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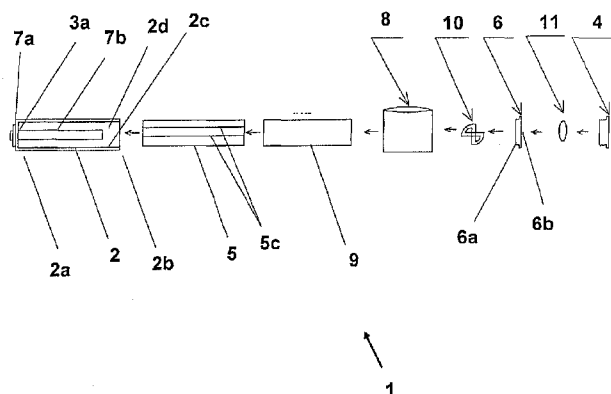


FIG. 1

(57) Abstract: A liquid-activatable battery(1) including a tube(2) having an inner side surface(2c) defining a chamber(2d) in which a liquid-activatable electrolyte powder mixture is disposed therein, a first end(2a) of the tube(2) being sealed by a first end cap(3) and a second end(2b) of the tube(2) being sealed by a second end cap(4) wherein the tube(2) is adapted to allow delivery of a liquid therethrough into the chamber(2d); a conductive surface(5) positioned between the inner side surface(2c) of the tube(2) and the electrolyte powder mixture; a permeable separator sheet(9) for electrically isolating the electrolyte powder mixture from the conductive surface(5); a conductive rod(7) having a first end located adjacent the first end(2a) of the tube(2), and, the conductive rod(7) having a second end in contact with the electrolyte powder mixture; and a passage(5c) extending within the tube(2) configured to allow a liquid that is delivered in to the chamber(2d) to flow into contact with the electrolyte powder mixture via a surface region of the electrolyte powder mixture adjacent the inner side surface(2c) of the tube(2) so as to activate the electrolyte powder mixture, whereby the activated electrolyte powder mixture is adapted to generate a potential difference between the conductive surface(5) and the conductive rod(7).

## A LIQUID-ACTIVATABLE BATTERY

### Technical Field

[0001] The present invention relates to the field of reusable batteries and particularly batteries which are activated by addition of a liquid such as water.

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### Background of the Invention

[0002] Conventional off-the-shelf type AA and AAA batteries tend to deteriorate in performance over time during storage. This can pose a serious problem where the reliability in performance of the batteries is of critical importance - for instance, in an emergency situation where the batteries are required to power a flashlight, a radio, a mobile telephone, or other potentially life-saving electronic device.

[0003] In seeking to address this problem, water-activatable batteries have been developed which can be stored for a relatively long period of time in an inactive state (that is, where water has not yet been mixed with the electrolyte powder mixture within the battery to activate the electrolyte powder mixture) without substantial loss in performance of the battery when the battery is subsequently activated by addition of water.

[0004] However, existing water-activated batteries also exhibit certain drawbacks. For instance, in order to add water to the electrolyte powder mixture to activate certain batteries of this type, the water must be injected in to the battery via a tiny aperture in the end of the battery using a pipette. This can be a tedious and messy procedure, and, if the pipette is lost or broken, it may not be possible to properly inject water into the battery at all. Even when water is injected in to the battery via the tiny aperture, it is difficult for the water to penetrate effectively and efficiently into contact with the bulk of the electrolyte powder within the battery and this diminishes the electrical performance of the battery.

[0005] Furthermore, it is perceived that the large-scale production of existing batteries has an ongoing adverse impact upon the environment due to disruption caused by the mining of raw metals which are required in component parts of such batteries. The cost of mining and processing the raw metals used in conventional

batteries also contributes to the per unit cost of such batteries. Accordingly, it is also desirable to reduce the per unit cost of manufacture of existing batteries as well as to alleviate the adverse impact upon the environment.

## 5 Summary of the Invention

[0006] The present invention seeks to alleviate at least one of the problems discussed above in relation to the prior art.

10 [0007] The present invention may involve several broad forms. Embodiments of the present invention may include one or any combination of the different broad forms herein described.

[0008] In a first broad form, the present invention provides a liquid-activatable battery including:

15 a tube having an inner side surface defining a chamber in which a liquid-activatable electrolyte powder mixture is disposed therein, a first end of the tube being sealed by a first end cap and a second end of the tube being sealed by a second end cap wherein the tube is adapted to allow delivery of a liquid therethrough into the chamber;

20 a conductive surface positioned on or between the inner side surface of the tube and the electrolyte powder mixture;

a permeable separator sheet for electrically isolating the electrolyte powder mixture from the conductive surface;

25 a conductive rod having a first end located adjacent the first end of the tube, and, the conductive rod having a second end in contact with the electrolyte powder mixture; and

30 a passage extending within the tube configured to allow a liquid that is delivered in to the chamber to flow into contact with the electrolyte powder mixture via a surface region of the electrolyte powder mixture adjacent the inner side surface of the tube so as to activate the electrolyte powder mixture, whereby the activated electrolyte powder mixture is adapted to generate a potential difference between the conductive surface and the conductive rod.

[0009] Preferably, the passage may extend along the tube between the first and second ends of the tube. Also preferably, the passage may extend substantially along a full length of the inner side surface of the tube or at least a full length of the electrolyte powder mixture adjacent the inner side surface of the tube so as to assist in increasing surface area contact between the liquid and the electrolyte powder mixture. Also preferably, the passage may extend in a substantially straight path between first and second ends of the tube. Typically, the passage may extend in a substantially parallel path relative to an elongate axis of the tube. Preferably, the present invention may include a plurality of passages extending within the tube. Preferably, the plurality of passages may be evenly spaced apart to assist in improving more even distribution of the liquid around surface regions of the electrolyte powder mixture adjacent to the inner side surface of the tube. Alternatively, in certain embodiments the passage may include a passage extending as a tunnel through the electrolyte powder mixture itself in an orientation either substantially lengthwise along the tube or laterally to the length of the tube.

[0010] Preferably, the tube may include a plastic material. Typically, the plastic material may include a biodegradable plastic material. Also preferably, the first end cap may include a plastic material. Also preferably, the first end cap and the tube may be moulded as a single-piece of plastic. Advantageously, the use of a plastic battery tube and a plastic first end cap in certain embodiments of the present invention may assist in alleviating adverse disruption to the environment due to the reduced amount of raw metal that needs to be mined during large-scale manufacture of such battery embodiments. In comparison, the large scale manufacture of certain existing batteries has a much greater adverse impact upon the environment due to the relatively larger amounts of raw metal that needs to be mined in order to form the battery tubes and end caps (which are entirely formed from metal).

[0011] Preferably, the second end of the tube may be releasably sealable by the second end cap wherein when the second end cap is released from the second end of the tube, the liquid may be delivered into the chamber of the tube via the unsealed second end of the tube. Typically, the second end cap may include a conductive plastic material such as polypropylene or nylon. Alternatively, the second end cap may include a non-conductive plastic material coated in a conductive material such as nickel. Preferably, the second end cap may be adapted for releasable engagement with the second end of the tube either directly or indirectly so as to

releasably seal the second end of the tube. Typically, the present invention may include at least one of a screw-thread type engagement mechanism, a friction-fit engagement mechanism or any other suitable engagement mechanism to effect releasable engagement of the second end cap with the tube so as to releasably seal the second end of the tube. In alternative embodiments of the present invention, the liquid may be delivered into the chamber of the tube via an aperture or valve in the tube. Typically the aperture or valve may be disposed in the second end of the tube. Typically the liquid may be delivered into the chamber via the aperture valve using a pipette or the like.

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[0012] As it may be difficult to obtain effective electrical contact between the second end cap and the conductive surface if the second end cap is directly attached to the second end of the tube, the present invention may include a ring nut wherein a first region of the ring nut may be configured for snug-fitting electrical contact with the conductive surface within the second end of the tube whilst a second region of the ring nut may be configured for releasable engagement with the second end cap. The mechanism for effecting releasable engagement may include at least one of a screw-thread type engagement mechanism and a friction-fit engagement mechanism. Typically, the ring nut may include a conductive plastic material such as polypropylene or nylon. Alternatively, the ring nut may include a non-conductive plastic material coated in a conductive material such as nickel.

[0013] Alternatively, the second end cap may be configured for direct releasable engagement with the second end of the tube by way of at least one of a screw-thread type engagement mechanism, a friction-fit engagement mechanism or any other suitable engagement mechanism whereby the second end cap may be in electrical contact with the conductive surface.

[0014] Typically, the conductive surface may include a metal sheet disposed on or adjacent the inner side surface of the tube. Typically, the metal sheet may be configured to form a substantially cylindrical or looped configuration which may be fitted within the chamber of the tube. Typically the metal sheet may include a corrugated configuration wherein the passage may be formed by a groove running along the corrugated metal sheet when the metal sheet is positioned in the tube. Additionally and/or alternatively, the passage may include a groove or a channel

etched, moulded and/or shaped into the metal sheet. Preferably, the metal sheet may include a zinc foil sheet. More preferably, the zinc foil sheet may include a thickness of at least about 0.1mm. Also preferably, the zinc foil sheet may include at least approximately 99.99 percentage pure zinc by weight. Also preferably, the zinc foil sheet may weigh approximately 1.6 gm.

[0015] Alternatively, the conductive surface may include a metal layer coated on to the inner side surface of the tube. Typically, the metal layer may be coated on to the inner side surface of the tube using a thermal spraying or "arc spraying" process. Typically the passage may include a groove or a channel etched, moulded and/or shaped into the metal layer. Preferably, the metal layer may include a zinc layer. Also preferably, the zinc layer may include a thickness of at least about 0.1mm. Also preferably, the zinc layer may include at least approximately 99.99 percentage pure zinc by weight. Also preferably, the zinc layer may weigh approximately 1.6 gm.

[0016] Yet alternatively, the tube may include a metal tube and the conductive surface may include an integrally formed inner side surface of the metal tube. Typically, the passage may include a groove or a channel etched, moulded and/or shaped into the inner side surface of the metal tube.

[0017] Additionally and/or alternatively the passage may include a groove or channel formed by etching or moulding the electrolyte powder mixture or by folding or shaping a permeable separator sheet disposed in the tube.

[0018] Preferably, the conductive surface may include at least one of zinc, magnesium, aluminium, and a combination thereof. Also preferably, the conductive surface may be bathed in a solution of indium to slow down or alleviate corrosion of the conductive surface.

[0019] Preferably, the first end of the conductive rod may extend outwardly of the first end of the tube via an aperture disposed in the first end cap. Preferably, the second end of the conductive rod may be substantially embedded within the electrolyte powder mixture. Typically, the conductive rod may include at least one of a brass, a carbon a stainless steel material and a combination thereof.

[0020] Preferably, the electrolyte powder mixture may include a metal oxide powder. Typically, the metal oxide may include at least one of an activated carbon, manganese dioxide, iron oxide and crystalline silver oxide.

5 [0021] Typically, the electrolyte powder mixture may include particles formed from a mixture of ammonium chloride particles, zinc chloride particles, manganese dioxide particles, acetylene carbon black particles, and zinc oxide particles. More typically, in preferred embodiments, the electrolyte powder mixture may include approximately 3% ammonium chloride particles, 16% zinc chloride particles, 68% manganese  
10 dioxide particles, 12.4% acetylene carbon black and 0.6% zinc oxide particles by percentage weight of the electrolyte powder mixture.

[0022] Typically, the electrolyte powder mixture may be ball-milled using a rotary or planetary ball mill. Typically the ball mill used to ball mill the electrolyte powder  
15 mixture may include ceramic balls. Typically, electrolyte powder mixture particles may include diameters in the nanometre to micrometre range. More typically, the electrolyte powder mixture may include particles having diameters substantially in the nanometre to micrometre range. More typically, the electrolyte powder mixture particles may include diameters of substantially around 4.32 micrometres.

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[0023] Typically, the present invention may include approximately 4.75 and 5.75 gm of electrolyte powder mixture in the chamber of the tube.

[0024] Preferably, the permeable separator sheet may extend substantially along the  
25 length of the tube so as to electrically isolate the electrolyte powder mixture from the conductive inner side surface. Typically, the permeable separator sheet may include at least one of a permeable paper material such as Kraft paper, a permeable synthetic polymer material, and a permeable natural polymer material. Preferably, the permeable separator sheet may include a thickness of substantially around  
30 0.08mm. Also preferably, the permeable separator sheet may include a double-layer of 0.08mm permeable separator sheets.

[0025] Typically, the permeable separator sheet may be shaped to substantially complement a contour of the inner side surface of the tube. Typically the permeable separator sheet may be formed in a cylindrical or looped configuration. Preferably, a portion of the permeable separator sheet may be shaped to cover over a top region of the electrolyte powder mixture adjacent the second end of the tube so as to alleviate leakage of loose electrolyte powder mixture outwardly of the second end of the tube when unsealed.

[0026] Preferably, a membrane may be disposed in the chamber between the second end cap and the portion of the permeable separator sheet shaped to cover over the top region of the electrolyte powder mixture. Preferably, the membrane may include at least one aperture to allow fluid communication therethrough from the unsealed second end of the tube into contact with the permeable separator sheet covering the top region of the electrolyte powder mixture and thereafter into contact with the electrolyte powder mixture. Typically, the membrane may include a plurality of apertures disposed therein.

[0027] Typically, the present invention may include an outer casing removably surrounding the tube which may assist in reinforcing the tube against deformation due to the effects of heat and stress. Typically, the outer casing may include a thickness of between approximately 0.2 to 1 mm and preferably, a thickness of 0.5mm. Typically, the outer casing may include a metal or a plastic material.

[0028] In a second broad form, the present invention provides a liquid-activatable battery including:

a tube having an inner side surface defining a chamber in which a liquid-activatable electrolyte powder mixture is disposed therein, a first end of the tube being sealed by a first end cap and a second end of the tube being releasably sealed by a second end cap wherein the second end of the tube is adapted to allow delivery of a liquid therethrough into the chamber when unsealed;

a conductive surface positioned on or between the inner side surface of the tube and the electrolyte powder mixture;

a permeable separator sheet for electrically isolating the electrolyte powder mixture from the conductive surface; and

a conductive rod having a first end located adjacent the first end of the tube, and, the conductive rod having a second end in contact with the electrolyte powder mixture;

5 wherein when the liquid is delivered in to the chamber via the unsealed second end of the tube, the electrolyte powder mixture is activated via contact with the liquid and a potential difference is able to be generated between the conductive surface and the conductive rod.

[0029] Preferably, the present invention may include a passage extending within the tube configured to allow a liquid that is delivered in to the chamber via the second end of the tube when unsealed to flow into contact with the electrolyte powder mixture via a surface region of the electrolyte powder mixture adjacent the inner side surface of the tube so as to activate the electrolyte powder mixture. More preferably, the passage may extend between the first and second ends of the tube. Typically the passage may extend substantially along a full length of the tube.

[0030] In a third broad form, the present invention provides a liquid-activatable battery including:

20 a tube having an inner side surface defining a chamber in which a liquid-activatable electrolyte powder mixture is disposed therein, a first end of the tube being sealed by a first end cap and a second end of the tube being releasably sealed by a second end cap wherein the tube is adapted to allow delivery of a liquid therethrough into the chamber when unsealed;

25 a conductive surface positioned on or between the inner side surface of the tube and the electrolyte powder mixture;

a permeable separator sheet for electrically isolating the electrolyte powder mixture from the conductive surface;

30 a conductive rod having a first end located adjacent the first end of the tube, and, the conductive rod having a second end in contact with the electrolyte powder mixture; and

a passage extending between the first and second ends of the tube, the passage being configured to allow a liquid that is delivered in to the chamber via the second end of the tube when unsealed to flow into contact with the electrolyte powder mixture via a surface region of the electrolyte powder mixture adjacent the inner side surface of the tube so as to activate the electrolyte powder mixture,

whereby the activated electrolyte powder mixture is adapted to generate a potential difference between the conductive surface and the conductive rod.

[0031] Advantageously, due to battery embodiments of the present invention being  
5 kept in an inactive state until use, such battery embodiments may enjoy a shelf-life of considerably longer duration than conventional off-the-shelf type batteries intended for comparable performance in similar applications. In contrast, conventional type batteries tend to deteriorate in performance relatively faster when in storage due to the electrolyte powder mixture being activated at the point of manufacture. Whilst  
10 embodiments of the present invention described herein may be well-suited for use in emergency situations due to the benefit of longer shelf-life, the actual output performance of such battery embodiments may remain comparable to the power output expected of certain conventional batteries, upon activation.

15 [0032] Also advantageously, embodiments of the present invention may be designed so as to be relatively easily and efficiently assembled and disassembled from component parts either manually by hand or by use of an automated machine. This relative ease and efficiency in assembly and disassembly may assist in reducing the processing time and costs involved in recycling/reusing the component parts.

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[0033] Additionally, in contrast to certain existing batteries in which the tube is entirely made from metal (particularly, relatively expensive metals such as zinc), the use of a plastic tube having a metal sheet positioned between the inner side surface of the tube and the electrolyte powder mixture, or, a metal layer coated on the inner  
25 side surface of the tube, may assist in providing at least one of the following advantages:

[0034] (i) Reduction in manufacturing costs due to the reduced amount of metal, such as zinc, that is used to form the battery tube whilst maintaining comparable  
30 electrical output performance in comparison to a battery having a tube formed entirely of metal. Typically, approximately 1.6 gm of zinc may be used to form the zinc foil sheet or the zinc layer coating on or adjacent the inner side surface of the plastic tube, as opposed to the requirement for approximately 15 gm or more zinc where the tube is entirely formed from zinc in certain existing batteries. Furthermore,  
35 the per unit cost for batteries produced in accordance with embodiments of the present invention may typically be around USD0.12 due to the reduced amount of

zinc metal that is used compared to approximately USD0.25 for batteries in which the entire battery tube may be formed from zinc;

5 [0035] (ii) Reduced adverse impact upon the environment as a smaller amount of metal is used in the battery and hence reduced mining of such raw metals is required;

10 [0036] (iii) *Reduced transportation costs due to the reduced weight per battery* made in accordance with embodiments of the present invention. The approximate overall weight of batteries made in accordance with embodiments of the present invention may be typically around 13 gm compared to approximately 23 gm per conventional AA alkaline battery. Accordingly, this per unit weight saving may reduce the total transportation costs; and

15 [0037] (iv) Increased battery performance as the walls of the tube may be relatively easily made thinner and the increased internal volume of the battery chamber may enable more electrolyte powder to be stored therein.

20 [0038] In addition to the advantages outlined above, embodiments of the present invention may also satisfy the requirements of the Restriction on the Use of Hazardous Substances in Electrical and Electronic Equipment Directive 2002/95/EC (ROHS). Accordingly, battery embodiments may be considered to provide an environmentally-friendly alternative to prior art batteries due to the high percentage of the component parts that may be recycled/reused in compliance with the ROHS  
25 Directive.

[0039] Furthermore, embodiments of the present invention may also satisfy the requirements of Article 4(1) of Directive 2006/66/EC and EN 71 Part 3 relating to the mercury content of the batteries wherein embodiments may not typically contain  
30 levels of mercury exceeding prescribed limits and may therefore be considered safe for human usage in this context.

#### **Brief Description of the Drawings**

[0040] The present invention will become more fully understood from the following  
35 detailed description of a preferred but non-limiting embodiment thereof, described in

connection with the accompanying drawings, wherein:

[0041] **Figure 1** shows an exploded view of a first embodiment liquid-activatable battery in accordance with the present invention;

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[0042] **Figure 2(a)** shows a perspective view of a plastic tube with a zinc layer coated on an inner side surface of the plastic tube in accordance with a second embodiment;

10 [0043] **Figure 2(b)** shows a perspective cut-away view of the plastic tube with a zinc layer coated on the inner side surface of the plastic tube in accordance with the second embodiment;

15 [0044] **Figure 2(c)** shows a side cut-away view of the plastic tube of the second embodiment with grooves etched in the zinc layer coating the inner side surface of the plastic tube;

20 [0045] **Figure 2(d)** shows an end view of the plastic tube of the second embodiment with the evenly spaced-apart grooves in the zinc layer coating the inner side surface of the plastic tube visible;

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[0046] **Figure 3** shows a perspective view of the plastic tube used in the first embodiment with the plastic first end cap integrally formed with the plastic tube from a single piece of plastic;

[0047] **Figure 4(a)** shows a top view of a second end cap adapted for releasably sealable engagement to the second end of the tube via a ring nut in accordance with the first embodiment;

30 [0048] **Figure 4(b)** shows a bottom view of the second end cap of the first embodiment;

[0049] **Figure 4(c)** shows a first side view of the second end cap of the first embodiment;

5 [0050] **Figure 4(d)** shows a second side view of the second end cap of the first embodiment;

[0051] **Figure 5(a)** shows a side view of a conductive rod including a steel contact and a carbon stick;

10 [0052] **Figure 5(b)** shows a first perspective view of the conductive rod;

[0053] **Figure 5(c)** shows a second perspective view of the conductive rod;

15 [0054] **Figure 5(d)** shows a topological view of the conductive rod; and

[0055] **Figure 5(e)** shows a bottom view of the conductive rod.

#### **Detailed Description of Preferred Embodiments**

20 [0056] Preferred embodiments of the present invention will now be described with reference to the accompanying drawings 1 to 5. The exemplary embodiments described herein include liquid-activatable batteries which may be suitably configured to comply with standard shape and dimension requirements of off-the-shelf type AA and AAA batteries and providing an electrical output comparable to off-the-shelf type AA and AAA batteries.

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30 [0057] Figure 1 shows an exploded view of a battery in accordance with an embodiment of the present invention. The battery (1) includes a tube (2) having a first end (2a) sealed by a first end cap (3) and an opposed second end (2b) which is releasably sealable by a second end cap (4). The first end cap (3) is integrally moulded with the tube (2) from a single-piece of biodegradable plastic and includes an aperture (3a) located centrally of the first end cap (3).

[0058] A conductive surface (5) is positioned within the tube (2) on or adjacent to an inner side surface (2c) of the tube (2). The conductive surface (5) includes a zinc foil sheet (5) rolled in a cylindrical configuration so as to snugly fit within and complement the curved inner side surface (2c) of the tube (2). The zinc foil sheet (5) includes a thickness of at least about 0.1mm and includes at least approximately 99.99 per cent zinc by weight. The zinc foil sheet (5) includes a corrugated shape configuration such that when it is positioned within the tube (2), the grooves (5c) of the corrugated zinc foil sheet (5) form a plurality of passages (5c) extending between the first and second ends of the tube (2) via which water is able to travel when delivered in to the chamber (2d) of the tube (2). The passages assist in improving flow of water from the unsealed second end of the tube around surface regions of the electrolyte powder mixture adjacent the inner side surface of the tube so as to increase exposure of the electrolyte powder mixture surface area to contact with and penetration by the water to activate the electrolyte powder mixture. In particular, the passages in the corrugated configuration of the zinc foil sheet running lengthwise along the tube between the zinc foil sheet and the electrolyte powder mixture may assist in increasing the surface area of the electrolyte powder which may be exposed to contact with the liquid in the tube.

[0059] Figures 2(a)-2(d) shows an alternative embodiment of the present invention in which the conductive surface (5) includes a zinc layer (5) coated on to the inner side surface (2c) of the tube (2). The tube (2) may be initially formed in two separate halves as shown in Figs. 2b and 2c such that the zinc layer (5) can be coated more easily on to the inner side surface (2c) of each half of the tube (2) before the halves are securely joined together to form the finished tube (2) as shown in Figs. 2(a) and 2(d). Alternatively, the zinc layer (5) can be coated on to the inner side surface (2c) of a fully-formed tube (2) by use of a thermal spraying or arc spraying process. In this regard, a special nozzle can be attached to a thermal spraying gun with the nozzle being suitably configured for insertion into a chamber (2d) of the tube (2) via the unsealed second end (2b) of the tube (2) to allow the heated zinc particles to be sprayed and deposited uniformly around the inner side surface (2c) of the tube (2).

[0060] The second end cap (4) includes a conductive plastic material such as polypropylene or nylon and can be releasably engageable directly with the second end (2b) of the tube (2) so as to releasably seal the second end (2b) of the tube (2). However as it may be difficult to obtain effective electrical contact between the

second end cap (4) and the zinc foil sheet (5) when the second end cap (4) is releasably engaged directly with the second end (2b) of the tube (2), embodiments of the present invention include a ring nut (6) having a first region (6a) which is configured for snug-fitting engagement neatly within the second end (2b) of the tube (2) to effect electrical contact with the zinc foil sheet (5) whilst a second region (6b) of the ring nut (6) is configured for releasable engagement with the second end cap (4). The mechanism for effecting releasable engagement includes at least one of a screw-thread type engagement mechanism and a friction-fit engagement mechanism.

10 [0061] Figs. 4(a)-4(d) show an exemplary second end cap (4) which has a screw-thread (4a) on a first side to effect releasable engagement with the second region (6b) of the ring nut (6) to releasably seal the second end (2b) of the tube (2). It also has a slot-shaped indent (4b) on a second side to allow the second end cap (4) to be screwed into or out of engagement with the ring nut (6) by a screwdriver. In  
15 alternative embodiments, the indent could be a cross-shaped slot configuration. An O-ring (11) of approximately 0.5mm in thickness is positioned between the second region (6b) of the ring nut (6) and the second end cap (4) when they are releasably engaged so as to alleviate leakage via the second end (2b) of the tube (2).

20 [0062] In alternative embodiments, the second end cap includes a non-conductive plastic material coated in a conductive material such as nickel. The second end cap (4) and the zinc foil sheet (5) positioned in the tube (2) are in electrical communication and together form a negative electrode of the battery (1).

25 [0063] The battery (1) also includes a conductive rod (7) as shown in Figs. 5(a)-5(e) having a first end consisting of a steel contact (7a) and a second end consisting of a carbon stick (7b). The carbon stick (7b) is adapted for positioning inwardly of the tube (2) where it is embedded within the electrolyte powder mixture (8). The steel contact (7a) coupled to the carbon stick (7b) is positioned so as to extend outwardly  
30 of the first end (2a) of the tube (2) via the aperture (3a) in the first end cap (3). The conductive rod (7) is electrically isolated from the zinc foil sheet (5) and the second end cap (4). When assembling battery embodiments, the conductive rod (7) is able to be manoeuvred inwardly of the tube (2) in a direction from the unsealed second end (2b) of the tube (2) towards the first end (2a) until the steel contact (7a) protrudes  
35 outwardly of the aperture (3a) of the first end cap (3) before the tube (2) is filled with

the electrolyte powder mixture (8). The aperture (3a) is sized and shaped to allow the steel contact (7a) to pass through whilst preventing movement of the carbon stick (7b) through the aperture (3a). The aperture (3a) of the first end cap (3) is also sized and shaped to be snug-fitting with the diameter of the steel contact (7a) so as to  
5 alleviate escape of any loose electrolyte powder mixture (8) adjacent the first end (2a) of the tube (2). In certain embodiments, the first end cap (3) could be moulded *separately to the plastic tube (2) and then later attached to the tube (2)*. In such cases an O-ring is disposed between the first end cap (3) and the first end (2a) of the plastic tube (2) to assist in effecting air-tight sealing.

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[0064] A permeable separator sheet (9) is adapted for positioning in the chamber (2d) of the tube (2) between the zinc foil sheet (5) and the electrolyte powder mixture (8) so as to electrically isolate the zinc foil sheet (5) from the electrolyte powder mixture (8). *The permeable separator sheet (9) is rolled into a cylindrical*  
15 *configuration which can be slid into the chamber (2d) of the tube (2) within the boundary formed by the cylindrical zinc foil sheet, before the electrolyte powder mixture (8) is then deposited into the chamber (2d) of the tube (2) within the boundary formed by the cylindrical permeable sheet (9).* The permeable separator sheet (9) is formed from a double-layer of 0.08mm Kraft paper. In alternative  
20 embodiments, a synthetic or natural polymer material could be used. The permeable separator sheet (9) enables wicking of a liquid from regions along the lengths of the grooves (5c) as the liquid travels along the grooves (5c) and thereafter into contact with the electrolyte powder mixture (8) via the permeable separator sheet (9).

25 [0065] After the permeable separator sheet (9) has been positioned within the tube (2), the electrolyte powder mixture (8) is deposited by a machine into the chamber (2d) of the tube (2) within the boundary formed by the looped configuration of the permeable separator sheet (9). During or after the electrolyte powder mixture (8) has been deposited into the chamber (2d) of the tube (2), the tube (2) is shaken to assist  
30 in more uniformly distributing the electrolyte powder mixture (8) within the chamber (2d). A plunger is also used to compress the electrolyte powder mixture (8) within the chamber (2d) of the tube (2). These steps may be repeated one or more times if necessary to assist in maximising the amount of electrolyte powder mixture (8) in the chamber (2d) of the tube (2). Embodiments of the present invention are typically  
35 assembled in a humidity controlled environment, commonly referred to as a "dry

room" to alleviate risk of moisture activating the electrolyte powder mixture (8) and thereby corrupting operation of the batteries.

5 [0066] An end portion of the permeable separator sheet (9) is folded over to cover a top region of the electrolyte powder mixture (8) adjacent the second end (2b) of the tube (2) and this assists in keeping any loose electrolyte powder mixture (8) from leaking out of the second end (2b) of the tube (2) when unsealed. Additionally, a plastic membrane (10) having a figure-8 shaped configuration fits snugly inside the second end (2b) of the tube (2) and sits upon the folded over portion of the permeable separator sheet (9) which covers the top portion of the electrolyte powder mixture (8) adjacent the second end (2b) of the tube (2).

15 [0067] Advantageously, the membrane (10) not only assists in holding the folded over portion of the permeable separator sheet (9) in place to keep loose electrolyte powder mixture (8) from escaping via an unsealed second end (2b) of the tube (2), but it also allows water to flow through it into contact with the electrolyte powder mixture (8) via the folded over portion of the permeable separator sheet (9). When water is delivered into the unsealed second end (2b) of the tube (2), water not only flows along the length of the tube (2) via the grooves (5c) in the corrugated configuration of the zinc foil sheet (5), but some water also flows through the apertures formed by the membrane (10), into contact with and penetrating the electrolyte powder mixture (8) via the top of the electrolyte powder mixture (8) covered by the folded over portion of the permeable separator sheet (9).

25 [0068] The battery (1) remains in an inactive state until the second end cap (4) is unscrewed from the tube (2) and a liquid (such as a water-based liquid) is delivered into the chamber (2d) of the tube (2) and into contact with the electrolyte powder mixture (8). In seeking to obtain optimal electrical performance, it is preferable to submerge the entire unsealed tube (2) within a glass of water for several minutes so that the water may enter via the unsealed second end (2b) of the tube (2), and flow freely along the grooves (5c) in the corrugated zinc foil sheet (5). In embodiments of the present invention it is possible to activate the electrolyte powder mixture (8) by scooping or pouring at least about 1.7 grams of water into the unsealed second end (2b) of the tube (2).

[0069] Upon delivery into the chamber (2d), the water is able to flow freely along the grooves (5c) formed in the corrugated configuration of the zinc foil sheet (5) substantially along a length of the tube (2) and into contact with the electrolyte powder mixture (8) at regions substantially along the length of the tube (2). In this manner, the liquid within the tube (2) is able to more readily penetrate the electrolyte powder mixture (8) across a greater surface area of the electrolyte powder mixture (8) in contrast to certain prior art liquid-activatable batteries where water must penetrate the electrolyte powder mixture substantially from a top region of the electrolyte powder mixture. Once water has suitably contacted with the electrolyte powder mixture (8), the activated electrolyte powder mixture (8) chemically reacts with the zinc foil sheet (5) via the permeable sheet (9) whereby a potential difference is generated between the electrically-isolated positive electrode consisting of the conductive rod (7), and, the negative electrode consisting of the combination of the second end cap (4) and the zinc foil sheet (5). Whilst the permeable separator sheet (9) disposed between the positive electrode (i.e. the conductive rod (7)) and the negative electrode (i.e. the zinc foil sheet (5) and second end cap (4)) of the battery (1) physically and electrically isolates the positive and negative electrodes of the battery (1), it also allows for free flow therethrough of positive ions created as a result of the chemical reactions from the negative electrode zinc foil sheet (5) towards the positive electrode via the electrolyte powder mixture (8) and permeable sheet (9) so as to continue to generate and maintain the potential difference. Electrons formed at the negative electrode are therefore able to flow from the negative electrode through a load device and back to the positive electrode of the battery (1). Once the second end cap (4) has been screwed back on to the ring nut (6) to releasably seal the second end (2b) of the plastic tube (2), the battery (1) is ready to be inserted into an electronic device to power the device.

[0070] When the potential difference across the battery (1) falls to an unusable level, water can be re-filled in to the battery (1) as described above to reactivate the electrolyte powder mixture (8) and to again generate a usable potential difference across the positive and negative electrodes of the battery (1).

[0071] The electrolyte powder mixture (8) includes a metal oxide powder such as manganese dioxide, iron oxide or crystalline silver oxide which substantially fills the chamber (2d) of the tube (2). In preferred embodiments, the electrolyte powder

mixture (8) includes approximately 3% ammonium chloride particles, 16% zinc chloride particles, 68% manganese dioxide particles, 12.4% acetylene carbon black particles and 0.6% zinc oxide particles by percentage weight of the electrolyte powder mixture (8).

5

[0072] The electrolyte powder mixture (8) is ball-milled using a rotary or planetary ball mill and ceramic balls such as agate (carnelian). During testing, a laboratory ball-milling machine of 500ml volume was used with ceramic milling balls weighing 110g and having diameters of 22.4mm, or, small sized balls weighing 190g weight and  
10 having diameters of 10.0mm. Also during testing, 150g of electrolyte powder mixture (8) was milled on each occasion. It would be understood that the ball milling of the electrolyte powder mixture (8) can be suitably scaled up to industrial size to accommodate much larger production.

15 [0073] Electrolyte powder mixture (8) particles resulting from the ball-milling included diameters in the nanometre to micrometre range. In preferred embodiments, the diameters of the electrolyte powder mixture (8) particles is around 4.32 micrometres.

[0074] In certain embodiments, an outer casing is used to surround the tube (2) to  
20 assist in re-enforcing the tube (2) against possible deformation in use due to heat and other stresses. In such embodiments, the outer casing is adapted to slide over the plastic tube (2) as a snug-fitting outer sleeve. The outer casing could be formed from a non-conductive plastic material for ease of debossing and/or decoration with branding and/or other commercial indicia and to reduce overall weight of the product.

25

[0075] The use of zinc metal in the conductive surface may be preferable to other metals such as magnesium as it tends to provide a relatively lower but more controlled and conventional electrical output over a relatively longer lifespan upon  
30 activation compared to use of magnesium which tends to provide a relatively higher output power over a relatively shorter lifespan upon activation. Use of magnesium may also result in an unconventional initial voltage spike which may cause damage to certain electronic products if used in serial. Typically, if the conductive surface is formed from magnesium it is expected that the usable lifespan of such embodiments may last for approximately 2-3 weeks after activation whilst the usable lifespan of

embodiments using zinc on the conductive surface may last for at least approximately 6-12 months after activation. It is conceivable that in yet alternative embodiments of the present invention, a sacrificial anode may be included in the battery which serves to slow down the corrosion of the zinc foil sheet.

5

[0076] Embodiments of the present invention which have been tested have been found to provide between approximately 900-1000mAh capacity at a constant current drain of 25mA with a cut-off voltage of 0.8V.

10 [0077] Advantageously, embodiments of the present invention have been engineered to comply with the physical parameters of standard AA, AAA type batteries so as to be suitable for use in flashlights, radios, mobile phones etc, whilst at the same time providing an output performance comparable to conventional batteries for powering such devices.

15

[0078] Those skilled in the art will appreciate that the invention described herein is susceptible to variations and modifications other than those specifically described without departing from the scope of the invention. All such variations and modification which become apparent to persons skilled in the art, should be  
20 considered to fall within the spirit and scope of the invention as broadly hereinbefore described. It is to be understood that the invention includes all such variations and modifications. The invention also includes all of the steps and features, referred or indicated in the specification, individually or collectively, and any and all combinations of any two or more of said steps or features.

25

[0079] The reference to any prior art in this specification is not, and should not be taken as, an acknowledgment or any form of suggestion that that prior art forms part of the common general knowledge.

30 [0080] The term "adjacent to" as referred to herein should not necessarily be interpreted to mean "directly next to" but may be interpreted to mean substantially "near" to or "close to".

**Claims**

1. A liquid-activatable battery including:

5 a tube having an inner side surface defining a chamber in which a liquid-activatable electrolyte powder mixture is disposed therein, a first end of the tube being sealed by a first end cap and a second end of the tube being sealed by a second end cap wherein the tube is adapted to allow delivery of a liquid therethrough into the chamber;

a conductive surface positioned on or between the inner side surface of the tube and the electrolyte powder mixture;

10 a permeable separator sheet for electrically isolating the electrolyte powder mixture from the conductive surface;

a conductive rod having a first end located adjacent the first end of the tube, and, the conductive rod having a second end in contact with the electrolyte powder mixture; and

15 a passage extending within the tube configured to allow a liquid that is delivered in to the chamber to flow into contact with the electrolyte powder mixture via a surface region of the electrolyte powder mixture adjacent the inner side surface of the tube so as to activate the electrolyte powder mixture, whereby the activated electrolyte powder mixture is adapted to generate a potential difference between the  
20 conductive surface and the conductive rod.

2. A liquid-activatable battery as claimed in claim 1 including a plurality of passages.

25 3. A liquid-activatable battery as claimed in claims 1 or 2 wherein the passage extends substantially along a full length of tube between the first and second ends adjacent the inner side surface of the tube.

4. A liquid-activatable battery as claimed in any one of the preceding claims  
30 wherein the tube includes a plastic material.

5. A liquid-activatable battery as claimed in claim 4 wherein the plastic material includes a biodegradable plastic material.

6. A liquid-activatable battery as claimed in any one of the preceding claims wherein the first end cap includes a plastic material.

7. A liquid-activatable battery as claimed in claim 6 wherein the first end cap and the tube are moulded as a single-piece of plastic.

8. A liquid-activatable battery as claimed in any one of the preceding claims wherein the second end of the tube is releasably sealed by the second end cap wherein when the second end cap is released from the second end of the tube, the liquid is able to be delivered into the chamber of the tube via the unsealed second end.

9. A liquid-activatable battery as claimed in anyone of the preceding claims wherein the second end cap includes a conductive plastic material.

15

10. A liquid-activatable battery as claimed in claim 9 wherein the conductive plastic material includes at least one of polypropylene and nylon.

11. A liquid-activatable battery as claimed in any one of claims 1 to 8 wherein the second end cap include a plastic material coated in nickel.

20

12. A liquid-activatable battery as claimed in any one of claims 8 to 11 wherein the second end cap is adapted for releasable engagement with the second end of the tube so as to releasably seal the second end of the tube.

25

13. A liquid-activatable battery as claimed in claim 12 wherein the second end cap is adapted for electrical communication with the conductive surface when releasably engaged with the second end of the tube.

14. A liquid-activatable battery as claimed in any one of claims 12 or 13 including at least one of a screw-thread type engagement mechanism and a friction-fit

30

engagement mechanism to effect releasable engagement of the second end cap to the second end of the tube.

15. A liquid-activatable battery as claimed in any one of claims 8 to 14 wherein  
5 the second end cap is adapted for releasable engagement with the second end of the tube via a ring nut, the ring nut being adapted to provide electrical communication between the second end cap and the conductive surface.

16. A liquid-activatable battery as claimed in claim 15 wherein the ring nut  
10 includes a conductive plastic material such as polypropylene or nylon.

17. A liquid-activatable battery as claimed in any one of the preceding claims wherein the liquid is able to be delivered into the chamber of the tube via an aperture or valve in the tube.

15

18. A liquid-activatable battery as claimed in claim 17 wherein the aperture or valve is disposed in the first or second ends of the tube.

19. A liquid-activatable battery as claimed in claims 17 or 18 wherein the liquid is  
20 able to be delivered into the chamber via the aperture valve using a pipette or the like.

20. A liquid-activatable battery as claimed in any one of the preceding claims including a plurality of passages within the battery.

25 21. A liquid-activatable battery as claimed in any one of the preceding claims wherein the conductive surface includes a metal sheet disposed on or adjacent the inner side surface of the tube.

22. A liquid-activatable battery as claimed in claim 21 wherein the metal sheet is  
30 configured to form a substantially looped configuration.

23. A liquid-activatable battery as claimed in claims 21 or 22 wherein the metal sheet includes a corrugated configuration wherein the passage is formed by a groove running along the corrugated configuration of the metal sheet when the metal sheet is positioned in the tube.

5

24. A liquid-activatable battery as claimed in any one of claims 21 to 23 wherein the passage includes a groove or a channel etched, moulded and/or shaped into the metal sheet.

10 25. A liquid-activatable battery as claimed in any one of claims 21 to 24 wherein the metal sheet includes a zinc foil sheet.

26. A liquid-activatable battery as claimed in claim 25 wherein the zinc foil sheet includes a thickness of at least about 0.1mm.

15

27. A liquid-activatable battery as claimed in claims 25 or 26 wherein the zinc foil sheet includes at least approximately 99.99 percentage pure zinc by weight.

28. A liquid-activatable battery as claimed in any one of claims 25 to 27 wherein  
20 the zinc foil sheet includes a weight of approximately 1.6 gm.

29. A liquid-activatable battery as claimed in any one of claims 1 to 20 wherein the conductive surface includes a metal layer coated on to the inner side surface of the tube

25

30. A liquid-activatable battery as claimed in claim 29 wherein the metal layer is coated on to the inner side surface of the tube using a thermal spraying or "arc spraying" process.

30 31. A liquid-activatable battery as claimed in claims 29 or 30 wherein the passage includes a groove or a channel etched, moulded and/or shaped into the metal layer.

32. A liquid-activatable battery as claimed in any one of claims 29 to 31 wherein the metal layer includes a zinc layer.

33. A liquid-activatable battery as claimed in claim 32 wherein the zinc layer  
5 includes a thickness of at least about 0.1mm.

34. A liquid-activatable battery as claimed in any one of claims 32 or 33 wherein the zinc layer includes at least approximately 99.99 percentage pure zinc by weight.

10 35. A liquid-activatable battery as claimed in any one of claims 32 to 34 wherein the zinc layer weighs approximately 1.6 gm.

36. A liquid-activatable battery as claimed in any one of claims 1 to 20 wherein the tube includes a metal tube and the conductive surface includes an integrally  
15 formed inner side surface of the metal tube.

37. A liquid-activatable battery as claimed in claim 36 wherein the passage includes a groove or a channel etched, moulded and/or shaped into the inner side  
20 surface of the metal tube.

38. A liquid-activatable battery as claimed in any one of the preceding claims wherein the electrolyte powder mixture includes a metal oxide powder.

25 39. A liquid-activatable battery as claimed in claim 38 wherein the electrolyte powder mixture includes approximately 3% ammonium chloride particles, 16% zinc chloride particles, 68% manganese dioxide particles, 12.4% acetylene carbon black and 0.6% zinc oxide particles by percentage weight of the electrolyte powder mixture.

30 40. A liquid-activatable battery as claimed in any one of the preceding claims including at least approximately 4.75-5.75 gm of electrolyte powder mixture in the chamber of the tube.

41. A liquid-activatable battery including:

a tube having an inner side surface defining a chamber in which a liquid-activatable electrolyte powder mixture is disposed therein, a first end of the tube being sealed by a first end cap and a second end of the tube being releasably sealed  
5 by a second end cap wherein the second end of the tube is adapted to allow delivery of a liquid therethrough into the chamber when unsealed;

a conductive surface positioned on or between the inner side surface of the tube and the electrolyte powder mixture;

a permeable separator sheet for electrically isolating the electrolyte powder  
10 mixture from the conductive surface; and

a conductive rod having a first end located adjacent the first end of the tube, and, the conductive rod having a second end in contact with the electrolyte powder mixture;

wherein when the liquid is delivered in to the chamber via the unsealed  
15 second end of the tube, the electrolyte powder mixture is activated via contact with the liquid and a potential difference is able to be generated between the conductive surface and the conductive rod.

42. A liquid-activatable battery as claimed in claim 41 including a passage  
20 extending within the tube configured to allow a liquid that is delivered in to the chamber via the second end of the tube when unsealed to flow into contact with the electrolyte powder mixture via a surface region of the electrolyte powder mixture adjacent the inner side surface of the tube.

25 43. A liquid-activatable battery as claimed in claims 41 or 42 including a plurality of passages.

44. A liquid-activatable battery as claimed in any one of claims 41 to 43 wherein the passage extends substantially along a full length of tube between the first and  
30 second ends adjacent the inner side surface of the tube.

45. A liquid-activatable battery including:

a tube having an inner side surface defining a chamber in which a liquid-activatable electrolyte powder mixture is disposed therein, a first end of the tube  
35 being sealed by a first end cap and a second end of the tube being releasably sealed

by a second end cap wherein the tube is adapted to allow delivery of a liquid therethrough into the chamber when unsealed;

a conductive surface positioned on or between the inner side surface of the tube and the electrolyte powder mixture;

5 a permeable separator sheet for electrically isolating the electrolyte powder mixture from the conductive surface;

a conductive rod having a first end located adjacent the first end of the tube, and, the conductive rod having a second end in contact with the electrolyte powder mixture; and

10 a passage extending between the first and second ends of the tube, the passage being configured to allow a liquid that is delivered in to the chamber via the second end of the tube when unsealed to flow into contact with the electrolyte powder mixture via a surface region of the electrolyte powder mixture adjacent the inner side surface of the tube so as to activate the electrolyte powder mixture,  
15 whereby the activated electrolyte powder mixture is adapted to generate a potential difference between the conductive surface and the conductive rod.

46. A liquid-activatable battery as claimed in any one of the preceding claims wherein the passage includes a groove or channel formed by etching or moulding the  
20 electrolyte powder mixture or by folding or shaping the permeable separator sheet disposed in the tube.

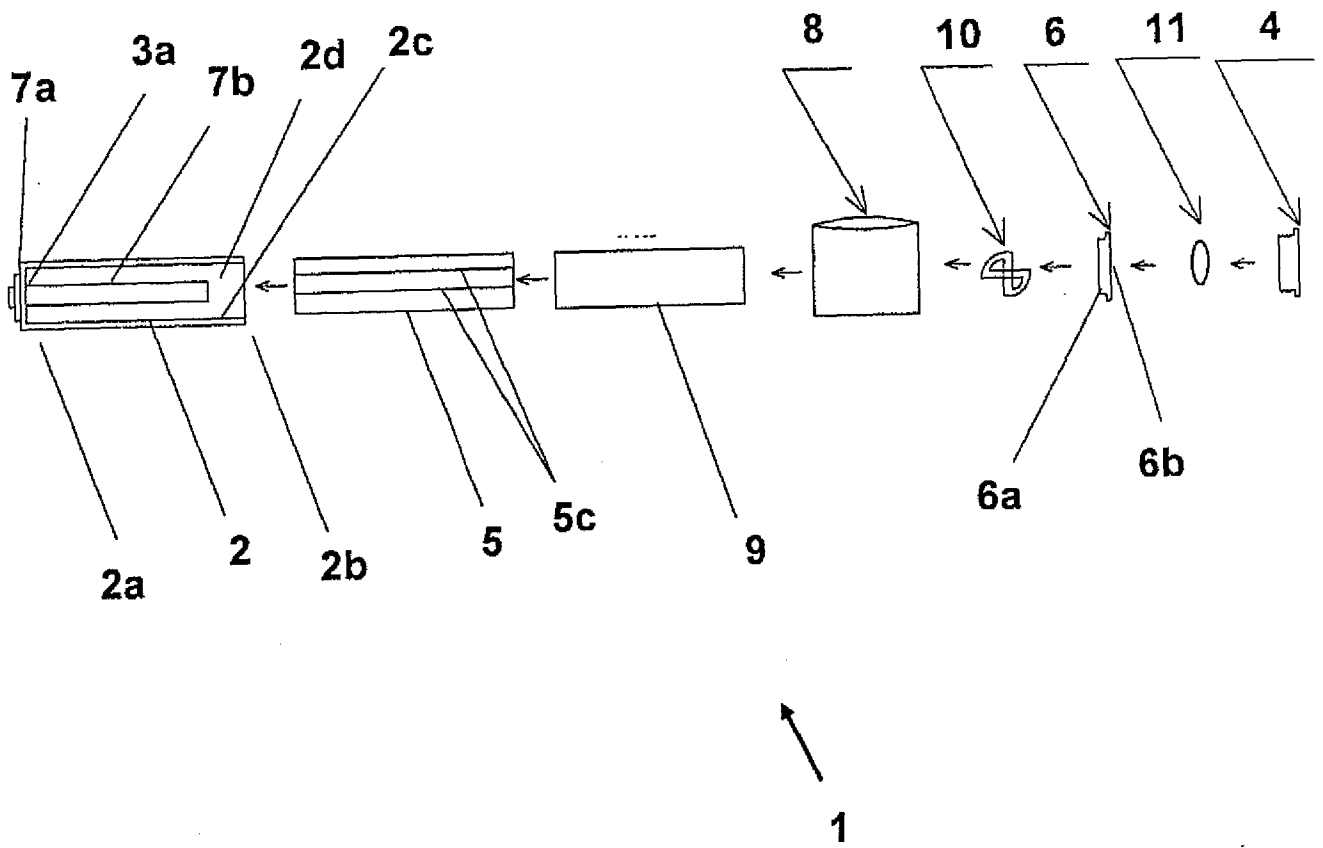
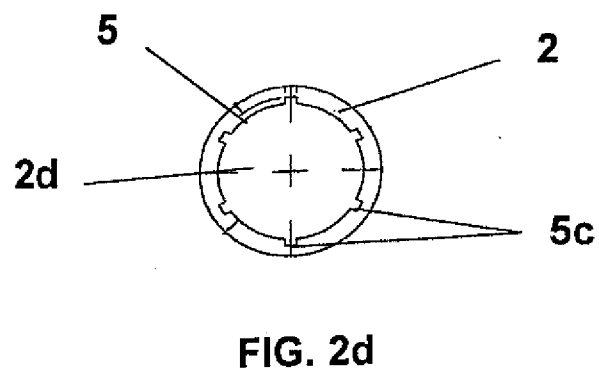
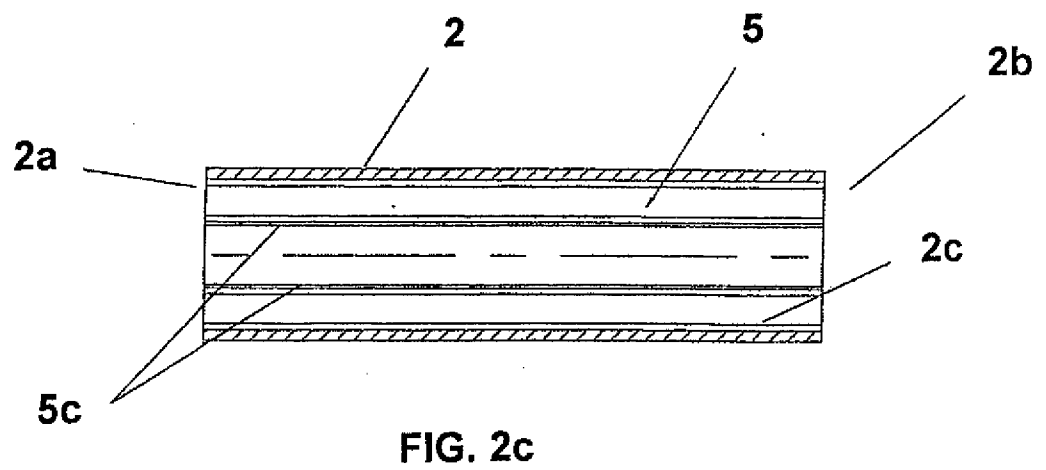
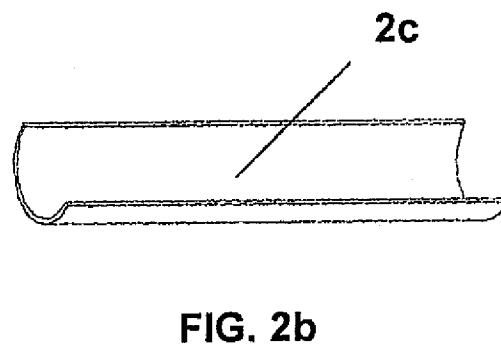
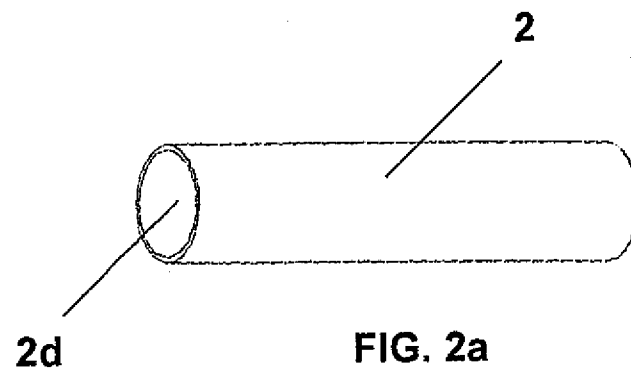


FIG. 1



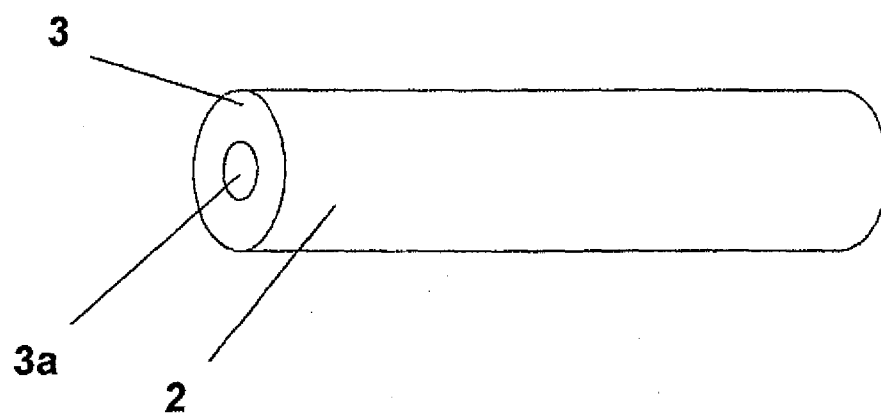


FIG. 3

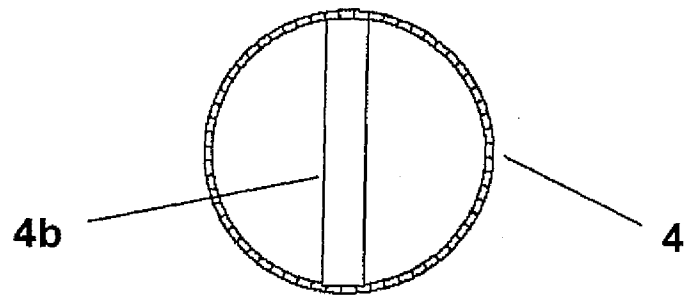


FIG. 4a

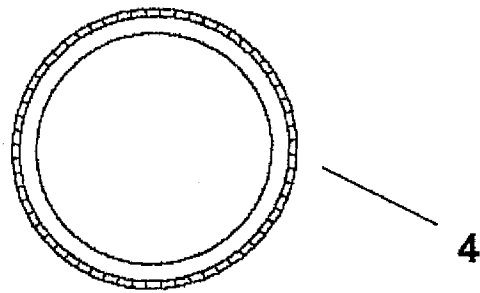


FIG. 4b

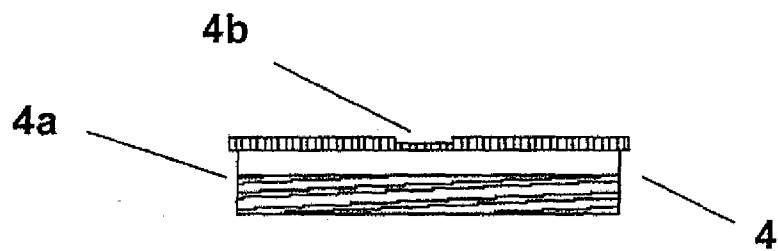


FIG. 4c

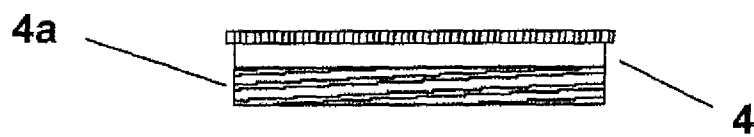


FIG. 4d

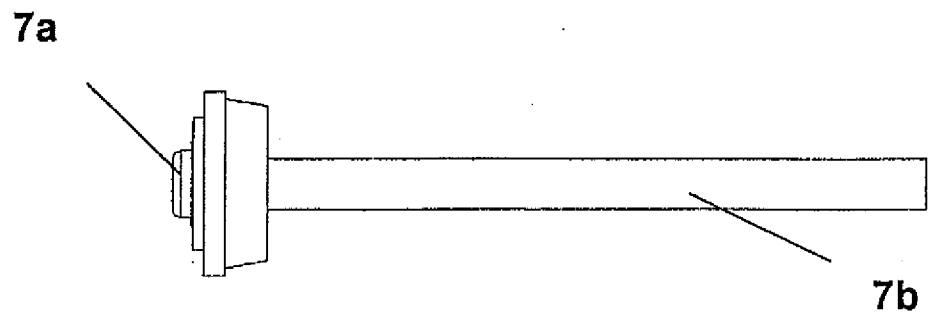


FIG. 5a

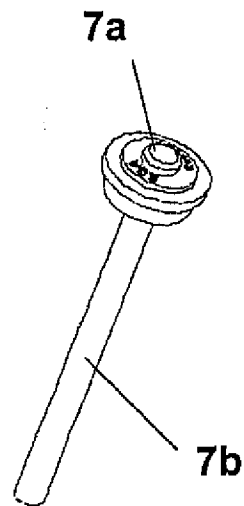


FIG. 5b

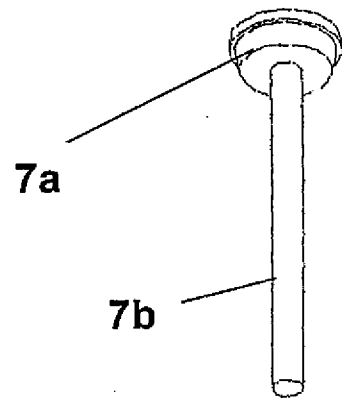


FIG. 5c

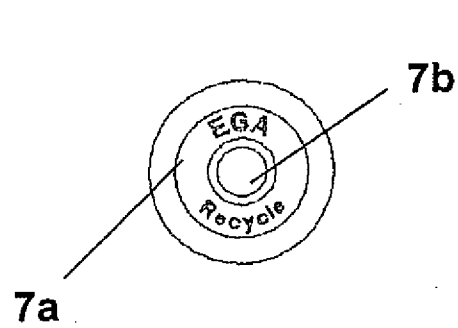


FIG. 5d

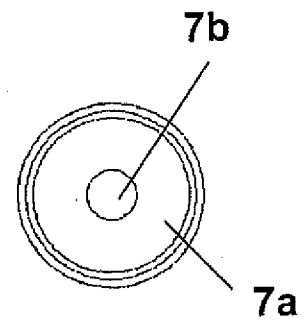


FIG. 5e

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2013/089129

## A. CLASSIFICATION OF SUBJECT MATTER

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: H01M

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)

CNABS, CNTXT, VEN, CNKI: liquid, active+, batter???, cell?, passage, path, groove, channel, plastic, complex

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                               | Relevant to claim No. |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | CN102340011 A (ECO ASIA ENVIRONMENTAL PROT GROUP CO LTD)<br>01 february 2012 (01.02.2012) paragraphs [0008]-[0047], [0082]-[0110] and figure 1-7 | 1-3,6,8-20,36-46      |
| A         | US 2006/0269837 A1 (Sueng-Nien Kao) 30 November 2006 (30.11.2006) the whole document                                                             | 1-46                  |
| A         | US 4063006 A (THE UNITED STATES OF AMERICA AS REPRESENTED BY THE SECRETARY OF THE NAVY ) 13 December 1977 (13.12.1977) the whole document        | 1-46                  |
| A         | WO 2012036671 A1 (EMPIRE TECHNOLOGY DEVELOPMENT LLC)<br>22 March 2012 (22.03.2012) the whole document                                            | 1-46                  |

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

|                                                                                                                                                                          |                                                                                                                                                                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| “E” earlier application or patent but published on or after the international filing date                                                                                | “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 |
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Date of the actual completion of the international search  
25 February 2014 (25.02.2014)

Date of mailing of the international search report  
**20 Mar. 2014 (20.03.2014)**

Name and mailing address of the ISA/CN  
The State Intellectual Property Office, the P.R.China  
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100088  
Facsimile No. 86-10-62019451

Authorized officer  
**YIN, Chaoli**  
Telephone No. (86-10)62089113

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.

PCT/CN2013/089129

| Patent Documents referred<br>in the Report | Publication Date | Patent Family    | Publication Date |
|--------------------------------------------|------------------|------------------|------------------|
| CN102340011A                               | 01.02.2012       | AU 2011274091 B2 | 27.06.2013       |
|                                            |                  | US 2012148882 A1 | 14.06.2012       |
|                                            |                  | EP 2589098 A1    | 08.05.2013       |
|                                            |                  | JP 2013533590 A  | 22.08.2013       |
|                                            |                  | CA 2770532 A1    | 05.01.2012       |
|                                            |                  | HK 1179766 A0    | 04.10.2013       |
|                                            |                  | WO 2012000446 A1 | 05.01.2012       |
|                                            |                  | CA 2770532 C     | 22.01.2013       |
|                                            |                  | AU 2011274091 A1 | 10.01.2013       |
|                                            |                  | CN202333044U     | 11.07.2012       |
|                                            |                  | WO2012000195A1   | 05.01.2012       |
|                                            |                  | HK1153618A2      | 30.03.2012       |
|                                            |                  | HK1153906        | 05.04.2012       |
|                                            |                  | CN202333045U     | 11.07.2012       |
|                                            |                  | HK1166422A0      | 26.10.2012       |
| US 2006269837 A1                           | 30.11.2006       | GB 2427065 A     | 13.12.2006       |
|                                            |                  | GB 2427065 B     | 21.03.2007       |
| US 4063006A                                | 13.12.1977       | None             |                  |
| WO 2012036671 A1                           | 22.03.2012       | JP 2013539897 A  | 28.10.2013       |
|                                            |                  | US 8615864 B2    | 31.12.2013       |
|                                            |                  | KR 20130060319 A | 07.06.2013       |
|                                            |                  | CN 103098276 A   | 08.05.2013       |
|                                            |                  | US 2012060339 A1 | 15.03.2012       |

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2013/089129

## Continuation of International Patent Classification (IPC) or both national classification and IPC:

H01M6/34 (2006.01) i

H01M6/32 (2006.01) i