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(54) Title: AN ELECTRICAL ENERGY STORAGE DEVICE

(57) Abstract: Embodiments of an electrical energy storage device is described. Such electrical energy storage device comprises an anode including a metal plate, a cathode including a current collector component, a device activator sandwiched between a pair of the anode and the cathode. The device activator includes a water absorbent arranged to absorb water for transforming salt contained in the device activator into an electrolyte disposed between the anode and the cathode, so as to facilitate an electrochemical reaction taking place at the anode and/or the cathode in a presence of water supply to the device activator.

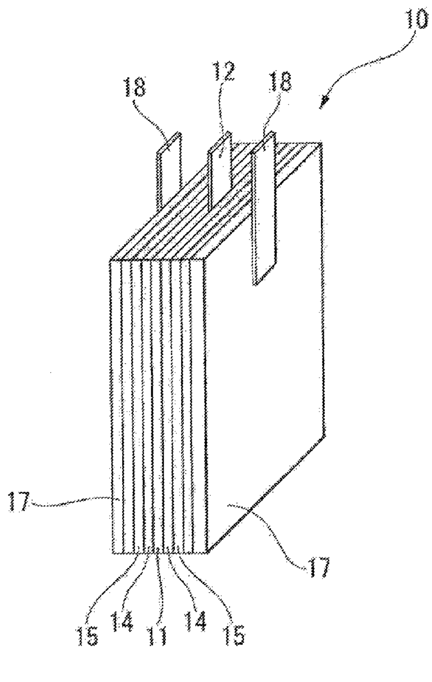

Fig. 1

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AN ELECTRICAL ENERGY STORAGE DEVICE

TECHNICAL FIELD

The present invention relates to an electrical energy storage device, more particularly a water battery operable to generate electrical energy upon being injected with water supply.

BACKGROUND

To date, electric battery is commonly used for a wide range of electronic applications to provide electrical energy. For example, these electronic applications may be torches, mobile phones, electric cars, laptops, watches and so on. Owing to the form factor of these applications and other needs, battery may comprise different form factor, capacity, material and so on.

Despite the aforementioned potential differences amongst various types of batteries, the technical theory behind a battery remains more or less the same. A battery may comprise a positive terminal namely the cathode, a negative terminal namely the anode and the electrolyte. The chemical reaction, depending on the material used in the battery, causes the electrons to accumulate at the anode. In subsequence, this causes an electrical difference between the anode and the cathode. In order to balance such difference and to reach equilibrium between the anode and the cathode, electrons due to the repelling force may then push each other specifically towards the cathode. Such flow of electrons creates the electric current and voltage.

Based on this theory, various types of batteries such as dry battery, fuel cell and water battery are created for difference electrical appliances or devices. These types of batteries may store the potential electrical energy and release upon connecting to a load or injecting some liquid into the water battery. Such energy may be released until for example the electrode materials cannot charge or discharge or the liquid within a water battery is dried up.

SUMMARY OF THE INVENTION

In accordance with an aspect of the present invention, there is provided an electrical storage device, comprising: an anode including a metal plate, a cathode including a current collector component, a device activator sandwiched between a pair of the anode and the cathode. The device activator includes a water absorbent arranged to absorb water for transforming salt contained in the device activator into an electrolyte disposed between the anode and the cathode, so as to facilitate an electrochemical reaction taking place at the anode and/or the cathode in a presence of water supply to the device activator.

Preferably, the electrical energy storage device remains deactivated when the water absorbent is substantially dehydrated.

Preferably, the device activator comprises a salt-containing carrier adjacent to water absorbent.

More preferably, the salt-containing carrier includes salt-containing cloth.

More preferably, the salt-containing carrier includes salt-containing paper.

Furthermore preferably, the salt-containing paper includes a multi-layered structure.

More preferably, the salt-containing carrier includes solid-state salt produced by dehydration of a salt solution.

Furthermore preferably, the salt solution includes a concentration of salt greater than 15 %.

Preferably, the water absorbent includes at least one of nonwoven cloth, cotton cloth, water-absorbing paper and sponge.

Preferably, the current collector component comprises an electrically conductive material.

More preferably, the electrically conductive material includes copper and/or carbon nanotube.

More preferably, the current collector component comprises nonwoven fabric of the electrically conductive material.

Furthermore preferably, the nonwoven fabric is disposed on a positive terminal support structure.

Yet furthermore preferably, the nonwoven fabric wraps around the positive terminal support structure.

Yet furthermore preferably, the positive terminal support structure includes an electrical insulator.

Preferably, the metal plate comprises at least one of titanium, magnesium, aluminum and lithium.

Preferably, the metal plate defines a negative terminal support structure.

Preferably, the electrical energy storage device further comprises a cell unit encapsulation arranged to substantially encapsulate the anode, the cathode, and the device activator to define a single cell unit.

More preferably, the cell unit encapsulation comprises at least one opening which allows an access of water supply to the water absorbent encapsulated therein.

More preferably, the electrical energy storage device further comprises a positive terminal connector and a negative terminal connector respectively connected to the current collector and to the metal plate encapsulated within the cell unit encapsulation.

Furthermore preferably, the positive terminal connector and the negative terminal connector respectively weld or soldered on separate electrode support planes in the cathode and the anode.

Furthermore preferably, the positive terminal connector and the negative terminal connector include copper.

More preferably, the cell unit encapsulation includes heat-shrink tubing. Alternatively, elastic plastic tape also may be used for encapsulating the cell unit.

More preferably, the electrical energy storage device further comprises a housing accommodating a single cell unit, or a plurality of single cell units in series and/or parallel connections.

Furthermore preferably, the housing comprises a fluidic cavity for receiving and at least temporally retaining the water supply, wherein the fluidic cavity is accessible to the water absorbent within the encapsulation.

Yet furthermore preferably, the housing further comprises an inlet in fluid communication with the fluidic cavity.

Yet furthermore preferably, the housing further comprises a vent for gas exchange between an internal cavity of the housing and an external environment.

Furthermore preferably, the plurality of single cell units are physically fixed together.

Furthermore preferably, the electrical energy storage system comprises an electrical connector in electrical connection with the anode and the cathode in the housing.

Preferably, the water supply includes at least one of freshwater, drinkable water, waste water and urine. Other sources of water may include beverages such as tea, juice, beer or soft drinks.

Preferably, the water supply includes any aqueous solution with a pH value between 4 – 10.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the device for generating electrical energy will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 illustrates an embodiment of a single cell unit.

Figure 2 illustrates a planar diagram of a piece of material such as carbon fabric and CNT for measurement of resistance between the points A, B, C, D, E.

Figure 3 illustrates a perspective view of an embodiment of a cylindrical single cell unit.

Figure 4 illustrates an embodiment of a cell unit encapsulation.

Figure 5a illustrates a schematic diagram of a single cell unit

Figure 5b illustrates a schematic diagram of 2 single cell units connecting to each other physically and electrically in parallel, forming a plurality of cell units.

Figure 5c illustrates a schematic diagram of 4 single cell units connecting to each other physically and electrically in parallel, forming a plurality of cell units.

Figure 5d illustrates a schematic diagram of 2 single cell units connecting to each other physically and electrically in series, forming a plurality of cell units.

Figure 5e illustrates a schematic diagram of 4 single cell units connecting to each other physically and electrically in series, forming a plurality of cell units.

Figure 6 illustrates an embodiment of multiple physically connected cell unit encapsulations.

Figure 7 illustrates a perspective view of an embodiment of a housing which contains a cell unit encapsulation within.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Traditional fuel cell such as but not limited to manganese dioxide battery, lead-acid battery and so on are normally made of various substances such as acid, lead, nickel and so on. If these batteries are being discarded improperly, the battery may disintegrate and the toxic chemicals or even heavy metals may infiltrate into soil and water resources. Thus, it may pollute the environment and cause direct harmful effects such as cancer or other disease to plants, animals and human.

To solve problem brought by the traditional fuel batteries, water battery that generates a difference in salinity of fresh water and sea water have been developed. In this water battery, the positive and negative electrodes are immersed in ionic liquid. Upon activation, fresh water is injected into the battery. It will then discharge the fresh water and be injected with salt water. Since electron ions in seawater is sixty to a hundred times more than in fresh water, this will increase the voltage between the positive electrode and the negative electrode and thus yield an output voltage.

However, such traditional water battery also suffers a problem. As both the positive and negative electrodes are immersed in the seawater and stored in this manner, it is thus prone to corrosion expansion. Hence, this type of battery may be dead without knowing. This may be a problem in emergencies whenever electricity is required for lightings.

With reference to Figure 1, an embodiment of the present invention is illustrated. This embodiment is arranged to provide a single cell unit 10 of an electrical energy storage device, comprising: anode 17 including metal plate; cathode 14 including a current collector component, and device activator 15 sandwiched between a pair of the anode 17 and the cathode 14. The device activator 15 may include a water absorbent arranged to absorb water for transforming salt contained in the device activator 15 into an electrolyte disposed between the anode 17 and the cathode 14, so as to facilitate an electrochemical reaction taking place at the anode 17 and/or the cathode 14 in a presence of water supply to the device activator 15.

In this embodiment, the single cell unit 10 provides an anode material 17 and a cathode material 14 that would typically undergo chemical reaction with an electrolyte to generate a current. The current generated would then be collected by a current collector component. In a default configuration, the anode material 17 and the cathode material 14 are separated by separating means that is initially in a solid state. The separating means is transformable from the solid state to an aqueous state upon contacting by a fluid e.g. ingress of water, thereby providing a medium for chemical reaction in an activated configuration.

When the electrical energy storage device is in a non-operating state, the water absorbent or even other components of the single cell unit 10 may be initially in a dehydrated state. In other words, the single cell unit 10 may be activated by injecting water supply therein and subsequently hydrating the water absorbent and maybe other components of the single cell unit 10.

The separating means may be a device activator 15 that includes a water absorbent. Preferably, the water absorbent may be made of an environmentally friendly material that has great water absorption ability. Such material may include at least one of nonwoven cloth, cotton cloth, water-absorbing paper, sponge, or otherwise. Advantageously, by using environmentally friendly material that has great water absorption ability, it may extend the length of each battery cycle as the battery may produce voltage until the water absorbent is dehydrated, while it may rectify the environmental problem brought upon by traditional fuel cell.

The device activator 15 may also comprise a salt-containing carrier adjacent to water absorbent. Such salt-containing carrier may be any material that can contain salt within or on its surface. Such material may be cloth, paper, towel, fabric or otherwise which may be a multi-layered structure. For example, the salt-containing carrier may contain at least two layers of paper. The salt-containing carrier may further contain a composite of different materials. For example, it may be made of at least two layers of paper and at least two layers of fabric.

To introduce salt onto or into the material, in one embodiment, the material may be immersed, submerged, being poured with salt solution that may have at least fifteen percent concentration of salt. The material once soaked in salt solution may then be dried thereby to dehydrate the salt solution to extract solid-state salt, such that the salt-containing carrier may be dry. In an alternative embodiment, salt solution with at least fifteen percent concentration of salt may be dehydrated thereby to extract solid-state salt in advance before being sprinkled, smeared, spread or otherwise on the material.

The device activator 15 may be activated by injecting water supply or hydrating with the supply of water. The water supply may be any liquid or aqueous solution that may be conducive to the flow of electrons or ionized salt. Preferably, the aqueous solution may include a pH value between 4 – 10.

For example, the water supply for activating the cell may be fresh water, drinkable water, waste water, urine and so on. Other sources of water, such as can/bottle drinks or beverages such as beer, juice or soft drinks may also be used.

Advantageously, for example, an emergency situation may not allow a specific type of water supply, however, as this single cell unit 10 accepts a wide range of water supply, a user may still be able to provide urine as the last resort to activate the single cell unit 10. Hence, this device may have the ability to handle variety of emergencies to power up devices such as but not limited to torch, power bank and so on.

The solid-state salt may dissolve into electrolyte ion when the water absorbent is soaked with water supply injected and may thereafter form an electrolyte solution. The cathode 14 may then react to the ions and release positive electrons. At the same time, anode 17 may then react to the ions and receive the released positive electrons from the cathode 14.

Without wishing to be bound by theory, the inventors have, through their own research, trials and experiments, devised that the internal resistance of cathode 14 should be as small as possible such that the voltage source can yield greater voltage. To achieve that, the internal resistance of cathode should have low resistance.

In one example embodiment of the present invention, the cathode 14 may include a current collector component. The current collector component within the cathode 14 may comprise an electrically conductive material. Preferably, in one embodiment, the electrically conductive material may include a material that has a low resistance. For example, such material may be made of nonwoven fabric which may include copper and/or carbon nanotube (CNT).

With reference to the following table and Figure 2, there is shown the measured resistance on a piece of carbon fabric which is commonly used for water battery and CNT material, both materials have the same surface area. In one embodiment, the resistance measured between point A and point B for carbon fabric and CNT give 5.2 Ω and 0.8 Ω respectively. In an alternative embodiment, the resistance measured between point C and point D give 5.3 Ω and 0.6 Ω respectively. In a different embodiment, the resistance measured between point A and point D give 4.4 Ω and 0.84Ω respectively. In another embodiment, the resistance measured between point C and point B give 4.6Ω and 0.3 Ω respectively. In an alternative embodiment, the resistance measured between point A and point E give 4.3 Ω and 0.32 Ω respectively. The resistance of CNT is generally six times to twelve times smaller than that of carbon fabric.

Advantageously, a low cathode internal resistance may help establish a greater source voltage and source current. It may also warrant the stability of voltage thereby to avoid problems such as but not limited to voltage spike or expected voltage drop.

Measurements	distance	distance	distance	distance	distance

	(A-B)	(C-D)	(A-D)	(C-B)	(A-E)
resistance of carbon fabric	5.2 Ω	5.3 Ω	4.4 Ω	4.6 Ω	4.3 Ω
resistance of CNT	0.8 Ω	0.6 Ω	0.4 Ω	0.3 Ω	0.32 Ω

To reinforce the single cell unit 10, there is provided one or more terminal support structures for holding the inner components of the single cell unit 10 in place. For instance, the cell unit 10 may include one or more positive terminal support structures 11 and negative terminal support structures.

The cathode 14 or the current collector component may wrap around the positive terminal support structure 11. The positive terminal support structure 11 may be used as a “backbone” for the cathode 14 or the current collector component, such that it may forestall for example but not limited to any dislocation or unnecessary movement of the cathode 14 or the current collector component. Such positive terminal support structure 11 may be made of any electrically insulated material. For example, it may be plastic, wood, glass, ceramic and so on.

At the same time, the positive terminal support structure 11 may be connected to a positive terminal connector 12. The positive terminal connector 12 may be made of conductive metal such as but not limited to copper, silver, aluminum and so on. They may be connected by means such as but not limited to welding, soldering and so on. The positive terminal connector 12 may also be physically and electrically connected to the cathode 14. Advantageously, this structure may help secure the positive terminal connector 12 in place from moving, dislocating or losing the connection with the positive terminal support structure 11 and the cathode 14.

On the other hand, the anode 17 of the single cell unit 10 may be made of metal plate. Such kind of metal plate may be copper, silver, aluminum, titanium, magnesium, lithium and so on. Additionally, such metal plate may also be acted as a negative terminal support structure, such that it may properly sandwich the positive terminal support structure 11, the cathode14 and the device activator 15 and thus may keep them in place from any dislocation.

A negative terminal connector 18 may also be physically and electrically connected to the anode 17. The negative terminal connector 18 may be made of conductive metal such as but not limited to copper, silver, aluminum and so on. The negative terminal connector 18 may be connected by means such as but not limited to welding, soldering and so on to the anode 17. Advantageously, this structure may help secure the positive terminal connector 12 in place from moving, dislocating or losing the connection with the positive terminal support structure 11 and the cathode 14.

In an alternative embodiment, an aforementioned single cell unit 10 may be rolled up to form a single cell unit 30 preferably in circular shape as shown in Figure 3. In this embodiment, the single cell unit 30 also includes an anode 31, a cathode 39, a device activator 36, each fabricated in a sheet form. The single cell unit 30 further includes a positive terminal support structure that is also provided in sheet form. A positive terminal connector 38a and a negative terminal connector 38b are at least partially exposed from the cell unit 30. A water tube 32 in fluid communication with the device activator 36 is also provided on and partially exposed from the cell unit 30.

The single cell unit 30 may be rolled about an axis aligned with the longitudinal axis of the water tube 32, such that two opposite sides of each of the positive terminal support structure 37, the cathode 39, the device activator 36 and the anode 31 may be in physical touch. Such physical contact may be reinforced or secured by any possible means without sacrificing the electrical conductivity such as welding, soldering and so on. The positive terminal connector 38a and the negative terminal connector 38b may be in physical and electrical contact with the cathode 39 and the anode 31 respectively.

Advantageously, such configuration may facilitate easy and convenient stowing of the single cell unit 30 within any container.

In one or more preferred embodiment, the anode and the cathode are not necessarily exposed on the outer side of a single cell unit. For instance, these electrical components may be covered by a cell unit encapsulation of arbitrary shape such as circular, rectangular etc.

Referring to Figure 4, a cell unit encapsulation 51 containing a single cell unit may encapsulate the anode, the cathode, the device activator, the positive terminal connector, the negative terminal connector which are not shown in the diagram. Such cell unit encapsulation 51 may contain a single cell unit and also provide a fluid cavity within to contain water supply upon activation. The cavity may be accessible through one or more openings 52a, 52b. For instance, wires from the external which may be the positive connection 56b and the negative connection 56a may be connected to the positive terminal connector and the negative terminal connector through the opening 52b respectively. In addition, water supply may be injected into the single cell unit by the water tube 55 through the opening 52a.

Advantageously, such design may provide a compact and secure compartment to contain a single cell unit. In this way, the single cell unit may not be easily damaged or dislocated during traveling, work or operation.

Preferably, the cell unit encapsulation 51 may also include material or protective coat for such as but not limited to wires, connections, joints, terminals and other components in an electrical device. Such material or protective coat may be heat-shrink tubing, in which the tubing may tightly wrap around the single cell unit. In addition, one of the two openings of the tubing may allow an access to water supply in the storage device structure to activate the cell unit, while the other opening at the opposite end may allow the wires and/or electrical connections to pass through. Advantageously, such material or protective coat may be able to provide the required insulation, abrasion resistance and mechanical protection for the aforementioned entities.

Alternatively, elastic plastic tape also may be used for encapsulating the cell unit. For example, elastic plastic tape may be wrapped around each of the single cell unit to form one or more layers of protection film to provide protection/insulation similar to that of the abovementioned heat-shrink tubing.

In one application of the example embodiment, the wires 56a, 56b connecting to positive terminal connector and the negative terminal connector of the single cell unit may be connected to a load which may consume electricity from batteries. For example, the load may be a torch, a neon sign or light, a toy, a power bank, a fan and so on. After injecting water supply through the water tube 55 to the single cell unit, the components such as the water absorbent may be soaked in the water supply. The solid-state salt may be dissolved and may thus form an electrolyte solution containing electrolyte ion. For example, the electrolyte ion may flow from the anode to the cathode and the positive terminal support structure through the device activator. The electrolyte ion may then flow between the load and the single cell unit via the positive terminal connector through the wire 56b and the negative terminal connector through the wire 56a respectively.

The inventors have also devised that electrical devices normally may require more than one cell unit to power up as they may require a voltage greater than a single battery can provide. To satisfy such prerequisite, the present invention also discloses method and system physically and electrically connecting multiple cell units such that the connected cell units may provide a sufficient voltage to the load.

Referring to Figure 5a to 5e, there is provided a cross-sectional schematic diagram of an activated cell unit 205. For the ease of illustration of how cell unit 205 may be interconnected in parallel or in series, components such as the water absorbent, salt-containing carrier etc. are not shown in the figures.

In Figure 5a, the cell unit encapsulation 201 may include a cathode 204 and an anode 203 which may enclose three sides of the cathode 204 with a distal end on either one side. In one embodiment, the anode 203 may surround two long sides and one short side of the cathode 204 i.e. with one short side of the cathode exposed from the anode 203. In one alternative embodiment not shown in the figure, the cathode 204 and anode 203 may be switched around such that the cathode 204 may surround and enclose any three sides of the anode 203, leaving a distal end on the remaining one side. The distal end of the cathode 204 and anode 203 may be electrical connection means which may be the positive connector and negative connector respectively for connection to the load or other cell units 205.

Advantageously, such an open-end configuration of anode 203 and cathode 204 may allow easier and simpler interconnection between the anode 203 and cathode 204 between multiple cell units 201.

Referring to Figure 5b to 5d, there is provided cross-sectional schematic diagrams of two or four cell units 205 connected to each other physically and electrically. In the first embodiment, cell units 205 may be placed such that they are aligned along the same lateral axis and their respective longitudinal axis are in parallel to each other such that their long sides may be abutting each other. These cell units 205 may further be arranged such that that the distal end of the anodes 203 faces towards one direction whereas distal end of the anode 203 of the adjacent cell unit 205 may face the opposite direction. In another example, the distal end of anodes 203 of the cell units within the same plurality of single cell units 200 may face towards the same direction.

In the second embodiment not shown in diagram, two or more cell units 205 may be arranged such that they are aligned on the same longitudinal axis and their respective lateral axis are in parallel with each other such that their short sides are abutting each other. In another embodiment, some cell units 205 in a plurality of single cell units 200 may be placed in accordance with the first embodiment while some in the same plurality of single cell units 200 may be arranged in accordance with the second embodiment.

Advantageously, the aforementioned physical arrangement of the cell units 205 within a plurality of single cell units 200 may provide flexibility to the overall shape of the plurality of single cell units 200. For example, this may help accommodate the shape of the plurality of single cell units 200 to fit within a compartment or space within a device.

The cell units 205 within a plurality of single cell units 200 may be fastened with each other by some mechanical or physical means 206. These mechanical or physical means 206 may be fastened, attached, welded or soldered to the outer surface of the cell unit encapsulation 201 of each cell unit 205 by manufacturer, user or other personnel. For example, the mechanical or physical means 206 may be rivet, plastic tapes, screw, clamp, nail and so on. Advantageously, such mechanical or physical means 206 may keep the cell units 205 intact with each other such that the cell units 205 may not dislocate or move relative to other cell units 205 during, for example, work or operation.

Preferably, such fastening means may allow the user, manufacturer or other personnel to add or remove cell units 205 in a plurality of single cell units 200 by for example unscrewing and dismounting the mechanical or physical means 206. Advantageously, the ability to add or remove cell units 205 in a plurality of single cell units 200 may provide extra flexibility to the number of cell units 205 required based on various factors such as but not exhaustive to the required output voltage, internal capacity of a device reserved for the container containing the plurality of single cell units 200, water supply 202 available for activation. In subsequence, this may boost the efficiency of the entire process.

Referring to Figure 5b and 5c, there is provided a configuration of a plurality of single cell units 200 in which two or four cell units 205 are respectively connected electrically in parallel to each other. In one embodiment, the cathodes 204 of the cell units 205 within a plurality of single cell units 200 may be all electrically connected. In the meantime, the anodes 203 of the cell units 205 with the same plurality of single cell units 200 may be all electrically connected as well.

Referring to Figure 5d and 5e, there is provided a configuration of a plurality of single cell units 200 in which two and four cell units 205 respectively are connected in series to each other. In one embodiment, the cathode 204 of a cell unit 205 may be connected to the anode 203 of the adjacent cell unit 205. Likewise, the anode 203 of the cell unit 205 may be connected to the cathode 204 of another adjacent cell unit 205.

The electrical connection connecting cell units 205 within a plurality of single cell units 200 may be made of conductive material. For example, such conduct material may be copper, aluminum, steel and so on.

Advantageously, a plurality of cell units 205 may generate a higher output voltage than a single cell unit 200. In one embodiment, a single cell unit 200 may be able to yield 0.8-1.1 direct current voltage; whereas the plurality of cell units 205 may be able to provide 1.1-12 direct current voltage. Thus, the combined usage of single cell unit 200 and cell units 205 may be able to power more types of electrical devices such as torches, neon light or signs, power bank and so on.

Referring to Figure 6, there is shown an embodiment in which multiple cell encapsulations 10 may be joined and electrically connected with each other. These multiple cell encapsulations 10 may be kept in a housing all together.

Figure 7 illustrates an example embodiment of a cell unit that comprises a housing 80, a cell unit encapsulation 84 for encapsulating essential electrical components including an anode, a cathode, a device activator, a fluidic cavity 89 within which the cell unit encapsulation 84 is kept, and an inlet 82 in fluid communication with the fluidic cavity 89.

In one embodiment, the housing 80 may be in a circular shape although there is no constraint to the shape of the housing 80. The housing 80 may be sealed by a sealing mechanism such as a lid 81. The cell unit encapsulation 84 may contain single cell unit or multiple cell units as aforementioned which are not shown in the present diagram. The cell unit within the cell unit encapsulation 84 may connect to the external load connected to the housing 80 through the wires 85.

Advantageously, the housing 80 and the sealing mechanism 81 may keep for example the wires, connections, joints, terminals and so on within, such that it may avoid unnecessary or unintended mishandling of the aforementioned entities and may provide sufficient protection to its content. Furthermore, the sealing mechanism 81 may allow easy fixing, changing, adding, removing, or other types of handling the cell unit encapsulation 84 or the cell unit within the cell unit encapsulation 84.

In one embodiment, to activate the cell unit, a user, manufacturer or other personnel may pour water supply into the inlet 82 for water on the sealing mechanism 81. An external tube connecting the inlet 82 may connect to the cell unit encapsulation 84, which may direct the water supply to the single cell unit or multiple cell units within for activation. Advantageously, the external inlet 82 may be exposed from the housing 80 through the lid and thus allow easy and convenient activation of the cell unit by user, manufacturer and other personnel.

The water supplied from the external source is not necessarily introduced into the device activator encapsulated by the cell unit encapsulation 84 immediately. Optionally, the fluidic cavity 89 may temporally receive and store the water supply injected in the inlet 82. Such design may separate the water supply from physical contact with the cell unit and retain the supplied water within the cell unit encapsulation 84. Advantageously, this may prevent over soaking the cell unit for a long period thus causing any form of damage. Furthermore, with such storage of water supply, the cell unit may be activated anytime even if there is no water supply in the environment.

In case the external and internal pressure of the housing 80 differ, for example, in which the cell unit may generate heat during charge or discharge process due to enthalpy charges or the cell unit itself may generate gas during charge or discharge. In one embodiment, the housing 80 may also provide a vent 83 for gas exchange on the lid 81, such that it may maintain the balance of pressure between the internal cavity of the housing 80 and the external environment. Advantageously, such design may avoid damaging the cell unit encapsulation 84 or its content due to shrinking or expansion of the housing 80.

Advantageously, as the battery itself may not necessarily contain any form of liquid at start in non-operating state, it may facilitate easier and more convenient transport. In addition, such design may also facilitate long-term storage as the problem of corrosion expansive prevalent in traditional water battery may be avoided.

Furthermore, advantageously in one embodiment, such type of electrical energy storage device may have a battery life ranging between 100-300 hours; whereas the traditional fuel cell may normally have a battery life ranging between 5-10 hours. Thus, the electrical energy storage device of the present invention may have a longer lifespan as compared to other types of batteries.

It will also be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

Any reference to prior art contained herein is not to be taken as an admission that the information is common general knowledge, unless otherwise indicated.

CLAIMS

1. An electrical energy storage device comprising:

an anode including a metal plate;

a cathode including a current collector component;

a device activator sandwiched between a pair of the anode and the cathode, wherein the device activator includes a water absorbent arranged to absorb water for transforming salt contained in the device activator into an electrolyte disposed between the anode and the cathode, so as to facilitate an electrochemical reaction taking place at the anode and/or the cathode in a presence of water supply to the device activator.

2. The electrical energy storage device in accordance with Claim 1, wherein the electrical energy storage device remains deactivated when the water absorbent is substantially dehydrated.

3. The electrical energy storage device in accordance with Claim 1, wherein the device activator comprises a salt-containing carrier adjacent to water absorbent.

4. The electrical energy storage device in accordance with Claim 3, wherein the salt-containing carrier includes salt-containing cloth.

5. The electrical energy storage device in accordance with Claim 3, wherein the salt-containing carrier includes salt-containing paper.

6. The electrical energy storage device in accordance with Claim 5, wherein the salt-containing paper includes a multi-layered structure.

7. The electrical energy storage device in accordance with Claim 3, wherein the salt-containing carrier includes solid-state salt produced by dehydration of a salt solution.

8. The electrical energy storage device in accordance with Claim 7, wherein the salt solution includes a concentration of salt greater than 15 %.

9. The electrical energy storage device in accordance with Claim 1, wherein the water absorbent includes at least one of nonwoven cloth, cotton cloth, water-absorbing paper and sponge.

10. The electrical energy storage device in accordance with Claim 1, wherein the current collector component comprises an electrically conductive material.

11. The electrical energy storage device in accordance with Claim 10, wherein the electrically conductive material includes copper and/or carbon nanotube.

12. The electrical energy storage device in accordance with Claim 10, wherein the current collector component comprises nonwoven fabric of the electrically conductive material.

13. The electrical energy storage device in accordance with Claim 12, wherein the nonwoven fabric is disposed on a positive terminal support structure.

14. The electrical energy storage device in accordance with Claim 13, wherein the nonwoven fabric wraps around the positive terminal support structure.

15. The electrical energy storage device in accordance with Claim 13, wherein the positive terminal support structure includes an electrical insulator.

16. The electrical energy storage device in accordance with Claim 1, wherein the metal plate comprises at least one of titanium, magnesium, aluminum and lithium.

17. The electrical energy storage device in accordance with Claim 1, wherein the metal plate defines a negative terminal support structure.

18. The electrical energy storage device in accordance with Claim 1, further comprising a cell unit encapsulation arranged to substantially encapsulate the anode, the cathode, and the device activator to define a single cell unit.

19. The electrical energy storage device in accordance with Claim 18, wherein the cell unit encapsulation comprises at least one opening which allows an access of water supply to the water absorbent encapsulated therein.

20. The electrical energy storage device in accordance with Claim 18, further comprising a positive terminal connector and a negative terminal connector respectively connected to the current collector and to the metal plate encapsulated within the cell unit encapsulation.

21. The electrical energy storage device in accordance with Claim 20, wherein the positive terminal connector and the negative terminal connector respectively weld or soldered on separate electrode support planes in the cathode and the anode.

22. The electrical energy storage device in accordance with Claim 20, wherein the positive terminal connector and the negative terminal connector include copper.

23. The electrical energy storage device in accordance with Claim 18, wherein the cell unit encapsulation includes heat-shrink tubing or an elastic plastic tape.

24. The electrical energy storage device in accordance with Claim 18, further comprising a housing accommodating a single cell unit, or a plurality of single cell units in series and/or parallel connections.

25. The electrical energy storage device in accordance with Claim 24, wherein the housing comprises a fluidic cavity for receiving and at least temporally retaining the water supply, wherein the fluidic cavity is accessible to the water absorbent within the encapsulation.

26. The electrical energy storage device in accordance with Claim 25, wherein the housing further comprises an inlet in fluid communication with the fluidic cavity.

27. The electrical energy storage device in accordance with Claim 25, wherein the housing further comprises a vent for gas exchange between an internal cavity of the housing and an external environment.

28. The electrical energy storage device in accordance with Claim 24, wherein the plurality of single cell units are physically fixed together.

29. The electrical energy storage device in accordance with Claim 24, further comprising an electrical connector in electrical connection with the anode and the cathode in the housing.

30. The electrical energy storage device in accordance with Claim 1, wherein the water supply includes at least one of freshwater, drinkable water, waste water, a beverage and urine.

31. The electrical energy storage device in accordance with Claim 1, wherein the water supply includes an aqueous solution with a pH value between 4 to 10.

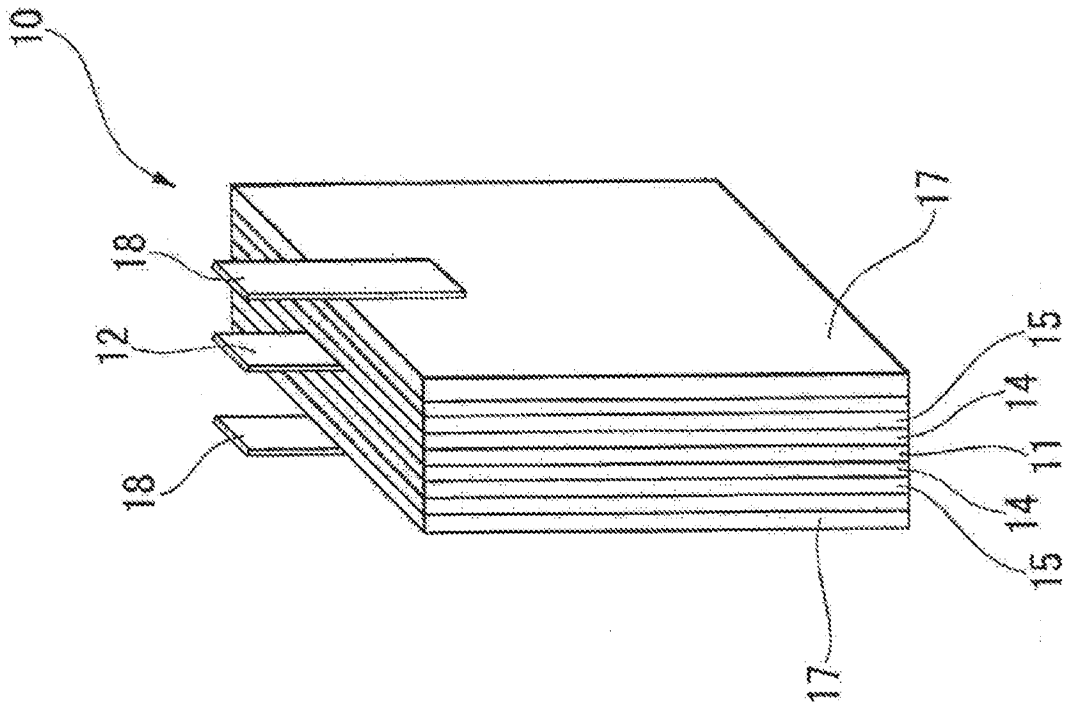

Fig. 1

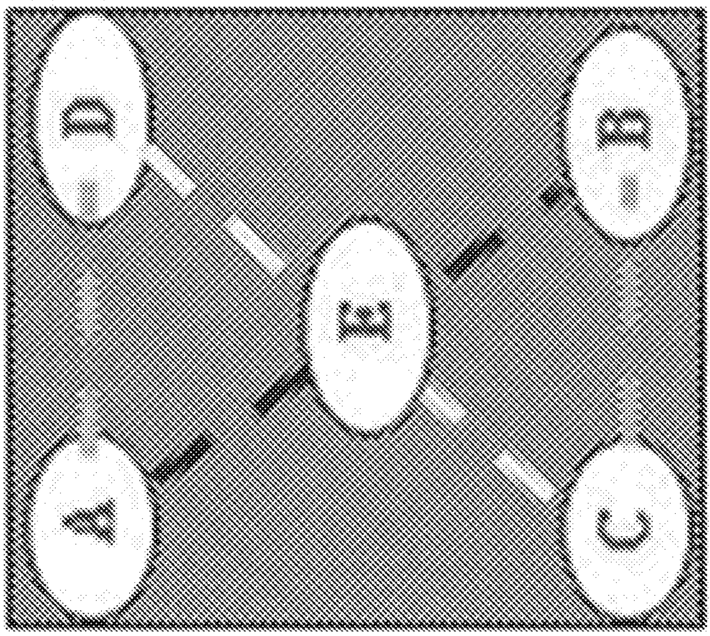

Fig. 2

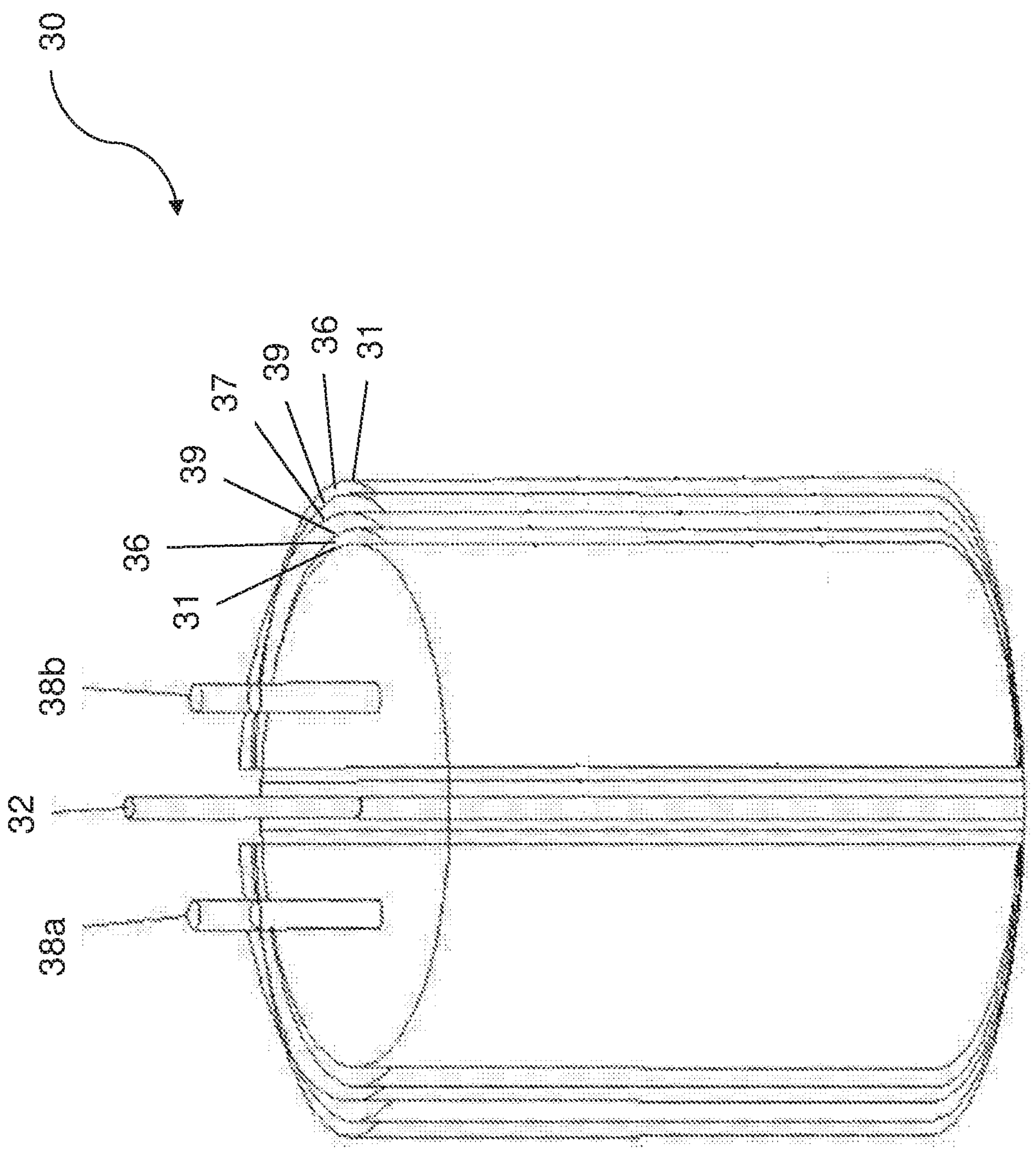

Fig. 3

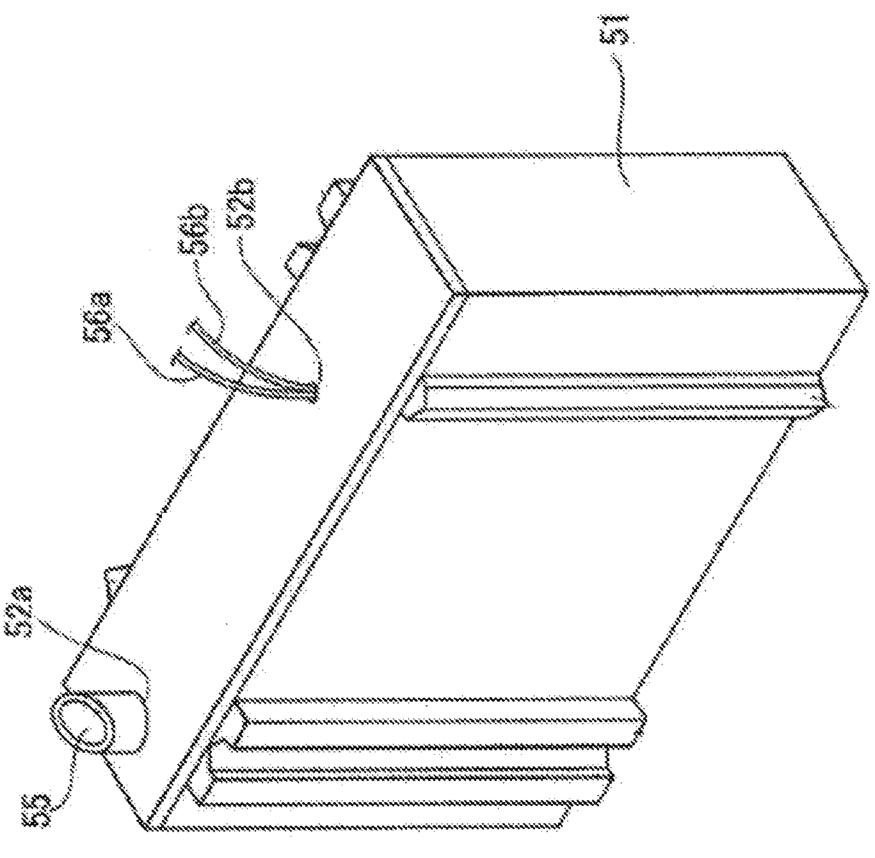

Fig. 4

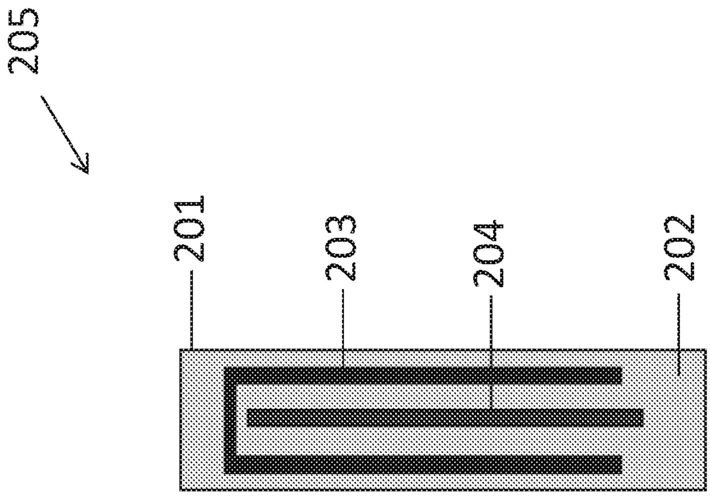

Fig. 5a

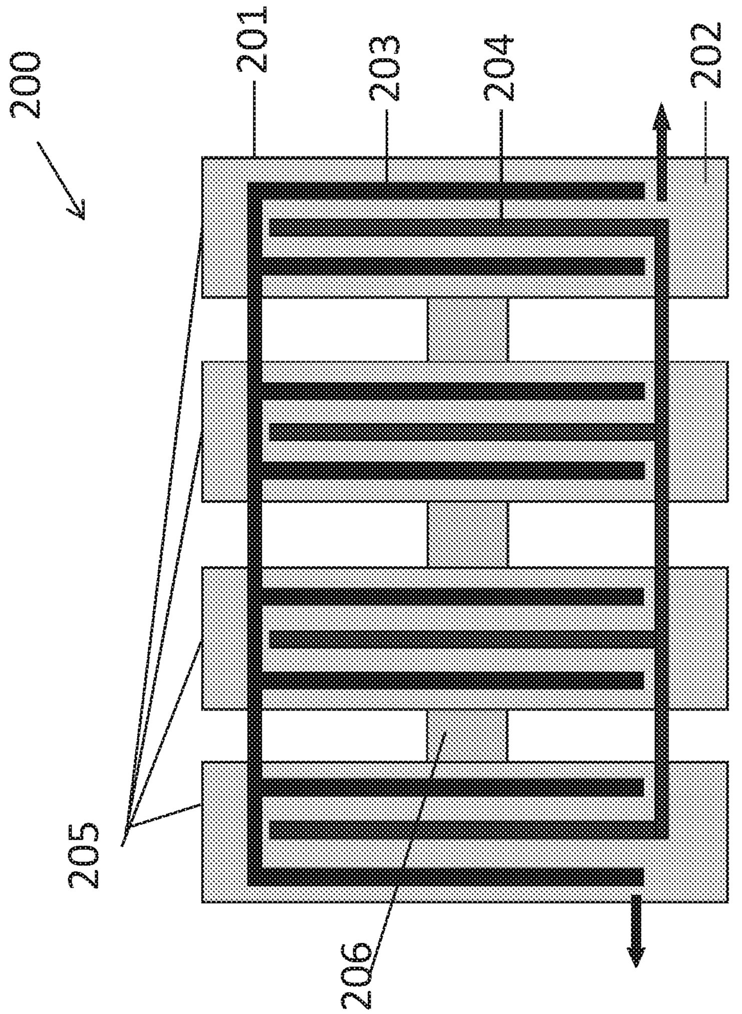

Fig. 5c

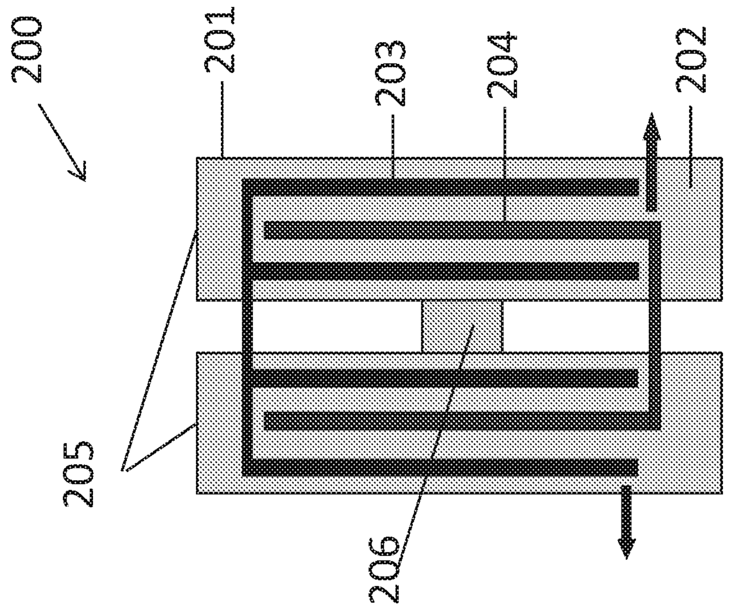

Fig. 5b

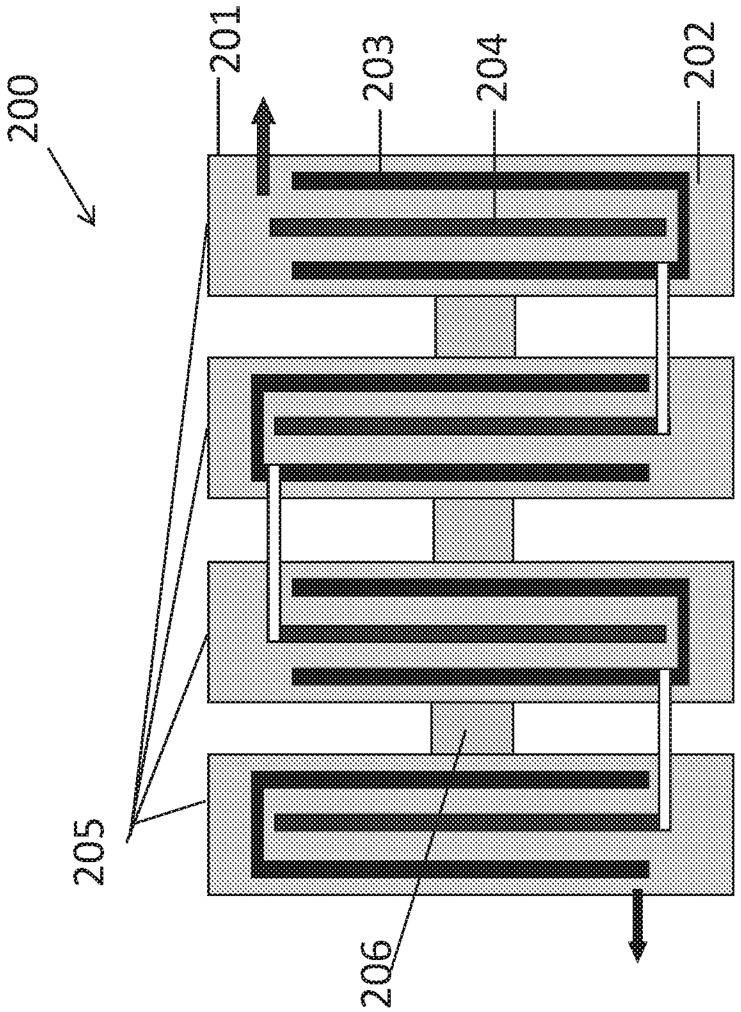

Fig. 5e

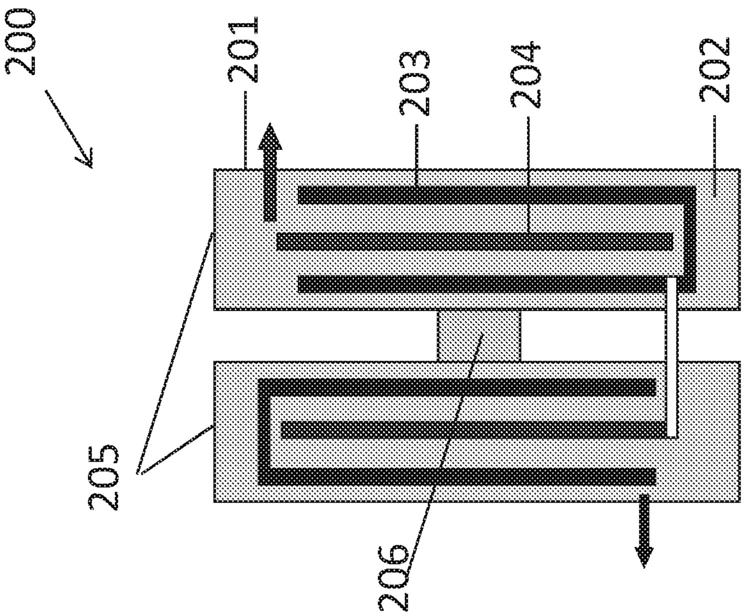

Fig. 5d

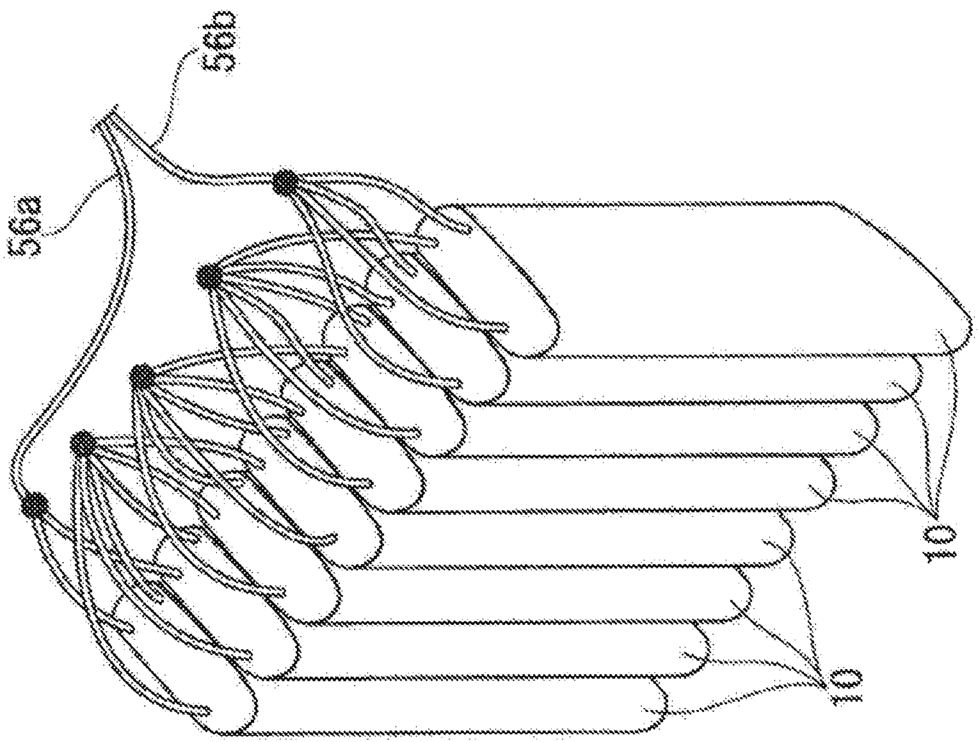

Fig. 6

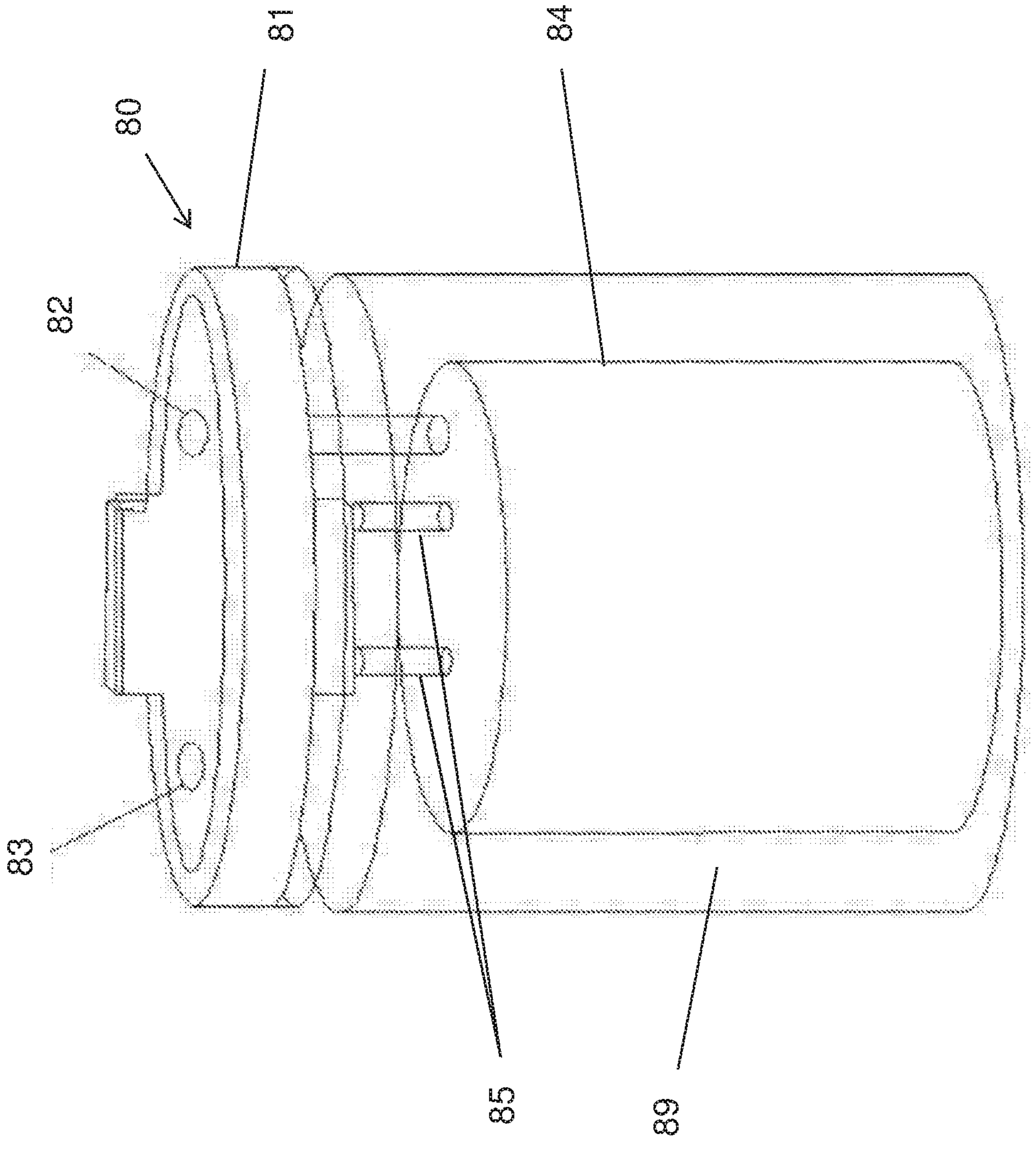

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2019/100081

A. CLASSIFICATION OF SUBJECT MATTER

H01M 6/32(2006.01)i; H01M 6/48(2006.01)i; H01M 2/02(2006.01)i; H01M 4/06(2006.01)i

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)

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)

CNPAT,CNKI,EPODOC,WPI: battery, liquid, water, salt, absorb, cloth, cotton, sponge, carbon, layer, sheet, plate, anode, cathode

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 109103487 A (ECO INNOTECH LIMITED) 28 December 2018 (2018-12-28) description, paragraphs [0005]-[0017], [0024]-[0031] and figures 1-4	1-31
PX	CN 208548407 U (ECO INNOTECH LIMITED) 26 February 2019 (2019-02-26) description, paragraphs [0005]-[0017], [0024]-[0031] and figures 1-4	1-31
PX	JP 3220136 U (ECO INNOTECH LIMITED) 14 February 2019 (2019-02-14) description, paragraphs [0005]-[0013], [0015]-[0021] and figures 1-4	1-31
X	CN 103618096 A (NIIYAMA, K.) 05 March 2014 (2014-03-05) description, paragraphs [0012], [0050]-[0107] and figures 1, 2(A)-2(F), 21-32	1-31
X	JP 2012124142 A (MISHIMA DENSHI CO., LTD.) 28 June 2012 (2012-06-28) description, paragraphs [0026]-[0069] and figures 1, 2(A)-2(F), 5-7, 24-28	1-31
X	CN 103682385 A (ECO BATTERY TECHNOLOGY LTD.) 26 March 2014 (2014-03-26) description, paragraphs [0012], [0050]-[0106] and figures 1, 2(A)-2(F), 21-32	1-31
A	US 2016056477 A1 (MISHIMA DENSHI CO., LTD.) 25 February 2016 (2016-02-25) the whole document	1-31

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09 October 2019	**29 October 2019**

Name and mailing address of the ISA/CN

National Intellectual Property Administration, PRC
6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088
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Facsimile No. **(86-10)62019451**

Authorized officer

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Telephone No. **86-(10)-53961241**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2019/100081

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