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EN

EUROPEAN QUALIFYING EXAMINATION 2021

Paper C

Part 1

This paper comprises:

Encrypted e-mail from:

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To:

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Sent: Friday 05 March 2021 08:58

Subject: Opposition against EP3141592B1

Dear Ms Pauley,

Please file an opposition on behalf of my company against the European Patent EP3141592B1.

Due to unforeseen circumstances the European Patent Register does not seem to be functioning properly this morning. I present you with the information we have available now and will give you the rest of the information when the European Patent Register is available again.

EP3141592B1 contains: a description having 23 paragraphs, a set of claims with 6 claims, and 5 figures. However, up to now I was only able to download the following from the European Patent Register: paragraphs [1] to [17] of the description, claims 1 to 3, and figures 1 to 4. These documents are attached to this message as Annex 1.

I have also started to consult the file history of EP3141592B1. This is what I have found out up to now:

> Annex 1 claims priority of the applications NO20150000333 and NO20150000355. NO20150000333 has the following parts of Annex 1: paragraphs [1] to [11] of the description and figures 1 to 3. NO20150000333 has only one claim and it is identical to claim 1 in Annex 1. NO20150000355 contains the following parts of Annex 1: paragraphs [1] to [17], claims 1 to 3, and figures 1 to 4.

Further annexes are attached which I hope will also be useful for filing the opposition.

The European Patent Register is expected to function properly again soon. I will then send you the completed version of EP3141592B1 together with the attachments sent already with the present letter. I will also send you all the relevant information found in its file history.

In the meantime please prepare as much of the notice of opposition as is possible based on the documents at hand.

Kind regards,

Eilasie Kaceth

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Annexes:
    Annex 1 – paragraphs 1-17, claims 1-3 and fig. 1-4
              of EP3141592B1
    Annex 2 – Excerpt from the magazine "European Scientist":
              "Depths of imagination – pumped storage gets a
              makeover"
    Annex 3 – US 9,109,358
    Annex 4 – EP 2 718 281 A1
    Annex 5 – US 6,626,070
    Annex 6 – DE 101 6021 7662.0
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(19) **Europäisches Patentamt**
European Patent Office
Office européen des brevets

(11) **EP 3 141 592 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:

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(51) Int. Cl.: **B65D88/18, F03B13/06**

(21) Application number: **16180339.8**

(22) Date of filing: **5 March 2016**

(54) **Underwater Energy Storage Device**

Unterwasser-Energiespeichervorrichtung

Dispositif de stockage d'énergie sous-marin

(84) Designated Contracting States:

AT BE CH DE ES FR FI IS IT GB HR LI NL SE NO

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[0001] Sunlight and wind can be used as a source of electric energy but they are not continuously available. The need to buffer electric energy has been addressed in the prior art using underwater hydroelectric energy storage.

[0002] To illustrate this well-known concept, figures 1 and 2 show a reservoir 11 in a body of water 13 and the electromechanical components necessary for underwater hydroelectric energy storage, which are an electric motor 14, a pump 15, a turbine 16 and a generator 17. The hydrostatic pressure experienced by the reservoir 11 depends on the deployment depth in the body of water 13. According to this invention, a reservoir is any compartment surrounded by a wall, out of which compartment water can be pumped out and into which water can be let in.

[0003] In figure 1, electric energy coming from an electric input cable 18 powers electric motor 14 which drives pump 15 to pump water out of the reservoir against the hydrostatic pressure. This converts and stores the electric energy as potential energy. Later, shown in figure 2, water is let into the reservoir. Propelled by hydrostatic pressure, the water passes through turbine 16 which drives generator 17. This converts the potential energy into electric energy delivered to an electric output cable 19.

[0004] The reservoir experiences mechanical stress caused by hydrostatic pressure when water is pumped out of the compartment. Therefore, the reservoir necessarily has a structure providing buckling resistance. Buckling resistance according to this invention means that at the deployment depth the reservoir does not collapse irrespective of the amount of water pumped out of the compartment. It is well known that the wall of the reservoir may be designed to be part of such a structure providing buckling resistance.

[0005] The reservoir also experiences a buoyancy force when water is pumped out of the compartment. Thus, a device for underwater hydroelectric energy storage requires that the reservoir be provided with anti-buoyancy means. Anti-buoyancy means according to this invention ensure that the device as a whole does not rise irrespective of the amount of water pumped out of the compartment. Known anti-buoyancy means are anchors attached to the seabed, or ballast whose weight provides a downward force.

[0006] There is a need to facilitate the installation and de-installation of underwater energy storage devices, in particular when a plurality of devices is to be connected in an array.

[0007] Figures 1 and 2 illustrate the prior art. The other figures show embodiments of the invention.

[0008] Figure 3 shows a view of an underwater energy storage device according to a first embodiment of the invention having the features of claim 1. The device comprises the electromechanical components necessary for underwater hydroelectric energy storage. Since the exact location of these components is not relevant for the invention, they are not shown in figure 3.

[0009] The anti-buoyancy means of the first embodiment comprise holding means 26 and a ballast body 27 connected thereto. The weight of the ballast body 27 provides a downward force. Preferably, the ballast body 27 is made of concrete and rests on the ground 22 of a body of water.

[0010] The reservoir 21 has a protrusion 25 along its external surface. The holding means 26 releasably engage with the reservoir's protrusion so that the downward force of the ballast body's weight is conveyed to the reservoir. Such holding means facilitate deployment and enable servicing because the reservoir can be brought into and out of the holding means as needed.

[0011] Spacers 29 are arranged between the reservoir and the anti-buoyancy means. The spacers are made from an elastomer to reduce the impact if the reservoir is inadvertently moved against the spacers, e.g. caused by underwater currents. Preferably, the elastomer contains 13 to 47 % by weight of RZCH, a reinforcing filler.

[0012] The first embodiment may be modified with a first and a second reinforcing arrangement, as defined in claim 2 and illustrated in figure 4.

[0013] The first reinforcing arrangement may be a framework of reinforcing beams 32 which are in contact with the wall 23 at a plurality of locations while permitting water to rise or fall freely within the reservoir. Such a framework inside the compartment 24 extends between opposing parts of the reservoir's wall and thereby establishes a direct mechanical connection between them. As a result, the forces arising from the hydrostatic pressure are at least partly counterbalanced. The beneficial effect is a reduction of the net resulting mechanical stress on the reservoir's wall.

[0014] This beneficial effect can be exploited for a reservoir which has already been manufactured for use at a shallow depth (for instance a depth less than 200 m below sea level) and has only its wall as the structure providing buckling resistance for said shallow depth. By additionally inserting the first reinforcing arrangement into the manufactured reservoir, the range of usage is extended to lower depths (for instance depths greater than 200 m below sea level), where the higher hydrostatic pressure allows more energy to be stored than at said shallow depth.

[0015] The second reinforcing arrangement may be a stiff mesh of steel bars 34 laid into the ballast body if the latter is made of concrete. Such a mesh extends within the ballast body as a skeleton. A skeleton improves stiffness, so the ballast body is able to better withstand any bending strain it is subjected to.

[0016] Such strain can arise if the ballast body rests on an uneven surface. Thus, the second reinforcing arrangement will allow safe deployment of the device in locations where the ground of the body of water is uneven.

[0017] As defined in claim 3, a plurality of devices according to the first embodiment may be connected to a common pump driven by an electric motor and to a common turbine driving a generator.

Paragraphs 18-23

not available

in part 1

of the examination

Paragraphs 18-23

not available

in part 1

of the examination

Claims

1. An underwater energy storage device comprising
a reservoir (21), a structure providing buckling resistance thereto,
anti-buoyancy means having a ballast body (27) with holding means (26), and
spacers (29) made from an elastomer;
wherein
said reservoir (21) has a protrusion (25) along its external surface,
said spacers (29) are arranged between the reservoir (21) and the anti-buoyancy means, and
said holding means (26) releasably engages with the protrusion (25) so that the weight of the ballast body (27) is conveyed to the reservoir (21).

2. A device according to claim 1 for use at depths greater than 200 m below sea level in which the reservoir comprises a wall (23) surrounding a compartment (24); and
the structure providing buckling resistance comprises a first reinforcing arrangement (32) inside the compartment (24) which extends between opposing parts of the wall (23); and
the anti-buoyancy means comprises a second reinforcing arrangement (34) extending as a skeleton within the ballast body.

3. A plurality of devices according to claim 1 connected, for the purpose of storing energy, to a common pump driven by an electric motor and connected, for the purpose of releasing energy, to a common turbine driving a generator.

Claims 4-6

not available

in part 1

of the examination

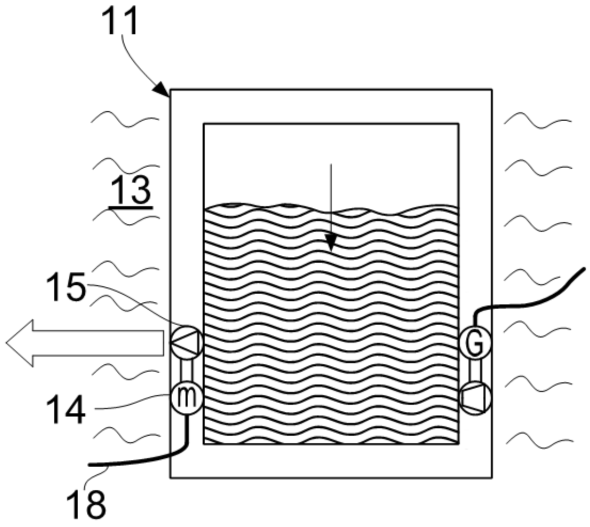

FIG. 1

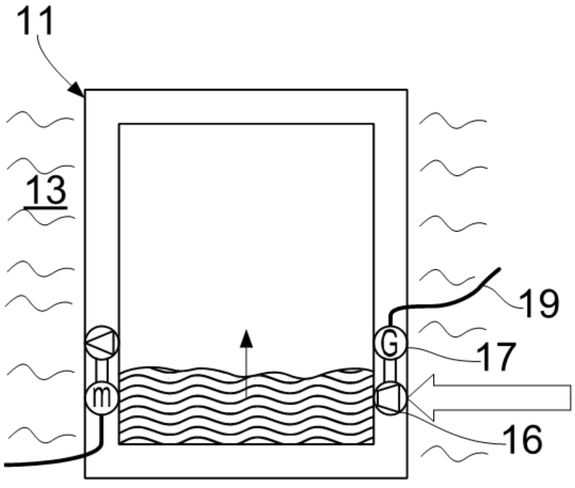

FIG. 2

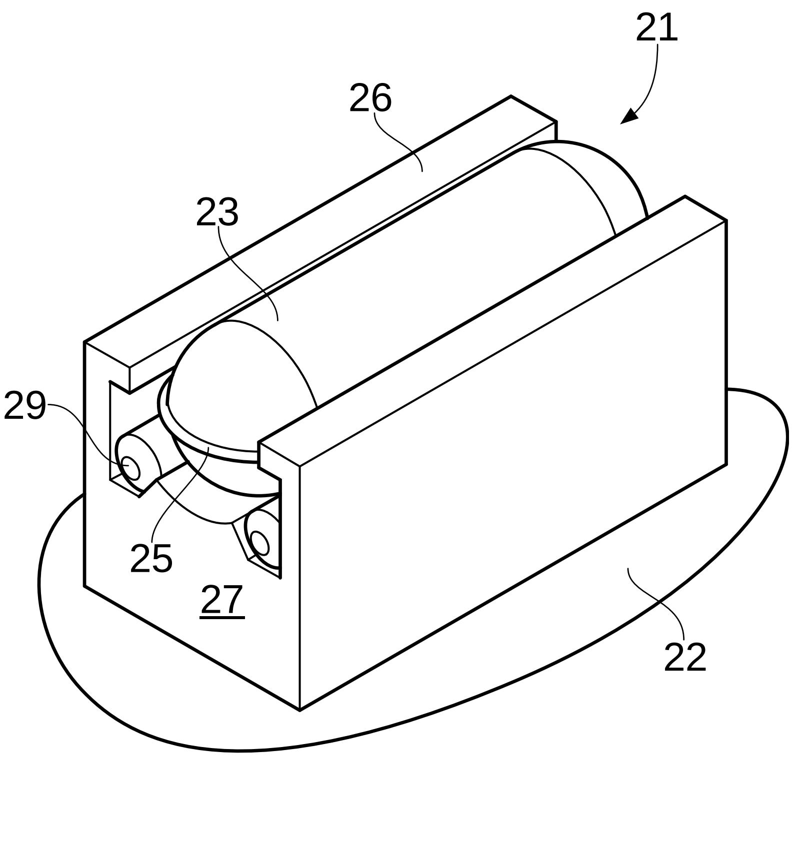

FIG. 3

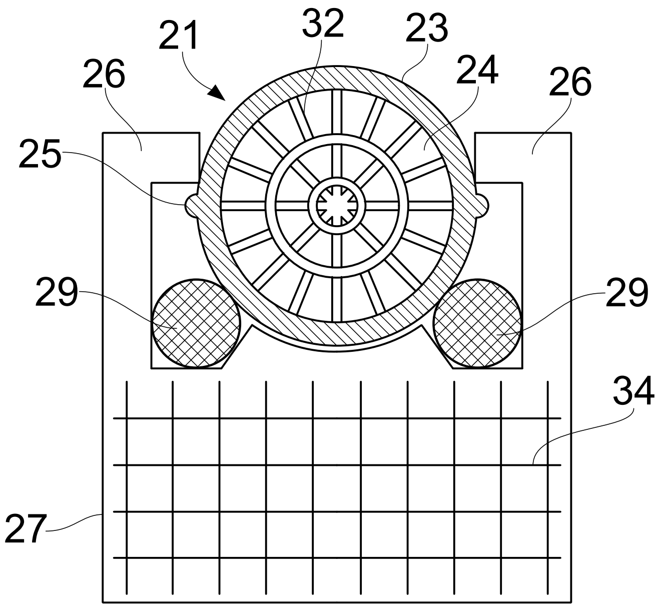

FIG. 4

Figure 5

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in part 1

of the examination

Published 06.08.2015 – Excerpt from the magazine "European Scientist"

DEPTHS OF IMAGINATION

–

PUMPED STORAGE GETS A MAKEOVER

In the last week of May, several big pieces of steel were assembled at the private shipyard of the Calypso Foundation in the harbour of Warnemouth. The public does not have access to the shipyard but spectators on tourist barges saw what is shown in figure 1: workers strung wire ropes through duct channels in the pieces of steel to assemble them into an elongated structure.

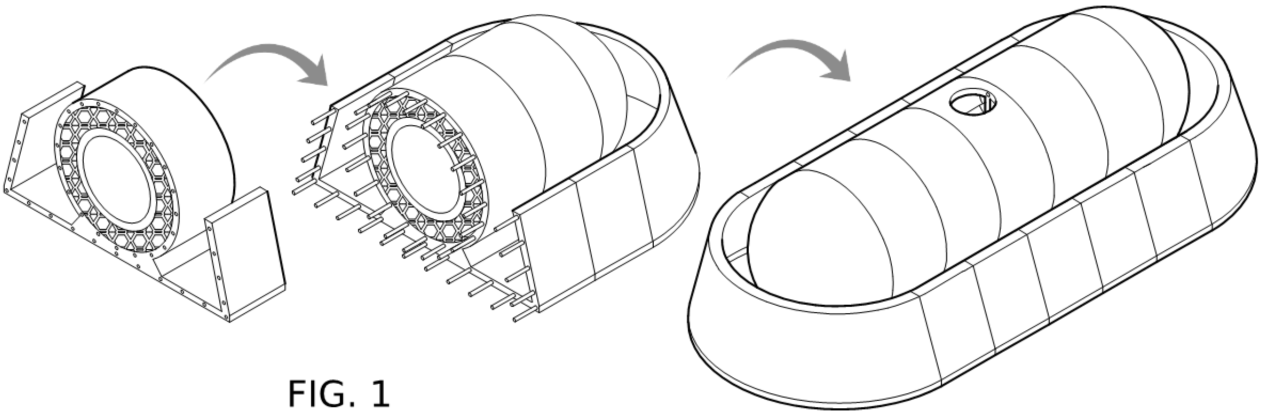

FIG. 1

Last week our correspondent Carla Columna met with Jeanne Costaud, Calypso Foundation's head scientist, to talk about their latest project.

C. Columna: Is the steel structure assembled recently at your shipyard another high-pressure submarine for investigating the deep seas?

J. Costaud: No, it is a prototype of a hydroelectric power plant for the deep sea. In the discharged state, the plant's tank is filled with water from the surrounding sea. If surplus electric energy becomes available, it is used to charge the plant by pumping water out of the tank. The temporarily stored energy can be recovered later by driving a turbine-generator with water that is allowed to rush back into the tank. The idea itself is old, but is worth studying as more and more electric energy is generated by intermittent sources such as wind farms or solar panels.

C. Columna: If this is an old idea, what are the basic difficulties?

J. Costaud: The most critical situation is when water has been pumped out of the tank so that the plant is fully charged. The hydrostatic pressure has two effects: a strong buoyancy force acting on the plant and severe mechanical stress on the tank.

C. Columna: So, the plant has to somehow be kept from floating up to the surface and also has to be highly pressure resistant?

J. Costaud: Precisely. But there is a difference. The buoyancy force is essentially independent of depth, so a given anti-buoyancy set-up will pretty much work for any depth. Pressure, however, increases with depth. The deeper down we go, the sturdier the tank has to be. These two requirements are not completely unrelated, though, since a sturdier tank has more weight and thereby acts as a ballast structure. Our research concentrates on finding which pressure-resistant structures and ballast structures work best for different depths.

Epipelagic depths, i.e. depths down to 200 m below sea level, are interesting because many wind farms are built in coastal areas of that depth. Mesopelagic depths, i.e. depths between 200 and 1 000 m below sea level, are also of interest because the higher hydrostatic pressure there allows you to store more energy.

C. Columna: To make the idea work on a large scale, costs probably have to be kept low. Could you explain this using figures 2 to 4, which we will publish alongside this article?

J. Costaud: Some aspects of our prototype were inspired by old subsea storage tanks for petroleum products – in a way they are also devices which store energy underwater, although they cannot be used as hydroelectric power plants. Several pieces 11 are joined by stringing them together with wire ropes 27. The wire ropes are tensioned between end pieces 33. The inner side of each piece is essentially a pipe segment. Between any two neighbouring segments, there is a sealing layer 24 to make the connection watertight.

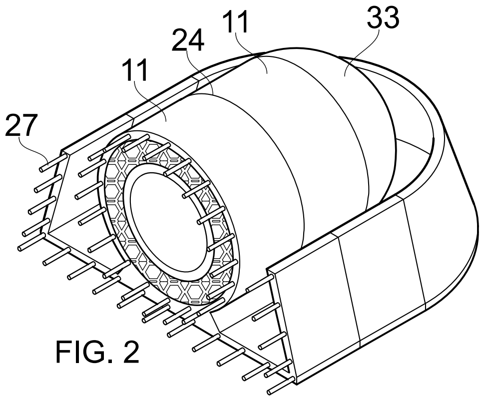

FIG. 2

Once assembled, you have a reservoir. One piece has a hole 35 to which, during operation, a hydroelectric energy conversion module is connected.

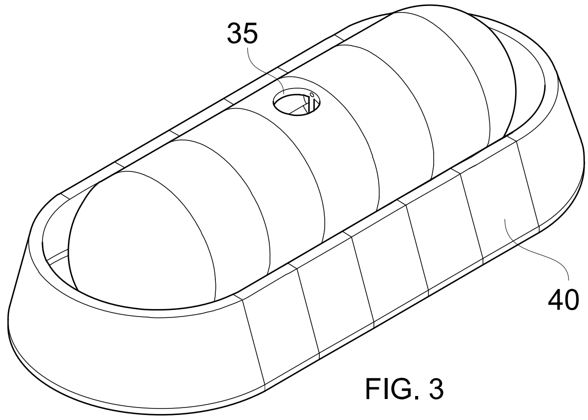

FIG. 3

For buckling resistance at mesopelagic depth, the pieces have a double steel wall 13 sandwiching a novel honeycomb reinforcement structure 15. They also hold duct channels for the wire ropes.

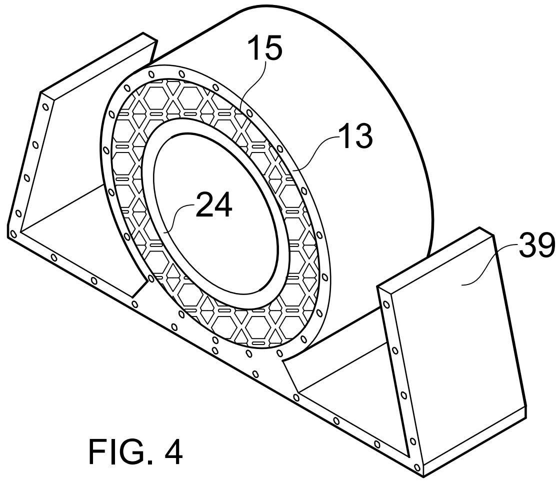

FIG. 4

Each piece has a skirt 39. After assembly the skirts jointly form around the reservoir a receptacle 40 into which sand or gravel can be filled; its weight keeps the plant on the seabed even when pumped empty.

One lucky break for our concept is that the pieces will be forced tightly together by the pressure underwater, so the wire ropes can be of low tensile strength. We use inexpensive wire ropes of type PI-R[1]. To ensure long-term stability against deformation of the sealing layers, they are made from an elastomer comprising RZCH as a filler.

We are quite happy with the results for our prototype, but work continues. A real hydroelectric power plant will be as big as a container ship.

C. Columna: Ms Costaud, thank you for this interview.

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[1]Editor's footnote: The petroleum industry has used standard wire ropes of type PI-F and PI-R since 1970. Wire ropes of type PI-F have a high tensile strength. They always have more than 7 strands of twisted metallic wires, so they are very expensive. Wire ropes of type PI-R have 7 strands of twisted metallic wires or fewer; they have a comparatively low tensile strength but are also less expensive. It is not possible to tell the type of wire rope by way of external inspection.

(19) US-Patent

(11) Patent number: **US 9,109,358**

(45) Date of patent: **January 3, 2012**

(51) Int. Cl.: **B65D88/18, F03B13/06**

(21) Application number: **12/566 370**

(30) Priority: **July 6, 2010 US 29/9792458**

(22) Filed: **July 2, 2011**

(71) Assignee: **Waterhole Science Laboratories**

(72) Inventors: **Gohan G. Asalami, Nolemon S. Nomelon**

(54) Energy container array

[0001] This invention relates to improving an energy container array into which vessels can be easily inserted and extracted underwater to facilitate servicing.

[0002] Figure 1 shows, as vessel 10, model YT-1300 of the product line of Mustard Submarines. It is essentially an upright cylinder made to be buckling resistant for epipelagic depths using double walls of marine-grade steel between which concrete has been poured. A bulge 12 protruding on the outer circumference of the cylinder is typical of model YT-1300.

[0003] At the bottom of the vessel, two conduits 13 permit a transfer of water between the deep sea and the compartment surrounded by the double walls. This transfer may be made via a hydroelectric energy conversion module 15. A hydroelectric energy conversion module holds, for storing energy, a pump driven by an electric motor and, for releasing energy, a turbine driving a generator.

[0004] Figure 2 shows a first embodiment. Vessels 10 have been arranged in an array on pedestals 21 next to each other. Each pedestal may carry a hydroelectric energy conversion module 15 to which the vessel's conduits are automatically connected as it is deployed on the pedestal.

[0005] The downward force of each pedestal's weight is conveyed to the respective vessel via a roof plate 22 and retaining connectors 23 coupled to the pedestal. The weight of each pedestal has to be sufficient to prevent the respective vessel from rising when the vessel is emptied.

[0006] Several individual pedestals may be replaced by one enlarged pedestal of equivalent weight. Such an enlarged pedestal may carry a common hydroelectric energy conversion module. The conduits of each vessel on the enlarged pedestal feed into such a common module. However, an enlarged pedestal requires additional measures to be able to resist the strain caused by resting on an uneven seabed.

[0007] Figure 3 shows a second embodiment. It may have all the features discussed above in the context of the first embodiment except that the downward force is conveyed to the respective vessel via an interaction of the vessel's bulge 12 with a pair of rim sections 32, each having a respective straight section 33.

[0008] The straight sections 33 are coupled to the pedestal. Bumpers 36 may be mounted on each pedestal 21 inside the straight sections 33 to assist in positioning and holding the vessel.

[0009] In operation, the rim sections 32 are closed over the vessel's bulge 12 and clamp it down. The straight sections 33 are movable, e.g. by having a hinge 34, so that the bulge can easily pass the rim sections 32 when the vessel is brought into or taken out of the array. Thus, multiple insertion and extraction is easier, and servicing is simplified to the extent that it can be fully remotely controlled. This also allows use at mesopelagic depths, which is desirable for a high energy-storage capacity.

[0010] Modifications of the second embodiment include using an arrangement comprising an enlarged pedestal as described above for the first embodiment. The bumpers 36 may be made of an elastomer comprising 25 % by weight of ARZK. This reduces the impact if underwater currents push the vessel sideways.

[0011] Use of model YT-1300 in the invention is preferred because its bulge 12 is strong enough to convey the weight of the pedestal. However, at mesopelagic depths, model YT-1300 should be adapted to achieve the necessary buckling resistance.

Claims

1. An array of energy-containers comprising a plurality of vessels (10) and at least one pedestal (21), the array furthermore comprising a restraining structure conveying the weight of the pedestal to each vessel arranged thereon.

2. Array according to claim 1 in which the pedestal (21) is made of concrete.

3. Array according to claims 1 or 2 in which the restraining structure either comprises a roof plate (22) and retaining connectors (23), or a pair of rim sections (32), each rim section having a respective straight section (33).

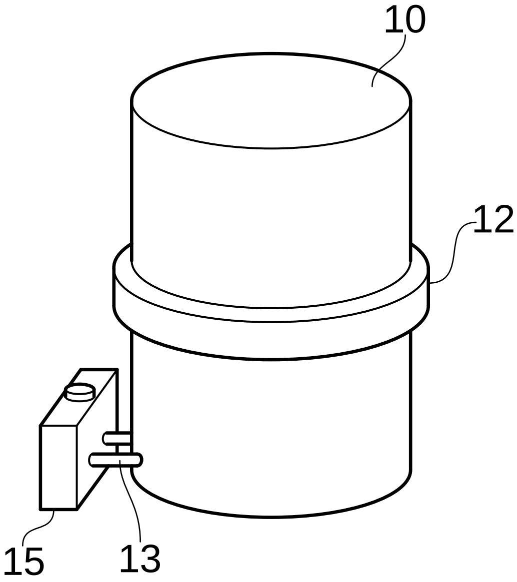


FIG. 1

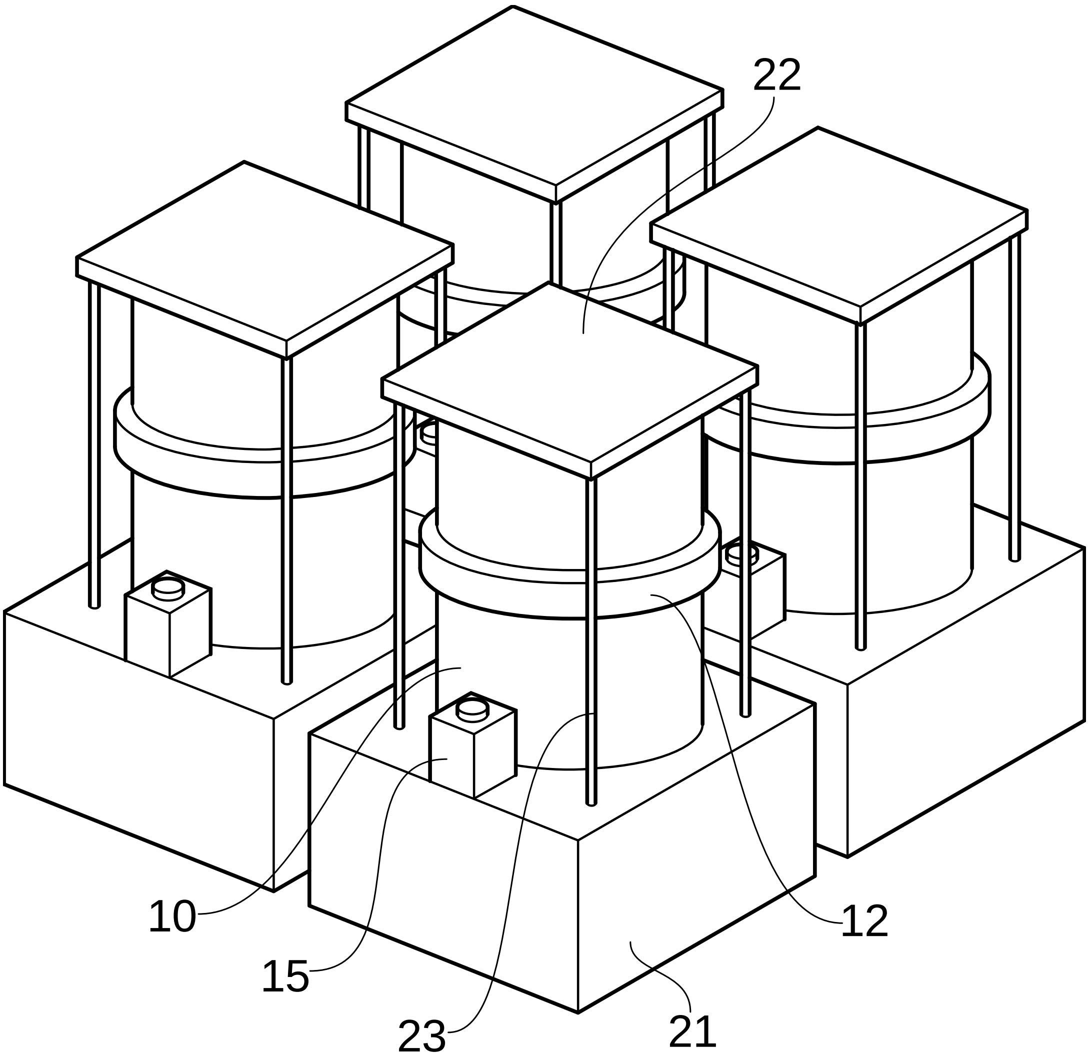


FIG. 2

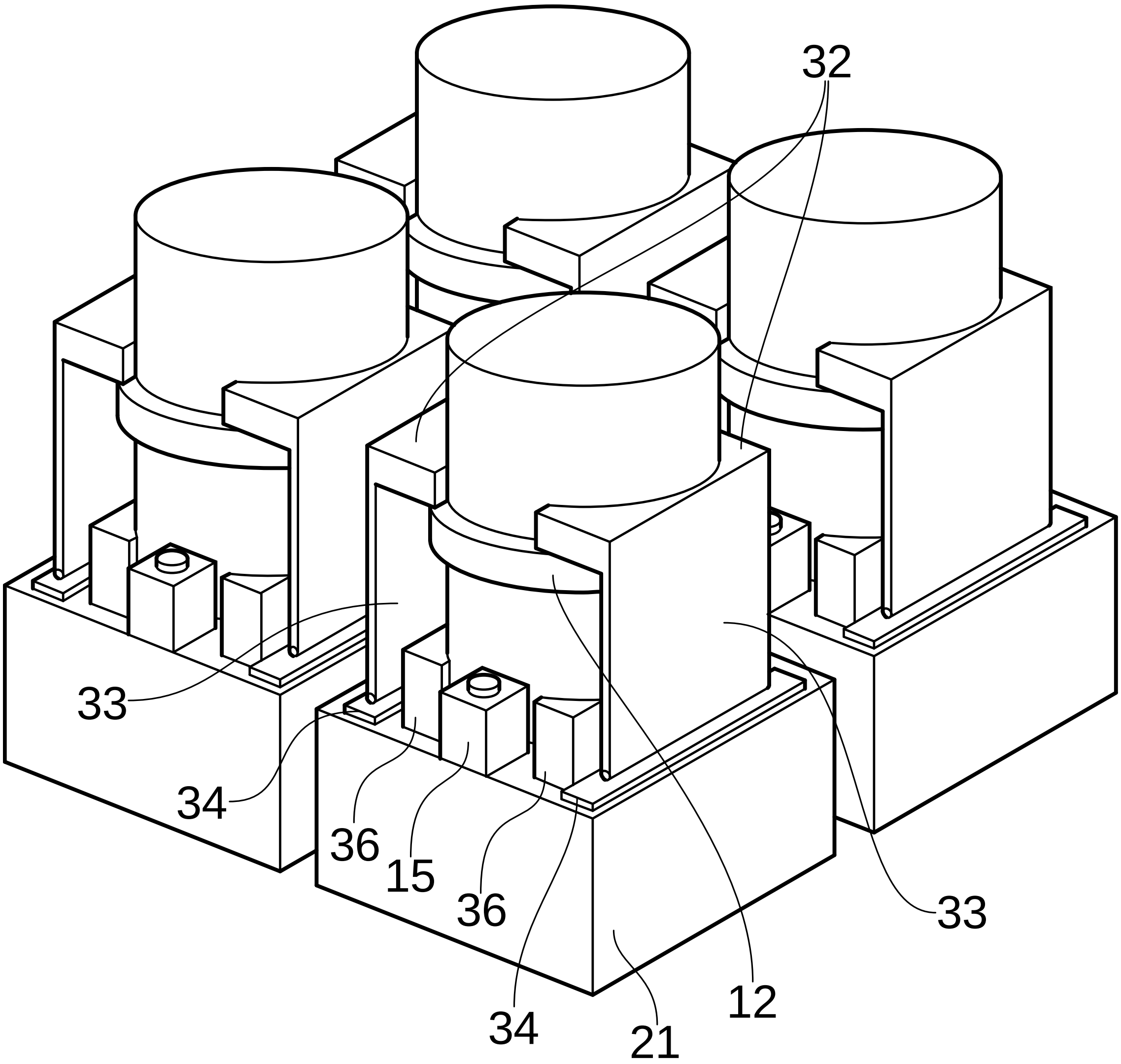


FIG. 3

(19) **European Patent Office**
(12) **European Patent Application**

(21)	Application number:	**14142135.6**
(11)	Publication number:	**EP 2 718 281**
(45)	Date of filing:	**05 October 2014**
(30)	Priority:	**02 October 2013 DE 10 2013 7183088**
(43)	Date of publication:	**06 April 2015**
(51)	Int. Cl.:	**B65D88/18, F03B13/06**
(71)	Applicant:	**Waterhole Science Laboratories**
(72)	Inventor:	**Nev E. Roddoreven, Subid Ura Arudibus**
(84)	Designated contracting states:	**AT BE GB HU IS LU LV**

Modular reservoir and modular assembly for epipelagic depths

[0001] To facilitate scalability, a modular reservoir and a modular assembly for storing electric energy underwater at epipelagic depths are proposed.

[0002] Figure 1 shows two pipe segments 21 with a trapezoidal cross-section (other cross-section shapes are possible). They are connected using external tensioning screws 22 between adjacent pipe segments. By connecting several such pipe segments and corresponding end pipe segments lengthwise in this manner, a modular reservoir according to the invention is obtained.

[0003] Preferably, each pipe segment has a double wall made from steel sheets between which concrete is poured as a filling. This renders the modular reservoir resistant to buckling for epipelagic depths. The concrete filling can be solid or can comprise lengthwise cylindrical cavities in order to reduce the weight. This facilitates handling of the pipe segments.

[0004] A gasket made from an elastomer may be used to ensure a watertight connection between adjacent pipe segments. For sufficient long-term stability against deformation, the elastomer should contain at least 10 % by weight of RZCH. The inventors have found that the content of RZCH has to be 20 % by weight or less. Otherwise the elastomer is very rigid and may not be watertight.

[0005] The pipe segments of the modular reservoir are later held together by the hydrostatic pressure, so the external tensioning screws are mainly needed during assembly. Their main advantage is that the pipe segments can be assembled successively. However, the exposure to the outside environment means that there is risk of damage to the screws, for instance when deploying the modular reservoir. To avoid this, other tensioning methods may be used.

[0006] Figure 2 shows an embodiment of the invention. A modular reservoir 20 is mounted on a ballast pad 24 with a restraining structure 26. A hydroelectric energy conversion module integrated in the end pipe segment 28 contains the electromechanical components necessary for underwater hydroelectric energy storage.

[0007] Its trapezoidal cross-section gives the modular reservoir a shape around which water can flow with very low resistance. Therefore it is protected from underwater currents caused by storms which might otherwise exert a considerable force at epipelagic depths.

[0008] The modular reservoir according to the invention is therefore well adapted for epipelagic depths. However, its shape renders it unsuitable for mesopelagic depths, because sufficient buckling resistance cannot be obtained.

[0009] The restraining structure 26 is optimised for epipelagic depths at which servicing by deep-sea divers is possible. It consists of a plurality of wire ropes of type PI-F. After tightening of the wire ropes, the modular reservoir is held down by the weight of the ballast pad, which acts as an anti-buoyancy means.

[0010] The body of the ballast pad may have a design that is known to work both for mesopelagic and epipelagic depths. It is made of concrete reinforced with a stiff mesh of steel bars laid into the ballast pad's body.

[0011] This design allows the ballast pad to withstand the strain caused by resting on an uneven seabed.

[0012] A modular assembly may be obtained by installing a plurality of modular reservoirs which share a common electrical connection.

Claims:

1. A modular reservoir for epipelagic depths which has been assembled by connecting pipe segments (21) having a trapezoidal cross-section.

2. A modular reservoir according to claim 1 mounted on a ballast pad (24) with a restraining structure (26).

3. Modular assembly for storing electric energy underwater at epipelagic depths comprising a plurality of modular reservoirs according to one of the previous claims.

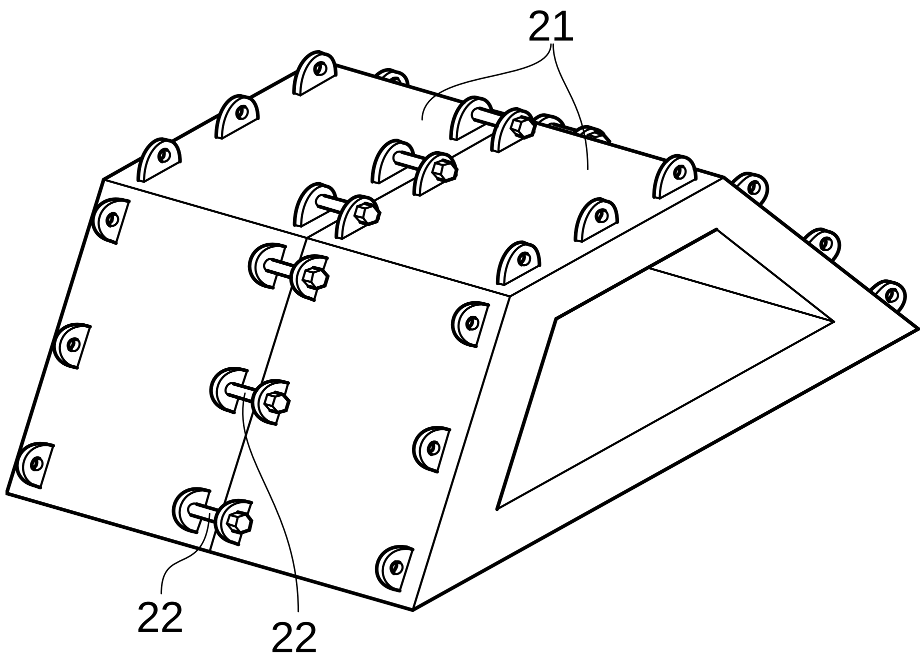


FIG. 1

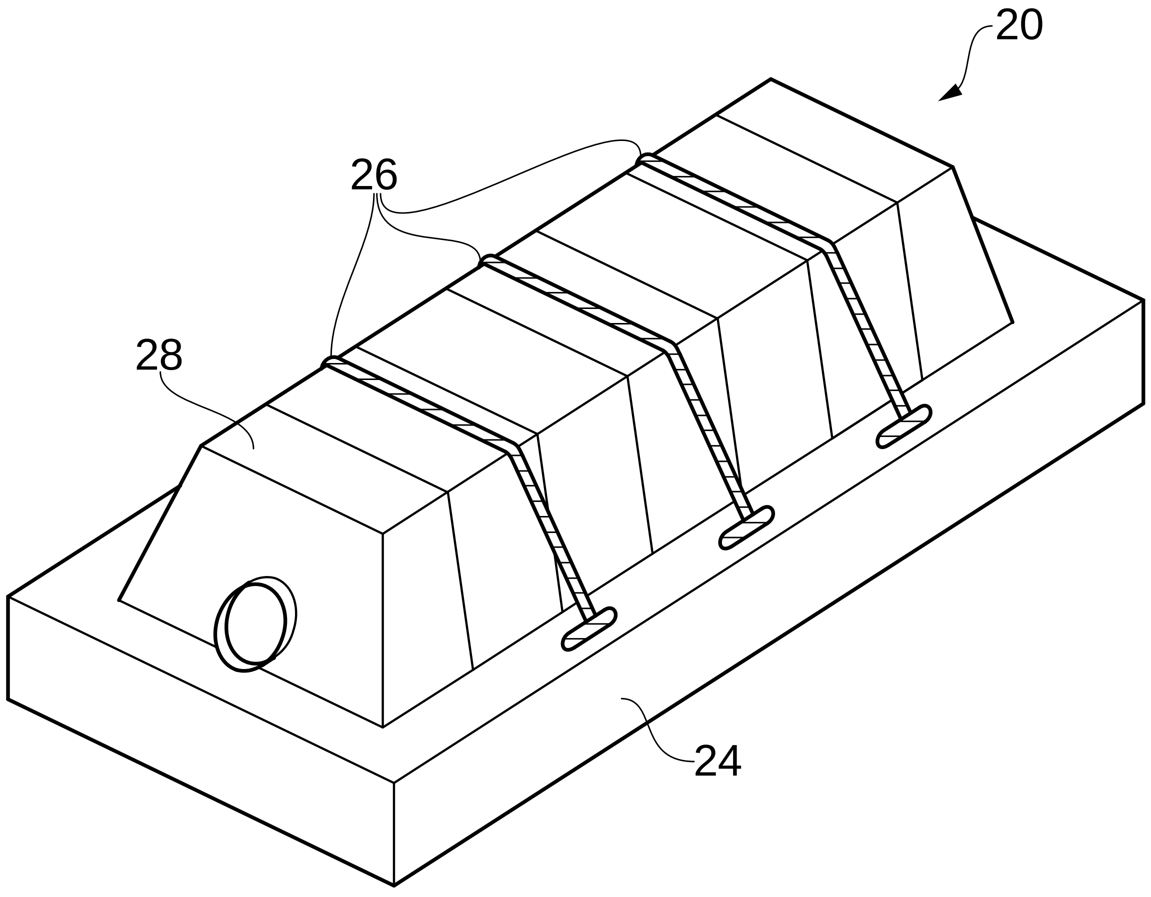


FIG. 2

(19) US-Patent

(11) Patent number: **US 6,626,070**

(45) Date of patent: **January 6, 1980**

(51) Int. Cl.: **B65D88/18, F03B13/06**

(21) Application number: **23/995,155**

(22) Filed: **July 5, 1979**

(30) Priority: **July 4, 1978 US 23/995,140**

(71) Assignee: **David Locker & Jones Benthic Enterprises**

(72) Inventors: **Elstead Ptarmigan, Ned Aronnax, Shrake Kelpie**

Modular underwater storage

[0001] In the past, only the armed forces have used underwater storage tanks, mainly for energy in fossil form, for instance petroleum products. Underwater storage reduced the likelihood of destruction in an attack and provided offshore refueling facilities.

[0002] Figures 1a and 1b show a tank according to the invention which is assembled from a plurality of pipe segments 12 and two end pipe segments 11, all having a circular cross-section. Each pipe segment, and thereby the tank after assembly, has the configuration of a double steel wall sandwiching a layer of concrete.

[0003] The combined weight of the concrete compensates for buoyancy when the tank is filled with a fluid that is lighter than water, for instance a petroleum product.

[0004] The cut view of figure 1b reveals wire ropes 14 strung through lengthwise boreholes in the layer of concrete of each pipe segment. The wire ropes 14 are tensioned with tensioners 15 provided in the end pipe segments 11.

[0005] The wire ropes serve only to align the pipe segments and provide solidity when lowering or lifting the tank. Thus, it is sufficient that the wire ropes are of type PI-R.

[0006] Between any two neighboring pipe segments, a gasket 13 is provided. A gasket is a sealing layer and ensures impermeability. Its composition should contain an elastomer, preferably with a filler such as RZCH for long-term stability against deformation.

[0007] A wire rope rigging as in the tank of figures 1a and 1b is preferred because the wire ropes are shielded against external damage so that a long service period can be expected. Alternatively, external tensioning screws between neighboring pipe segments may be used. This has the advantage that assembly can happen later in the deployment process.

[0008] A flexible, impermeable membrane may partition the compartment inside the tank into an upper and lower portion. A pipe 17 is connected to the upper portion. It is preferably mounted with a valve 16 so that a fluid (e.g. a petroleum product) may be pumped in or out.

[0009] A pipe 18 connected to the lower portion is open to the sea so that the amount of water in the lower portion adjusts by itself to the filling level of the fluid in the upper portion. Figure 1b shows the membrane in a non-filled state of the upper portion (dotted line 150), in a half-filled state (dash-dot line 151) and in a filled state (dashed line 152).

[0010] Since the inside pressure is always identical to the outside pressure, the tank's walls are not built to resist forces arising from hydrostatic pressure. The tank will not collapse, irrespective of the amount of water pushed away by the fluid. Such a tank is therefore usable both at epipelagic and mesopelagic depths.

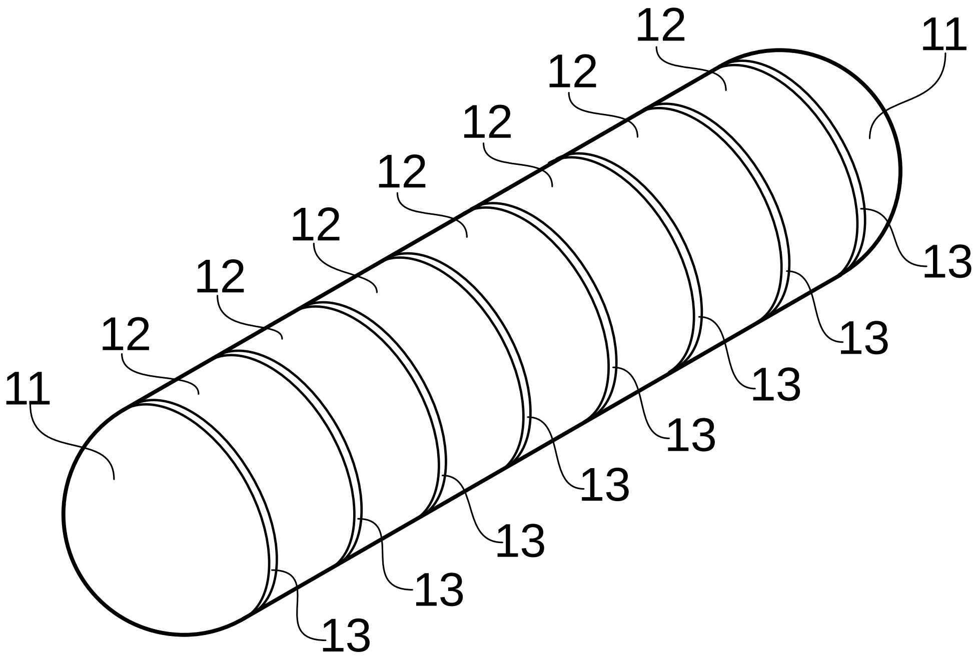
[0011] Figures 2a and 2b show an underwater storage rack holding two tanks 21 according to the invention. Bumpers 31 are added to the outside wall of the tanks to lower the impact of inadvertent movement against the rack. Bumpers are elastic spacers, so they facilitate positioning while the storage tank is being moved into the rack. Preferably, they have a material composition of which at least one third consists of the vulcanizer ARZK for sufficient firmness.

[0012] The pipe segments from which a tank is assembled may have a hexagonal or trapezoidal cross-section. To ensure that the tank fits into the rack, it should not have protrusions. The bumpers may be attached to the rack instead of the outside wall of the tanks.

Claims:

1. A tank assembled from a plurality of pipe segments (12) and two end pipe segments (11) held together by wire ropes (14).

2. Rack for storing two or more tanks according to claim 1, the rack comprising bumpers (31).


12
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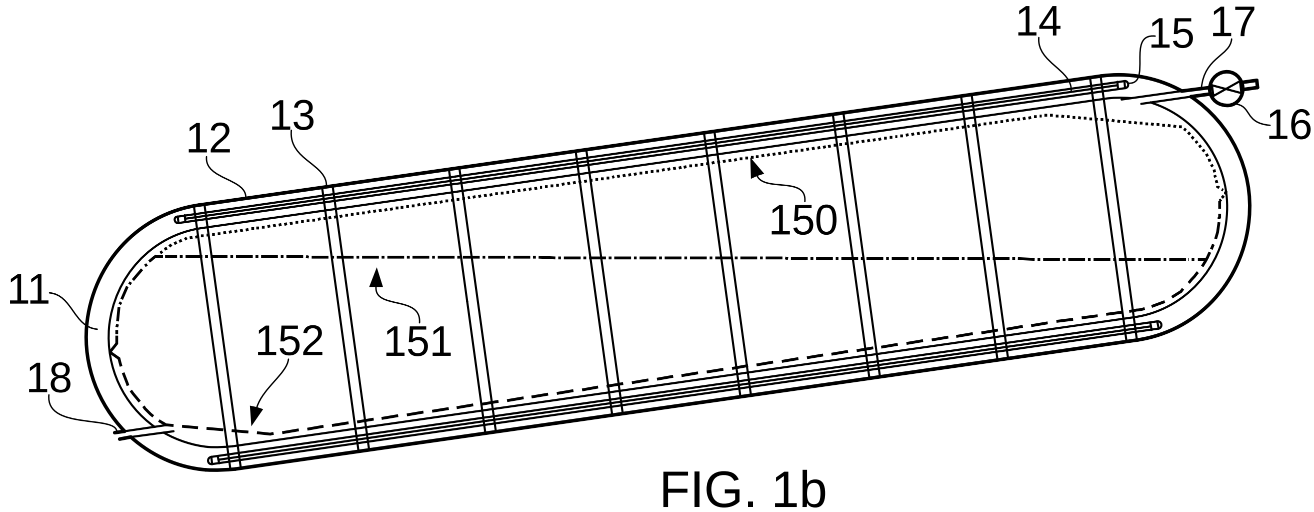
13

FIG. 1a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151
18

FIG. 1b

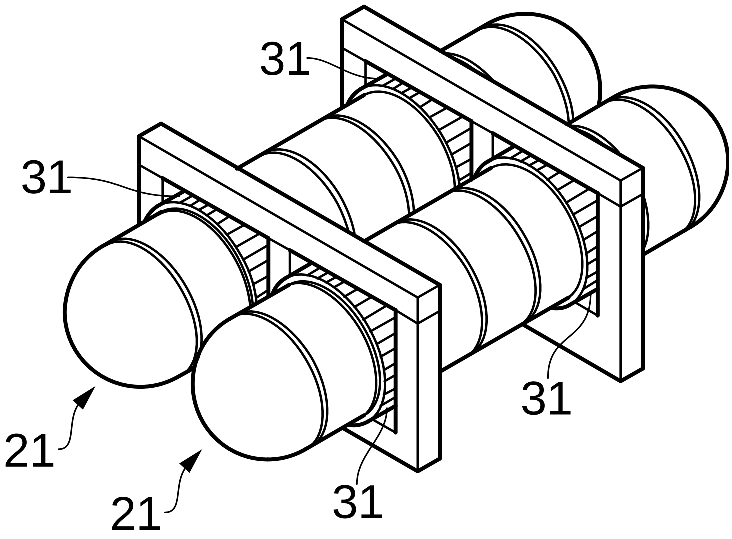

FIG. 2a

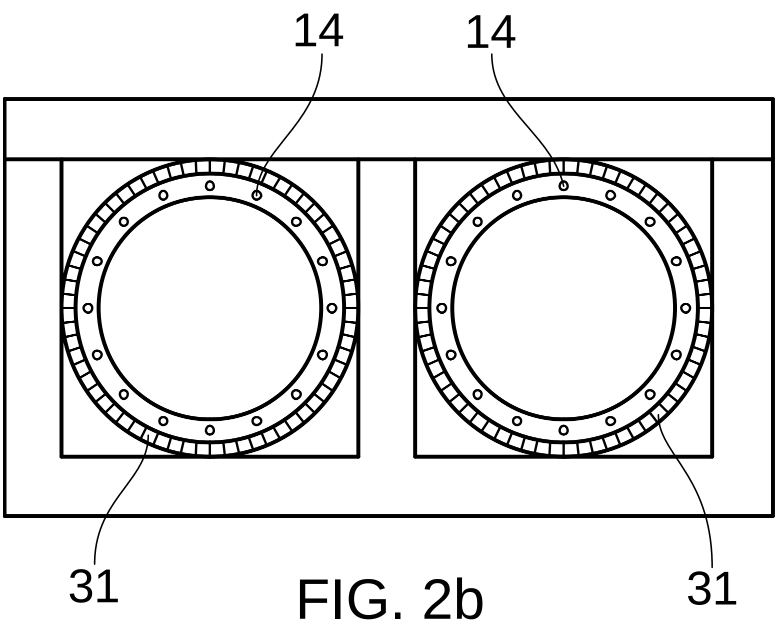

FIG. 2b

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Low-cost one-time deployment reservoir

[0001] Fig. 1 (a perspective view) and 2 (a cross-sectional view) illustrate a reservoir of the invention.

[0002] A reservoir 11 is obtained by stacking ring segments 13 and sealing layers 14 alternately between a bottom plate 15 and a lid 16. The lid 16 is locked to the bottom plate 15 with three or more solid metal rods 18, which also align the ring segments. The bottom plate 15 holds an encapsulated electromechanical unit 19 enabling the reservoir to be used for underwater hydroelectric storage.

[0003] The reservoir 11 is designed for one-time deployment and will be abandoned at the end of its lifetime. Therefore its construction is kept as simple as possible. The ring segments 13 are all shaped identically. They are made of reinforced concrete, which should not contain any cavities because that would lower the buckling resistance of the reservoir. The bottom plate 15 and the lid 16 are made of concrete as well and are heavy enough to serve as anti-buoyancy means. The sealing layers 14 are made from an elastomer containing RZCH for long-term stability against deformation.

[0004] As shown in fig. 3 (a cross-sectional view), in a first embodiment the reservoir may additionally be filled to the top with coarse gravel 12 before the lid is attached. Coarse gravel contains many small but interconnected voids so that water can rise or fall freely within the reservoir 11.

[0005] The coarse gravel distributes the outside forces within the reservoir because it constitutes an internal scaffolding. An internal scaffolding lowers the amount of usable volume, but reduces the net resulting mechanical stress on the reservoir's wall because it establishes a direct mechanical connection between opposing parts of the reservoir's wall.

[0006] Coarse gravel also provides ballast weight at low cost, which eases the ballast requirements for the bottom plate and the lid. The gravel has to be filled in after the reservoir is deployed on the seabed, so the first embodiment is only usable at epipelagic depths.

[0007] Fig. 4 (a cross-sectional view) and 5 (a perspective view of the interior arrangement) illustrate a second embodiment of the invention.

[0008] Pipes are vertically aligned in a bundle and tightly fit into the reservoir 11 during its construction, thereby creating a reinforcing bundle of pipes 23. The lower ends of the pipes are open or perforated so that water can rise or fall freely within the reservoir 11.

[0009] The reinforcing bundle of pipes 23 constitutes an internal scaffolding just as the coarse gravel does in the first embodiment. Based on the known buckling resistance of the reservoir's walls, the overall buckling resistance of the reservoir may be set by the number of pipes, their diameter and their wall thickness.

[0010] However, this concept can also be taken to improve the buckling resistance of any other previously manufactured reservoir because such a reinforcing bundle of pipes 23 can be added as internal scaffolding. Preferably, such a reservoir should be cylindrical.

[0011] The inventive concept of the second embodiment is recommended for mesopelagic depths since a high buckling resistance is provided without using thick, bulky and costly walls as in the prior art. This does not, however, restrict its suitability to this depth, because any structure that is buckling resistant at mesopelagic depths will also be buckling resistant at epipelagic depths.

[0012] However, the higher pressure at mesopelagic depths allows, compared to epipelagic depths, a higher amount of RZCH to be used in the elastomer for the sealing layer, for instance 30 % by weight of RZCH. This results in improved long-term stability against deformation so that the reservoir can remain in service for longer.

[0013] A further embodiment of the invention is obtained by connecting several reservoirs of the invention so that they share their respective electromechanical unit.

Claims:

1. Energy storage device comprising a reservoir (11) for one-time deployment having an internal scaffolding extending to the top of the reservoir.

2. Energy storage device according to claim 1, the internal scaffolding comprising coarse gravel (12) or a reinforcing bundle of pipes (23).

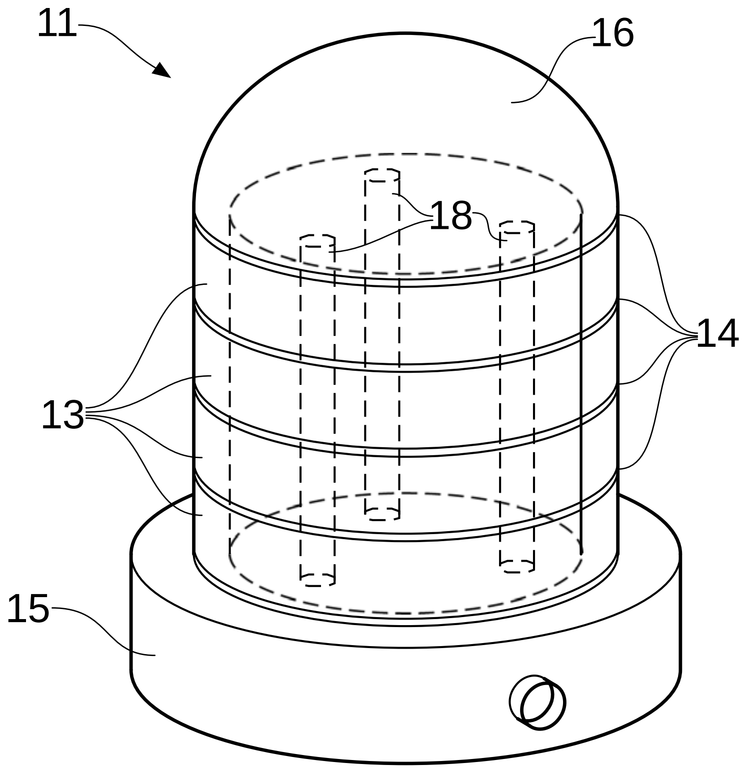

FIG. 1

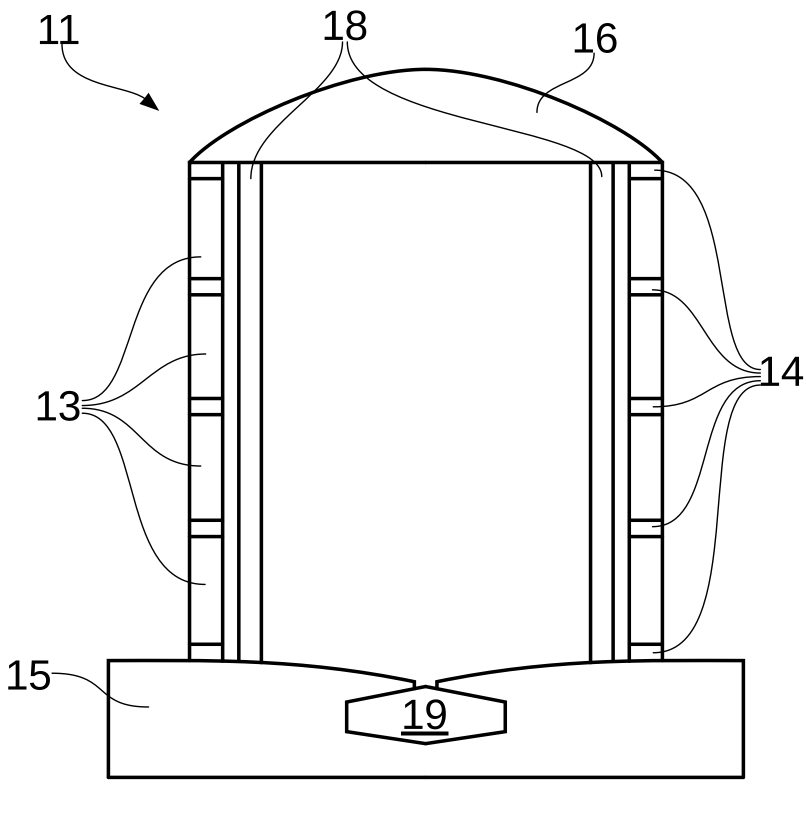

FIG. 2

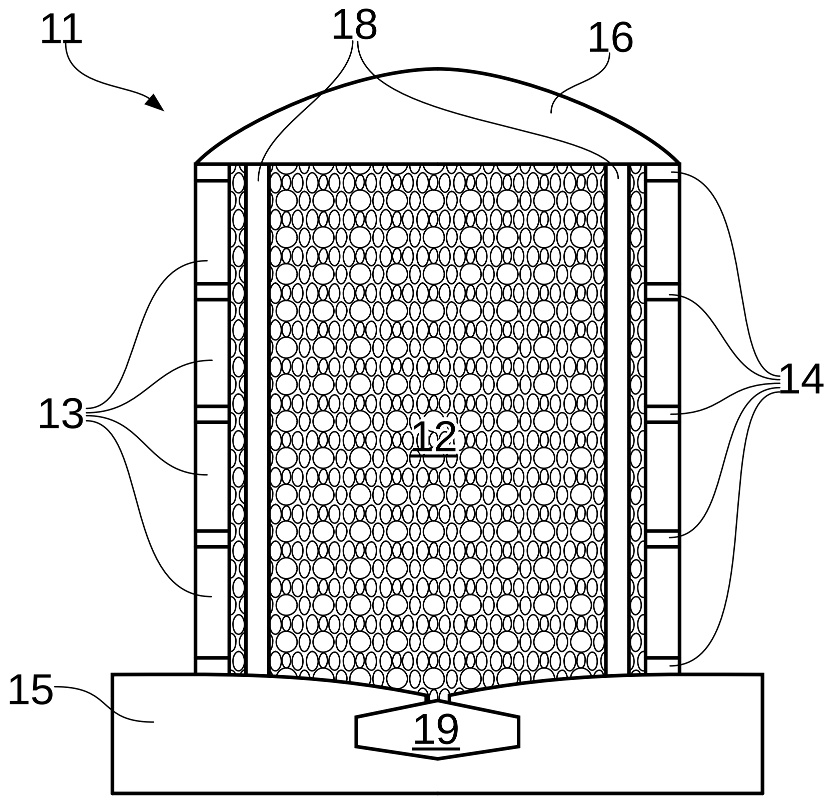

FIG. 3

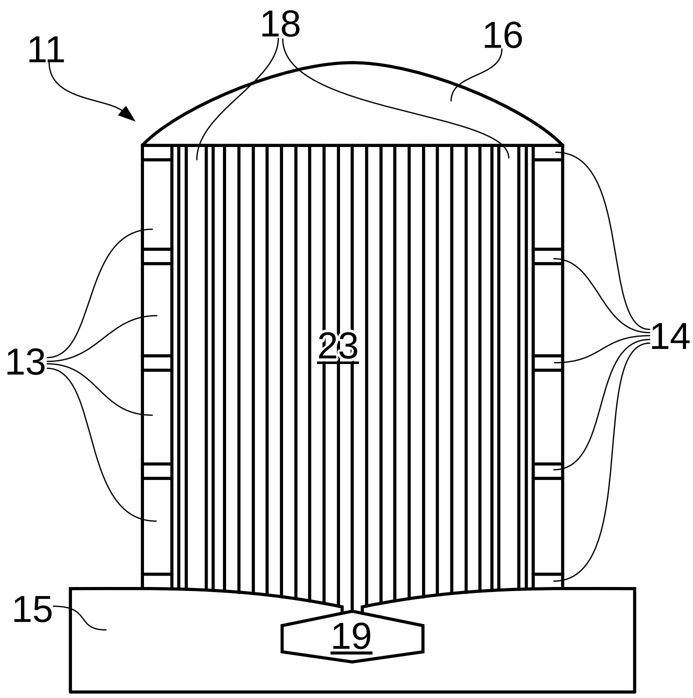

FIG. 4

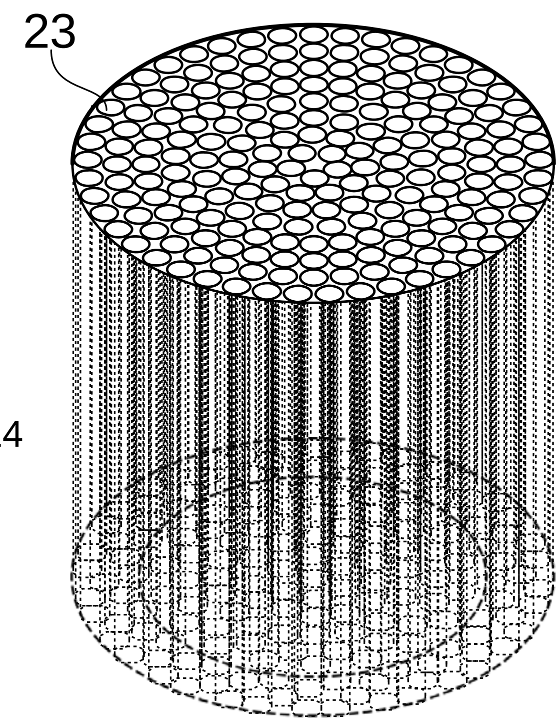

FIG. 5