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(72) Inventor; and
(71) Applicant : **ØIGARDEN, Hans** [NO/NO]; Årvollveien 48B, N-0590 Oslo (NO).

(74) Agent: **PROTECTOR IP CONSULTANTS AS**; Oscarsgate 20, N-0352 Oslo (NO).

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(54) Title: DEVICE FOR PRODUCTION OF FRESH WATER AND/OR PRODUCTION OF POWER WITH THE HELP OF WAVE ENERGY

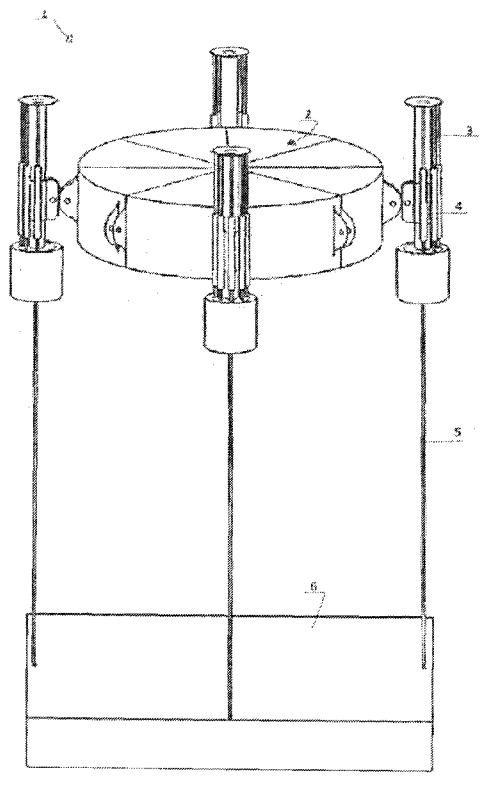

FIG. 1.

(57) Abstract: Device (1) for freshwater production and/or production of energy with the help of wave energy, encompassing a float body (2) which is connected via a coupling means (9) to a corresponding number of appliances (3) for the transfer of energy to an appliance (19) for the production of energy and/or for production of freshwater by reverse osmosis, as the coupling means (9) encompasses universal joints which are connected, in the main, to an outer circumference of the float body (2).

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DEVICE FOR PRODUCTION OF FRESH WATER AND/OR PRODUCTION OF POWER WITH THE HELP OF WAVE ENERGY

The present invention relates to a device for production of fresh water and/or production of power with the help of wave energy. In more detail, the invention relates to a device as given in the introduction to claim 1.

Devices for the production of fresh water and/or production of power with the help of wave energy are previously known, where the fresh water production takes place with the use of reverse osmosis using pressure generated by the wave energy. In particular, reference is here made to Norwegian patent no. 327758 from the same inventor as the present invention, and where the device comprises a central, first extended floating body anchored to the sea bed and a second floating, movable body that surrounds the first body and which is set up to move in relation to the first body under the influence of the waves, to thereby produce electrical energy as energy transfer appliances are coupled between the first and the second body, preferably encompassing one or more hydraulic cylinders for the transfer of kinetic energy to an electricity generator arranged on the first body. Alternatively, the water from the hydraulic cylinders can be led to a high pressure tank for the production of fresh water by reverse osmosis, either directly or via an associated turbine.

Further aspects of the above mentioned device appear in US 2011/0036085 A1, where it appears in section [0081] that the hydraulic cylinders can stretch through a channel in the ring-formed, surrounding body and be arranged to this with the help of suitable fastening means so that it can flip over.

Although the hydraulic cylinders in the above mentioned prior art are formed to allow a flip movement between the extended body and the surrounding ring-formed body, the surrounding configuration will clearly lead to limitations as to how large this flip movement can be and which, in turn, will place limitations to the possible or appropriate operating area with respect to weather and wave

conditions for the device. Furthermore, the surrounding configuration itself will necessarily place limited possibilities with regard to the choice of other surrounding float bodies, i.e. the float body that shall follow the wave motions.

With regard to the present invention the above mentioned or other problems or shortcomings are endeavoured to be solved by a device as given in the characteristics of claim 1.

Advantageous embodiments of the invention appear in the dependent claims.

In the following description the advantageous, non-limiting embodiments of the invention are described in more detail with reference to the enclosed figures, where

figure 1 is a perspective outline of a first embodiment of a device according to the invention, with a centrally arranged cylindrical float body and with regulating cylinders anchored to a foundation on the ocean bed via tension struts.

figure 2 is a perspective outline of a second embodiment of the device according to the invention, with a centrally placed cylindrical float body and with regulating cylinders directly anchored to a foundation on the ocean bed.

figure 3 is a perspective part outline of a device corresponding to the embodiment shown in figure 1, but with an alternative form of the float body.

figure 4 is an enlarged perspective outline of one of the appliances encompassing a regulating cylinder and two hydraulic cylinders as shown in figure 3, and which shows, in particular, a universal joint that connects the appliance with a float body not shown here, and

figures 5 and 6 are principle outlines of the operation of a system for production of fresh water and/or production of power encompassing a hydraulic cylinder as shown in the figures 1 to 5, with upward and downward, respectively, movement

of a float body connected to the hydraulic cylinder, and as can also be seen in US 2011/0036085 A1.
In the following description and in the claims, the direction designations such as “upper”, “lower”, “upwardly directed”, “downwardly directed” etc., are given as references to the enclosed figures only and shall not be regarded as limiting for the invention.

The principle for reverse osmosis is assumed to be known, but briefly implies that fresh water is achieved in that salty water (seawater) is driven through a membrane. The salt molecules (strictly speaking ions) are too large to be able to penetrate the membrane. The only water which comes through is fresh water. For this process to take place the salty water must be subjected to a pressure, preferably of the order of 50 - 80 bar, most preferably around 60 bar. It is known that in osmosis, in contrast to reverse osmosis, a pressure is generated and at the same time the salt content of the water will be in equilibrium on both sides of the membrane.

By first referring to fig. 1, a first embodiment is shown of a device 1 according to the invention, comprising a float body 2, a number of appliances 3 for energy transfer, here incorporating hydraulic cylinders 4, and the construction of which is shown in more detail in fig. 4. The device 1 is connected, with the help of a corresponding number of tension struts 5, here four, to their own respective appliance 3 anchored to a foundation 6 on the ocean bed, alternatively (and not shown) directly to the ocean bed itself, for example, with the help of suction anchors or the like where the conditions permit and where this otherwise would be preferred. However, one advantage with the use of the foundation 6 is that it ensures a simple control of the anchoring. The float body 2 is anchored independently of the tension struts 5 by a slack anchoring wire or chain (not shown). This anchoring prevents the float body from moving horizontally to any extent, but does not prevent the vertical, wave induced movements. This anchoring principle also relates to all the embodiments described in the following.

Furthermore, with reference to figure 4, the appliance 3 favourably incorporates a regulating cylinder 7 surrounded by a slide 8 so that it can glide arranged to which is a universal joint 9 for free rotatory connection to the float body 2. Furthermore, the slide 8 is permanently fastened to two hydraulic cylinders 4 with respective cylinder shafts 10 running in parallel with the control cylinder 7. Instead of a cylinder 7 a solid strut or other elements can be used that provide rigidity to the system and allow the slide 8 to glide along.

The figures 5 and 6 are principle diagrams that illustrate the operation of the hydraulic system. The cylinder 4 is shown integrated in the float body 2 for simplicity. As shown in figs. 5 and 6 a piston 11 is rigidly arranged inside the hydraulic cylinder 4 to the cylinder shaft 10, such that at respective sides of the piston 11 a pressure side and a suction side are delineated inside the cylinder, and where the pressure side and the suction side alternate dependent on the movement direction of the float body 2, indicated by the arrows 12 and 13 in fig. 5 and fig.6. Thus, in fig. 5 the suction side corresponds to the upper part of the cylinder 4, and vice-versa in figure 6.

The operation of the system for production of fresh water and/or production of power encompassing the hydraulic cylinder 4, as it also can be seen in US 2011/0036085 A1, is thereby advantageous as follows: An inlet valve 14, 15 and an outlet valve 16, 17 are arranged at each end of the hydraulic cylinder 4 and where the outlet valves 16, 17 are connected to an accumulator tank 18 which in turn is connected to a further appliance 19, which can either be a turbine, for example, a Penton turbine, for production of power and/or a system for the production of fresh water by reverse osmosis. By an upwardly directed movement of the float body 2, and thus also by the hydraulic cylinder 4 (fig. 5), the inlet valve 14 and the outlet valve 17 are opened, while the inlet valve 15 and the outlet valve 16 are shut so that water is sucked into the top side of the piston 11 and that the water that is on the bottom side of the piston 11 is pumped out of the cylinder 4 and to the accumulator 18. By a downwardly directed movement of the float body 2 (fig. 6), the situation will be the opposite where the water that is on the top side of the piston 11 is pumped out of the cylinder 4 and to the accumulator tank.

It is an advantage if the outlet valves 16, 17 can be adjustable, thus to open at a desired pressure. The pressure can be set at a pressure that leads to the water that is to be delivered to the osmosis installation having a pressure of between 50 to 80 bar, preferably around 60 bar. The pressure which the valves 16 and 17 are set to open at will contribute to the floating body being held back when a wave top passes and get a larger submersion than if it is permitted to move unhindered.

In that water is pumped at the upwardly directed and the downwardly directed movement of the float body 2, the hydraulic cylinder 4 can be said to have a double effect. However, it will appear that the hydraulic cylinder could alternatively be a single effect operation, for example, with a different configuration of the valves 14 -17, for example, in that either the upper 14, 16 or the lower 15, 17 valve pair is omitted.

Furthermore, with reference to figs. 1 and 4, a buoyancy body 20 is arranged to the appliance 3 with a buoyancy adjusted to ensure that the associated tension strut 5 is always under tension, taking into consideration the downwardly directed movement of the connected float body 2 in wave troughs. The tension strut 5 can withstand high tension forces, while the force at a downwardly directed movement is thus limited in relation to the volume of the buoyancy body 20, so that the force which can be made use of is limited to the volume of the buoyancy body 20. In practice, this means that one can only utilise the power from the waves with an upwardly directed movement, and where a such embodiment in this way functions at greater ocean depths.

Another embodiment of the invention is shown in fig. 2, where the difference with respect to the first embodiment shown in fig. 1 is that instead of the tension strut 5 and the buoyancy body 20, regulating cylinders 7' are used that extend all the way down to a foundation 6 on the ocean bed and are directly anchored to this. Both the upwardly and the downwardly directed power from the waves (wave peaks and wave troughs) can thus favourably be utilised via double effect hydraulic cylinders 4. The regulating cylinder 7' must then be dimensioned for

the forces it is subjected to against breaking, in addition to the pressure forces the downwardly directed movement of the float body 2 generates itself. Thus, this embodiment gives the same advantageous effect with upwardly and downwardly directed movement, but at the same time results in a limitation with respect to the ocean depth, as the diameter of the regulating cylinder 7' which increases with the ocean depth will finally be impractically large.

Fig. 3 shows a perspective part outline of a device 1 corresponding to the embodiment shown in fig. 1, but with an alternative shape of the float body 2, here in a quadratic ring form, and with a different number of appliances 3 encompassing hydraulic cylinders 4 than in the embodiments shown in the figs 1 and 2, and where also each appliance 3 incorporates a different number of hydraulic cylinders 4, here two. The number of hydraulic cylinders 4 can be varied per appliance 3 dependent on the size of each cylinder 4, based on costs per cylinder 4 and the type of wave regime one will have at any given location.

In that the float body 2 according to the invention can, in principle, have any shape it is possible to design this according to the particular weather and wave situations and/or make it possible to combine the use of the float body 2 with, for example, floating piers, floating wave breakers, floating marinas, etc.

With regard to the embodiments of the invention that are shown in the figures, it shall also be mentioned that these do, in general, include a traditional mooring system, not shown, for the uptake of sideways forces experienced by device 1 from wind, waves and/or ocean currents.

Although embodiments of the invention are described above the extent of the invention shall only be regarded limited by the enclosed claims.

Claims

1.
Device (1) for freshwater production and/or production of energy with the help of wave energy, encompassing a float body (2) which is connected via a coupling joint (9) to at least one energy uptake appliance (3) for the uptake of wave energy, characterised in that the coupling joint (9) comprises a universal joint.

2.
Device according to claim 1, characterised in that the coupling joint (9) is connected to an outer circumference of the float body (2).

3.
Device according to claims 1 or 2, characterised in that the appliance (3) for the energy transfer encompasses at least one hydraulic cylinder (4) the cylinder axis (10) of which runs in parallel with a regulating cylinder (7; 7') or a regulating strut and is connected to the regulating cylinder (7; 7') or the strut via a slide (8) that surrounds the regulating cylinder (7; 7') or the regulating strut so that it can glide.

4.
Device according to claim 3, characterised in that the appliance (3) is connected to a tension strut (5) which is anchored to the ocean bed or to a foundation (6) on the ocean bed.

5.
Device according to claim 3, characterised in that the regulating cylinder (7') or the regulating strut extends to the ocean bed and is anchored to the ocean bed or to a foundation (6) on the ocean bed.

6.
Device according to claim 4, characterised in that a buoyancy body (20) is connected to the appliance (3).

7.

Device according to any of the preceding claims, c h a r a c t e r i s e d i n that the float body (2) has any suitable shape, including cylindrical or a quadratic ring-form.

8.

Device according to any of the claims 3 to 7, c h a r a c t e r i s e d i n that at the first end of the hydraulic cylinder (4) a first pair of inlet and outlet valves (14, 16) are connected and at the other end of the hydraulic cylinder (4) a second pair of inlet and outlet valves (15, 17) are connected, as the outlet valves (16, 17) are connected to an accumulator tank (18) which, in turn, is connected to the appliance (19).

9.

Device according to claim 8, c h a r a c t e r i s e d i n that the outlet valves (16, 17) are set up to open at a pressure which gives a pressure of 50 – 80 bar, preferably around 60 bar, in a reverse osmosis installation that is in communication with the outlet valves (16, 17).

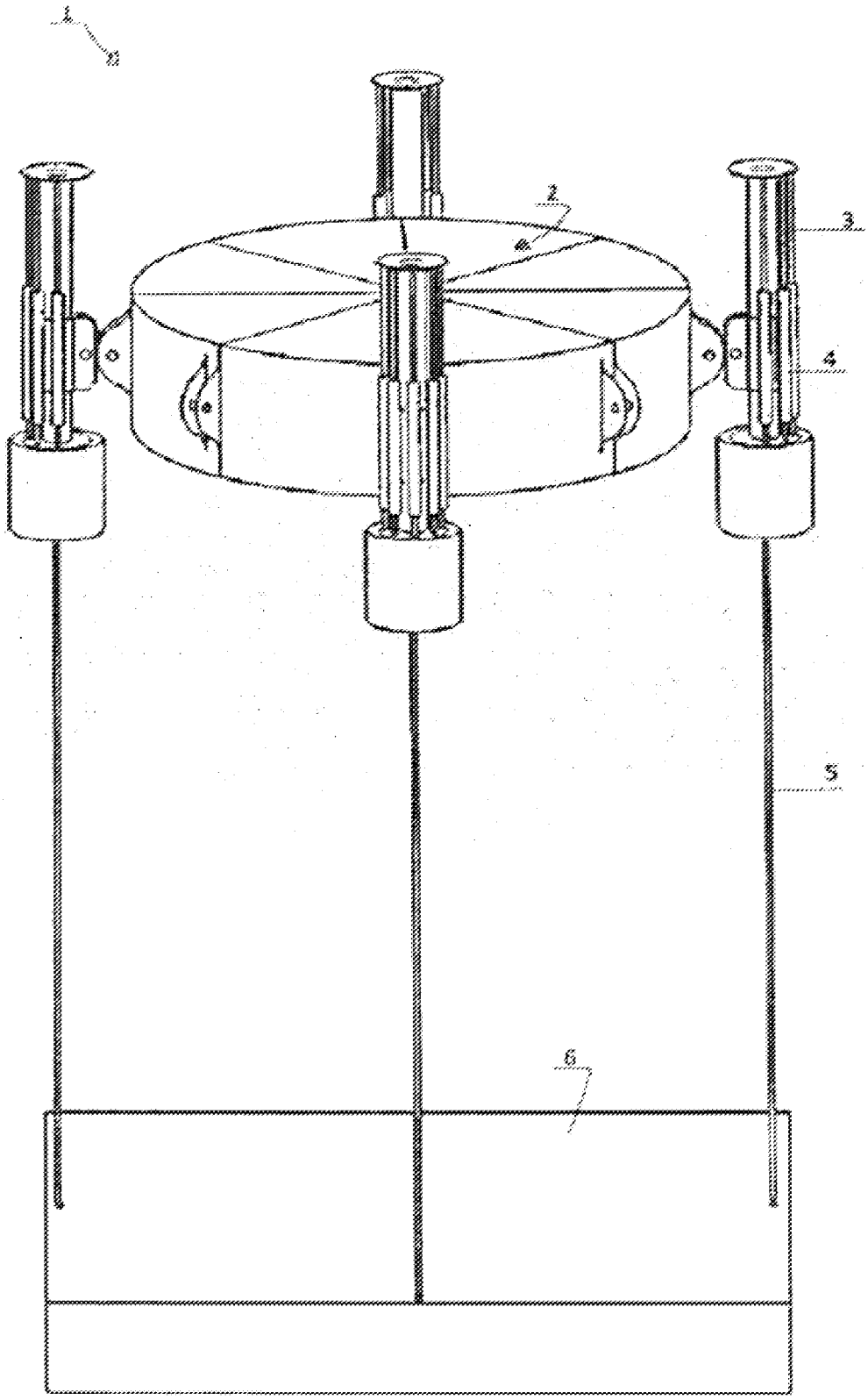

FIG. 1.

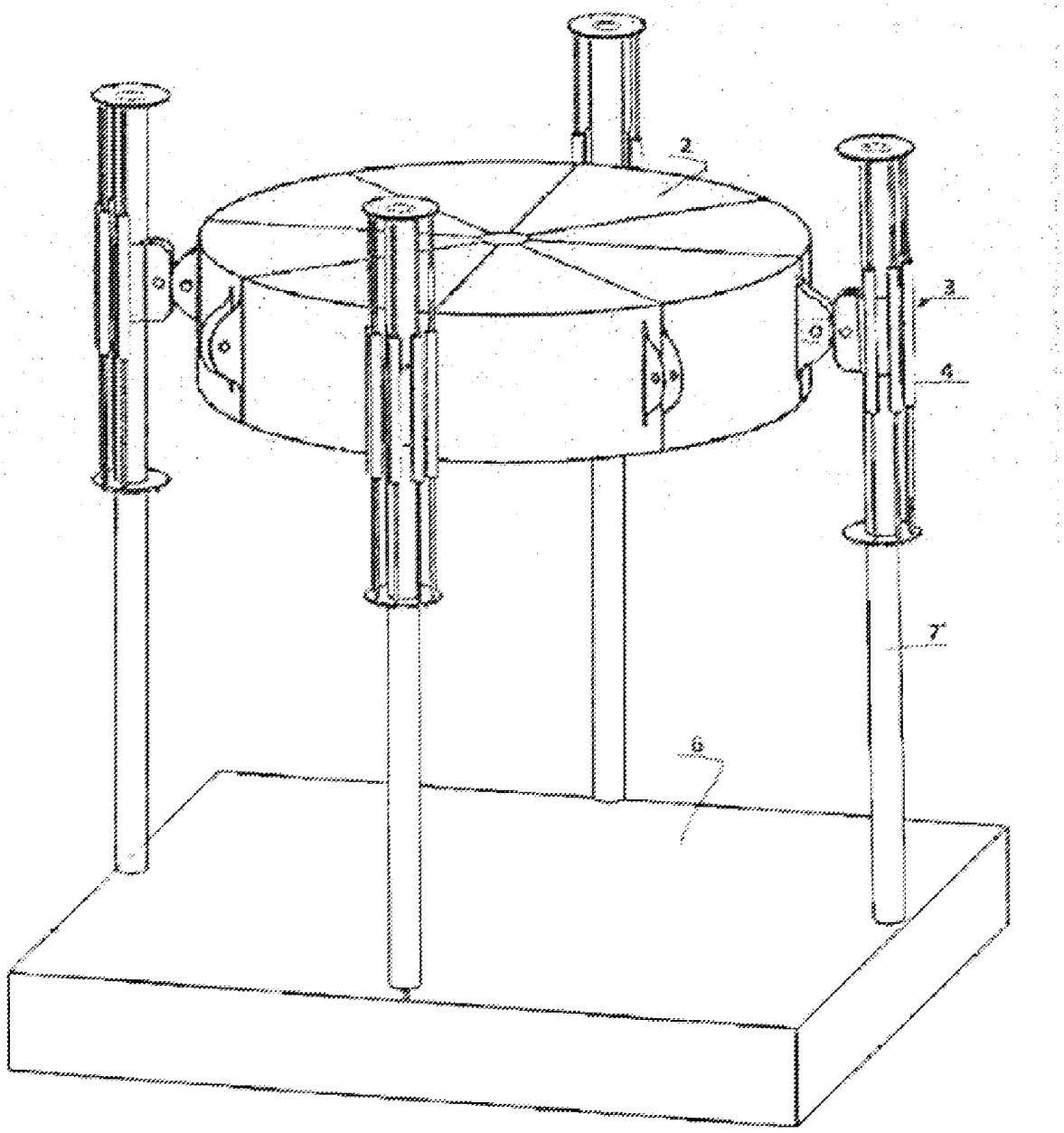

FIG. 2

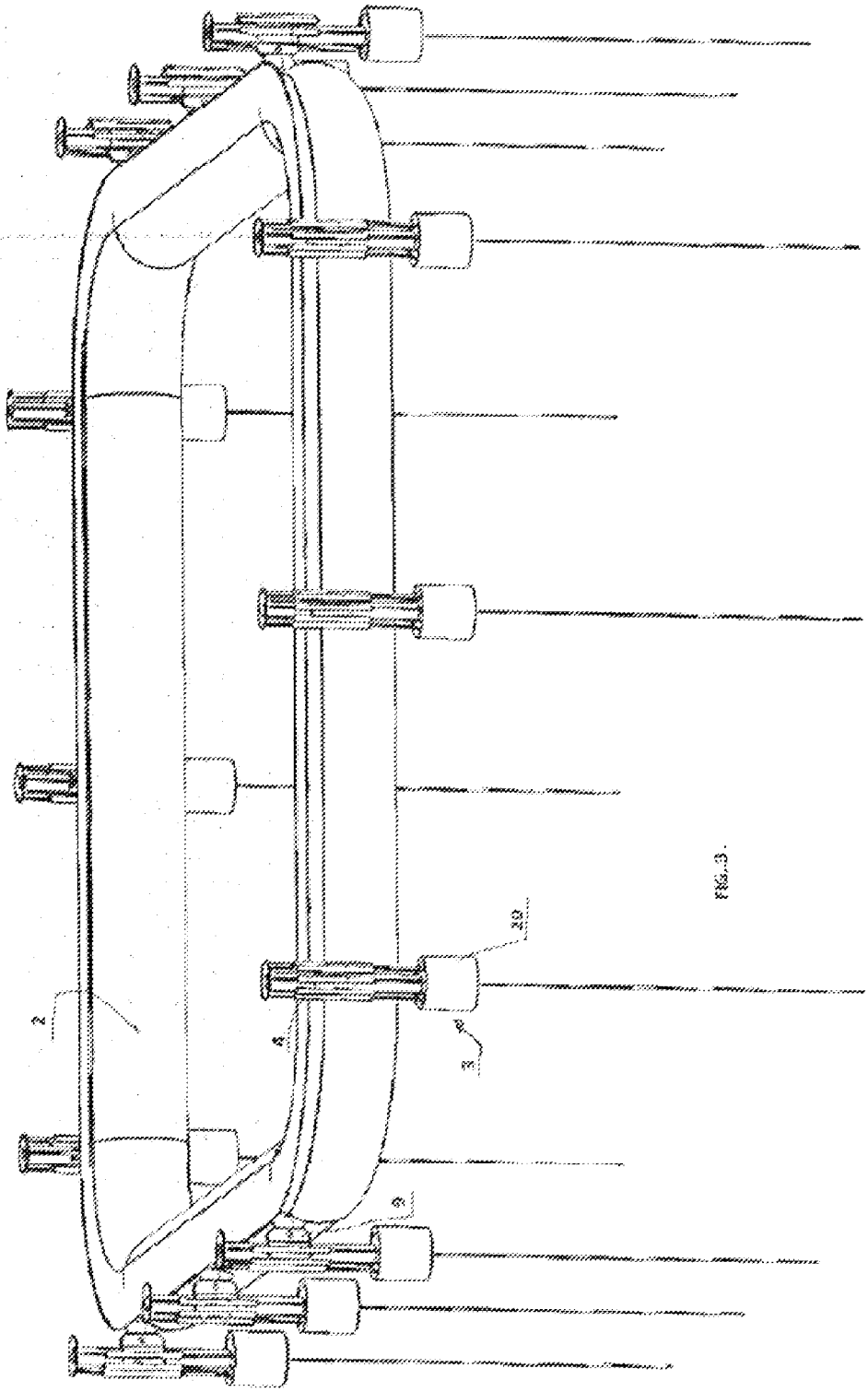

FIG. 3.

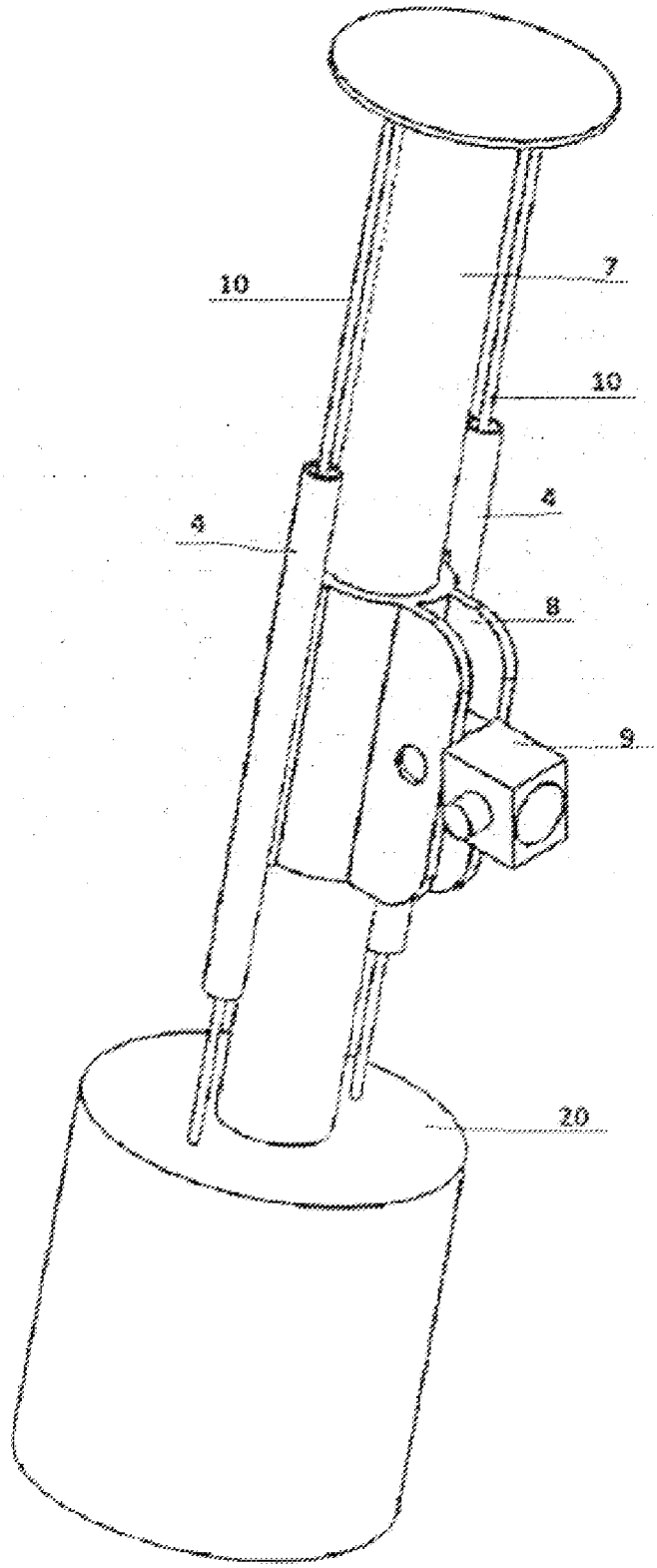

FIG.4

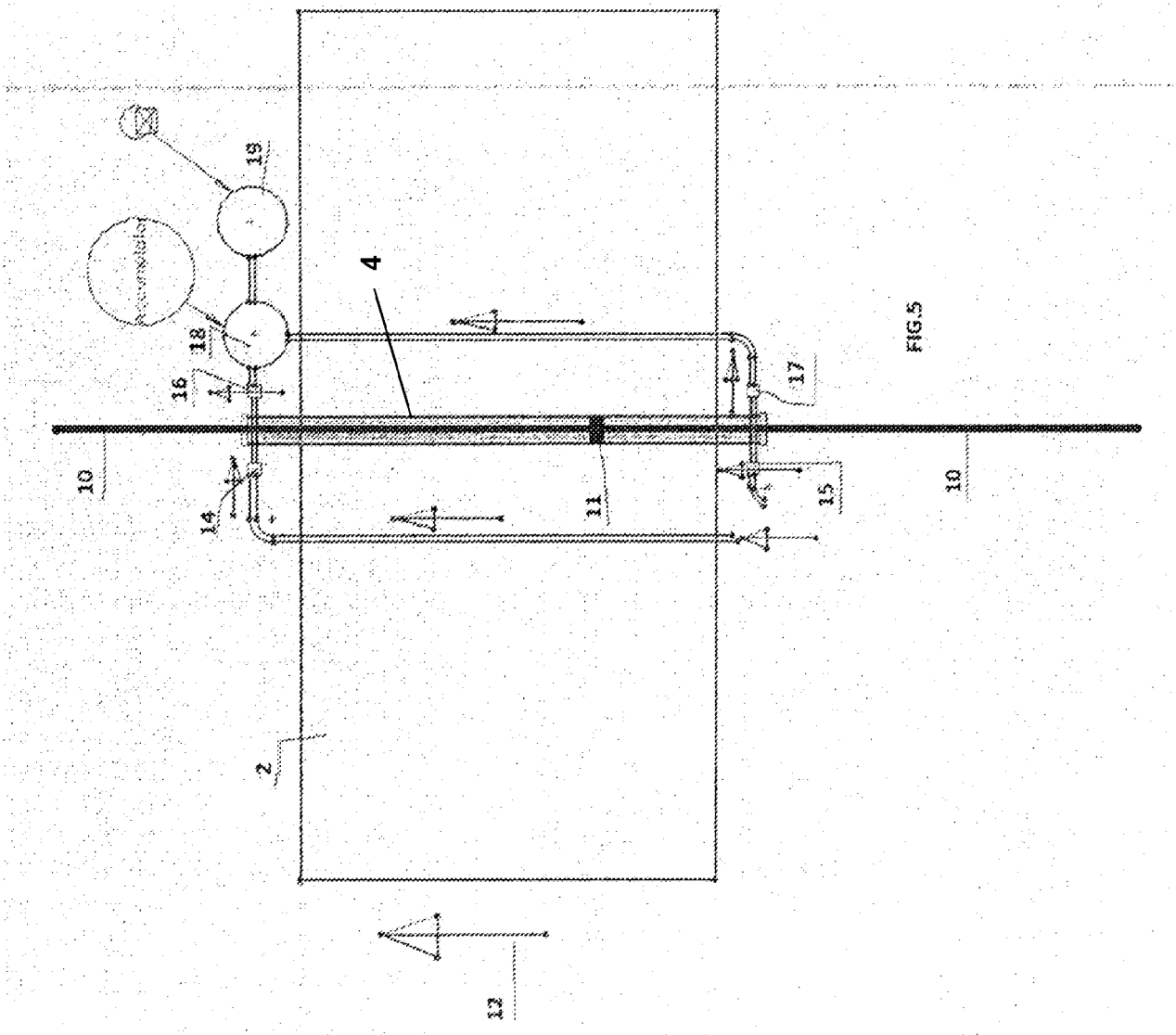

FIG.5

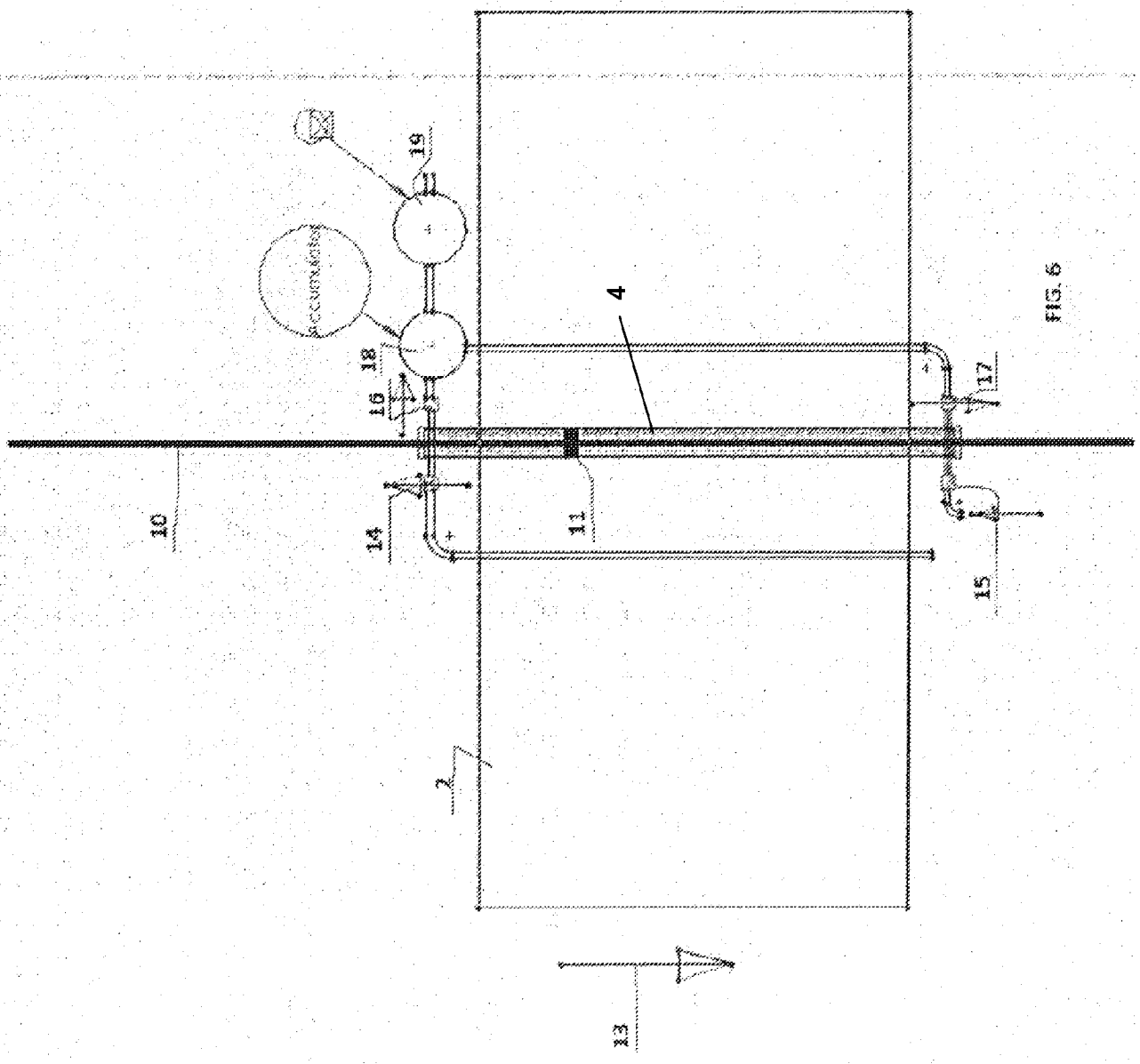

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO2012/050228

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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: F03B, F16B, F16D

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2031240 A1 (NAT UNIV CORP KOBE UNIV), 4 March 2009 (2009-03-04); abstract; paragraphs [0048]-[0051]; figure 7	1, 2, 7
	--	
X	US 4931662 A (BURTON LAWRENCE C), 5 June 1990 (1990-06-05); abstract; figure 1	1, 7
	--	
A	US 20110036085 A1 (OIGARDEN HANS), 17 February 2011 (2011-02-17); whole document	1-9
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A	WO 0173289 A1 (NESHEIM ARVID), 4 October 2001 (2001-10-04); abstract; figures	1-9
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☒ Further documents are listed in the continuation of Box C. ☒ 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
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Date of the actual completion of the international search	Date of mailing of the international search report
27-03-2013	28-03-2013
Name and mailing address of the ISA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer Andreas Westberg Telephone No. + 46 8 782 25 00

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO2012/050228

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 5986349 A (EBERLE WILLIAM J), 16 November 1999 (1999-11-16); abstract; figure 1 ---	1-9
A	US 20110049897 A1 (HOUSER MICHAEL ET AL), 3 March 2011 (2011-03-03); paragraph [0038]; figure 12 --- --------	1-9

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