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(54) Title: DEVICE FOR GENERATING HYDROELECTRIC ENERGY

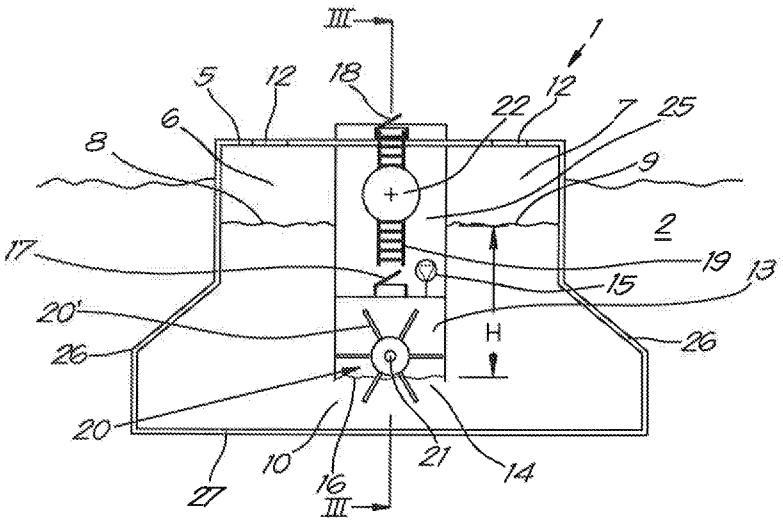

Fig. 2A

(57) Abstract: The invention relates to a device for generating hydroelectric energy, using the swell of a mass of water, said device containing an impeller (20) which is rotatable around a shaft (21) and at least one electric generator group (22), the drive shaft of which is coupled at least in one direction of rotation in a torque transmitting manner to the impeller shaft (21), whereby the device is provided with a floating casing (5) which contains two compartments (6 and 7) which are partly filled with fluid and which via a passage are fluidly connected with each other, whereby the device furthermore contains an air- filled caisson (13), which has an open bottom and opens out to said passage and whereby in said caisson (13) the impeller (20) is rotatably mounted around a shaft (21) which extends perpendicular to the direction of the passage and whereby the impeller (20) is partly mounted in the air-filled space of the caisson and partly in the fluid in the passage.

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[Continued on next page]

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Device for generating hydroelectric energy.

The present invention relates to a device for generating hydroelectric energy.

In particular the invention is intended for generating renewable hydroelectric energy, using waves or swell.

Known systems have a serious problem with working parts that are below water level. Such working parts are very sensitive to corrosion and also to maritime fouling such as algae and barnacles which severely impair the efficiency of the systems and also require a lot and difficult maintenance of sometimes complex forms of moving parts.

A kind of underwater turbine is already known, whereby a screw, rotor or the like are placed under water which will start to rotate by the flow of the water and can thus generate an electric current.

Such known installations show the disadvantage that turbines and the generators connected thereto need to be meticulously sealed to prevent the adverse effects of exposure to the water.

This not only makes the installation expensive, but also difficult to maintain.

Moreover, the rotating blades of the screw, rotor or the like form a danger to marine life.

The purpose of the present invention is to provide a solution to at least one of the aforementioned and other disadvantages.

To this end, the invention relates to a device for generating hydroelectric energy, using waves or the swell of a mass of water, said device containing an impeller which is rotatable around a shaft and at least one electric generator group, the drive shaft of which is coupled at least in one direction of rotation in a torque transmitting manner to the impeller shaft, whereby the device is provided with a floating casing which contains two compartments which are partly filled with fluid and which via a passage are fluidly connected with each other, whereby the device furthermore contains an air-filled caisson, which has an open bottom and opens out to said passage and whereby in said caisson the impeller is rotatably mounted around a shaft which extends perpendicular to the direction of the passage and whereby the impeller is partly mounted in the air-filled space of the caisson and partly in the fluid in the passage.

A condition is that the device must be able to move freely in the swelling of the water.

Thus, the device is provided with means to convert the energy of the swelling of the water to a motion of the impeller. These means are formed by communicating vessels, formed by the two compartments which are connected at the bottom by means of a fluid passage.

The motion of the waves throws the device back and forth, such that the fluid flows through the passage from the one compartment to the other and back, such that the impeller starts rotating.

Preferably, the air or the gas in the caisson is kept under pressure by a compressor or the like, such that the level of the fluid in the caisson can preferably be kept constant and preferably under the level of the impeller shaft, such that the shaft can rotate in the dry part and only the lower section of the impeller is driven by the flow of the fluid in the passage on the outer contour of the impeller where the generated torque is greatest , while the upper section can rotate in the air or in the gas in the caisson in a friction-free way.

In a preferred embodiment the floating casing is held in place at a height above the bottom of the swelling water by means of an anchor in the bottom, such that the device can roll freely with the wave motion and the passage between both compartments is located in the motion direction of the waves to have the greatest effect of the swell.

Preferably, the direction of the anchor is such that the waves realise a maximum effect on the communicating vessels in the casing. This will ensure that the device is able to obtain hydroelectric energy from the swelling of the water in the most optimal way.

This provides the advantage that the impeller is isolated from the mass of water of the sea or the like and consequently

is not subjected to maritime conditions, such as algae and corrosion.

The fluid can be a neutral non-corrosive fluid such as distilled water or the like in which maritime bodies do not grow well due to the lack of nutrients and/or light.

Indeed, all working parts are inside the enclosed casing. Preferably, the casing is accessible via access hatches.

This has the advantage that the parts of the device are not exposed to the seawater such that their construction and more specifically their sealing will have to be less subject to strict requirements. Also, the maintenance of the device will be much easier and cheaper.

Moreover, the device is hidden from view, such that the natural view is not disturbed.

Such device can for example be made in a vessel, provided that the vessel is sufficiently sensitive to the wave motion.

Preferably, the device is used at sea, where there is sufficient swelling.

In a preferred embodiment of a device according to the invention, the impeller is provided with a number of blades at least one of which continuously partially extends into the fluid of the casing during operation.

In this way the impeller can be set in motion by the water without it being necessary to place the impeller shaft under water as well.

In another embodiment the impeller shaft is not in the water.

This offers the advantage that the device is very simple which makes its construction affordable. Apart from the blades of the impeller there are no other moving parts under water, such that therefore no extra attention is necessary for seals and other prevention measures to prevent the damaging effects of the seawater.

Preferably, the generator and the compressor are housed in a dry section of the internal space of the casing, such that no extra high demands need to be set on these components in terms of moisture resistance.

In a further preferred embodiment of a device according to the invention, the drive shaft of at least one generator rotates with the impeller shaft in a first direction of rotation and is freely rotatable in the other second direction of rotation and the drive shaft of at least one generator which is freely rotatable in the first direction of rotation rotates in the second direction of rotation with the impeller shaft.

In another preferred embodiment of a device according to the invention the generator contains a freewheel which allows a free rotation in one direction and forms a non-rotatable coupling in the other direction of rotation.

The device can be provided with a transmission between the generator and the impeller shaft and contains a mechanism to reverse the direction of rotation of the shaft of the generator in relation to the impeller to ensure that the generator is always driven in the same direction of rotation, regardless of the direction of rotation of the impeller.

In a preferred embodiment of a device according to the invention, all parts of the device which come into contact with the water are treated with a non-toxic coat of paint based on a surface-treated composite coating, genre Ecospeed®.

Such coating will ensure that any fouling of slime, algae etc. of said parts can be easily removed.

Moreover, such coating offers a very good protection against corrosion, such that the metal components can be made thinner because possible damage by corrosion does not have to be taken into account.

The invention also relates to a series of devices whereby they are placed in the waves at a distance from each other seen in the direction of the waves and spread over such a distance that at least one device is always in a zone with swelling.

With the intention of better showing the characteristics of the invention, a preferred embodiment of a device for

generating hydroelectric energy according to the invention is described hereinafter, by way of an example without any limiting nature, with reference to the accompanying drawings, wherein:

figure 1 schematically shows a preferred embodiment of a device according to the invention for generating hydroelectric energy whereby the device is mounted in a swelling medium;

figure 2A 2 shows a cross-section according to line II-II of figure 1;

Figure 2B shows a cross-section as that of figure 2A, but for an alternative embodiment according to the invention;

figure 3 shows a cross-section according to the line III-III in figure 2A;

figure 4 shows the cross-section of figure 2A during operation in a swelling medium with waves coming from the left; and

figure 5 shows an analogue figure as that of figure 4 but with waves coming from the right.

Figure 1 shows a device 1 according to the invention which has been floatingly placed on a mass of water 2 with swelling, for example on a sea. The device 1 floats on the water and is anchored to the bottom of the mass of water by means of an anchor 3 to stay in place and to not float away.

The anchor 3 is such that the device 1 can still roll freely around a rolling axis X-X' which is perpendicular to the motion direction LR of the waves 4.

The device 1 consists of a floating closed casing 5 with two separate compartments 6 and 7 therein on either side of the rolling axis X-X' located between said compartments 6 and 7.

The compartments 6 and 7 are partly filled up to a certain level 8, respectively 9, with a fluid 10 and are connected to each other as communicating vessels via a passage.

The fluid is distilled water, for example.

The compartments 6 and 7 are provided with ventilation holes 12.

In the casing 5 between the compartments 6 and 7, a caisson 13 is provided in the form of a clock with an open bottom 14 which opens to said passage 11.

The caisson 13 is filled with air or with another gas which by means of a compressor 15 or another means is kept under pressure, such that the level 16 of the fluid 10 in the caisson 13 is kept as low as possible under the levels 8 and 9 and preferably constant. To this end a pressure is necessary equal to the pressure of a fluid column with height H which, in the position of figure 2A, is equal to the difference in level between the level 9 of the fluid 10 in the compartments and the desired level 16 in the caisson 13.

The caisson 13 is hermetically sealed at the top, but is provided with an access hatch 17 to provide access to maintenance staff which can descend into the casing 5 via a ladder 19 via a second access hatch 18.

A water turbine in the form of an impeller 20 is located in the caisson 13 which is rotatably mounted around a shaft 21 which extends perpendicular to the direction of the passage 11, whereby the impeller 20 is mounted partly in the air-filled space of the caisson 13 and with its lower blades 20' in the fluid in the passage 11.

In this case, the blades 20' are radial blades which extend parallel with the shaft 21.

Preferably, the shaft 21 is located at a certain height above the level. The impeller 20 is designed in such a way that it partly extends in the fluid in the passage 11 and partly in the air in the caisson 13, whereby at least one of said blades 14 continuously extends at least partially in the water.

The device can also contain more than one impeller 20 as in the example of figure 3 in which several impellers 20 are set up next to and/or behind each other.

In the arrangement of figure 3 there is a separate passage 12 for every impeller 20 to channel the fluid between the compartments 6 and 7. The shafts 13 of the different impellers 20 are in each other's extension, although that is not necessary.

The device 1 is further provided with one or more generators 22 which can be driven by the one or more impellers 20 via a chain drive 23 or another drive which may contain a transmission 24 which may be designed such that for example the drive shaft drives the generators 22 faster than the respective impellers 20.

Preferably, the generators 22 and the transmissions, as well as the compressor 15 are located in a dry section 25 of the internal space of the casing 5.

Preferably, the casing 5 has the form of a bar with a wider part at the bottom in the form of wings 26, as shown in the figures. Said form is advantageous for the stability and for absorbing the wave motion of the mass of water 2 and converting it in a motion of the fluid 10 in the casing 5 as will be explained hereafter based on the figures 4 and 5 between the communicating vessels or compartments 6 and 7.

Figure 4 shows a cross-section according to the line II-II in figure 1 whereby the device 1 is mounted in a swelling medium 2 with waves 4 which move to the right in the figure as indicated by arrow R, with a swell which preferably is oriented perpendicular to the longitudinal direction X-X' of the casing 4.

When the device is mounted in the waves 4 the swell will roll the casing 5 around its longitudinal axis X-X', such that the swell is transferred to the fluid 10 in the casing 5 and initially the water level 8 in the left compartment is

higher than the water level 9 in the right compartment space 10'.

By the effect of the communicating vessels the water of the left compartment 6 flows via the passage 11 to the right compartment 7 in the direction of the arrows C in figure 4, such that the impeller 9 will start rotating in said direction and consequently the generator 7 is driven in the direction of rotation D to generate electricity.

The ventilation holes 12 prevent that in the left compartment 6 the air could be compressed and create a vacuum in the right compartment, which would counteract the motion of the fluid between the communicating vessels.

When a wave 4 has passed, the device 1 will roll in the other direction as shown in figure 5, such that the level 8 will now be lower than the level 9 and the water will flow back in the direction of the arrows C' in figure 5, such that the impeller 20 will be driven in the other direction.

Preferably, a freewheel is provided in the transmission 24 which when the fluids flow back in the direction C' can rotate the impeller 20 freely without the generator 22 being driven, all this to ensure that the impeller 20 in said situation does not form an obstacle for the fluid flowback and the generator 22 is driven in only one single direction D, be it with intervals of the succession of the waves.

The succession of the waves means that during certain periods the impeller 20 is driven in one direction of rotation around

its shaft 21 and in other periods in the reverse direction of rotation and the generator group 7 will only generate electricity in one out of the two periods.

To still be able to generate electricity continuously, the device 1 can be conceived such that when the freewheel of one impeller 20 works in one direction, the freewheel of another impeller 20 works in the other direction, such that one generator 22 of both impellers 20 supplies electricity during one period, while in the following period in which said generator 22 does not supply electricity it is the other generator 22 which does supply electricity in this period. Thus, current peaks are smoothed out.

The use of batteries to store the electricity can also help to smooth out the current even further.

Another way, instead of using freewheels, is to switch the transmission 24 such that the input shaft of the transmission 24 is driven in any direction, while the output shaft is always driven in the same direction D.

Preferably, the width of the blades 20' is slightly less than the width of the passage 11 such that there is only little lateral play between the blades 20' and the passage 11 and the blades consequently get to process the whole flow through the passage 11. Analogously, preferably there is little play between the outer contour of the impeller 20 and the bottom 27 of the passage to allow as little fluid flow to leak away unutilised next to and under the impeller 9 and the hydraulic flow pressure of the water is thus utilised to

a maximum extent to drive the impeller 9.

The generated energy of one or several devices 1 can for example be transmitted via a cable to an inverter on the quay. This can be realised by fittingly connecting one or several generator groups with each other.

The present invention is by no means limited to the embodiments described as an example and shown in the drawings, but a device and method according to the invention as defined by the claims can be realised in all kinds of variants without departing from the scope of the invention.

Claims.

1. Device for generating hydroelectric energy, using waves (4) or the swell of a mass of water (2), said device (1) containing an impeller (20) which is rotatable around a shaft (21) and at least one electric generator (22), the drive shaft of which is coupled at least in one direction of rotation in a torque transmitting manner to the shaft (21) of the impeller (20), whereby the device (1) is provided with a floating casing (5) which contains two compartments (6 and 7) which are partly filled with fluid and which via a passage (11) are fluidly connected with each other, whereby the device (1) furthermore contains an air- or gas-filled caisson (13), which has an open bottom (14) and opens out to said passage (11), whereby in said caisson (13) the impeller (20) is rotatably mounted around a shaft (21) which extends perpendicular to the direction of the passage (11) and whereby the impeller (20) is partly mounted in the air- or gas-filled space of the caisson (13) and partly in the fluid (10) in the passage (12), characterised in that the air or the gas in the caisson (13) is under pressure due to a compressor or the like.

2. Device according to claim 1, characterised in that the level of the fluid (10) in the passage (11) is kept constant.

3. Device according to any one of the previous claims, characterised in that the compartments are provided with a ventilation hole (12).

4. Device according to any one of the previous claims, characterised in that the casing (5) is hermetically sealed with the possible exception of ventilation holes (12) for the compartments (6 and 7).

5. Device according to any one of the previous claims, characterised in that the device (1) is anchored to stop it floating away in such a way that the device can still freely roll in the swelling (4) around a rolling axis (X-X') perpendicular to the motion direction of the waves (4).

6. Device according to claim 5, characterised in that the rolling axis (X-X') is located between the compartments (6 and 7).

7. Device according to any one of the previous claims, characterised in that the shaft (21) of the impeller (20) is perpendicular to the passage direction of the passage (11).

8. Device according to claim 7, characterised in that the shaft (21) of the impeller (20) is located above the level of the open bottom (14) of the caisson (13), preferably above the level (16) of the fluid (10) in the caisson (13).

9. Device according to any one of the previous claims, characterised in that the impeller (20) is provided with a number of blades (20') at least one of which continuously partially extends in the fluid (10) in the passage (11) during operation.

10. Device according to claim 9, characterised in that the blades (20') of the impeller (20) are perpendicular to the passage direction of the passage (11).

11. Device according to claim 9 or 10, characterised in that the blades (20') are flat blades which are radially mounted on the shaft (21) of the impeller (20).

12. Device according to any one of the previous claims, characterised in that the casing (4), seen in cross-section perpendicular to the shaft (21) of the impeller, is wider at the bottom than at the top.

13. Device according to any one of the previous claims, characterised in that the generator (22) is located in a dry section (25) in the internal space of the casing (5).

14. Device according to any one of the previous claims, characterised in that several impellers (20) are provided in one casing (5), whereby the impellers (20) are parallel to each other with their shafts (21) and relative to the direction of the waves (4) are placed

behind or next to each other.

15. Device according to any one of the previous claims, characterised in that the drive shaft of at least one generator (22) rotates with the shaft (21) of the impeller (20) in a first direction of rotation and is freely rotatable in the other second direction of rotation and that the drive shaft of at least one generator (22) which is freely rotatable in the first direction of rotation rotates with the shaft (20') of the impeller (20) in the second direction of rotation.

16. Device according to any one of the previous claims, characterised in that the generator (22) contains a freewheel which allows a free rotation in one direction and forms a non-rotatable coupling in the other direction of rotation.

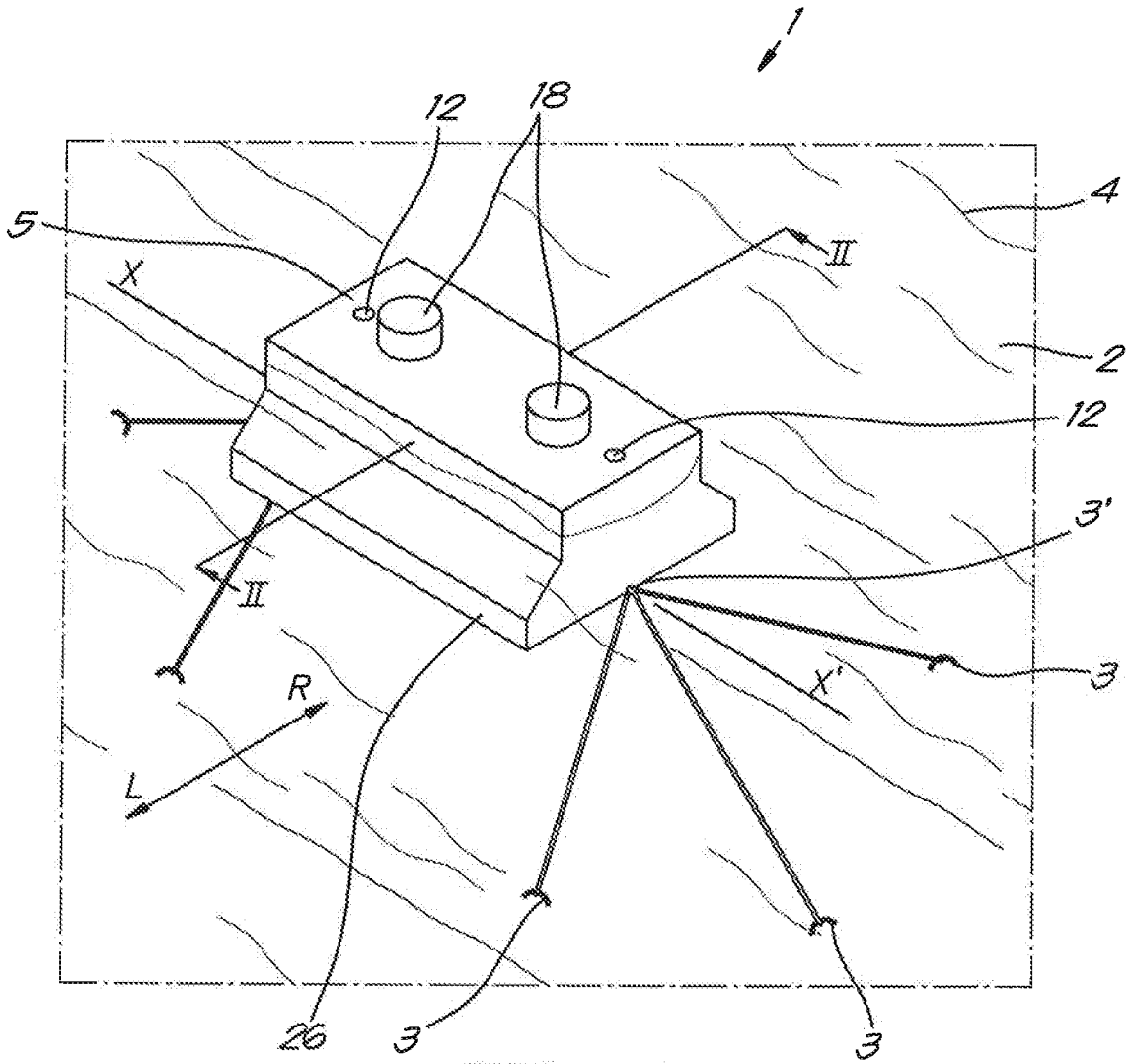

Fig. 1

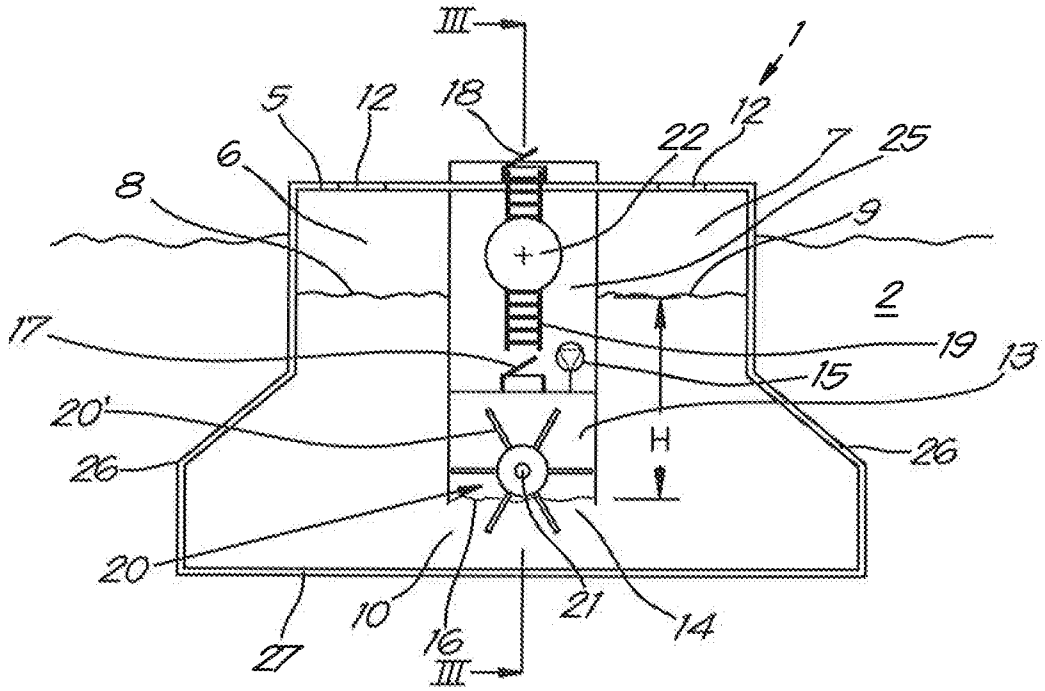
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Fig.2A

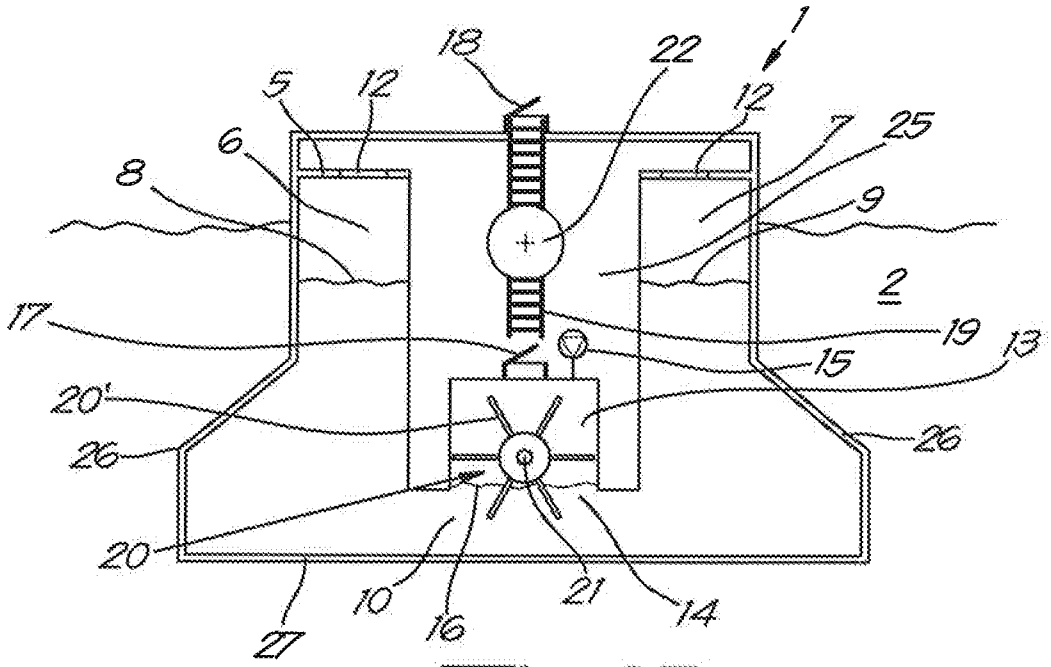
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Fig.2B

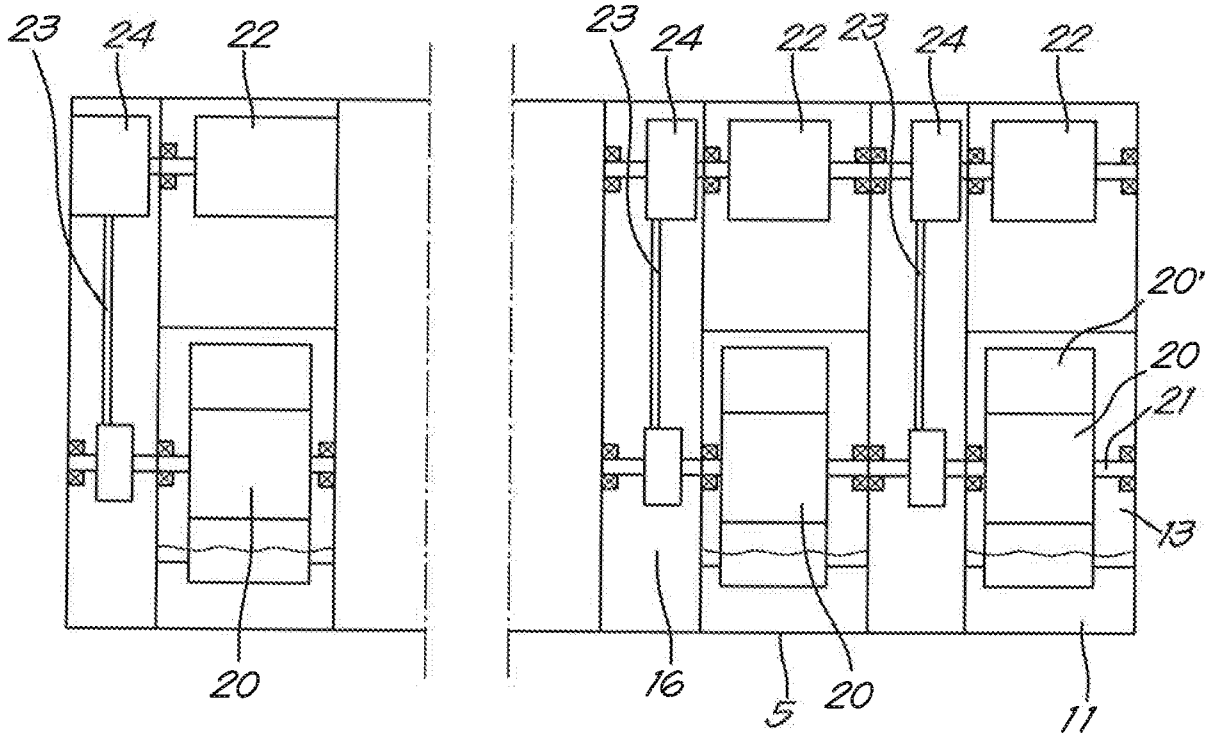
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Fig.3

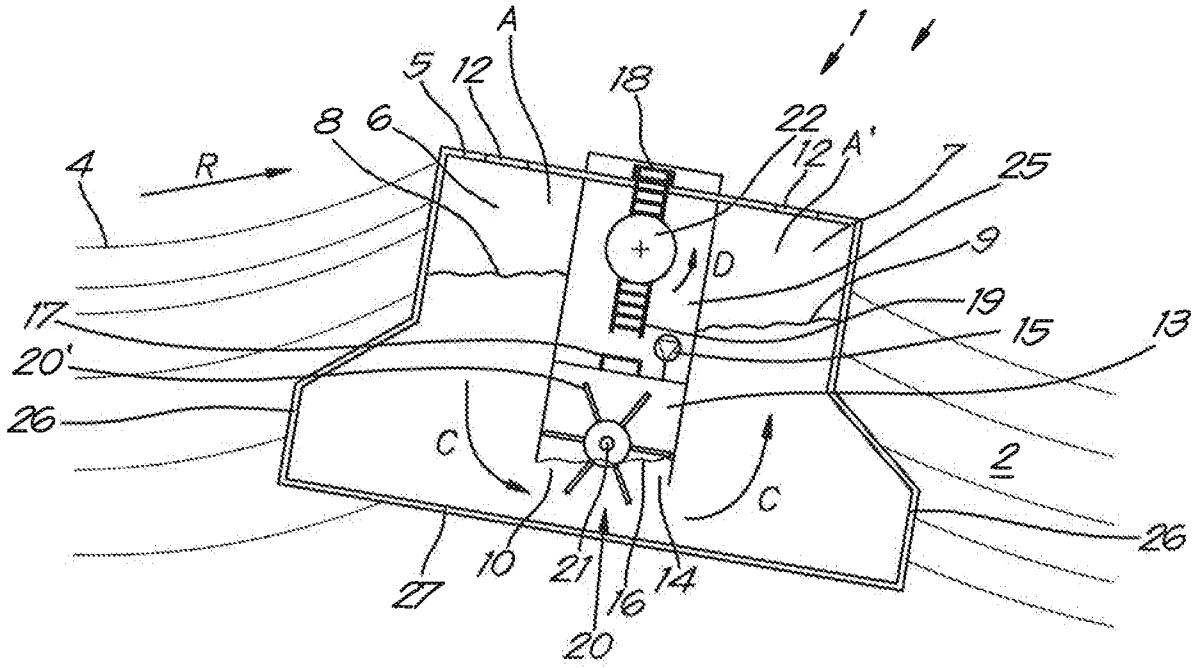
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Fig.4

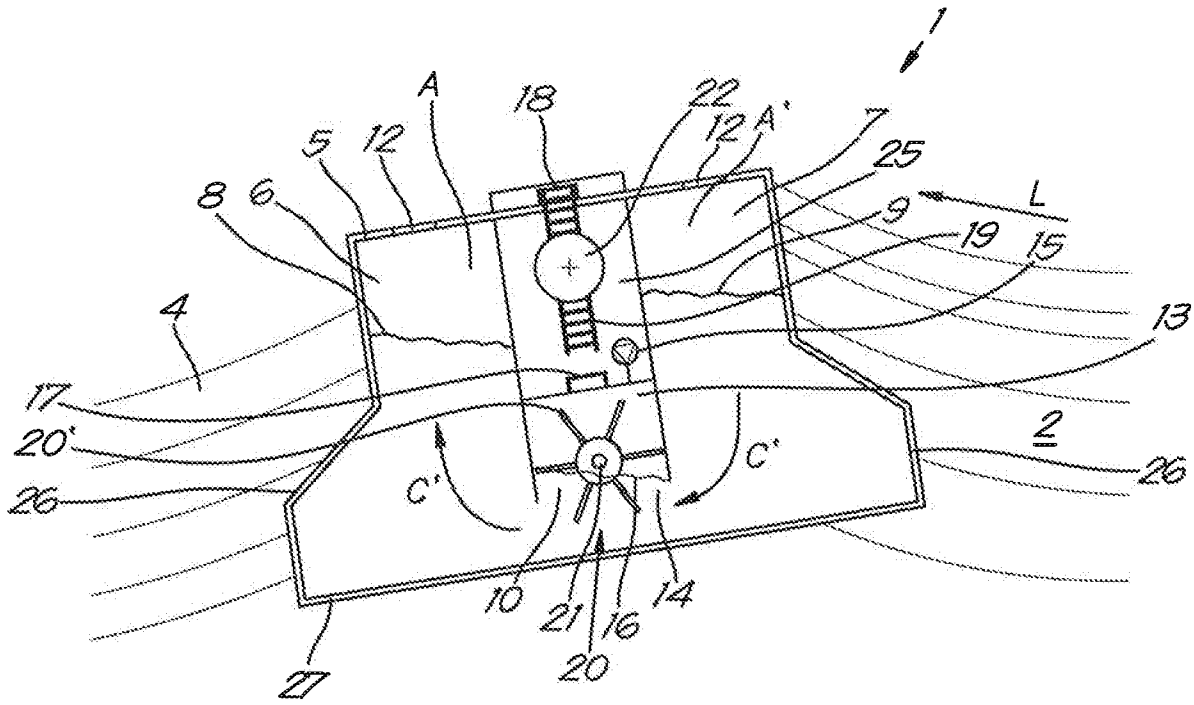

Fig.5

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2020/051435

A. CLASSIFICATION OF SUBJECT MATTER
INV. 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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 207 739 A (SCARPI BRUNO D [FR]) 17 June 1980 (1980-06-17) column 5, line 29 - line 45; figures 18-20	1-16
A	US 2013/119668 A1 (JO CHANG-HUI [KR]) 16 May 2013 (2013-05-16) paragraph [0041] - paragraph [0056]; figures	1-16
A	GB 2 476 860 A (SHIH HSIUNG CHEN [TW]) 13 July 2011 (2011-07-13) page 4, line 13 - page 7, line 17; figures	1-16
A	US 2015/167649 A1 (BARSACQ MATHIEU [FR] ET AL) 18 June 2015 (2015-06-18) paragraph [0066] - paragraph [0092]; figures	1-16

☐ 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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"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
28 May 2020	23/06/2020

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	Lux, Ralph

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2020/051435

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