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— as to the identity of the inventor (Rule 4.17(1))

— as to applicant’s entitlement to apply for and be granted a patent (Rule 4.17(2))

Published:

— with international search report (Art. 21(3))

Title: Modified water-activated battery

Abstract: A water-activated, deferred-action battery having a battery housing (17A) and/or a battery attachment housing (20) containing at least one cell, comprising: at least one anode (17B); at least one cathode (17C), at least one cavity (17E) separating said at least one cathode (17C) and said at least one anode (17B); and at least one aperture (17F) leading to said at least one cavity (17E) for the ingress of an electrolyte- forming, aqueous liquid, characterized by an electrolyte containing housing member (22, 23) having an inlet opening (23A) in a distant end of said housing member (22, 23), a through passage formed in an electrolyte containing space (22A) for an electrolyte composition (27) and an outlet opening (22B) in a proximate end of said electrolyte containing housing member (22, 23), said electrolyte containing housing member (22, 23) being positioned in a flow path leading to said aperture (17F), wherein an inner filter (21A) is arranged across said flow path next to said electrolyte containing space (22A) adjacent said outlet opening (22B).
MODIFIED WATER-ACTIVATED BATTERY

TECHNICAL FIELD

The present invention relates to a water-activated, deferred-action battery having a battery housing and/or a battery attachment housing containing at least one cell, comprising at least one anode, at least one cathode, at least one cavity separating said at least one cathode and said at least one anode and at least one aperture leading to said at least one cavity for the ingress of an electrolyte-forming, aqueous liquid.

BACKGROUND ART

The water-activated battery was first developed in the 1940s to meet a need for a high-energy-density, long-shelf-life battery, with good low-temperature performance, for military applications. The battery is constructed dry, stored in the dry condition, and activated at the time of use by the addition of water or an aqueous electrolyte. Immersion batteries are designed to be activated by immersion in the electrolyte. They have been constructed in sizes to produce from 1.0 V to several hundred volts at currents up to 50 A. Discharge times can vary from a few seconds to several days.

The most commonly used water-activated batteries are employed in marine environment, where activation of the battery takes place at immersion in seawater, which serves as a conducting electrolyte between the anode and cathode.

Various embodiments of deferred-action batteries have been described during the years, e.g. in US 2491640, 2636060, or 2655551. These seawater-activated batteries are inhibited in brackish or fresh water due to poor electrolyte conductivity. Few examples of attempted modifications have been published, in order to overcome this obstacle. US 4094028 describes an automatic inflating lifesaving buoy, which is driven by an electric cell or battery. Although seawater activated battery is mentioned as energy source, a modification for fresh water is suggested in the form of adding electrolyte particles consisting mainly of sodium chloride, which are packed with water soluble packing paper. While this solution may be simple, will have the drawback of short shelf-life, especially in marine environment,
where the high humidity level in the atmosphere will damage the water soluble packing paper. Moreover, the packing paper will generate a delay in the battery activation due to the time needed for the paper to dissolve in water, and will show no mechanical resistance for applications under the water surface, where the pressure generated by the water becomes rapidly very high with increasing the depth.

Another example of battery designed for fresh water is described in US 5424147. Here the cathode is modified with a heat-pressed, rigid static bed of active cathode material comprising (among other components) a water-ionizable salt, sparingly soluble in water. As a consequence, the salt will dissolve gradually in water and maintain the conductivity at a certain level over a required time. The limitation of this invention is the level of voltage achieved as a result of a limited concentration of dissolved salt in the water, i.e. limited electrolyte conductivity.

**SUMMARY OF INVENTION**

An objective of the invention is to provide a water-activated, deferred-action battery which can equally be actuated in seawater, as well as in brackish or fresh water. Moreover, the named battery should be capable of generating moderate to high operating voltages.

Another objective of the invention is to ensure instant activation of the battery at the immersion in water.

Still another object of the invention is to provide a water-activated, deferred-action battery designed to function at low temperatures and/or high pressures, such as prevailing deep waters or the bottom of the sea.

Still another object of the invention is to ensure a long shelf-life of the named battery even if exposed to highly corrosive marine environment.

In one embodiment of the invention, the water-activated, deferred-action battery of the present invention has a battery housing containing at least one cell, comprising at least one anode and at least one cathode. The anode(s) and cathode(s) are separated by at least one cavity. The battery housing comprises at least one aperture leading to said at least one cavity, for the ingress of an electrolyte-forming, aqueous liquid. The battery further
comprises an electrolyte containing housing member having an inlet opening in its distant end, a through passage formed electrolyte containing space for an electrolyte composition and an outlet opening in its proximate end. The electrolyte containing housing member is being positioned in a flow path leading to said aperture. By incorporating the electrolyte composition in the flow path, the is situ electrolyte formation is achieved when immersing the battery into water. In this way a high electrolyte concentration is achieved in the vicinity of the seawater-activated battery, which ensures the battery activation independently of the salt concentration of the incoming water. Thereby, the battery can equally be actuated in seawater, as well as in brackish or fresh water.

In another embodiment of the invention, the through passage formed electrolyte containing space can be arranged with filter adjacent to said inlet and/or outlet opening, across said flow path. In this way, the electrolyte composition is kept in place near the water-activated battery, and can generate an electrolyte solution as soon as the battery is activated as a result of the filter porosity keeping the particles of the electrolyte composition in place while allowing the water to pass unobstructed. Moreover, by choosing right mechanical resistance of the filters, the battery will suit for applications at high pressures, while the resistance to corrosion of the filters will open for long storage even in marine environment.

In another embodiment of the invention, the electrolyte containing housing member may form a part of a battery attachment housing that encloses or forms a part of said battery housing. Moreover, said electrolyte containing housing member may include a, preferably detachable, cap including said inlet opening, and an annular member, preferably ring shaped, forming said electrolyte containing space. This will ensure an easy handling and will simplify the modification of the seawater-activated battery according to the present invention.

In another embodiment of the invention, a mounting bracket is arranged for attachment of said battery attachment housing, preferably including a central passage enabling connection to said flow path. This makes easy the integration of the battery of the present invention in different complex systems.

In still another embodiment of the invention, said battery housing and/or battery attachment housing is arranged with an outlet in connection with at least one air pocket. Moreover, said air pocket may be arranged within said battery attachment housing, and/or arranged within a
hollow portion of a mounting bracket. The air pocket is of great importance in allowing a compressing volume for the trapped air when the activating water is flowing in the battery housing.

In still another embodiment of the invention, said water-activated battery has a magnesium anode and a cathode selected from the group consisting of silver chloride, lead chloride, cuprous iodide, cuprous thiocyanate, and cuprous chloride. These setups are known to be suitable for immersing seawater-activating batteries.

In still another embodiment of the invention, the battery housing is arranged within a pressure chamber cup, comprising at least one sealed aperture, preferably in the form of a releasable sealing plug, arranged to allow inflow of water when said aperture is open, wherein preferably said aperture is arranged with a sealing member. This arrangement will allow a simple activation of the battery, by simply unplugging the aperture before immersing in water. Moreover, when sealed, an increased shelf-life of the battery is ensured, where the battery is well protected and capable to resist even to highly corrosive marine environment.

In still another embodiment of the invention, the electrolyte composition is a water soluble body containing a water-soluble salt, being positioned within said electrolyte containing space. In this way the battery will be activated even by fresh water or seawater containing less than 2.5 g/l sodium chloride, as the electrolyte composition will ensure a high concentration of ions in water, resulting in a high electrolyte conductivity.

In still another embodiment of the invention, the water-activated, deferred-action battery according to the invention is included in a detonator device, wherein the battery is connected to an igniter squib, which subsequently is arranged to detonate a pyrotechnic composition. Moreover, the mounting bracket attached to the battery attachment housing can be arranged with a first inter fit part for sealed attachment of said battery attachment housing and a second inter fit part for sealed attachment of a container member including a pyrotechnic charge.
BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the invention will be described in more detail with reference to the figures wherein:

**Fig. 1** shows a perspective view of a battery attachment housing according to one embodiment of the invention;

**Fig. 2** shows an exploded view of battery attachment housing, wherein the battery is exposed, according to the embodiment of Fig. 1;

**Fig. 3** shows an exploded view of battery enclosing housing of the embodiment shown in Fig. 1;

**Fig. 4** shows a side view of a detonator device arranged with a battery attachment housing according to the invention;

**Fig. 5** shows a cross-sectional view along lines C-C in Fig. 4;

**Fig. 6** shows a partial cross-sectional view of the device in Fig. 5 in a secured state, and

**Fig. 7** shows a partial cross-sectional view of the device in Fig. 5 in an activated state.

DETAILED DESCRIPTION

Fig. 1 shows a perspective view of a battery attachment housing 20 and a mounting bracket 18 in accordance with the invention, while Fig. 2 shows an exploded view of the device presented in Fig. 1 wherein the battery 17 has been exposed. The battery attachment housing may be attached to the mounting bracket 18 having pre-defined threaded holes 18A by means of screws 25, e.g. to sealingly attach the flange 20A of the electrolyte and battery attachment housing 20 transverse wall portion 18E of the mounting bracket 18. The mounting bracket further is provided with an annular flange portion 18C, protruding in an axial direction, which is intended to provide fit for the flange 20A of the battery attachment housing 20. In the outer part 18B of the mounting bracket 18, away from the electrolyte and battery attachment housing 20, there are arranged holes 28A for attachment of a central tube 3 arranged to enclose pyrotechnic material (illustrated in figure 5). At the extremity of the
electrolyte and battery attachment housing 20 opposite to the mounting bracket 18, there is arranged an electrolyte housing cap 23.

The seawater-activated battery was chosen among the known immersing batteries, having a magnesium anode and a cathode selected from the group consisting of silver chloride, lead chloride, cuprous iodide, cuprous thiocyanate, and cuprous chloride.

In Fig. 3 there is shown an exploded view of the electrolyte and battery attachment housing 20, wherein the electrolyte housing cap 23 is shown in the upper part of the figure. As already mentioned the electrolyte housing cap 23 is intended for attachment to the extremity of the electrolyte and battery attachment housing 20, opposite to the mounting bracket 18. The electrolyte housing cap 23 is arranged with a central through hole 23A within its outer end wall, presenting an inlet opening 23A. Cylindrical portion 23D of the electrolyte housing cap 23 encloses a first filter 21A, a solid electrolyte composition 27, an annular member 22, able to embrace the solid electrolyte composition 27 when in mounted form, and finally a second filter 21B. Within the cylindrical portion of the electrolyte and battery attachment housing 20 there is arranged an annular edge 20D against which the second filter 21B may be supported.

Filter 21 was chosen from filters of stainless steel with a mesh opening between 25 and 220 microns.

The annular member 22 forms an electrolyte containing space 22A within its inner edges for positioning of the electrolyte composition 27, which preferably is in tablet form, more preferably comprising NaCl. The electrolyte housing cap 23 is sealingly attached to the electrolyte and battery attachment housing 20, to thereby merely provide opening 23A within the electrolyte housing cap 23 to provide an inlet flow opening 23A. The electrolyte and battery attachment housing 20A is sealingly attached to the mounting bracket 18 and provides sufficient length to enclose the battery 17 within the electrolyte and battery attachment housing 20, and preferably also an air pocket 20C (see Fig. 6).

Fig. 4 schematically illustrates a side view of a detonator device arranged with the water-activated battery arrangement in accordance with the invention. The detonator device has an outer tube member 33 enclosing a pyrotechnic composition 9 and being arranged at one extremity with a cartridge 1. The cartridge 1 in its inner portion is arranged with the battery 17 mounted within the electrolyte and battery attachment 20 sealingly combined with the electrolyte housing cap 23 and the mounting bracket 18.
As shown in Figs. 5 and 6, the mounting bracket 18 is sealingly attached to a central tube 3 by means of screws 28. At least one sealing 5 is arranged in the bottom of the central tube 3. Around the inner periphery of the cartridge 1 is arranged a pressure chamber cup 34 sealingly enclosing the battery enclosing arrangement 18, 20, 23, in a manner so as to create an open space between the inner walls of the pressure chambers cup 34 and the battery attachment housing 20, forming an annular passage which is also open between the outer end of the cap 23 and the inner wall face of the bottom 34A of pressure chamber cup 34. The pressure chamber cup 34 may be divided into a bottom part 34A and cylindrical wall part 34B. The bottom part 34A is sealingly fitted within the cylindrical wall portion 34B, by means of sealing members, e.g. O-rings. Further it is shown that there is a safety pin 19 arranged within a recess 19A in the bottom portion 34A. In Fig. 6 the safety pin 19 is shown to block the bottom portion 34A in its position, by means of having the safety pin 19 protruding out through an opening in the lower most part of the cylindrical wall 34B. Accordingly, the opening/pocket/pin will hinder any rotation of the bottom part 34A. As further shown in Fig. 6 the bottom portion is arranged with lugs 340 that protrude up to a level to at least partly cover through passages 7 within the cylindrical wall 34B. In the through passages 7 there are arranged plugs 7B, preferably having flanges that merely provide the possibility to remove the plugs 7B from the holes 7 by pushing them inwardly. Accordingly, the plugs 7B may not be removed when the bottom portion 34A is in its secured position, as shown in Fig. 6. Plug member 7 is sealingly positioned by means of O-ring 13 within the opening 7 in said cup shaped pressure chamber 34, whereby when said plug member 7B is being released, an open passage 7 is provided into the open space within the cartridge 1. Furthermore, there is arranged a sealing safety bracket 26 outside of the pressure chamber cup 34, which extends from the extremity of the tube member 33 adjacent to cartridge 1, up to a level above the passages. Fig 5 also shows that a securing ring 15 may be used to secure the bottom 34A to the cylindrical walls 34B of the pressure chamber cup 34.

Further, in Fig. 6 there is shown that the battery attachment housing 20 encloses a first air pocket 20C, i.e. an open space provided at the opposite end of the battery attachment housing 20 compared to electrolyte housing cap 23. In the preferred embodiment as shown in Fig. 6 the first air pocket 20C is in connection with the central opening 18D in the mounting bracket 18, which in turn includes a second air pocket 18E inside of the annular attachment portion 18B.
Further, Fig 5 also shows that at the top of the outer tube 33 there is arranged a top cap 2, having central protrusion 8 arranged with a hole for a top plug 10. Reference number 14 indicates that the central tube 3 preferably is arranged with an outer isolating layer. Moreover, the outer tube 33 may be equipped with a belt buckle 31, e.g. attached by means of cable fasteners 32.

In Fig. 7 there is shown a partial view of the arrangement shown in Fig. 5, illustrating the cartridge 1 and its components, when the sealing safety bracket 26, and the sealing plugs 7B have been removed, whereby water may flow into the inner space and then flow into the battery 17 via the inlet opening 23A to solubilize the electrolyte composition 27, thereby activating the battery 17A. Thanks to the arrangement according to the invention the activation of the battery will be quick. Firstly, because the outer inlet opening 7 for water are large enough to provide a quick inflow of water into the interior of the pressure chamber cup 34, secondly because the filters covering the solid electrolytic composition body 27 are sufficiently porous to allow a quick through passage of the water, and thirdly thanks to having the electrolytic composition body 27 in an easily soluble form that quickly will provide the flow electrolytic liquid to the battery. Furthermore, the use of at least one air pocket 20C at the outflow side 17G of the battery provides for a reliable flow also in shallow water. Preferably there is arranged further air pocket 18E in connection with a mounting bracket, whereby even increased reliability for activation of the battery 17 is achieved. Cable 29A, connected to the battery 17, will lead current to an igniter squib 29 which will initiate a detonation subsequently transferred to the main pyrotechnic composition 9.

The scope of the present invention is not restricted to the preferred embodiments shown in the drawings and described in the specification but can be varied with the scope of the claims. As an example, if desired, it would be possible without any inventive activity to use the battery attachment housing in connection with mounting brackets of some various form, with or without additional air pocket, and also to adapt the mounting bracket for attachment of different kind of pyrotechnic devices.
INDUSTRIAL APPLICABILITY

As illustrated in the examples above, but not restricted to solely these applications, the water-activated, deferred-action battery of the present invention is suitable for both civil and military applications, as such or as a component in a more complex detonating system.
CLAIMS

1. A water-activated, deferred-action battery having a battery housing (17A) and/or a battery attachment housing (20) containing at least one cell, comprising:
   a. at least one anode (17B);
   b. at least one cathode (17C),
   c. at least one cavity (17E) separating said at least one cathode (17C) and said at least one anode (17B); and
   d. at least one aperture (17F) leading to said at least one cavity (17E) for the ingress of an electrolyte-forming, aqueous liquid, characterized by an electrolyte containing housing member (22, 23) having an inlet opening (23A) in a distant end of said housing member (22, 23), a through passage formed in an electrolyte containing space (22A) for an electrolyte composition (27), and an outlet opening (22B) in a proximate end of said electrolyte containing housing member (22, 23), said electrolyte containing housing member (22, 23) being positioned in a flow path leading to said aperture (17F), wherein an inner filter (21A) is arranged across said flow path next to said electrolyte containing space (22A) adjacent said outlet opening (22B).

2. A water-activated, deferred-action battery according to claim 1, wherein an outer filter (21B) is arranged across said flow path next to said electrolyte containing space (22A) adjacent said inlet opening (23A).

3. A water-activated, deferred-action battery according to claim 1 or 2, wherein said electrolyte containing housing member (22, 23) forms a part of a battery attachment housing (20) that encloses or forms a part of said battery housing (17A).

4. A water-activated, deferred-action battery according to claim 3, wherein said electrolyte containing housing member (22, 23) includes a, preferably detachable, cap (23) including said inlet opening (23A).

5. A water-activated, deferred-action battery according to claim 3 or 4, wherein said electrolyte containing housing member (22, 23) includes an annular member (22), preferably ring shaped, forming said electrolyte containing space (22A).
6. A water-activated, deferred-action battery according to any one of the preceding claims, wherein a mounting bracket (18) is arranged for attachment of said battery attachment housing (20), preferably including a central passage (18D) enabling connection to said flow path.

7. A water-activated, deferred-action battery according to any one of the preceding claims, wherein said battery housing (17A) and/or battery attachment housing (20) is arranged with an outlet (17G) in connection with at least one air pocket (20C, 18E).

8. A water-activated, deferred-action battery according to claim 7, wherein said air pocket (20C) is arranged within said battery attachment housing (20).

9. A water-activated, deferred-action battery according to claim 7 or 8, wherein said air pocket (18E) is arranged within a hollow portion of a mounting bracket (18).

10. A water-activated, deferred-action battery according to any one of the preceding claims, wherein said water-activated battery has a magnesium anode and a cathode selected from the group consisting of silver chloride, lead chloride, cuprous iodide, cuprous thiocyanate, and cuprous chloride.

11. A water-activated, deferred-action battery according to any one of the preceding claims, wherein said battery housing (17A) is arranged within a pressure chamber cup (34) comprising at least one sealed aperture (7), preferably in the form of a releasable sealing plug (7B), arranged to allow inflow of water when said aperture (7) is open, wherein preferably said aperture (7) is arranged with a sealing member (7A).

12. A water-activated, deferred-action battery according to any one of the preceding claims, wherein said electrolyte composition (27) is a water soluble body containing a water-soluble salt, being positioned within said electrolyte containing space (22A).
13. A water-activated, deferred-action battery according to any one of the preceding claims, wherein said aqueous liquid is fresh water or seawater showing less than 1.5% salinity, preferably wherein said aqueous liquid is fresh water.

14. A water-activated, deferred-action battery according to any preceding claim, included in a detonator device (33), wherein said battery (17) is connected to an igniter squib (29), which subsequently is arranged to detonate a pyrotechnic composition (9).

15. A water-activated, deferred-action battery according to claim 14, wherein a mounting bracket (18) is arranged with a first inter fit part (18C) for sealed attachment of said battery attachment housing (20) and a second inter fit part (18B) for sealed attachment of a container member (3) including a pyrotechnic charge (9).
# INTERNATIONAL SEARCH REPORT

## 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:** H01 M

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 database consulted during the international search (name of database and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.

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"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: 30-03-2017

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Name and mailing address of the ISA/SE

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International Patent Classification (IPC)
H01M 6/34 (2006.01 )
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