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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
1 July 2004 (01.07.2004)

PCT

(10) International Publication Number
WO 2004/055363 A1

(51) International Patent Classification[7]: F03B 13/18

(21) International Application Number:
PCT/IB2003/005720

(22) International Filing Date: 8 December 2003 (08.12.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2002/10195 17 December 2002 (17.12.2002) ZA

(71) Applicant and
(72) Inventor: MENTIS, Andrew [ZA/ZA]; 42 Florence Avenue, Bedfordview, 2007 Johannesburg (ZA).

(74) Agent: BOWMAN GILFILLAN INC (JOHN & KERNICK); P O Box 3511, Halfway House, Midrand 1685 (ZA).

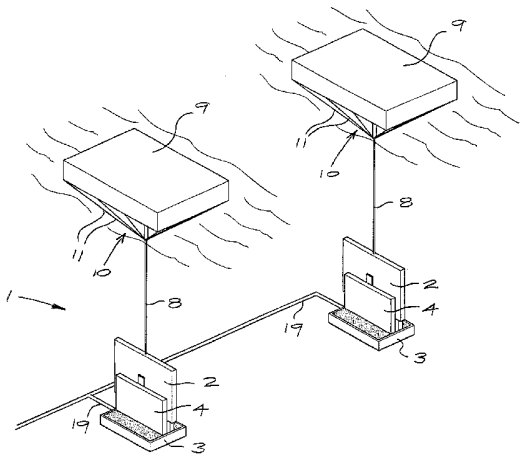
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *with amended claims*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: WAVE POWERED PUMP ASSEMBLY



(57) Abstract: The invention provides a pump assembly (1;100) which harnesses wave power to drive a pumping mechanism (6;105). The assembly (1;100) comprises a massive oscillatory member (2;104) guided for movement between an anchor (3;101) and a raft (9;112) and connected to the pumping mechanism (6;105). The anchor (3;101) includes guides (4;103) to control the movement and for the member (2;104) which is connected to the raft (9;112) by a centrally located cable. In one embodiment, the member (2;104) is cast in concrete and connected to a plurality of pumping mechanisms (6;105) which discharge into a common delivery pipe. Each pumping mechanism (6;105) includes a plurality of pumping units (13;106) having an annular resilient tubular construction, preferably a series of motor vehicle tyres (14;107). The valves for the pumping mechanisms (6;105) will preferably be simple flap valves and the vehicle tyre (14;107) pumping units (13;106) will be supported in individual guides (4;103) comprising parts of larger tyres (22;113) obtained by cutting the larger tyres (22;113) in a plane perpendicular to the tyres axis. These assemblies of unsophisticated concrete and steel structures and used tyres harness wave power to pump vast quantities of sea water which can be put to any of a number of uses.

WO 2004/055363 A1

WAVE POWERED PUMP ASSEMBLY

FIELD OF THE INVENTION

This invention relates to a pump assembly and more particularly to a pump assembly for pumping sea water using wave energy to power pump mechanisms.

BACKGROUND TO THE INVENTION

Waves contain an enormous amount of power. It is estimated that at a sea depth of 40 to 50 metres the average wave can contain about 50KW of power per linear metre of wave frontage. This power is progressively dissipated as the wave approaches the shore.

Many devices have been designed to harness some of this power and convert it to electrical power. Some of these use the waves to direct large volumes of air through wind turbines which drive generators, whilst others have the waves acting against large vanes which operate hydraulic cylinders or are mechanically linked to devices which convert the reciprocating motion to rotary motion, which

drive the generators. Others drive turbines directly as the waves rise and fall in enclosed areas.

Most of these machines are very large and can suffer from fatigue and storm damage. Furthermore, the mechanism is usually very expensive and prone to excessive wear and tear in the harsh marine environment.

OBJECT OF THE INVENTION

It is an object of this invention to provide a pump assembly which is of relatively simple construction and adapted for use in the harsh environment of the sea.

SUMMARY OF THE INVENTION

In accordance with this invention there is provided a pump assembly comprising a massive oscillatory member guided for submerged movement between an anchor and a raft and connected to drive a pumping mechanism.

Further features of this invention provide for the member to be cast in concrete, for the anchor to include guides to control the movement and for the member to be connected to the raft by a centrally located cable.

The invention also provides for the cable to be connected to a cradle structure depending from the raft.

Still further features of this invention provide for the member to be connected to a plurality of pumping mechanisms which may discharge into a common delivery pipe, for each pumping mechanism to include a plurality of pumping units and for

the units to be of an annular resilient tubular construction preferably a series of motor vehicle tyres.

The valves for the pumping mechanisms will preferably be simple flap valves and the vehicle tyre pumping units will be supported in individual guides comprising parts of larger tyres obtained by cutting the larger tyres in a plane perpendicular to the tyre axis.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of this invention will become apparent from the following description of one example given below wherein reference is made to the accompanying diagrammatic drawings in which -

Figure 1 is a part-section elevation of the lower portion of a first embodiment of a pump assembly;

Figure 2 a similar end elevation of the pump assembly of Figure 1;

Figure 3 a plan view of the pump assembly of Figures 1 and 2, without pumping units in the guides;

Figure 4 an oblique view of an installation of two pump assemblies;

Figure 5 a part-section elevation of a second embodiment of a pump assembly; and

Figure 6 a part-section plan view of the lower portion of the pump assembly of Figure 5.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Figures 1 to 3, the lower portion of a wave powered pump assembly (1) consists of a massive member (2) mounted above an anchor (3). The member is a concrete panel (2) and the anchor (3) has upwardly extending guides (4) for the panel (2).

The anchor (3) is a large open topped box which will contain a heavy ballast sufficient to hold it firmly in position on a seabed 40 to 50 metres below the sea surface.

The guides (4) will also be massive, of concrete structure and each is shaped to house a pumping mechanism (6).

Referring now also to Figure 4, the panel (2) has means (7) for the attachment of a cable (8) which extends between the panel (2) and a floating raft (9). The raft (9) will preferably have an open cradle structure (10) through which the cable (8) will extend and be centrally attached to the upper surface of the raft (9) thus stabilising the raft (9) under the forces which will be exerted through the cable (8) and waves during use. The length of the cable (8) is easily and automatically adjusted through a cable tension operated mechanism for example.

The cradle structure (10) is a series of elongate elements (11) extending between the cable (8) from a position below the raft (9) and the lower edges of the raft (9) along which they are spaced apart. The elements (11) may also be cables.

The lower end of the cable (8) will be attached to the panel (2) at the bottom of a blind socket (12) extending into the panel (2). The socket (12) will be centrally located in the upper edge of the panel (2) and end below the center of the panel (2).

The opening for the cable (8) will be through a tube and the length of cable (8) can thus be adjusted with suitable equipment such as an automatically controlled hydraulic piston and cylinder assembly located within the panel (2). This will be desirable to accommodate changes of sea level with differing wave heights and tides so that the panel (2) can operate continuously even though the stroke is variable. The details of this assembly can be designed by competent engineers, as can the details of suitable alternative assemblies.

Cables (not shown) will preferably be connected from the ends of the raft (9) to secure the raft (9) against rotation. These cables will also maintain the raft (9) in a desired position relative to the anchor (3) and panel (2).

In the preferred embodiment each pumping mechanism (6) includes a plurality of pumping units (13) which are illustrated as banks of six pumping units (13) in the guides (4) on each side of the panel (2). Each unit consists of a column (13) of identical motor vehicle tyres (14), coupled together with spacer guides (16) to form bellows.

The side walls of the tyres (14) are thus in sealing but flexible engagement with each other down the length of the column (13) such that the rim edges of the tyres (14) can be splayed apart and compressed together to provide a pumping action.

A common inlet (17) is provided to the central hollow core of the stacked column (13) of tyres (14). This inlet (17) is provided with a simple non-return flap valve (18).

The discharge from each column (13) of tyres (14) is into a common delivery pipe (19) which is laid to discharge at a particular location on land. The first length of pipe (19) will be housed within the anchor (3). A single non-return delivery valve

(not shown) will be provided from each column (13) of tyres (14) into the delivery pipe (16).

A suitable connection is provided between the panel (2) and each column (13). This connection will be made releasable so that each column (13) can be independently rendered operative for start up of the pump assembly (1), or for individual repair or replacement of pumping units (13) or an entire mechanism (6).

Retractable arms (20) extending through slots (15) in the guides (4) will releasably engage between the concrete panel (2) and a rod (21). This rod (21) is connected to extend in a guided manner from the upper end of its column (13) of tyres (14). One end of each column (13) will be anchored in its guide (4) so that movement of the panel (2) will, through the arms (20), cause compression and extension of the pumping units (13).

It will be understood that the panel (2) can be connected to the rod (21) to cause the pump assembly (1) to operate on either an up-stroke or a down-stroke of the panel (2) depending on the design of a particular assembly. Efficiencies between the two systems will not vary to any great extent.

It should be noted that the guiding of each tyre unit (13) within its guide (4) is facilitated by having some tyres (14) located in half tyres (22) of a larger size. These half tyres (22) move against the surface of the guides (4). As this movement is, in use, under water, there will be good lubrication between the half-tyres (22) and wall of the guides (4). The half tyres (22) will preferably be strapped together with flexible constant length elements (not shown).

In use pairs of assemblies (1) will be used spaced apart at distances of one half wavelength which will give a substantially constant delivery of sea water

dependant on wave height. A multiplicity of pairs of assemblies can be arranged to meet the power generation demand of an overall installation.

As will be appreciated each assembly (1) is of simple but massive construction.

An expected size of an installation can be judged from the sizes considered appropriate at this time with the panel (2) having a weight of 144 tons. The size of the raft would be about 16 metres by 30 metres by 0.5 metres giving a lift of some 250 tons.

As indicated above the design details of the assembly and an installation will be within good engineering competence and many variations to the above described embodiments can be made without departing from the scope of the invention.

A differently shaped and constructed embodiment of the invention is described with reference to Figs 5 and 6. This embodiment is of an equivalent massive structure to that described above.

Each pump assembly (100) has a box-like anchor (101) in which its ballast is located around the base of an octagonal steel framework (102). The framework (102) provides eight connected guides (103) for a massive member (104).

Each guide (103) is shaped to house a pumping mechanism (105) comprising a pair of a columns (106) of identical motor vehicle tyres (107). The columns (106) are each made from sixteen tyres (107) coupled together with spacer guides (108) to form bellows. The framework (102) accordingly incorporates sixteen pumping columns (106) of tyres (107).

The top of each column (106) carries an inlet valve (not shown) to admit the sea water during the upstroke, whilst the bottom of each column (106) is coupled to a common delivery pipe (109) which connects all the columns (106) and

discharges into a main pipe (not shown) going to shore. Each column (106) connection has a non-return valve (not shown).

The member is a slideable octagonal ram (104) inside the framework (102) which is of sufficient weight to compress the diaphragm pumping columns (106). It has sixteen retractable arms (110) which engage with the columns (106) through slots (111) in the guides (103). The ram (104) is suspended from a 32 metre diameter circular raft (112) which has sufficient buoyancy to raise the ram (104) with rising water level.

It will be appreciated that each column forms a pumping unit (106) including a flap controlled inlet valve which operates in the same manner as the first embodiment described above. This extends also to the support and guidance of the tyres (107) in larger half tyres (113).

The raft (112) may be similarly attached to the pumping assembly (100), with a cable (114) and cradle (115) arrangement as is described above with reference to the first embodiment. Further, also included will be an automatic, and preferably hydraulic, compensating mechanisms to vary the cable (114) length with varying height of the tides. In exceptional storms the rafts (112) may in fact be submerged.

The system is modular and can be expanded to suit demand.

An advantage of the above circular raft arrangement is that a constant configuration is presented facing changing wave directions.

Both of the embodiments described, which are clearly not limitative to the scope of the invention, enable individual pumping units to be removed and replaced without interfering with the ongoing operation of the remaining units. All that is required is a disconnection of the pumping unit from its associated panel or ram.

To benefit from substantial wave power, the installation needs a sea depth of 40 to 50 metres, but the system can also be used as a breakwater near the shore to create calm "lagoons" in the sea for harbours or recreational purposes. In this case the power generation capacity will be reduced but can still be substantial and viable.

The economic viability of the rafts can be enhanced if they are used for oyster or mussel cultivation and they can also accommodate large areas of solar panels which will enable them to be used as floating lighthouses.

A further benefit can be the creation of artificial reefs at the concrete bases which will attract crustations and fish. When the tyres have eventually served their purpose, they can be bundled and dumped alongside the bases to extend the reefs.

The concept provides a means to harness wave power using unsophisticated concrete and steel structures and used tyres which have for years created a disposal problem. The vast quantities of sea water pumped can be used to directly drive turbines or be delivered to elevated dams where it can be stored for power generation on demand. Some other potential uses could be desalinization plants, inland aquaculture, salt production, industrial cooling water or artificial lagoons for recreational or aesthetic purposes.

The economic viability of the system is enhanced by the use of redundant tyres for the pumping elements.

CLAIMS

1. A pump assembly (1;100) characterized in that it comprises a massive oscillatory member (2;104) guided for submerged movement between an anchor (3;101) and a raft (9;112) and connected to drive a pumping mechanism (6;105).

2. A pump assembly (1;100) as claimed in claim 1, characterized in that the member (2;104) is cast in concrete.

3. A pump assembly (1;100) as claimed in claim 1 or claim 2, characterized in that the anchor (3;101) includes guides (4;103) to control the movement of the member (2;104).

4. A pump assembly (1;100) as claimed in any one of the preceding claims, characterized in that the member (2;104) is connected to the raft (9;112) by a centrally located cable (8;114).

5. A pump assembly (1;100) as claimed in claim 4, characterized in that the cable (8;114) is connected to a cradle structure (10;115) depending from the raft (9;112).

6. A pump assembly (1;100) as claimed in any one of the preceding claims, characterized in that the member (2;104) is connected to a plurality of pumping mechanisms (6;105) which discharge into a common delivery pipe (19;109).

7. A pump assembly (1;100) as claimed in claim 6, characterized in that each pumping mechanism (6;105) includes a plurality of pumping units (13;106).

8. A pump assembly (1;100) as claimed in claim 7, characterized in that the units (13;106) are of an annular resilient tubular construction.

9. A pump assembly (1;100) as claimed in claim 8, characterized in that the units (13;106) are provided by a series of axially aligned motor vehicle tyres (14;107) operatively sealed to each other and having an axial inlet flap valve (18) and a common non-return outlet valve.

10. A pump assembly (1;100) as claimed in claim 9 or claim 10, characterized in that the vehicle tyre pumping units (13;106) have guides comprising parts of larger tyres (22;113) obtained by cutting the larger tyres (22;113) in a plane perpendicular to the tyre axis.

11. A pump assembly (1;100) as claimed in any one of the preceding claims in which the raft (9;112) is substantially circular.

12. A pump assembly (1;100) substantially as described with reference to Figures 1 to 4 or 5 and 6 of the drawings.

AMENDED CLAIMS

[received by the International Bureau on 18 May 2004 (18.05.2004);
original claims 1-12 replaced by new claims 1-11 (2 pages)]

1. A pump assembly (1;100) for submerged operation including a pumping mechanism having pumping units of annular resilient guided tubular bellows (13;106) construction characterized in that the assembly (1;100) includes a massive oscillatory member (2;104) guided for submerged movement between an anchor (3;101) and a raft (9;112) and connected to drive the pumping mechanism (6;105).

2. A pump assembly (1;100) as claimed in claim 1, characterized in that the member (2;104) is cast in concrete.

3. A pump assembly (1;100) as claimed in claim 1 or claim 2, characterized in that the anchor (3;101) includes guides (4;103) to control the movement of the member (2;104).

4. A pump assembly (1;100) as claimed in any one of the preceding claims, characterized in that the member (2;104) is connected to the raft (9;112) by a centrally located cable (8;114).

5. A pump assembly (1;100) as claimed in claim 4, characterized in that the cable (8;114) is connected to a cradle structure (10;115) depending from the raft (9;112).

6. A pump assembly (1;100) as claimed in any one of the preceding claims, characterized in that the member (2;104) is connected to a plurality of pumping mechanisms (6;105) which discharge into a common delivery pipe (19;109).

7. A pump assembly (1;100) as claimed in claim 6, characterized in that each pumping mechanism (6;105) includes a plurality of pumping units (13;106).

8. A pump assembly (1;100) as claimed in claim 1, characterized in that the units (13;106) are provided by a series of axially aligned motor vehicle tyres (14;107) operatively sealed to each other and having an axial inlet flap valve (18) and a common non-return outlet valve.

9. A pump assembly (1;100) as claimed in claim 8, characterized in that the vehicle tyre pumping units (13;106) have guides comprising parts of larger tyres (22;113) obtained by cutting the larger tyres (22;113) in a plane perpendicular to the tyre axis.

10. A pump assembly (1;100) as claimed in any one of the preceding claims in which the raft (9;112) is substantially circular.

11. A pump assembly (1;100) substantially as described with reference to Figures 1 to 4 or 5 and 6 of the drawings.

FIG 1

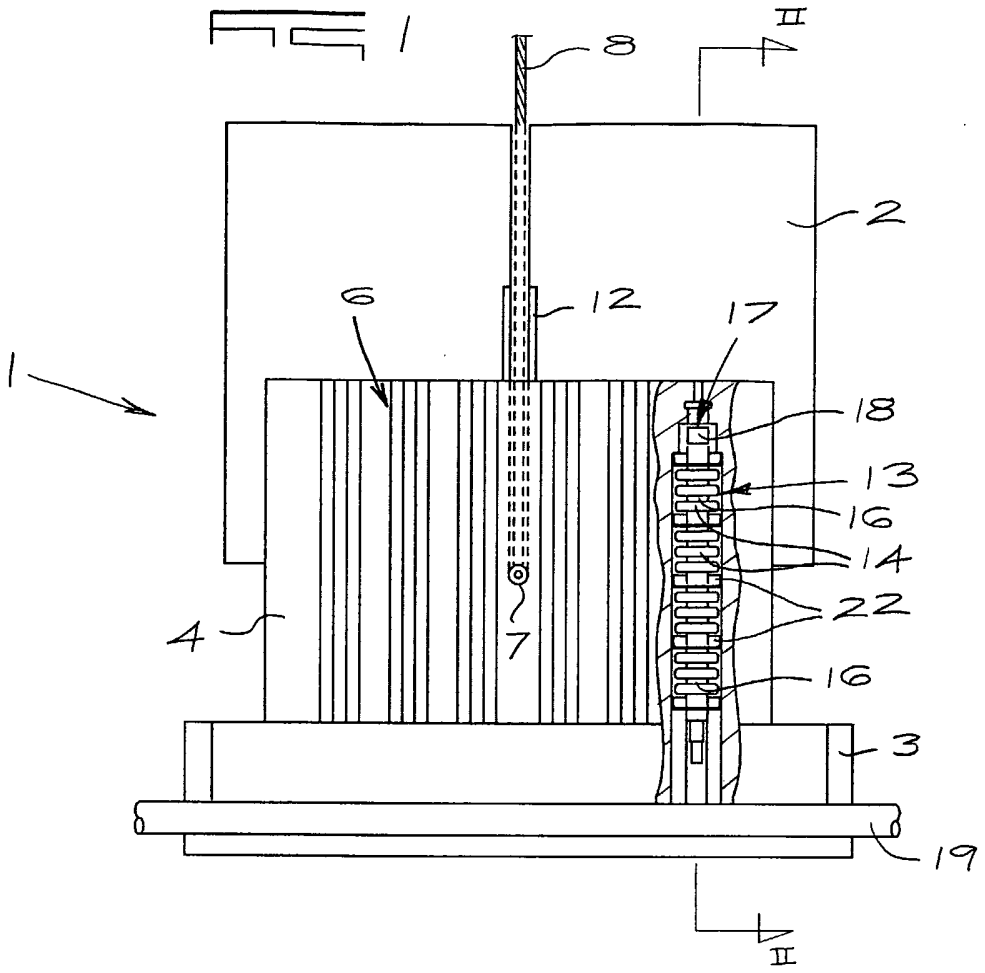

II
8
2
6
12
17
1
18
13
16
14
22
4
7
16
3
19
II

FIG 2

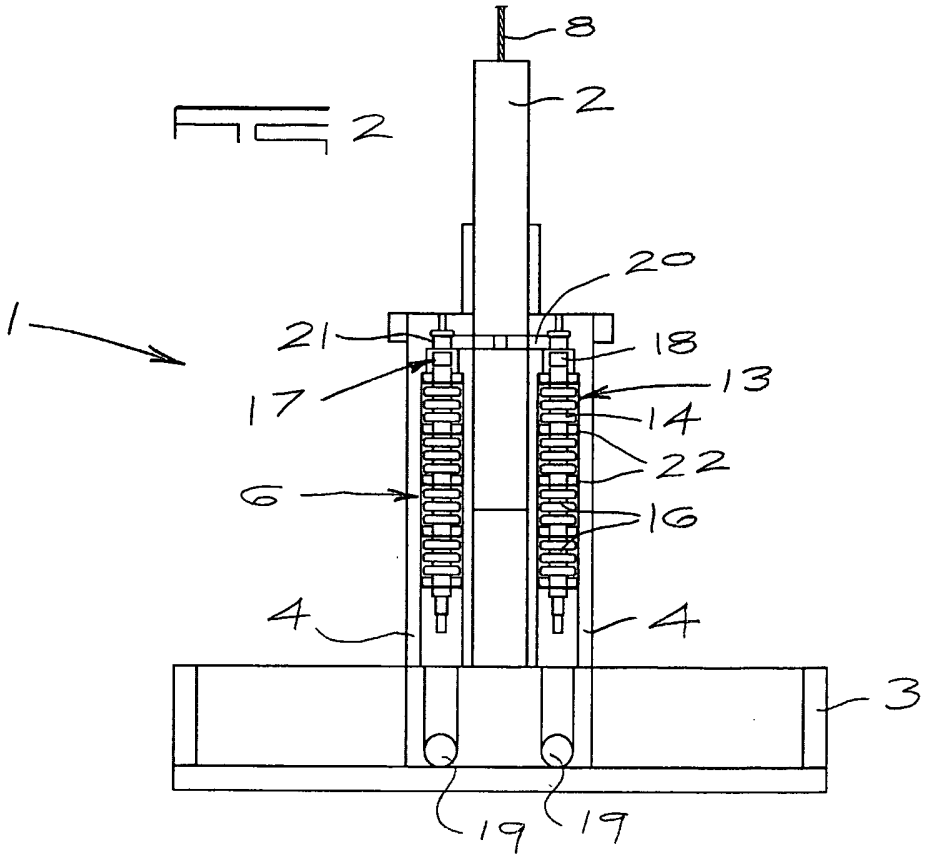
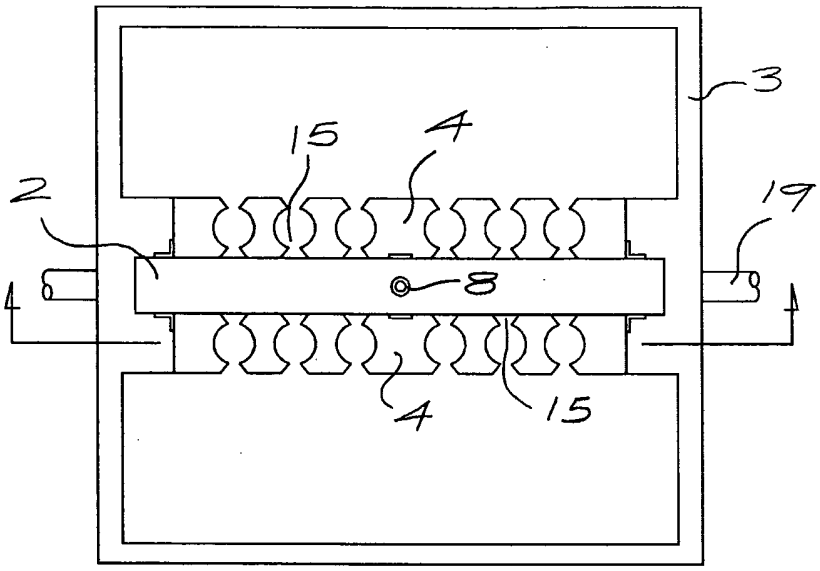

8
2
20
1
21
18
17
13
14
22
6
16
4
4
3
19
19

FIG 3



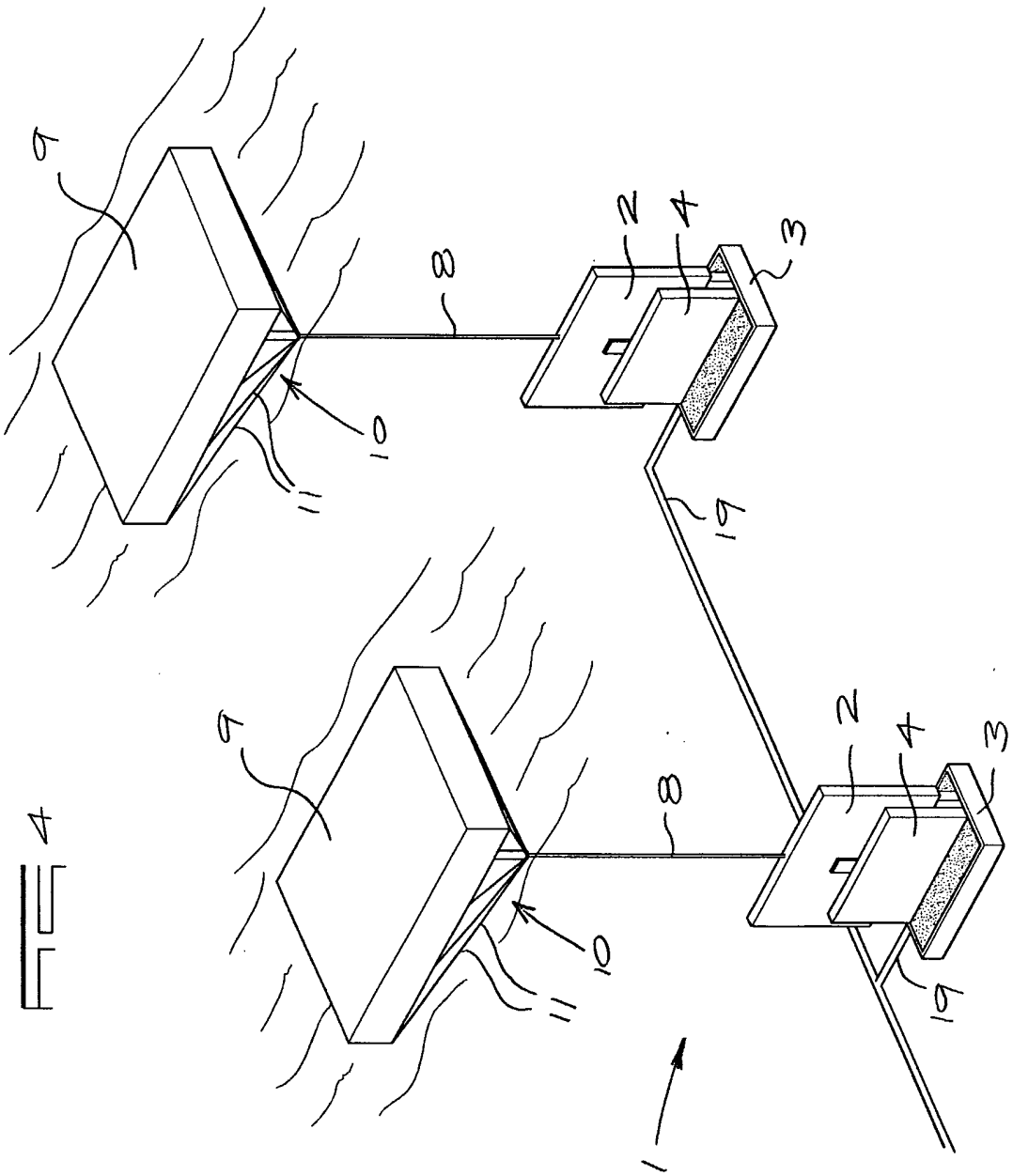

9
8
2
4
3
10
11
19
9
8
2
4
3
10
11
19
4
1

FIG 6

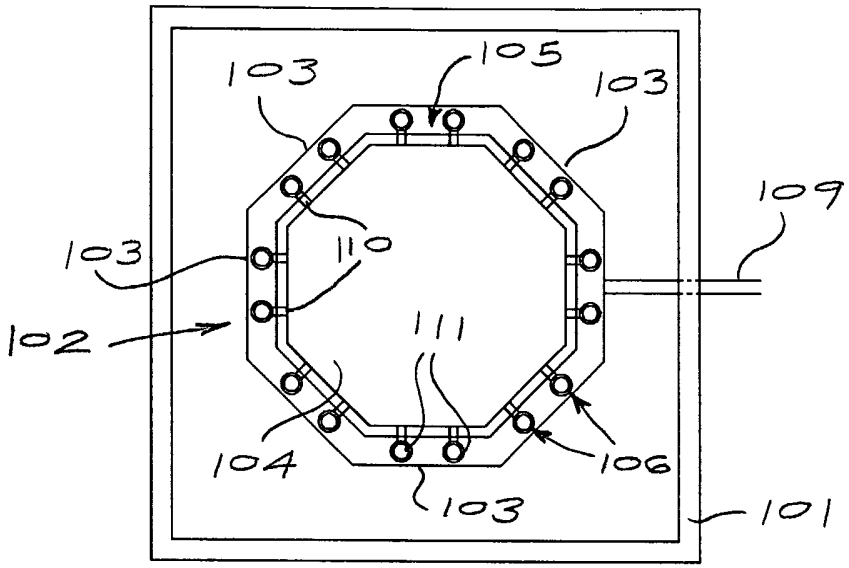
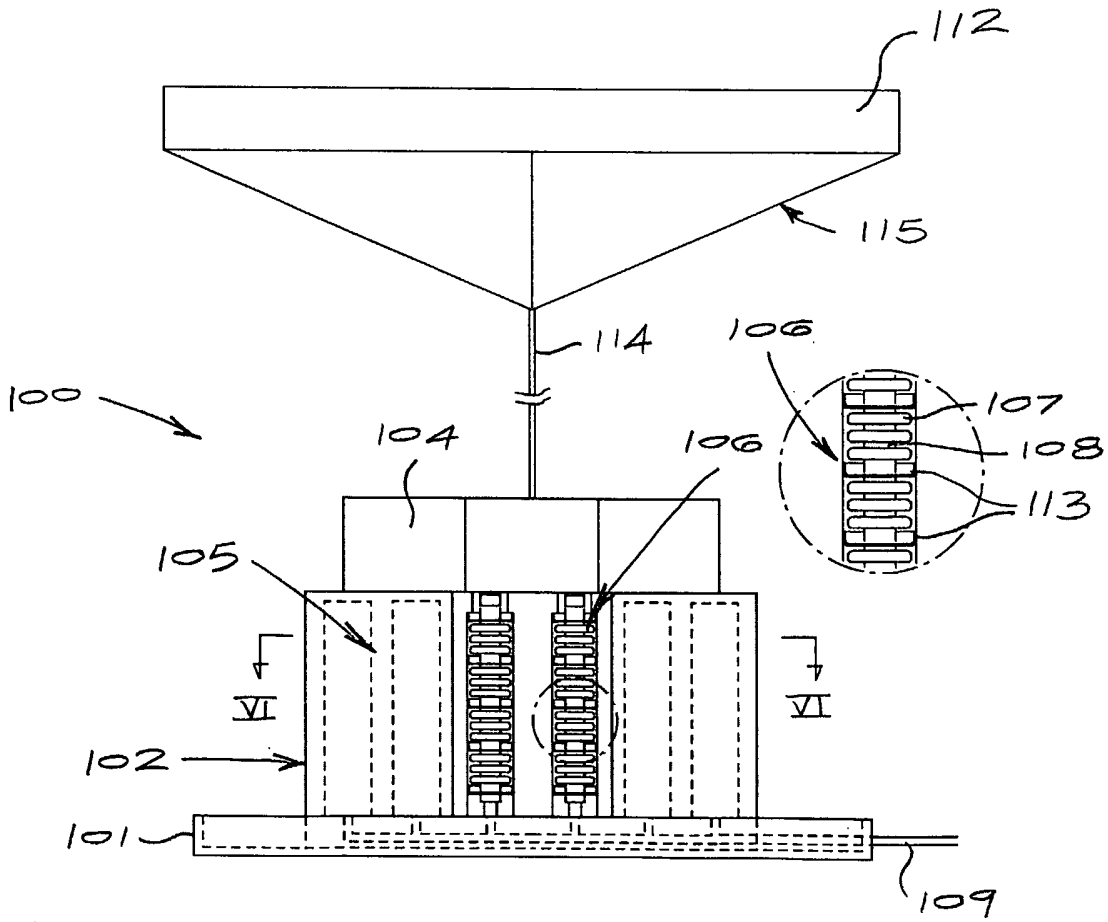

103
105
103
109
103
110
102
111
104
106
103
101

FIG 5


112
115
114
106
100
107
104
106
108
113
105
VI
VI
102
101
109

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB 03/05720

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F03B13/18

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

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 2 044 843 A (BRITISH PETROLEUM CO) 22 October 1980 (1980-10-22) abstract page 1, line 89 - line 94 page 2, line 25 - line 32 claim 1	1-9,11, 12
Y	US 4 954 052 A (SIMMONS WALTER J) 4 September 1990 (1990-09-04) abstract column 2, line 43 - column 3, line 21; figures 2,3	1-9,11, 12
Y	US 4 012 173 A (EVERSON JR KIRKE B) 15 March 1977 (1977-03-15) column 1, line 54 - line 64; figures 1,10	1-9,11, 12

-/--

[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)

"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
8 March 2004	18/03/2004

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	Criado Jimenez, F

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB 03/05720

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 329 497 A (PREVISIC BRANISLAV ET AL) 12 July 1994 (1994-07-12) column 4, line 18 - line 20 column 4, line 31 - line 33 column 5, line 31 - line 36 column 5, line 50 - line 54 figures	1
A	US 6 020 653 A (WOODBRIDGE THOMAS C ET AL) 1 February 2000 (2000-02-01) column 2, line 66 - column 324; figure 1	1
A	GB 2 272 026 A (CHILTON WILLIAM) 4 May 1994 (1994-05-04) abstract; figure 1	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Internatio pplication No
PCT/IB 03/05720

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2044843 A	22-10-1980	NONE	
US 4954052 A	04-09-1990	NONE	
US 4012173 A	15-03-1977	NONE	
US 5329497 A	12-07-1994	AU 662246 B2	24-08-1995
		AU 4862893 A	05-05-1994
		CA 2106503 A1	20-04-1994
		EP 0594537 A1	27-04-1994
		JP 6213134 A	02-08-1994
		NO 933694 A	20-04-1994
		NZ 248771 A	27-04-1995
		ZA 9307182 A	09-06-1994
US 6020653 A	01-02-2000	NONE	
GB 2272026 A	04-05-1994	NONE	