coastal or tidal areas. The main body portion 2 can also be secured in position on the support member 1, for example, to enable cleaning or maintenance of the device, or to secure such in extreme sea conditions.

Attached to the main body 2 is a lever-arm 4, which is pivotally connected to the main body 2, and which has at its distal end a float 5, which rises and falls with wave motion. A piston 3a is attached to lever arm 4 and is arranged so as to reciprocate within cylinder 3 under the action of wave motion acting on the float 5. The piston 3a forces water through an outlet opening in the cylinder 3 to force water through a flexible hose 6 to drive an impeller 7.

The piston and cylinder arrangement 3a, 3 will include appropriate non-return valves (not shown). Preferably at least a portion of the cylinder 3 is located under the water line so that the cylinder can refill with water as the piston 3a returns.

The impeller 7 is connected via a system of gears 8a and 8b to drive a generator 9, which generates electricity, which can then be taken off to drive electrical equipment or devices or feed into a power grid.

The lever-arm 4 is preferably adjustable in length, e.g., by providing such as a telescopic arm to allow the length of such to be adapted to the wave height, and further, alternative types of linkages other than shown could be utilised, subject only to the requirement that such can accommodate a piston which can be reciprocated by the lever arm attached to the float 5.

Figure 2 shows an alternative embodiment of a wave powered electricity generator according to the invention. The main body portion of the device 11 is mounted on to a support member 10. A lever arm 12 is pivotably connected to the main body portion 11.

Rather than having a float mounted on the lever arm 12 itself, the float 15 is mounted on a secondary arm 13, which is in turn mounted on the lever arm 12. Although the float 15 is shown in Figure 2 as being mounted at the top end of the secondary arm 13 it is envisaged that the float 15 might alternatively be mounted on the bottom end of the secondary arm 12.

The second arm 13 is slideably mounted on the lever arm 12 by suitable connecting means 14. The connecting means 14 ensures that the orientation of the lever arm 12 and secondary arm 13 is maintained so that they stay at a right angle to one another. The connecting means are also

operable to facilitate the sliding movement of the secondary arm 13 in both a vertical plane and a horizontal plane of movement relative to the lever arm 12.

It will be appreciated that this arrangement enables the position of the buoyant member (e.g. the float) 15 to be varied to suit different tide heights. This is important as the present embodiment as the main body portion 11 is fixed in position on the support member 10. However it is appreciated that the arrangement could also be usefully implemented when the main body portion is displaceably mounted on a support member to give additional control over the positioning of the float 15 relative to the lever arm 12.

It is envisaged that the connecting means 14 may comprise locking means, to lock the relative positions of the lever arm 12 and the secondary arm 13, and drive means (not shown) to move the secondary arm 13 relative to the lever arm 12.

The drive means could take the form of a rack and pinion arrangement or the like. It is also envisaged the drive means would be operable by electric motors, which could be controlled remotely or automatically to adjust the positioning of the float 15 relative to the lever arm 12.

As described in connection the embodiment shown in Figure 1 a piston 16a is attached to lever arm 12 and is arranged so as to reciprocate within cylinder 16 under the action of wave motion acting on the float 15. The piston 16a forces water through an outlet opening (not shown) in the cylinder 16 to force water through a flexible hose to drive an impeller, neither of which are shown in Figure 2.

A plurality of lever-arms and piston cylinder arrangements could be mounted to a single main body portion 2, 11 or support member to seek to achieve a smooth supply of electricity.

It is envisaged that the electricity generating devices of the present invention could be incorporated into sea-based wind farms to augment the supply of electricity, even in reduced wind conditions, or could be provided as free-standing devices possibly along a shoreline, feeding electricity to a shore-based station. Such devices could also be mounted on to oil-rigs and decommissioned oil-rigs.

Thus, there is provided an electricity generating device capable of converting wave action into electrical energy.

Claims

1. An electricity generating device for converting the power of waves into electricity, comprising:

a support member, a main body portion mounted on a support member, a lever arm pivotably connected to the main body portion, said lever arm having a buoyant member secured thereto, a piston being connected to the lever arm, said piston being arranged to reciprocate within a cylinder attached to, or within, the main body portion so that movement of the buoyant member, acting via the lever arm, causes the piston to reciprocate within the cylinder to provide a pumping action to force water through a pipe connected to an outlet of said cylinder to drive an impeller connected via a system of gears to an electrical generator.

2. The electricity generating device of claim 1 or 2, wherein the main body is displaceably mounted on the support member.

3. The electricity generating device of claim 3, wherein the main body portion is securable in position on the support member.

4. The electricity generating device of claim 1, 2 or 3, wherein the buoyant member is secured to the distal end of the lever arm.

5. The electricity generating device of claim 1, 2 or 3, wherein the buoyant member is secured to the distal end of a secondary arm, which is mounted perpendicular to the lever arm.

6. The electricity generating device of claim 5, wherein the secondary arm is mounted on the lever arm by connecting means that permit the buoyant member, which is mounted on the secondary arm, to move relative to the

lever arm in a horizontal direction, a vertical direction or both horizontally and vertically.

7. The electricity generating device of claim 6, wherein the connecting means comprise drive means that are operable to move the buoyant member relative to the lever arm.

8. The electricity generating device of any of the preceding claims, wherein the lever arm is telescopic.

9. The electricity generating device of any of the preceding claims, wherein the main body portion comprises a plurality of lever arm, float, piston arrangements operating in parallel.

10. The electricity generating device of any of the preceding claims, wherein the support member is securable to the seabed.

11. The electricity generating device of any of claims 1 to 9, wherein the support member is securable to or part of an existing structure that is preferably selected from the group consisting of: a wind tower; a pontoon or pier; and an oil rig.

12. An electricity generating device for converting the power of waves into electricity substantially as described, with reference to the drawing, hereinbefore.

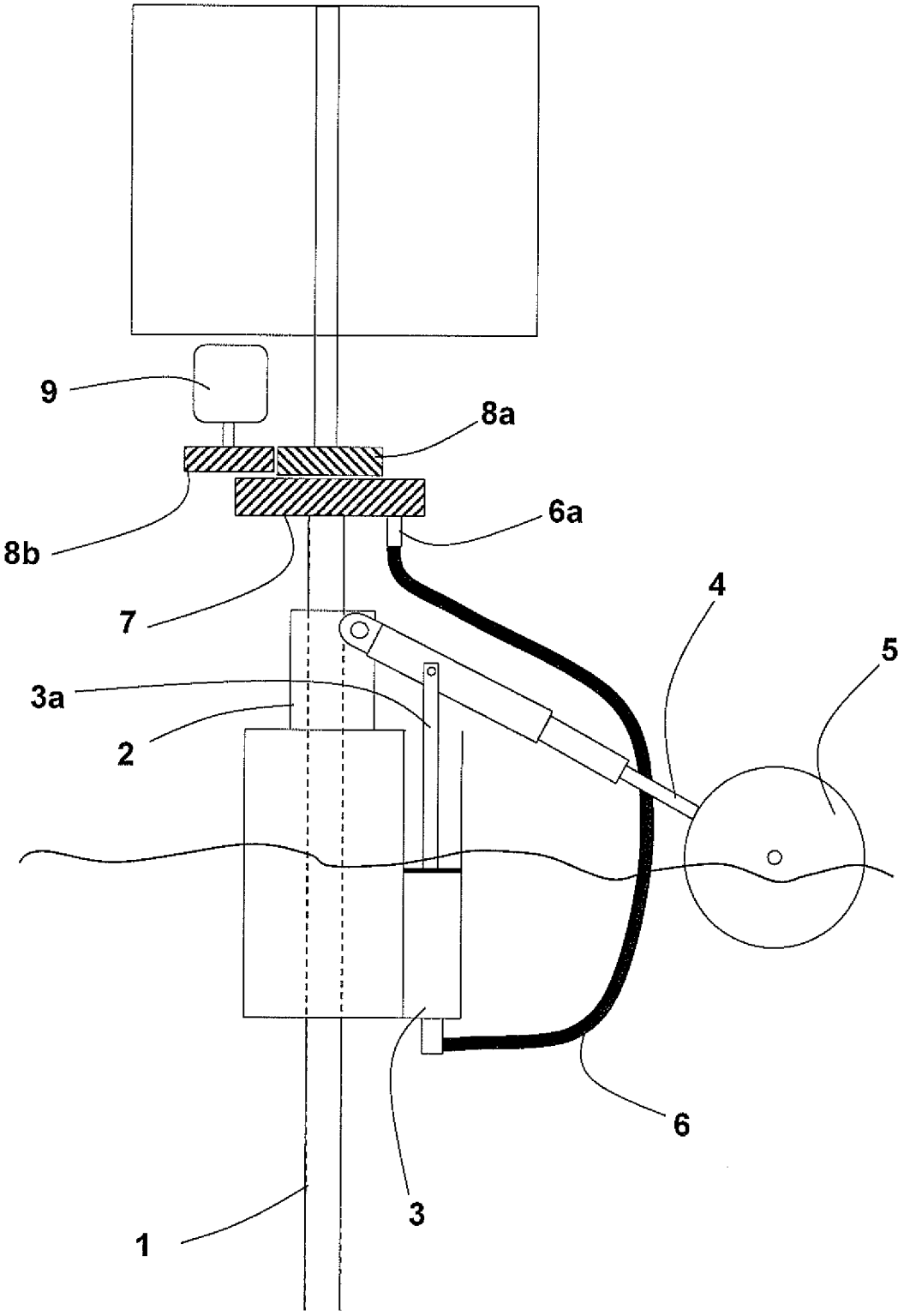

Fig. 1

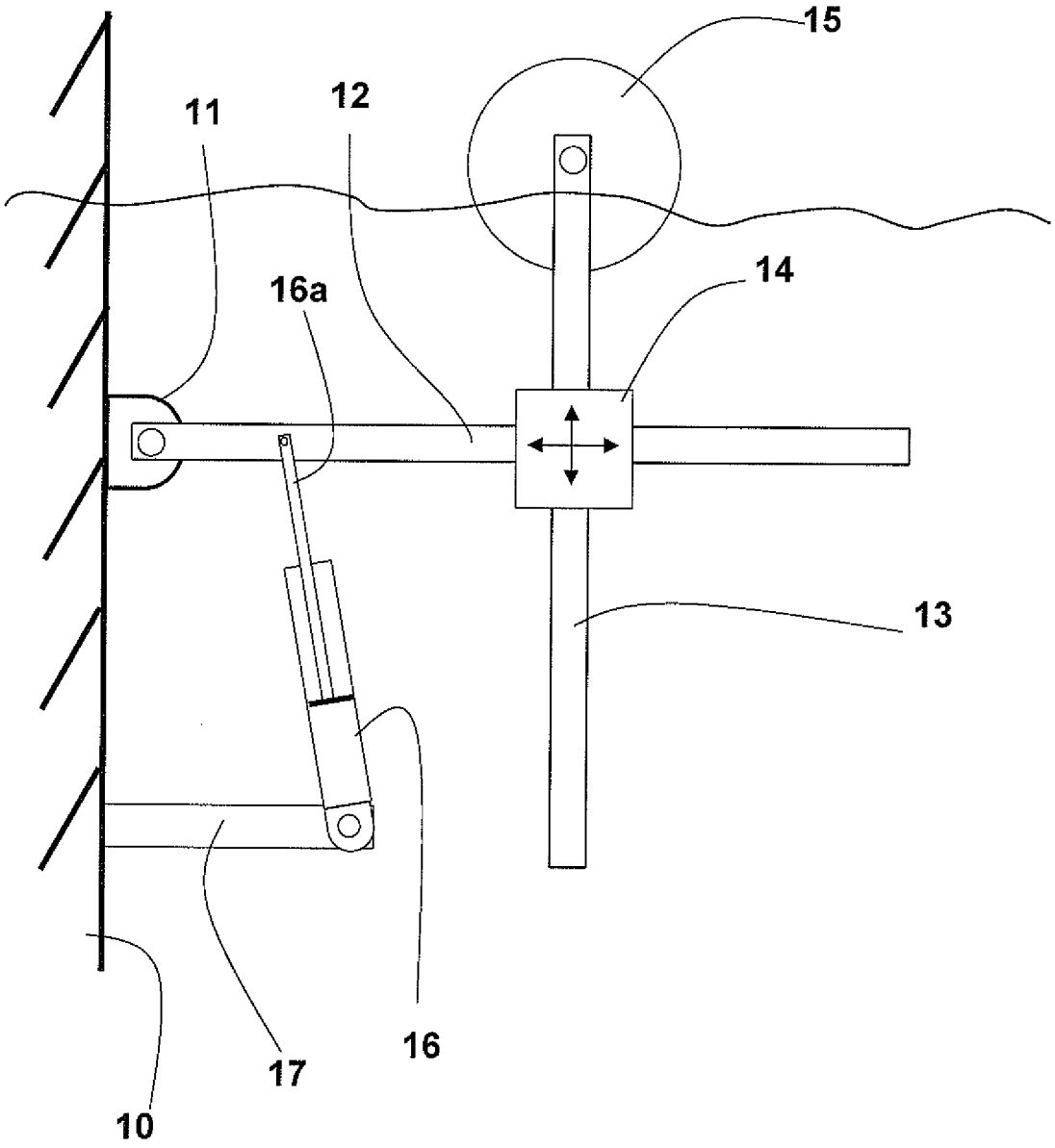

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2011/052502

A. CLASSIFICATION OF SUBJECT MATTER
INV. F03B13/18 F03B13/22
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F03B

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2009/093988 A2 (TERZIAKIN MEHMET [TR]) 30 July 2009 (2009-07-30)	1-6,9-12
Y	page 3 - page 13; claims 1,10; figures 1-5	7,8
X	US 3 970 415 A (WIDECRANTZ KAJ ET AL) 20 July 1976 (1976-07-20)	1-6,9-12
Y	column 1 - column 3; claims 1,2; figures 1-3	7,8
X	DE 20 2008 011580 U1 (HARRAND KURT [DE]) 30 October 2008 (2008-10-30)	1-6,9-12
Y	paragraph [0001] - paragraph [0004]; claim 1; figures 1-6	7,8

-/--

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

[X] See patent family 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 application or patent 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)

"O" document referring to an oral disclosure, use, exhibition or other means

"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
30 April 2012	09/05/2012

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

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2011/052502

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 092 828 A (GARZA ROBERTO M) 6 June 1978 (1978-06-06)	1-12
Y	column 1, line 64 - column 2, line 53 column 3, line 15 - column 7, line 66; claims 1-8; figures 1-6	7,8

X	GB 2 467 229 A (GREEN OCEAN ENERGY LTD [GB]) 28 July 2010 (2010-07-28)	1-12
Y	page 6, line 14 - page 11, line 14; figures 1-31 page 19 - page 26	7,8

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2011/052502

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2009093988 A2	30-07-2009	TR 200800454 A2	21-08-2009
		WO 2009093988 A2	30-07-2009
US 3970415 A	20-07-1976	NONE	
DE 202008011580 U1	30-10-2008	NONE	
US 4092828 A	06-06-1978	NONE	
GB 2467229 A	28-07-2010	CA 2748939 A1	29-07-2010
		GB 2467229 A	28-07-2010
		US 2012001431 A1	05-01-2012
		WO 2010084355 A2	29-07-2010