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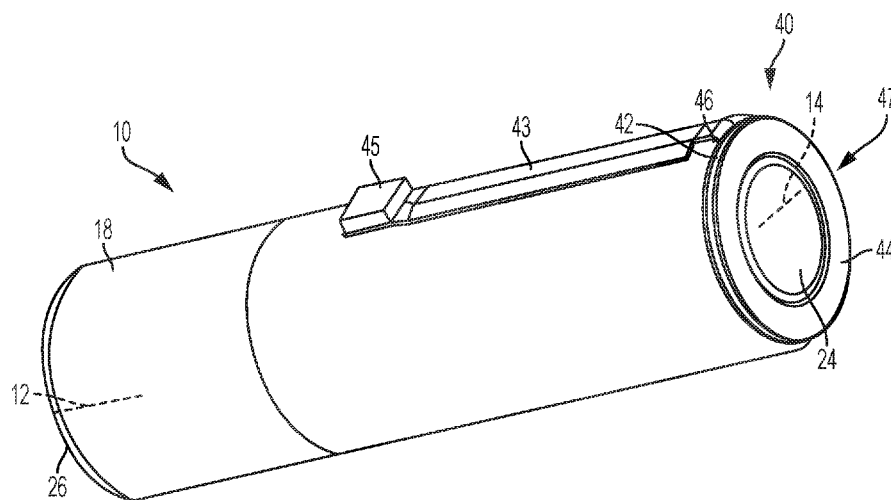


FIG. 1

(57) Abstract: A reusable battery indicator includes a voltage sensor, a communication circuit communicatively connected to the voltage sensor, an antenna operatively coupled to the communication circuit, and a connection mechanism having a connector and a retainer. The connector and the retainer are electrically connected to the voltage sensor, and the connector is adapted to be removably connected to a first battery terminal, thereby providing an electrical connection between the voltage sensor and the first battery terminal. The retainer is adapted to removably secure the voltage sensor to a can of a battery, thereby providing an electrical connection between the voltage sensor and the can of the battery. An electrical circuit is completed between the voltage sensor and the first battery terminal and between the voltage sensor and the can. The connection mechanism includes part of an electrical lock and key assembly.

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REUSABLE BATTERY INDICATOR WITH ELECTRICAL LOCK AND KEY

FIELD OF THE INVENTION

[0001] The disclosure relates generally to battery indicators and, more specifically, relates to a reusable battery characteristic indicator with an electrical lock and key.

BACKGROUND OF THE INVENTION

[0002] Electrochemical cells, or batteries, are commonly used as electrical energy sources. A battery contains a negative electrode, typically called the anode, and a positive electrode, typically called the cathode. The anode contains an electrochemically active anode material that can be oxidized. The cathode contains an electrochemically active cathode material that can be reduced. The electrochemically active anode material is capable of reducing the electrochemically active cathode material. A separator is disposed between the anode and the cathode. The battery components are disposed in a can, or housing, that is typically made from metal.

[0003] When a battery is used as an electrical energy source in an electronic device, electrical contact is made to the anode and the cathode, thereby completing a circuit that allows electrons to flow through the device, and which results in respective oxidation and reduction reactions that produce electrical power to the electronic device. An electrolyte is in contact with the anode, the cathode, and the separator. The electrolyte contains ions that flow through the separator between the anode and cathode to maintain charge balance throughout the battery during discharge.

[0004] There is a growing need for portable power for electronic devices such as toys; remote controls; audio devices; flashlights; digital cameras and peripheral photography equipment; electronic games; toothbrushes; radios; clocks, and other portable electronic devices. Consumers need to have power readily available for these electronic devices. Because batteries necessarily become depleted of power over time as they are used, consumers need to have access to spare batteries (and/or access to fully recharged rechargeable batteries). It is helpful for a consumer to know the power state of a battery currently in use so that the consumer can have quick access to the needed number of replacement batteries. Batteries come in common sizes, such as the AA, AAA, AAAA, C, and D battery sizes, that have fixed external dimensions and constrained internal volumes per ANSI standard.

[0005] Currently, some batteries include on-cell battery charge indicators to help a consumer determine when a battery is nearly depleted and in need of replacement. However, these current on-cell battery charge indicators are single use (i.e., attached to a single battery cell) and cumbersome (because typically two contact buttons must be simultaneously depressed to activate the indicator). Additionally, these on-cell battery indicators require removal of the battery from an electronic device (or package) in order to use the indicator.

SUMMARY OF THE INVENTION

[0006] According to some aspects, the present invention provides a reusable battery indicator system for indicating a characteristic of a battery, the reusable battery indicator system comprising: a battery comprising a first battery terminal, a second battery terminal and a label; and a battery indicator, the battery indicator comprising; a voltage sensor configured to convert sensed analog characteristics of the battery to digital information; a communication circuit communicatively connected to the voltage sensor; an antenna operatively coupled to the communication circuit; and a connection mechanism having a connector and a retainer, the connector being electrically connected to the voltage sensor, the connector being adapted to be removably and electrically connected to the first battery terminal, thereby providing an electrical connection between the voltage sensor and the first battery terminal when the connector is connected to the first battery terminal, and the retainer being adapted to be removably and electrically connected to a can of the battery, thereby providing an electrical connection between the voltage sensor and the can of the battery; wherein the connection mechanism includes an electrical key, and the electrical key comprises one of a split matching antenna network, an optical sensor, or a capacitive coupling connection, and the battery label comprises an electrical lock, and the electrical key interacts with the electrical lock to allow the indicator to function.

[0007] *[Intentionally left blank].*

[0008] In accordance with the teachings of the disclosure, any one or more of the foregoing aspects of a reusable battery indicator or a remote battery indication system may further include any one or more of the following optional forms.

[0009] In some optional forms, the connector is connected to a negative electrode of a battery and the retainer is connected to a positive electrode of the battery.

[0010] In other optional forms, the connector is one of a formed spring, a Kelvin connection, including separate power and sensing terminals to measure impedance, a split wire, a leaf spring, and combinations thereof.

[0011] In yet other optional forms, a voltage booster is electrically connected to or incorporated in the voltage sensor.

[0012] In yet other optional forms, the connector comprises at least one metal and at least one insulator.

[0013] In yet other optional forms, the communication circuit comprises at least one of radio-frequency identification circuitry, Bluetooth circuitry, Bluetooth low energy circuitry, Wi-Fi circuitry, Zigbee circuitry, LORA circuitry, and Z-wave circuitry.

[0014] In yet other optional forms, the voltage sensor is capable of reading an open circuit voltage of less than 1.8 Volts.

[0015] In yet other optional forms, the voltage sensor, and the communication circuit are formed on a printed circuit board that is adapted to be inserted between a the connector and the retainer.

[0016] In yet other optional forms, the voltage sensor, and the communication circuit are mounted within a housing, the housing being sized and shaped to fit between two cylindrical batteries that are arranged side-by-side.

[0017] In yet other optional forms, the housing has a cross-section that is in the shape of a triangular prism.

[0018] In yet other optional forms, the housing has one side that is concave or two sides that are concave.

[0019] In yet other optional forms, the housing has a volume of between about 102 mm³ and about 165 mm³.

[0020] In yet other optional forms, the voltage sensor is disc-shaped to and arranged to fit one end of a cylindrical battery cell.

[0021] In yet other optional forms, the voltage sensor is a thin disc BLE, UHF, or RF module.

[0022] In other optional forms, a computing device is communicatively connected to the communication circuit, and the computing device receives information from the communication circuit through the antenna.

[0023] In yet other optional forms, the computing device includes a processor and a memory, the memory storing a software routine that causes the processor to detect a wireless communication signal from the reusable battery indicator, to remotely control battery circuitry through the reusable battery indicator to determine battery characteristic data; and to send the battery characteristic data to a user interface.

[0024] In yet other optional forms, the battery characteristic data comprises at least one of an electrical capacity; a voltage; an impedance, a temperature, a current; an age, a charge/discharge cycle count, and a coulomb count.

[0025] In yet other optional forms, the software routine, when executed by the processor, causes the processor to determine at least one of a battery type, a physical location of the battery, and an electrical device that the battery is powering.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter, which is regarded as forming the present invention, the invention will be better understood from the following description taken in conjunction with the accompanying drawings.

[0027] FIG. 1 is a perspective view of a reusable battery indicator constructed in accordance with the teachings of the disclosure, the reusable battery indicator being connected to a battery cell.

[0028] FIG. 2 is a bottom perspective view of the reusable battery indicator of FIG. 1.

[0029] FIG. 3 is side cross-sectional view of the reusable battery indicator and battery cell of FIG. 1.

[0030] FIG. 4 is an electronic circuit schematic diagram of the reusable battery indicator of FIG.1.

[0031] FIG. 5 is a top plan view of a printed circuit board of the reusable battery indicator of FIG. 1.

[0032] FIG. 6 is an end elevational view of a second embodiment of a reusable battery indicator constructed in accordance with the teachings of the disclosure.

[0033] FIG. 7 is an end elevational view of a third embodiment of a reusable battery indicator constructed in accordance with the teachings of the disclosure.

[0034] FIG. 8 is a bottom perspective view of a battery compartment of an electronic device including two battery cells and a fourth embodiment of a reusable battery indicator that is connected to one of the battery cells.

[0035] FIG. 9 is a is a schematic diagram of a battery indication system including the reusable battery indicator of FIG. 1

[0036] FIGS. 10A and 10B are top and bottom perspective views of a fifth embodiment of a reusable battery indicator and a battery cell.

[0037] FIGS. 11A and 11B are top and bottom perspective views of a sixth embodiment of a reusable battery indicator and a battery cell.

[0038] FIGS. 12A and 12B are top and bottom perspective views of a seventh embodiment of a reusable battery indicator and a battery cell.

[0039] FIGS. 13a and 13B are top and bottom perspective views of a eighth embodiment of a reusable battery indicator and a battery cell.

DETAILED DESCRIPTION OF THE INVENTION

[0040] Electrochemical cells, or batteries, may be primary or secondary. Primary batteries are meant to be discharged, *e.g.*, to exhaustion, only once and then discarded. Primary batteries (or disposable batteries) are described, for example, in David Linden, *Handbook of Batteries* (4th ed. 2011). Secondary batteries (or rechargeable batteries) are intended to be recharged and used over and over again. Secondary batteries may be discharged and recharged many times, *e.g.*, more than fifty times, a hundred times, or more. Secondary batteries are described, for example, in David Linden, *Handbook of Batteries* (4th ed. 2011). Accordingly, batteries may include various electrochemical couples and electrolyte combinations. Although the description and examples

provided herein are generally directed towards primary alkaline electrochemical cells, or batteries, it should be appreciated that the invention applies to both primary and secondary batteries of aqueous, nonaqueous, ionic liquid, and solid state systems. Primary and secondary batteries of the aforementioned systems are thus within the scope of this application and the invention is not limited to any particular embodiment.

[0041] Referring to FIG. 1 a primary alkaline electrochemical cell, or battery cell 10, is illustrated that includes a cathode 12, an anode 14, and a housing 18. The battery cell 10 also includes an end cap 24. The end cap 24 serves as a negative terminal of the battery cell 10. A positive pip 26 is located at the opposite end of the battery cell 10 from the end cap 24. The positive pip 26 serves as a positive terminal of the battery cell 10. An electrolytic solution is dispersed throughout the battery cell 10. The battery cell 10 can be, for example, a AA, AAA, AAAA, C, or D alkaline battery. Additionally, in other embodiments, the battery cell 10 can be a 9V battery, a camera battery, a watch battery, or any other type of primary or secondary battery.

[0042] The housing 18 can be made of any suitable type of housing base material, for example cold-rolled steel or nickel-plated cold-rolled steel. In the embodiment illustrated in FIG. 1, the housing 18 may have a cylindrical shape. In other embodiments, the housing 18 may have any other suitable, non-cylindrical shape. The housing 18, for example, may have a shape comprising at least two parallel plates, such as a rectangular, square, or prismatic shape. The housing 18 may be, for example, deep-drawn from a sheet of the base material, such as cold-rolled steel or nickel-plated steel. The housing 18 may be, for example, drawn into a cylindrical shape. The housing 18 may have a sidewall. The interior surface of the sidewall of the housing 18 may be treated with a material that provides a low electrical-contact resistance between the interior surface of the sidewall of the housing 18 and an electrode, such as the cathode 12. The interior surface of the sidewall of the housing 18 may be plated, *e.g.*, with nickel, cobalt, and/or painted with a carbon-loaded paint to decrease contact resistance between, for example, the internal surface of the sidewall of the housing 18 and the cathode 12.

[0043] Attached to the battery cell 10 is one embodiment of communication mechanism, such as a reusable battery indicator 40. The reusable battery indicator 40 attaches to one end of the housing 18, in the embodiment illustrated in FIG. 1, to the negative or end cap 24 end of the housing 18. The reusable battery indicator 40 includes an integrated circuit, which may be incorporated into a printed circuit board (PCB) 42 (in one embodiment, the PCB is a multi-layered insulator/conductive structure that can be a rigid epoxy, FR4 phenolic with bonded

copper traces, or a flexible polyester, polyamide with bonded copper traces), which is sandwiched between a first connector 44 that is electrically connected to the PCB 42, and a retainer 46 that is electrically connected to the PCB 42. The first connector 44 and the retainer 46 form part of an electrical lock and key mechanism 39, which will be further described below.

[0044] The PCB 42 may have a generally annular shape, as illustrated in FIG. 1, and the PCB 42 may extend into a flexible PCB 43, which extends along an outer surface of the housing 18, generally away from the first connector 44 and from the retainer 46. At one end of the flexible PCB 43, additional electrical components may be located, such as a chip antenna 45, an IC, an IC with integral antenna, or passive components. Placing some electrical components, such as the antenna 45, at one end of the flexible PCB 43 may provide a more advantageous location for certain electrical components. For example, locating the antenna 45 at one end of the flexible PCB 43 may provide better transmission characteristics than locating the antenna closer to the first connector 44 and to the retainer 46. The antenna 45 may also be formed as an integral part of the flexible PCB 43 or of the rigid PCB 42 as part of the copper trace layer.

[0045] The first connector 44 may be removably and electrically connected to the end cap 24 to form a negative electrical connection and the retainer 46 may be removably and electrically connected to the housing 18, which generally has a positive electrical charge, to form a positive electrical connection. The first connector 44 and the retainer 46 may take virtually any physical form that allows the first connector 44 and the retainer 46 to form electrical connections with the battery cell 10 and the PCB 42 and that does not impede normal device terminal access. The first connector 44 and the retainer 46 may be formed from virtually any material that transmits analog information, such as electrical information, from the battery cell to the PCB 42. For example, in some embodiments, the first connector 44 and retainer 46 may be formed from one or more of the following materials, a metal, a metal alloy, cold-rolled steel, hard drawn ferrous and non-ferrous alloys, high and low carbon steel alloys, post or pre-plated ferrous and non-ferrous alloys, or any combination thereof. In some embodiments, at least one of the first connector 44 and the retainer 46 may comprise a metal and an insulator. In some embodiments, an insulator may be a non-conductive coating (such as a polymer layer, epoxy, or passivate) that is applied to the connector/retainer or an additional insulator ring (such as paper, phenolic, or polymer).

[0046] Generally, the integrated circuit receives electrical information, such as amperes or volts from the first connector 44 and from the retainer 46, and the electrical information is used

by the integrated circuit to calculate battery characteristic information, such as power or charge level, and the integrated circuit then transmits the battery characteristic information to a receiver, such as a computer, a smart phone, or a personal digital assistant, for use by the consumer. In this way, the reusable battery indicator 40 allows a consumer to acquire the battery characteristic information without removing the battery cell from an electronic device (or from a package). The first connector 44 and the retainer 46 deliver the electrical information to the integrated circuit without interfering with electrical contacts between the battery cell and the electronic device. Furthermore, the reusable battery indicator 40 is movable from one battery cell to another battery cell so as to be reused over and over again, thereby reducing the overall cost to a consumer.

[0047] Referring to FIG. 2, the reusable battery indicator 40 is illustrated in more detail. The first connector 44 is annularly shaped and located on an opposite side of the PCB 42 from the retainer 46, which is also annularly shaped. The first connector 44 includes a central opening 47, which is sized and shaped to surround a raised central portion of the end cap 24. Similarly, the retainer 46 includes a central opening 49 that is sized and shaped to surround the raised central portion of the end cap 24. Thus, the first connector 44, the PCB 42, and the retainer 46 form a ring-shaped (or annularly-shaped) sandwich structure that is sized to fit on one end (the negative end) of the battery cell 10.

[0048] The first connector 44 includes a plurality of connector tabs 51. The connector tabs 51 extend away from the first connector 44 and towards the retainer 46. The connector tabs 51 are spaced radially inward (towards a center of the central opening 47) from the retainer 46. More specifically, the connector tabs 51 are separated from the retainer 46 by the PCB 42. The connector tabs 51 are arranged to contact the end cap 24 of the battery cell 10, as will be further explained below. Additionally, the connector tabs 51 include crimped ends 53, which facilitate a removable connection with the end cap 24.

[0049] The retainer 46 includes a plurality of retainer tabs 55. The retainer tabs 55 extend away from the first connector 44. The retainer tabs 55 are spaced radially outward (away from a center of the central opening 49). More specifically, the retainer tabs 55 are separated from the first connector 44 by the PCB 42. The retainer tabs 55 are arranged to contact the can or housing 18 of the battery cell 10, as will be further explained below. Additionally, the retainer tabs 55 include crimped ends 57, which facilitate a removable connection with the housing 18.

[0050] Referring now to FIG 3, the PCB 42 is radially thicker than the retainer 46. As a result, the retainer tabs 55 are located radially outward of the connector tabs 51. The retainer tabs 55 extend into a can void 59 that is formed between a crimped wall 61 of the housing 18 and the end cap 24. As the battery indicator 40 is pressed onto the end cap 24, the crimped ends 57 of the retainer tabs 55 are pushed radially inward until the crimped ends 57 pass over an end of the crimped wall 61 of the housing 18, at which point, the crimped ends 57 expand radially outward to removably lock the retainer 46 in place on the end of the housing 18 and to provide a positive electrical connection (because the housing carries a positive charge).

[0051] Similarly, the connector tabs 51 extend into the can void 59, but the connector tabs 51 are located against the end cap 24. As the battery indicator 40 is pressed onto the end cap, the connector tabs 51 are pushed radially outward, which maintains physical contact between the connector tabs 51 and the end cap to provide a negative electrical connection (because the end cap carries a negative charge). As a result, the PCB 42 receives electrical information (e.g., volts and amperes) through the connector tabs 51 and through the retainer tabs 55.

[0052] The electrical lock and key mechanism 39 comprises the first connector 44, the retainer 46, the crimped wall 61, the end cap 24, and the can void 59. Essentially, the can void 59, which is formed by the space between the crimped wall 61 and the end cap 24, forms an electrical lock assembly 70. The can void 59 is arranged so that connection to the positive terminal of the battery cell 10 is available on one side (the radially outward side in FIG. 3) and connection to the negative terminal of the battery cell 10 is available on the other side (the radially inward side in FIG. 3). In other embodiments, the positive and negative connections may be reversed.

[0053] An electrical key 80 comprises the connector tabs 51 and the retainer tabs 55 and the PCB 42 may be electrically connected in series between the connector tabs 51 and the retainer tabs 55. Electrical connections can only be established if the electrical key 80 is formed to correctly contact the electrical lock 70 when the battery indicator 40 is connected to one end of the battery cell 10. Without the radial spacing of the connector tabs 51 and the retainer tabs 55, the battery indicator 40 would not establish the correct electrical connections and the battery indicator 40 would not receive power, and/or the battery indicator 40 would not receive the battery characteristic information that is used by the integrated circuit. For example, the connector tabs 51 and the retainer tabs 55 may not come into contact with one another or create a condition where a substantially low electrical impedance exists between the connector tabs 51 and the retainer tabs 55. Furthermore, any intended rotation or motion of the connector tabs 51

and retainer tabs 55 with respect to one another may not cause such contact or low electrical impedance.

[0054] In other embodiments, an electrical lock circuit could be formed in the crimped wall 61 in a manner in which contact by the retainer tabs 55 completes the electrical lock circuit and the integrated circuit would allow the battery characteristic analysis to continue only if the electrical lock circuit was completed. Such an electrical lock circuit would supplement the electrical lock and key mechanism 39 described above.

[0055] Turning now to FIGS. 4 and 5, formed on the PCB 42 is an integrated circuit 48, that includes an embedded voltage sensor 50 within the integrated circuit 48 that is communicatively connected to the first connector 44 and to the retainer 46. The embedded voltage sensor 50 senses analog characteristics of the battery cell, such as amperes and voltage, and converts the sensed analog characteristics to digital information. The PCB 42 also includes a communication circuit 52. An antenna 54 is operatively coupled to the communication circuit 52. The communication circuit 52 may comprise one or more of a radio-frequency identification circuit, a Bluetooth® circuit, a Bluetooth® low energy circuit, a Wi-Fi circuit, a Zigbee® circuit, a LORA circuit, and a Z-wave circuit. In one embodiment, an integrated circuit, such as a wireless Bluetooth Low-Energy voltage sensor, may incorporate the analog to digital converter, a microcontroller, a Bluetooth radio, a memory device, and a DC/DC voltage converter.

[0056] A voltage booster 56 is electrically connected to the integrated circuit 48 and the embedded voltage sensor 50. The embedded voltage sensor 50 and the voltage booster 56 are capable of reading the open circuit voltage of the battery that may be, for example, less than 1.8 volts. In some embodiments, the communication circuit 52 may comprise one or more of a thin disc BLE module, a UHF module, or a RF module.

[0057] In the embodiment illustrated in FIGS. 4 and 5, the integrated circuit 48, the voltage sensor 50, and the communication circuit 52 are all formed on the PCB 42, which is connected to the first connector 44 and to the retainer 46. However, in other embodiments, the integrated circuit 48, the voltage sensor 50, and the communication circuit 52 may be formed as separate components that are communicatively and operatively connected to one another.

[0058] In the embodiment illustrated in FIG. 6, similar elements are numbered exactly 100 greater than elements numbered in FIGS. 1-5. For example, the battery cell is numbered 10 in FIGS. 1-4 and the battery cell is numbered 110 in FIG. 6. Unless stated otherwise, any element from any illustrated embodiment may be incorporated into any other illustrated embodiment.

[0059] Turning now to FIG. 6, a second embodiment of the reusable battery indicator 140 is attached to a battery cell 110. The reusable battery indicator 140 is illustrated and located between two battery cells 110. In the embodiment of FIG. 6, the reusable battery indicator 140 includes a housing 198 that has only a single concave side able to fit into and up to the entire triangular prism void area delineated by the one or more batteries and the battery receptacle.

[0060] FIG. 7 illustrates an alternative housing shape area for which the reusable battery indicator can fit into. In this embodiment, the housing 298 is arranged to fit in the void formed by two cylindrical battery cells 210 that are arranged side by side and oriented such that the respective longitudinal axes of the battery cells 210 are parallel to one another. In the embodiment illustrated in FIG. 7, the housing 298 has a cross-sectional shape that is defined by the following equation:

$$A_v = (D_B^2 - \Pi/4 \times D_B^2)/2, \text{ where}$$

A_v is the cross-sectional area of the housing 298; and

D_B is a diameter of one battery cell 210.

[0061] A housing having a cross-sectional shape defined by the preceding equation maximizes the usable space between the battery cells. For example, a housing having the cross-sectional shape defined above would result in the following housing volumes for the given battery sizes (assuming that the housing length was equal to the battery cell length). For a AAA battery, the housing would have a volume of 526 mm³; and for a AA battery, the housing would have a volume of 1140 mm³. In other embodiments, the housing may have a cross-sectional shape that fits within the shape A_v , or that fits within a shape equal to $A_v/2$ in the case of a single battery cavity. For example, the housing may have a cross-sectional shape that is one of rectangular, trapezoidal, elliptical, semi-circular, and variable prism that fits within one of the above described voids.

[0062] Turning now to FIG. 8, yet another alternative embodiment of a reusable battery indicator 340 is illustrated. In the embodiment of FIG. 8, the reusable battery indicator includes a housing 398, the integrated circuit, the voltage sensor, and the communication circuit being mounted within the housing 398. In the embodiment of FIG. 8, the housing 398 is sized and shaped to fit between two cylindrical battery cells 310 that are arranged longitudinally side-by-side. In the embodiment illustrated in FIG. 8, the housing 398 has a cross-section that is in the shape of a triangular prism. More specifically, the housing 398 has a first side 397 that is concave and a second side 399 that is concave. In the embodiment of FIG. 8, the reusable battery

indicator 340 is mounted between the battery cells 310 and within a battery receptacle 395 of an electronic device 400.

[0063] Turning now to FIG. 9, a computing device 800 is communicatively connected to the communication circuit in the reusable battery indicator 740. The computing device receives information from the communication circuit through wireless signals sent by the antenna in the reusable battery indicator 740. For example, the wireless signal may be one or more of a wifi signal, a Bluetooth® signal, a RFID signal, or any other wireless signal. In other embodiments, the computing device 800 and the reusable battery indicator 740 may communicatively connected by a wired connection.

[0064] The computing device 800 includes a processor 802 and a memory 804. The memory 804 may store processor executable instructions that, when executed by the processor 802, cause the processor 802 to detect a wireless communication signal from the reusable battery indicator 740. In some embodiments the memory 804 may comprise a non-transitory computer readable medium with the processor executable instructions embedded thereon as an article of manufacture. The processor executable instructions may also cause the processor 802 to send wireless signals back to the reusable battery indicator 740 to remotely control battery circuitry through the reusable battery indicator 740. In this manner, the processor 802 may cause the reusable battery indicator 740 to determine battery characteristic data; and to send the battery characteristic data to a user interface, such as a display 806 on the computing device 800.

[0065] In some embodiments, the battery characteristic data may comprise at least one of an electrical capacity; a voltage; an impedance, a temperature, a current; an age, a charge/discharge cycle count, and a coulomb count.

[0066] In other embodiments, the processor executable instructions, when executed by the processor 802, causes the processor 802 to determine at least one of a battery type, a physical location of the battery, and an electrical device that the battery is powering by communicating with the reusable battery indicator 740.

[0067] Turning now to FIGS. 10A and 10B, yet another embodiment of a reusable battery indicator 540 is illustrated. The reusable battery indicator 540 is attached to a battery cell 510. The reusable battery indicator 540 includes a PCB 542, a first connector 544, and a second connector 546. While the battery cell 510 in FIGS. 10A and 10B is illustrated as a AA size battery, the illustration is not intended to limit the reusable battery indicator 540 to the illustrated

battery cell 510. Rather, the reusable battery indicator 540 may be sized and shaped to fit virtually any battery cell, especially those battery cell sizes listed elsewhere in the specification.

[0068] In the embodiment illustrated in FIGS. 10A and 10B, the first connector 544 and the second connector 546 comprise flexible wires. The flexible wires may be formed as spring wires (from hard drawn ferrous and non-ferrous spring alloys) that capture the positive battery terminal and the negative battery terminal to transmit electrical characteristics, such as voltage and amperes, to the integrated circuit formed on the PCB 542. In one embodiment, the spring wires may be formed of ASTM A228 music wire with re or post nickel plating to enhance conductivity, to reduce contact resistance, and to provide corrosion resistance.

[0069] In the embodiment illustrated in FIGS. 10A and 10B, the flexible wires include a first end, which is connected to a positive terminal on the PCB 542 and a second end, which is also connected to the positive terminal on the PCB 542. Other embodiments may include single ended wires. The flexible wires are oriented substantially parallel to a longitudinal axis of the battery cell 510. The flexible wires form end loops 576, 588, which lie in a plane that is substantially perpendicular to the longitudinal axis of the battery cell 510. The end loop 576 is sized and shaped to fit around the positive terminal of the battery cell 510 and the end loop 588 is sized and shaped to fit around the negative terminal. As a result, the flexible wire forms a positive electrical pathway from the positive battery terminal to the positive terminal on the PCB 542 and from the negative battery terminal to the negative terminal on the PCB 542. Moreover, the flexible wires may be formed to produce a spring force that biases the flexible wires into the attached position illustrated in FIG. 10A, while allowing the flexible wires to be temporarily deformed by a user to remove the reusable battery indicator 540 from the battery cell 510 when desired, as illustrated in FIG. 10B.

[0070] In some embodiments, one or more of the flexible wires may include a conductive magnet, or the one or more of the flexible wires may be formed from conductive magnetic material, to provide additional retention force between the first flexible wires and the battery terminals.

[0071] In other embodiments, one or more of the flexible wires may be formed as a Kelvin connection, including separate power and sensing terminals, to measure impedance. Additionally, in alternate embodiments, the flexible wires need not be formed as a single continuous wire, but may be formed as multiple wire pieces, for example, two wire pieces that are separated by a small distance in the end loop.

[0072] In the embodiment of FIGS. 10A and 10B, an electronic lock and key mechanism 539 includes a split matching antenna network as part of a wireless module antenna 501. A first electronic lock, which is formed as a printed electronic component on the battery label, includes a carbon film resistor or capacitor 503 that tunes or de-tunes the wireless module antenna 501. In other words, the wireless module antenna 501 requires the presence of the capacitor 503 (and thus the battery 510) for completion and tuning of the antenna circuit. A split capacitor may be created using a conductive plate 505 on the underside of the wireless module antenna 501 and a conductive plate 507 on the backside of the battery label film (facing the cell can) with the PVC battery label acting as a dielectric between the two capacitor plates. Split capacitors may also be used as a passive component which is part of the electronic module enable circuitry.

[0073] Turning now to FIGS. 11A and 11B, yet another embodiment of a reusable battery indicator 640 is illustrated. In the embodiment of FIGS. 11A and 11B, an electronic lock and key assembly 639 is formed by a Hall-effect sensor and circuit 605 on the electronic module and a printed magnetic strip 607, array, or symbol on the battery 610 label. Installation of the electronic module onto the battery creates a coupled magnetic sensor system. Rotation or translation of the electronic module (relative to the battery) results in a magnetic field pulse generated in the hall-effect sensor. Signal conditioning circuitry on the electronic module generates an enable pulse to the electronic module radio thereby enabling functionality.

[0074] Turning now to FIGS. 12A and 12B, yet another embodiment of a reusable battery indicator 740 is illustrated. The reusable battery indicator 740 includes an electronic lock and key assembly 739. The electronic lock and key assembly 739 includes a lock, such as an optical ID reflective pattern 707, text, or, symbol on the battery 710 label and an optical transmitter/sensor 705 on the electronic module. Installation of the electronic module onto the optical ID reflective pattern 707 creates a coupled system. Presence, rotation or translation of the electronic module (relative to the battery) results in a varied optical signal relative to sensing reflective changes of the label pattern. Use of a luminous (e.g., fluorescent) coating on the label may create a response sensor to enable electronic module functionality. In other embodiments, a light generator/sensor on the electronic module may activate the fluorescent coating with a led flash during initial power-up and may sense residual photon activity which activates electronic module operation. Alternately, use of a printed carbon/iron matrix pattern in conjunction with a magnetic field generator to sense eddy currents related to a particular pattern may enable electronic module functionality. Optional use of a reflective opto-isolator at a set reflective angle in conjunction with a curved reflective element on battery surface may also enable electronic

module functionality. In some embodiments, a Fresnel lens (flip/flop) or a louvered mask may isolate reflected light (visible, UV, IR) to a particular vector matched to the receiver vector.

[0075] Turning now to FIGS. 13A and 13B, yet another embodiment of a reusable battery indicator 840 is illustrated. The reusable battery indicator 840 includes an electronic lock and key assembly 839. The electronic lock and key assembly 839 includes a capacitive coupling connection having a label capacitive connector 807, which may be a foil pad with label micro piercings, and the electronic module has companion foil pad 805 with a deformable conductive polymer. When the foil pad 805 contacts the label capacitive connector 807, electronic functionality is enabled. In the embodiment of FIGS. 13A and 13B, the label capacity connector 807 is in the form of a conductive strip or ring on the product label, which creates an electrical coupling when the electronic module is installed on the battery 810. The conductive label strip may be formed by an adhesive metal that is foil applied to the battery label or is printed directly on the battery label with a conductive ink (e.g., carbon/graphite or metal loaded ink). The conductive label strip provides resistive, capacitive, or inductive characteristics provided by metal alloy characteristics or metal loading of the conductive ink. An electronic module measuring or response circuit may be tuned to the electrical characteristics of the conductive strip to provide communication or function only the authorized strip completes the circuit.

[0076] In other yet other embodiments, a reflective aperture may be used to isolate a radio wave to a particular direction and to provide a directional receiver antenna tuned to receive from that particular direction. In yet other embodiments, a user may be required to scan the battery label and to authorize activation of the electronic module with a software application that enables electronic module functionality.

[0077] The dimensions and values disclosed herein are not to be understood as being strictly limited to the exact numerical values recited. Instead, unless otherwise specified, each such dimension is intended to mean both the recited value and a functionally equivalent range surrounding that value. For example, a dimension disclosed as “40 mm” is intended to mean “about 40 mm.”

[0078] Every document cited herein, including any cross referenced or related patent or application and any patent application or patent to which this application claims priority or benefit thereof, is hereby incorporated herein by reference in its entirety unless expressly excluded or otherwise limited. The citation of any document is not an admission that it is prior art with respect to any invention disclosed or claimed herein or that it alone, or in any

combination with any other reference or references, teaches, suggests or discloses any such invention. Further, to the extent that any meaning or definition of a term in this document conflicts with any meaning or definition of the same term in a document incorporated by reference, the meaning or definition assigned to that term in this document shall govern.

[0079] While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

[0080] Finally, throughout the description and claims of this specification, the word “comprise” and variations of the word, such as “comprising” and “comprises”, is not intended to exclude other additives, components, integers or steps.

The claims defining the invention are as follows:

1. A reusable battery indicator system for indicating a characteristic of a battery, the reusable battery indicator system comprising:

a battery comprising a first battery terminal, a second battery terminal and a label; and

a battery indicator, the battery indicator comprising:

a voltage sensor configured to convert sensed analog characteristics of the battery to digital information;

a communication circuit communicatively connected to the voltage sensor;

an antenna operatively coupled to the communication circuit; and

a connection mechanism having a connector and a retainer, the connector being electrically connected to the voltage sensor, the connector being adapted to be removably and electrically connected to the first battery terminal, thereby providing an electrical connection between the voltage sensor and the first battery terminal when the connector is connected to the first battery terminal, and the retainer being adapted to be removably and electrically connected to a can of the battery, thereby providing an electrical connection between the voltage sensor and the can of the battery;

wherein the connection mechanism includes an electrical key, and the electrical key comprises one of a split matching antenna network, an optical sensor, or a capacitive coupling connection, and the battery label comprises an electrical lock, and

the electrical key interacts with the electrical lock to allow the indicator to function.

2. The reusable battery indicator of claim 1, wherein the retainer is electrically connected to a positive battery cathode through the battery can and the connector is electrically connected to a negative battery anode through the first battery terminal.

3. The reusable battery indicator of claim 2, wherein the connector includes a connector tab that extends away from the connector, the connector tab forming an electrical connection with the first battery terminal.

4. The reusable battery indicator of claim 3, further comprising a printed circuit board and wherein the voltage sensor and the communication circuit are formed on the printed circuit board and the connector is an annular platform that is electrically connected to a first side of the printed circuit board.

5. The reusable battery indicator of claim 4, wherein the retainer is electrically connected to a second side of the printed circuit board.

6. The reusable battery indicator of claim 5, wherein the retainer includes a retainer tab that extends away from the connector, the retainer tab being adapted to form an electrical connection with the battery can.

7. The reusable battery indicator of claim 5, further comprising a plurality of connector tabs and plurality of retainer tabs, the plurality of connector tabs being disposed radially outward of the plurality of retainer tabs.

8. The reusable battery indicator of any one of claims 1 to 7, further comprising a housing, the voltage sensor, and the communication circuit being mounted within the housing, the housing being sized and shaped to fit between two cylindrical batteries that are arranged side-by-side.

9. The reusable battery indicator of claim 8, wherein the housing has a cross-section that is in the shape of a triangular prism.

10. The reusable battery indicator of claim 8 or claim 9, wherein the housing has one side that is concave.

11. The reusable battery indicator of claim 8 or claim 9, wherein the housing has two sides that are concave.

12. The reusable battery indicator system of any one of claims 1 to 11, wherein the electrical key comprises the split matching antenna network and the electrical lock comprises one of a carbon film resistor or a capacitor, the carbon film resistor or the capacitor completing and tuning an antenna circuit in the split matching antenna network.

13. The reusable battery indicator system of any one of claims 1 to 11, wherein the electrical key comprises the optical sensor and the electrical lock comprises one of an optical ID reflective pattern, a text, or a symbol, the optical ID reflective pattern, text, or symbol coupling with the optical sensor to enable indicator functionality.

14. The reusable battery indicator system of any one of claims 1 to 11, wherein the electrical key comprises the capacitive coupling connection and the electrical lock comprises a capacitive connector, the capacitive connector contacting the capacitive coupling connection and an electronic module in the reusable battery indicator measuring electrical characteristics of the capacitive connector to provide indicator functionality.

15. An electronic device comprising the reusable battery indicator of any one of claims 1 to 14, wherein the reusable battery indicator is mounted within a battery receptacle of the electronic device.

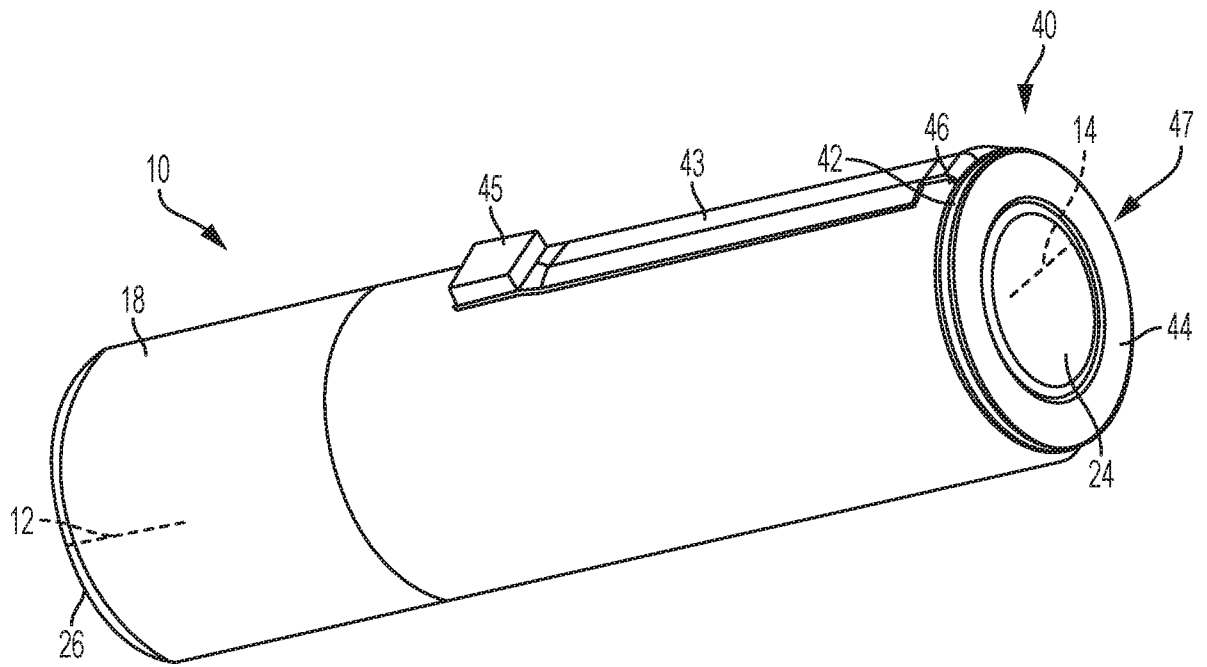


FIG. 1

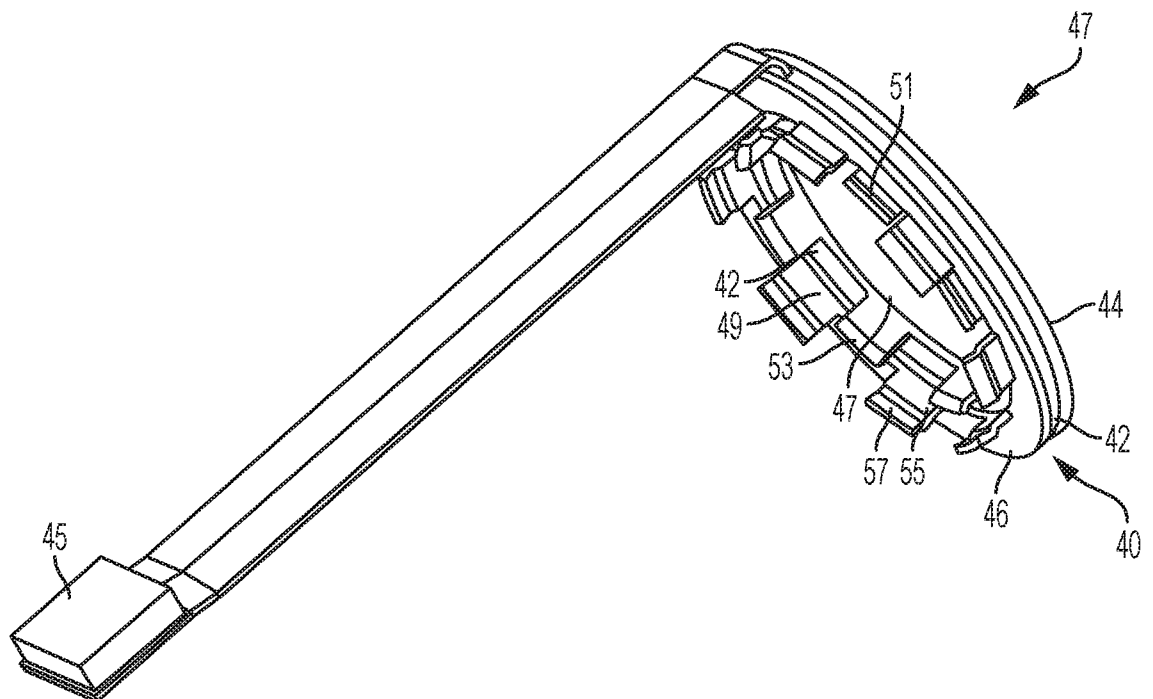


FIG. 2

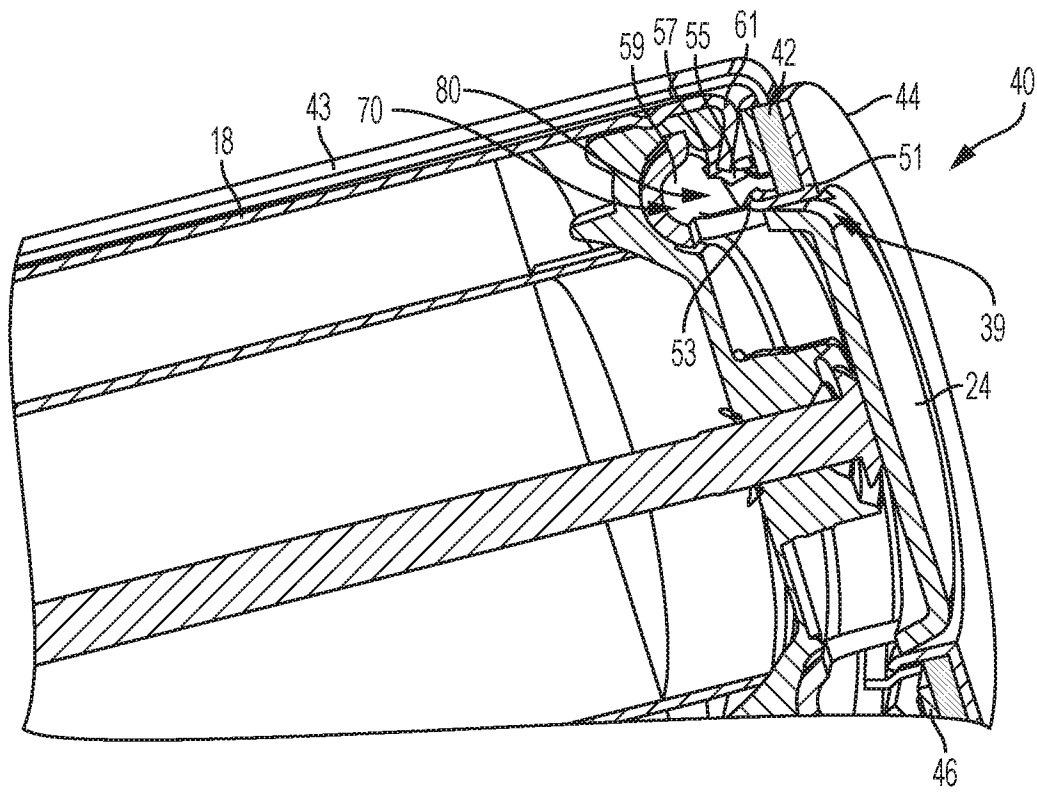


FIG. 3

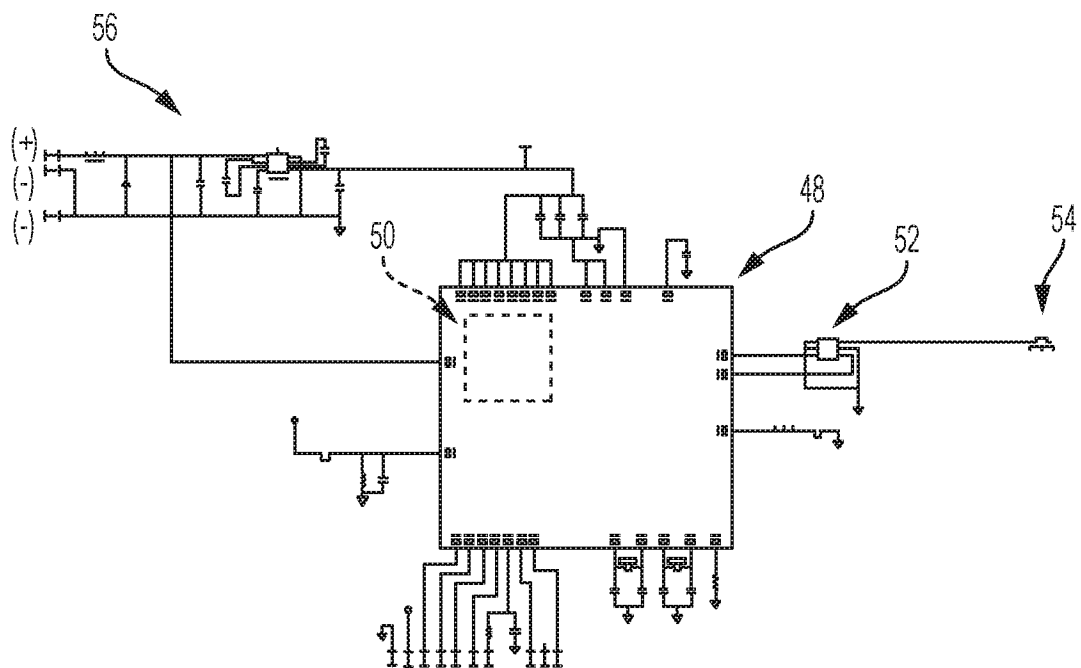


FIG. 4

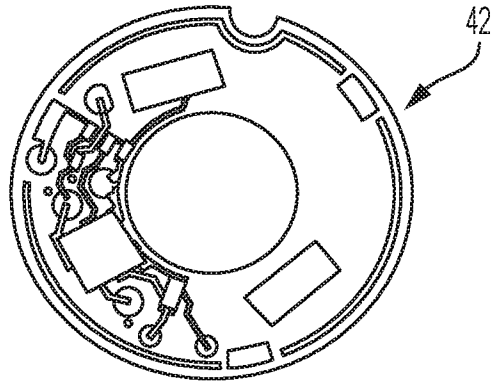


FIG. 5

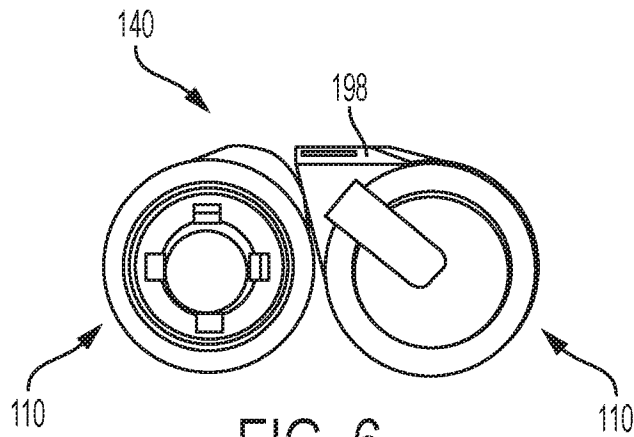


FIG. 6

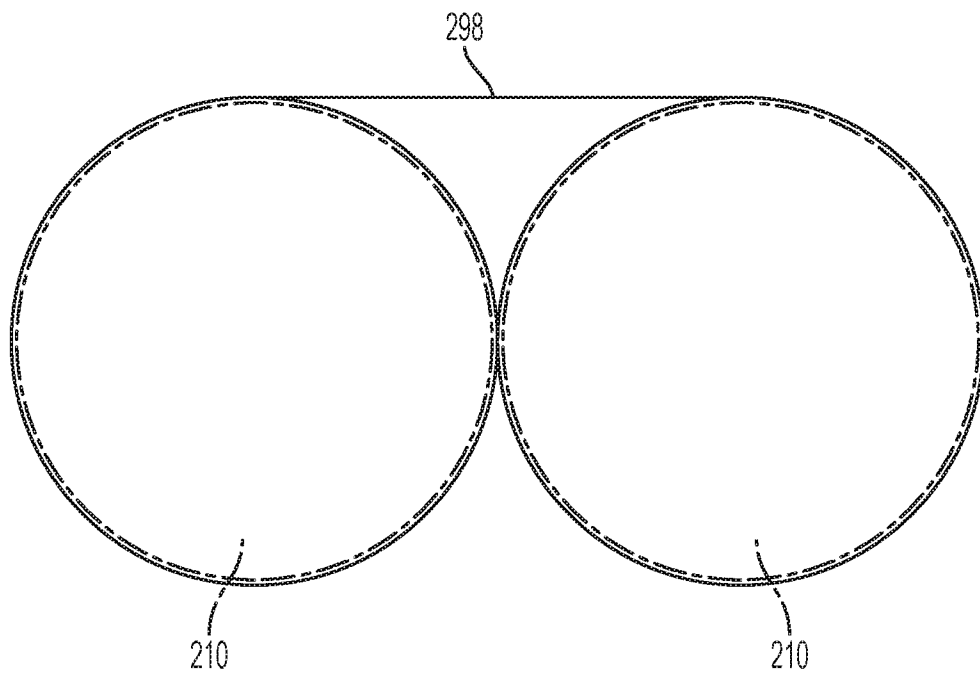


FIG. 7

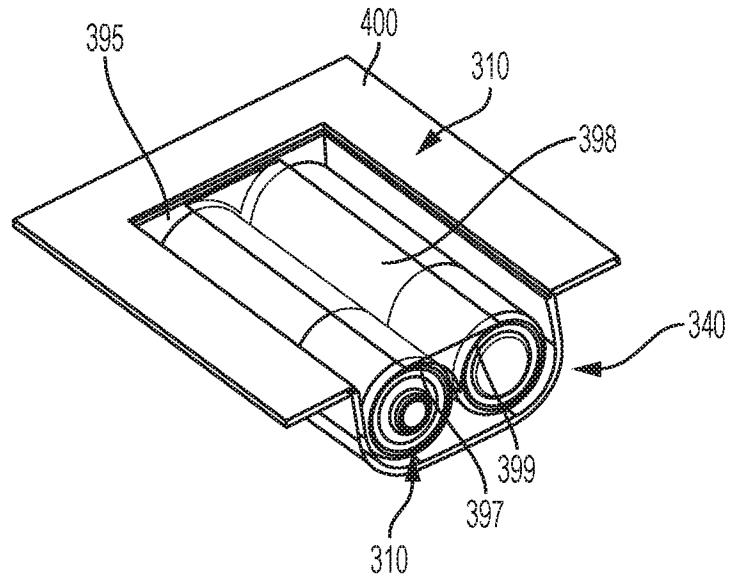


FIG. 8

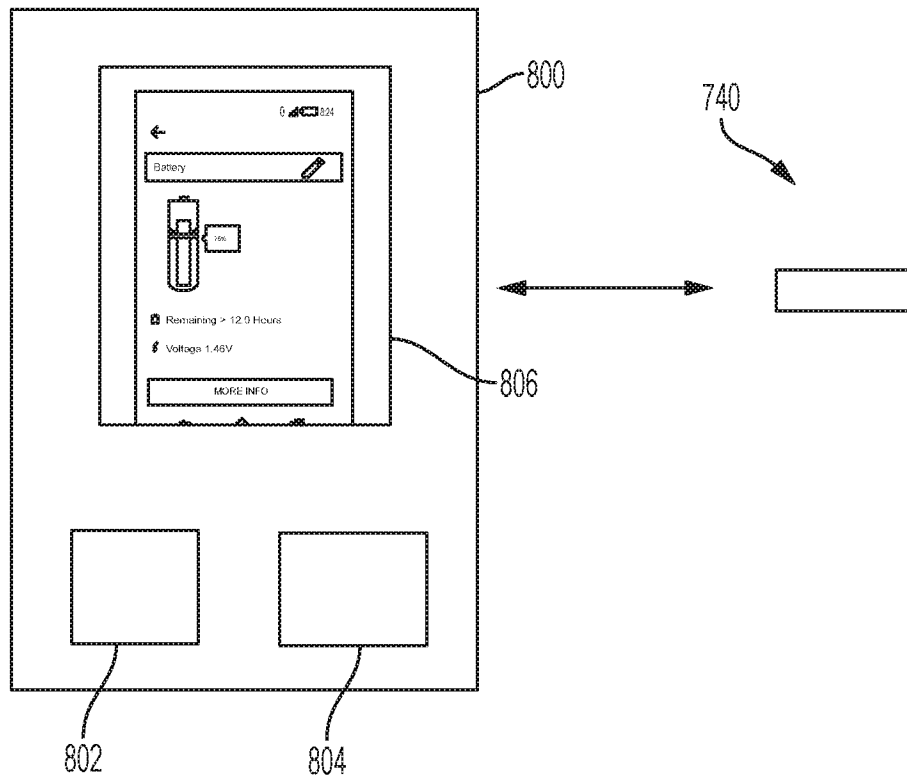


FIG. 9

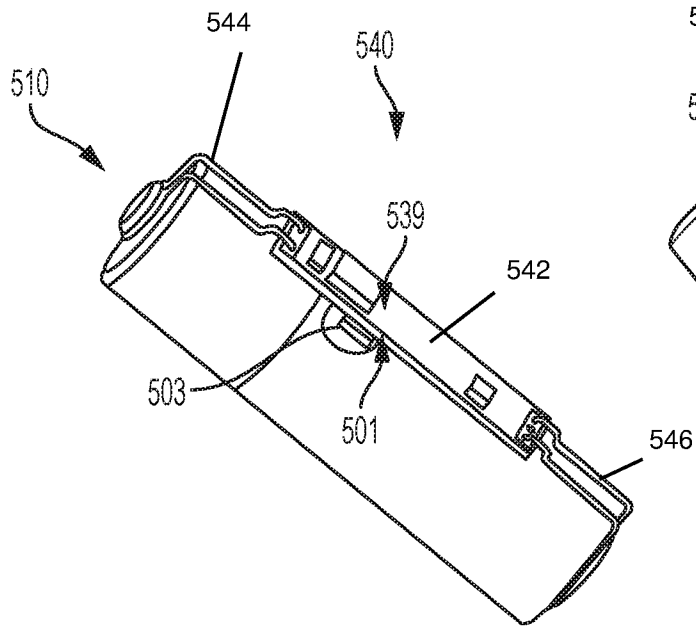


FIG. 10A

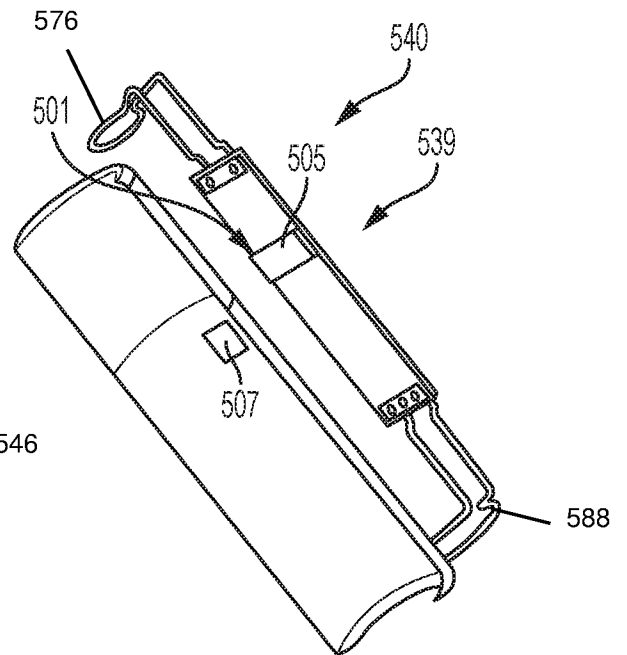


FIG. 10B

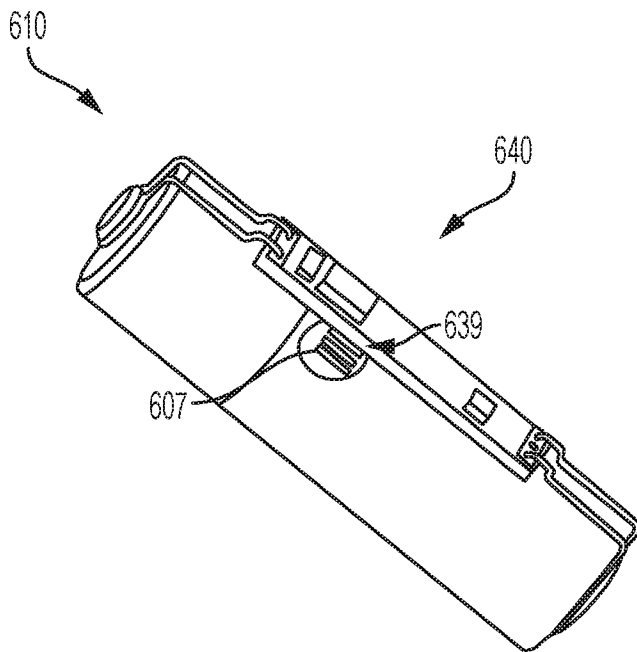


FIG. 11A

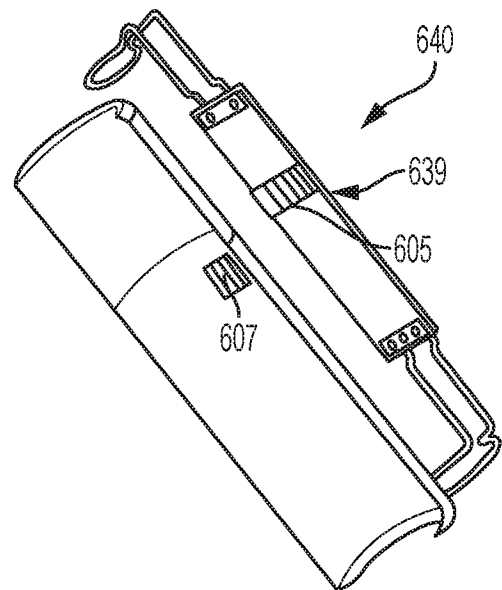


FIG. 11B

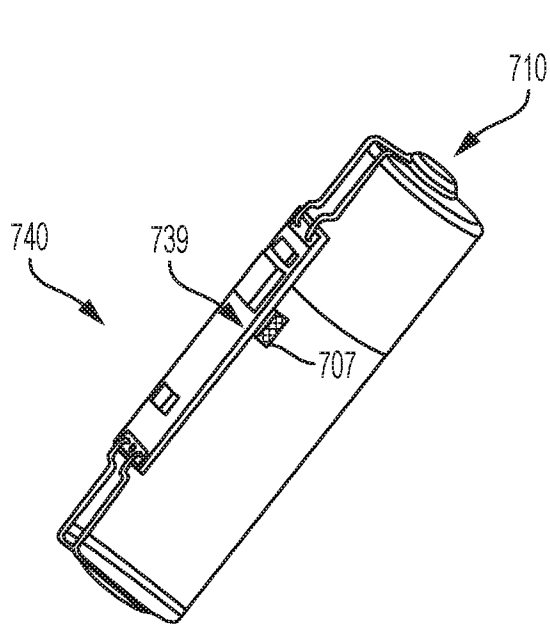


FIG. 12A

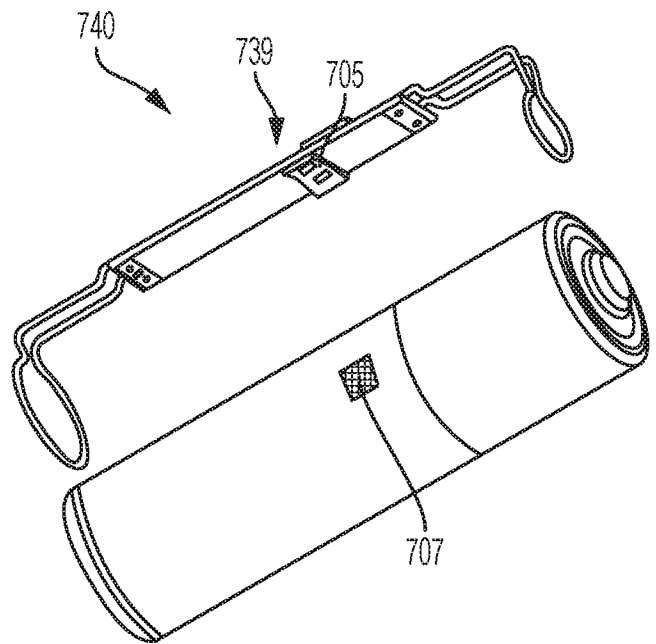


FIG. 12B

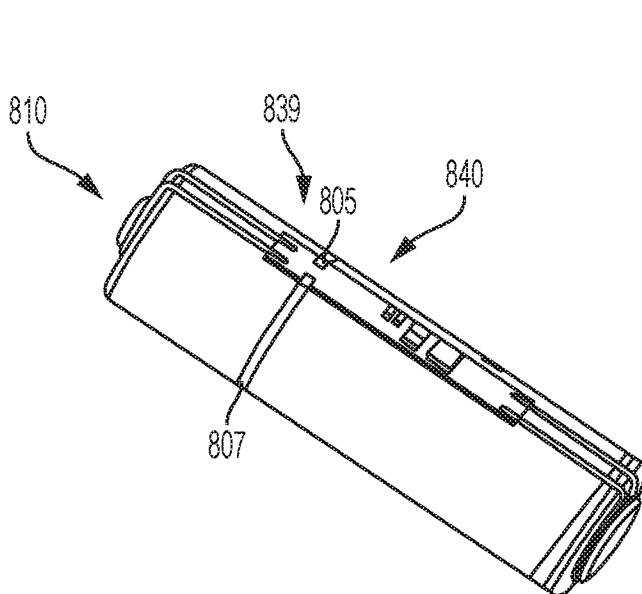


FIG. 13A

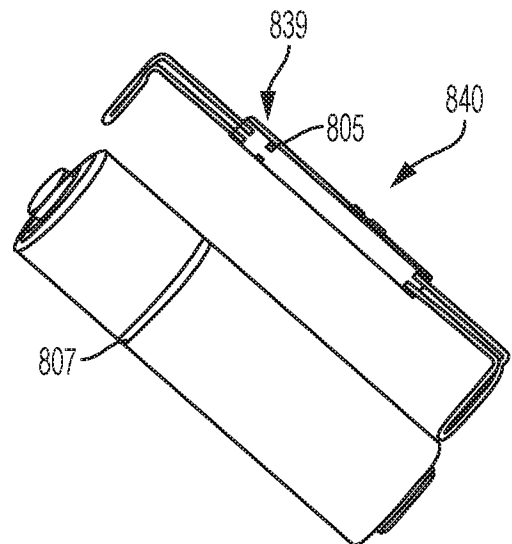


FIG. 13B