IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF PENNSYLVANIA

Philadelphia Scientific LLC 207 Progress Drive Montgomeryville, PA 18936, Plaintiff, v. **Fourshare, LLC** 6645 Holder Road Clemmons, NC 27012, Defendant.	:	**CIVIL ACTION NO: 2:13-cv-00186-CMR** **SECOND AMENDED COMPLAINT FOR PATENT INFRINGEMENT** **DEMAND FOR JURY TRIAL**

SECOND AMENDED COMPLAINT

Plaintiff, Philadelphia Scientific LLC ("Philadelphia Scientific") for its Second Amended Complaint against defendant, Fourshare, LLC ("Fourshare" or "Defendant"), alleges as follows:

THE PARTIES

1. Plaintiff Philadelphia Scientific is a limited liability company organized and existing under the laws of the State of Delaware and has a place of business at 207 Progress Drive, Montgomeryville, PA 18936.

2. Upon information and belief, FourShare is a limited liability company of the State of North Carolina having a principal place of business at 6645 Holder Road, Clemmons, North Carolina 27012.

3. Upon information and belief, FourShare currently does business as Battery Watering Technologies.

JURISDICTION AND VENUE

4. This action arises under the patent laws of the United States, Title 35 of the United States Code. This Court has subject matter jurisdiction under 28 U.S.C. §§ 1331 and 1338(a). Venue is proper in this judicial district under 28 U.S.C. §§ 1391 and 1400(b) for at least the reason that, on information and belief, a substantial part of the events giving rise to the claim occurred in this District, and that Defendant has committed acts of infringement and/or contributed to and/or induced acts of infringement in this District.

5. Philadelphia Scientific is informed and believes, and thereon alleges, that Defendant has continuous and systematic purposely directed contacts with the Commonwealth of Pennsylvania, including in this judicial district.

6. Philadelphia Scientific is informed and believes, and thereon alleges, that Defendant has acted, or caused or induced others to act, in a manner that constitutes patent infringement, and these acts include, but are not limited to, the manufacture, use, offer for sale, sale, and/or promotion of certain equipment and methods for monitoring the electrolyte level in batteries, with the knowledge and intent that the equipment would be sold, resold, offered for sale, reoffered for sale, combined with one or more batteries, and/or used in the United States, including in the Commonwealth of Pennsylvania and within this judicial district. This

equipment includes, but is not necessarily limited to, the battery electrolyte level sensor sold, offered for sale, advertised and marketed under the trade designation i-Lite Sensor.

CAUSE OF ACTION

7. Plaintiff incorporates by reference each and every allegation contained in paragraphs 1 through 6 above as though fully set forth herein.

8. Plaintiff is engaged in the business of conceiving of, developing, designing, patenting, licensing, manufacturing, selling and/or offering for sale products and services related to the use, installation and/or maintenance of batteries, and to products and services ancillary to the use, installation and/or maintenance of batteries, including innovative new devices, systems and methods for monitoring the electrolyte level in batteries.

9. U.S. Patent No. 5,936,382 (the "'382 patent") entitled "Battery Electrolyte Level Monitor," was duly and legally issued on August 10, 1999, and is now and at all times has been in full force and effect. A copy of the '382 patent is attached as Exhibit A.

10. U.S. Patent No. 7,812,613 (the "'613 patent") entitled "System and Method for Monitoring Electrolyte Levels in a Battery," was duly and legally issued on October 12, 2010, and is now and at all times has been in full force and effect. A copy of the '613 patent is attached as Exhibit B.

11. Plaintiff is now and at all relevant times has been the owner of the entire right, title and interest in and to each of the '382 patent and the '613 patent.

12. Upon information and belief, Defendant has been involved in at least one of manufacturing, using, offering for sale, selling, and/or importing devices and equipment and has

been involved in methods of using such devices and equipment, including but not limited to the i-Lite Sensor (collectively, the "Infringing Products") that are within the scope of claims 12-15 of the '382 patent and claims 1-4, 7-9, 12, 16 and 17 of the '613 patent (collectively, "the Asserted Claims"), in or into one or more states in the United States, including the Commonwealth of Pennsylvania and this Judicial District.

13. The i-Lite Sensor is packaged with detailed instructions for "[i]nstalling the i-Lite Sensor," (hereinafter "Installation Instructions") which describe the steps that, according to Fourshare, are "intended" to be taken by a "qualified personnel" for the installation by customers of Fourshare of the i-Lite sensor on a battery. The Installation Instructions also disclose how to use the i-Lite sensor to monitor the electrolyte level in the battery. A copy of the Installation Instructions for the BSVA-1000 i-Lite sensor is attached as Exhibit C. The Installation Instructions for the BSVA-2000 i-Lite sensor are the same in all respects relevant to the present suit.

14. The Installation Instructions for the respective BSVA-1000 and BSVA-2000 i-Lite sensors are posted on the web site of Battery Watering Technologies, at http://www.batterywatering.com/techinfo/files/Sensor%20Installation%20Instructions%20BSVA 1000_SS_web.pdf; and http://www.batterywatering.com/techinfo/files/Sensor%20Installation%20Instructions%20BSVA 2000_SS_web.pdf.

15. Fourshare's "Standard Warranty" is posted on its website (www.batterywatering.com). A copy of the Standard Warranty page is attached as Exhibit D. The Standard Warranty page indicates that Battery Watering Technologies is a division of

Fourshare, and states that "[n]o warranty whatsoever will apply if and when our operating and maintenance instructions are not complied with..."

16. The i-Lite Sensor is packaged with a label disclosing how the i-Lite Sensor is used to monitor the electrolyte level in the battery on which it has been installed. The label states "Apply this label to your battery after installing your electrolyte level indicator." The label does not disclose or suggest any application or use of the i-Lite Sensor inconsistent with the application and use disclosed in the Installation Instructions. A copy of the label is attached as Exhibit E.

17. Fourshare maintains a web page, http://www.batterywatering.com/video/videovault.asp#, on which is posted a video titled "How to Install the i-LITE SENSOR on an Industrial Battery." The video depicts, on a step by step basis, installation of the i-Lite Sensor on a battery. The video does not disclose or suggest any application or use of the i-Lite Sensor inconsistent with the application and use disclosed in the Installation Instructions.

18. The Fourshare web-site includes a web page, http://www.batterywatering.com/products/ilitesensor.asp#, that describes the i-Lite Sensor as "[t]he smartest, safest, and most accurate way to know when your batteries need water," and depicts the i-Lite sensor mounted on a battery. The web-site does not disclose or suggest any application or use of the i-Lite Sensor inconsistent with the application and use disclosed in the Installation Instructions. A copy of the web page is attached as Exhibit F.

19. An "i-Lite Sensor Flyer" is posted on the Fourshare web site, at http://www.batterywatering.com/products/files/i-Lite%20Slick%20Sheet_LowRes.pdf. The

flyer describes the i-Lite Sensor as "The smartest, safest, and most accurate way to know when your batteries need water," and depicts the i-Lite sensor mounted on a battery. The flyer does not disclose or suggest any application or use of the i-Lite Sensor inconsistent with the application and use disclosed in the Installation Instructions. A copy of the flyer is attached as Exhibit G.

20. Fourshare issued a press release, available on the web site of the 2013 Promat International Expo at http://www.promatshow.com/press/release.aspx?id=3396, entitled "Battery Watering Technologies Introduces the i-Lite™ Water Monitor." In this press release, Fourshare states, in relevant part, "The i-Lite water monitor alerts operators with the brightest L.E.D. visual indication when it is time to water the batteries," and depicts the i-Lite sensor mounted on a battery. The press release does not disclose or suggest any application or use of the i-Lite Sensor inconsistent with the application and use disclosed in the Installation Instructions. A copy of the press release is attached as Exhibit H.

21. Installing and/or using the i-Lite Sensor in accordance with the Installation Instructions (Exhibit C), and as described, instructed, and/or referenced in the documents attached as Exhibits D through H and the video referenced in paragraph 17, necessarily results in a battery meeting the requirements of claims 12–15 of the '382 patent and therefore constitutes infringement of '382 patent.

22. Installing and/or using the i-Lite Sensor in accordance with the Installation Instructions (Exhibit C), and as described, instructed, and/or referenced in the documents attached as Exhibits D through H and the video referenced in paragraph 17, necessarily results

in a system for monitoring the electrolyte level in a battery meeting the requirements of claims 1, 2–4, 7–9, 12, 16 and 17 of the '613 patent and therefore constitutes infringement of '613 patent.

23. All information provided by and available through Fourshare regarding installation and use of the i-Lite Sensor consistently depicts the same use and application for the device, and no other uses or applications are described or mentioned. On information and belief, no uses or applications for the device inconsistent with the uses and applications as described above in paragraphs 13 through 20 and in Exhibits C through H are reasonably possible, and any attempt to use or apply the i-Lite Sensor in a manner inconsistent with the Installation Instructions would violate Fourshare's warranty of the product. The i-Lite Sensor, therefore, has no substantial non-infringing uses. Furthermore, Fourshare designed and intended for installation and use of the i-Lite Sensor in accordance with the Installation Instructions and other materials described above and as such the use thereof by Fourshare customers according to the Installation Instructions necessarily results in a battery or system that has all the requirements of the Asserted Claims and therefore constitutes an infringement of the Asserted Claims.

24. Fourshare is instructing, showing and otherwise encouraging customers and other users of the i-Lite Sensor to make a monitored battery by installing and using the i-Lite Sensor in accordance with the Installations Instructions and the additional documents and materials attached as Exhibits D through H, and the video referenced in paragraph 17. Accordingly, the customers of Fourshare and other users who purchase and/or install the i-Lite in accordance with the Installation Instructions are directly infringing the Asserted Claims and are doing so upon the direction, guidance and encouragement of the Defendant.

25. On November 21, 2012, Plaintiff's counsel sent a letter to Scott D. Elliott who, on information and belief, was and is the President of Fourshare. The letter informed Mr. Elliott that the offer for sale of electrolyte monitors, including the i-Lite Sensor, by Fourshare's d/b/a Battery Watering Technologies infringes at least one claim of each of the '613 patent and the '382 patent. A copy of the letter is attached as Exhibit I.

26. On December 11, 2012, Fourshare, through its counsel, acknowledged Plaintiff's November 21, 2012 letter to Mr. Elliott.

27. From at least as early as about November 21, 2012, therefore, Fourshare knew of each of the '382 patent and the '613 patent, and that Plaintiff had accused the i-lite Sensor and its use of infringing those patents. Fourshare further knew that its communication with its customers, including its Installation Instructions and the other communications referenced above in paragraphs 13 through 20 and included as Exhibits C through H regarding installation and use of the i-Lite Sensor, would specifically direct and encourage its customers to make and/or use batteries and systems that necessarily satisfy all the elements of at least one claim of each of the '382 and '613 patents. As a result, Fourshare specifically intended to encourage and did encourage its customers to take those steps that constitute infringement of the Asserted Claims.

Infringement of the '382 Patent

28. This is a claim for patent infringement under 35 U.S.C. §§ 271 and 281.

29. Philadelphia Scientific hereby repeats, realleges and incorporates by reference paragraphs 1 through 27 of this First Amended Complaint as though fully set forth herein.

30. Philadelphia Scientific is informed and believes, and thereon alleges, that Defendant through its agents, employees and servants, have infringed and/or contributed to

infringement and/or induced others to infringe, and continue to infringe claims 12-15 of the '382 patent, in violation of 35 U.S.C. §§ 271(a), 271(b), 271(c) and/or 271(f). These acts were not and are not authorized by Philadelphia Scientific.

31. Defendant has received actual notice and/or constructive notice of the '382 patent, including at least as a result of receiving the letter dated November 21, 2012 (Exhibit I), sent on behalf of Plaintiff Philadelphia Scientific and providing a copy therewith of the '382 patent and, notwithstanding this notice, Defendants have continued to engage in acts constituting infringement of the '382 patent.

32. Philadelphia Scientific is informed and believes, and thereon alleges, that Defendant has derived, received and will continue to derive and receive gains, profits and advantages in amounts not presently known by Philadelphia Scientific with certainty, from their acts of infringement of the '382 patent.

33. Philadelphia Scientific is informed and believes, and thereon alleges, that such infringement has been and continues to be intentional, knowing, willful and deliberate, with full knowledge of Philadelphia Scientific's rights in the '382 patent.

34. Due to the acts of infringement by Defendant, Philadelphia Scientific has suffered great, imminent and irreparable injury and harm, and will continue to suffer such injury and harm unless enjoined by the Court from further acts of infringement of the '382 patent.

Infringement of the '613 Patent

35. This is a claim for patent infringement under 35 U.S.C. §§ 271 and 281.

36. Philadelphia Scientific hereby repeats, realleges and incorporates by reference paragraphs 1 through 27 of this First Amended Complaint as though fully set forth herein.

37. Philadelphia Scientific is informed and believes, and thereon alleges, that Defendant through its agents, employees and servants, have infringed and/or contributed to infringement and/or induced others to infringe, and continue to infringe claims 1-4, 7-9, 12, 16 and 17 of the '613 patent, in violation of 35 U.S.C. §§ 271(a), 271(b), 271(c) and/or 271(f). These acts were not and are not authorized by Philadelphia Scientific.

38. Defendant has received actual notice and/or constructive notice of the '613 patent, including at least as a result of receiving the letter dated November 21, 2012 (Exhibit I), sent on behalf of Plaintiff Philadelphia Scientific and providing a copy therewith of the '613 patent and, notwithstanding this notice, Defendant has continued to engage in acts constituting infringement of the '613 patent.

39. Philadelphia Scientific is informed and believes, and thereon alleges, that Defendant has derived, received and will continue to derive and receive gains, profits and advantages in amounts not presently known by Philadelphia Scientific with certainty, from their acts of infringement of the '613 patent.

40. Philadelphia Scientific is informed and believes, and thereon alleges, that such infringement has been and continues to be intentional, knowing, willful and deliberate, with full knowledge of Philadelphia Scientific's rights in the '613 patent.

41. Due to the acts of infringement by Defendant, Philadelphia Scientific has suffered great, imminent and irreparable injury and harm, and will continue to suffer such injury and harm unless enjoined by the Court from further acts of infringement of the '613 patent.

WHEREFORE, Philadelphia Scientific prays for relief as follows:

A. that FourShare be adjudged to have infringed each of the '382 and '613 patents;

a) that FourShare be adjudged to have willfully and deliberately infringed each of the '382 and '613 patents;

b) that FourShare, its officers, agents, servants, employees and attorneys, and those persons in active concert or participation with them who receive actual notice of the Order, be preliminarily and permanently restrained from infringing each of the '382 and '613 patents;

c) that FourShare account for damages to Philadelphia Scientific for its infringement of each of the '382 and '613 patents;

d) that a judgment be entered against FourShare awarding Philadelphia Scientific all damages to which it is entitled under 35 U.S.C. § 154(d) and 35 U.S.C. § 284, including increased damages for defendant's willful infringement;

e) that the damages in this judgment be trebled for the willful and deliberate infringement of each of the '382 and '613 patents by FourShare;

f) that an assessment be awarded to Philadelphia Scientific of interest on the damages so computed;

g) that the Court award Philadelphia Scientific to its reasonable attorneys fees and costs pursuant to 35 U.S.C. § 285; and

h) that Philadelphia Scientific receive such other and further relief as the Court may deem just and proper.

Jury Demand

Philadelphia Scientific demands a trial by jury on all issues so triable.

Respectfully Submitted,

FOX ROTHSCHILD LLP

Date: May 13, 2013

By: /Joseph F. Posillico/

Joseph F. Posillico
Frank T. Carroll
Seth A. Kramer
2000 Market Street, 20th Floor
Philadelphia, PA 19103
jposillico@foxrothschild.com
ghecht@foxrothschild.com
fcarroll@foxrothschild.com
skramer@foxrothschild.com
Phone: (215) 299-2000
Facsimile: (215) 299-2150

Attorneys for Plaintiff
Philadelphia Scientific LLC

EXHIBIT A

US005936382A

United States Patent [19]

Jones et al.

[11] Patent Number: 5,936,382

[45] Date of Patent: Aug. 10, 1999

[54] **BATTERY ELECTROLYTE LEVEL MONITOR**

[75] Inventors: **William E. M. Jones**, P. O. Box F42533, Water Edge, Freeport, Bahamas; **Evert C. Weldner**, Lansdale, Pa.

[73] Assignee: **William E. M. Jones**, Freeport, Bahamas

[21] Appl. No.: **09/017,173**

[22] Filed: **Feb. 2, 1998**

[51] **Int. Cl.**^{6} **H01M 10/46**

[52] **U.S. Cl.** **320/132**; 320/DIG. 21; 324/425

[58] **Field of Search** .... 320/132, 134, 320/136, DIG. 18, FOR 142, DIG. 21, FOR 147; 324/425, 426, 432, 446; 340/635

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,696,362	10/1972	Sieron	340/620
4,247,811	1/1981	Findl	320/134
4,284,951	8/1981	Dahl et al.	324/430
4,625,201	11/1986	Berry	340/636
4,913,987	4/1990	Dattilo	324/436
4,981,764	1/1991	Dattilo	324/436

OTHER PUBLICATIONS

Motive Energy Inc. product information circular detailing the features of and benefits to using their "Hydro-Eye" battery vent cap; publication date unknown.

Battery Master Inc. product information circular detailing the features of and benefits to using their "The Informer" electrolyte level monitor; publication date unknown.

Advanced Control Technology, Inc. product information circular detailing the features of and benefits to using their multiple switch liquid level monitor; publication date unknown.

New product announcement letter (unaddressed) from Janet L. Maurer, Director of Marketing for Philadelphia Scientific, detailing the features of and benefits to using their battery watering monitor, dated Jul. 23, 1996 (1 page w/enclosed 1 page battery watering monitor installation instructions).

Primary Examiner—Edward H. Tso
Attorney, Agent, or Firm—Synnestvedt & Lechner LLP

[57] **ABSTRACT**

An electrolyte level monitor used in combination with a battery having multiple cells. The monitor includes a circuit having an indicator which operates when the electrolyte level is at or above the minimum acceptable electrolyte level. The circuit is connected across cells of the battery to provide a potential to operate the monitor.

25 Claims, 4 Drawing Sheets

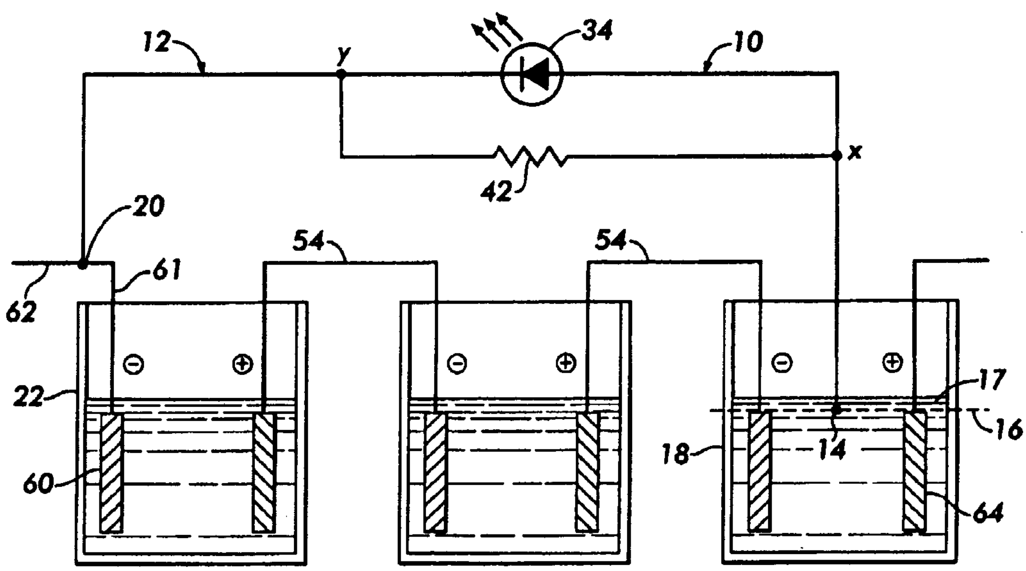
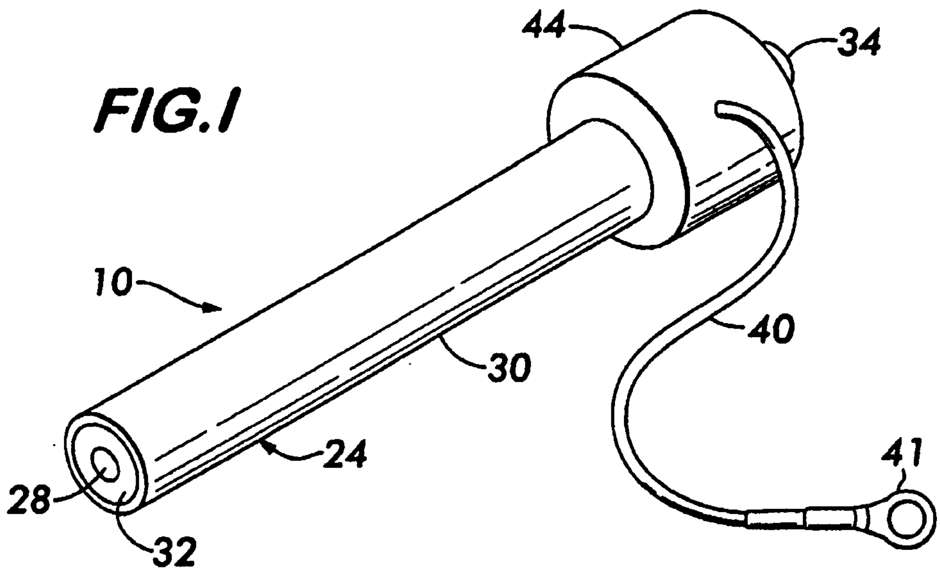


FIG. 1


44
34
10
40
30
24
28
32
41

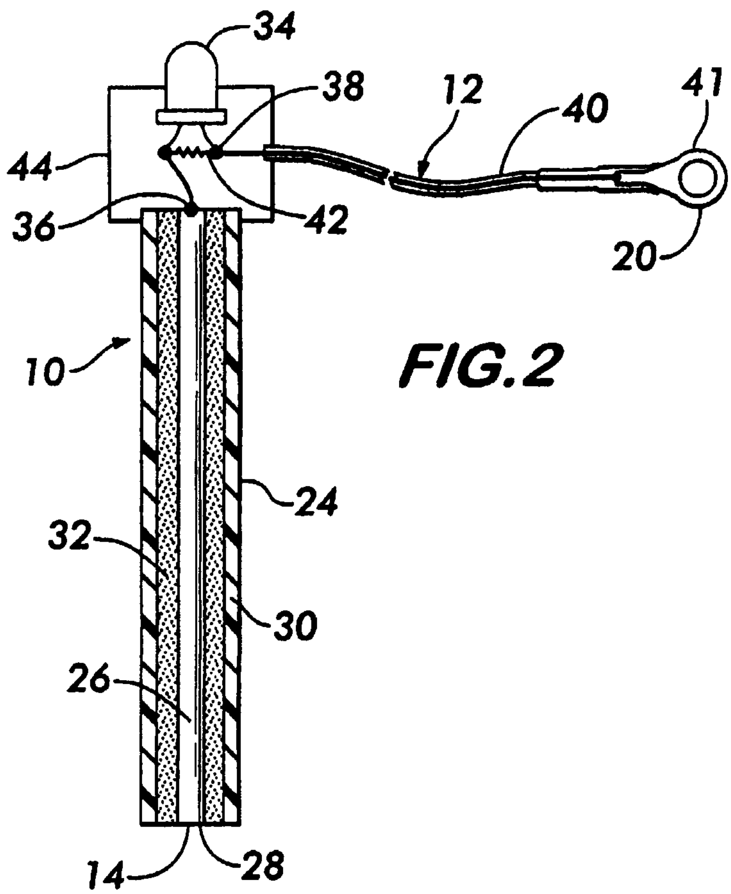

34
38
12
40
41
44
36
42
20
10
24
32
30
26
14
28

FIG. 2

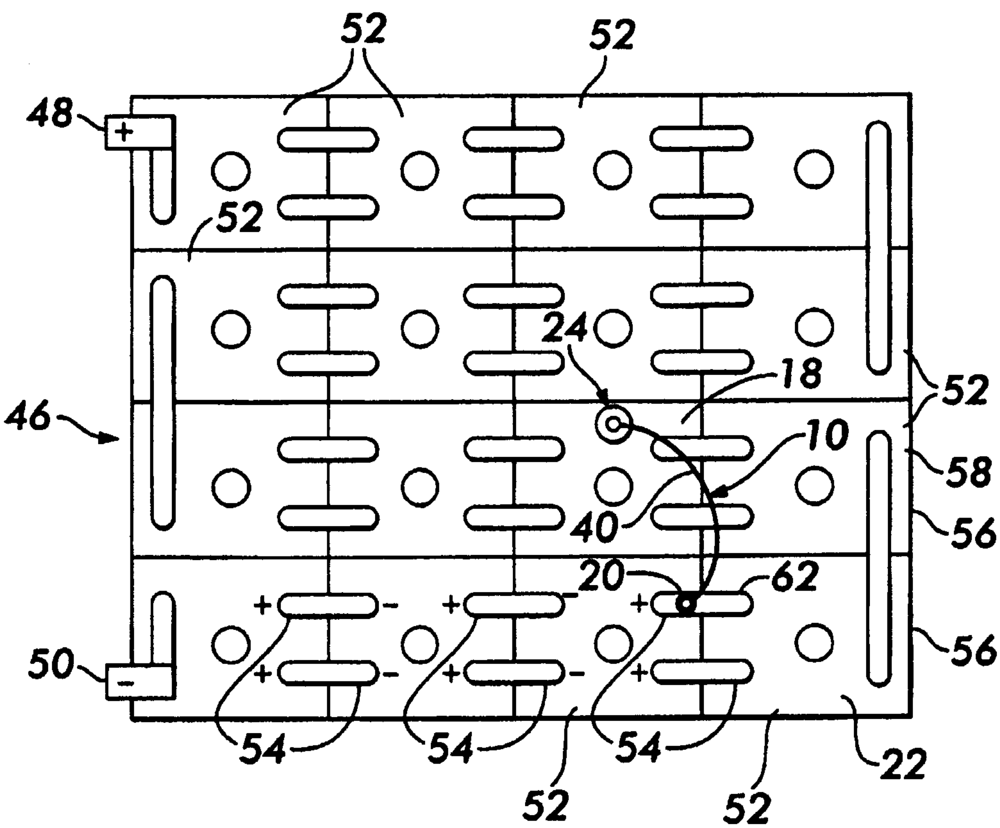


FIG. 3

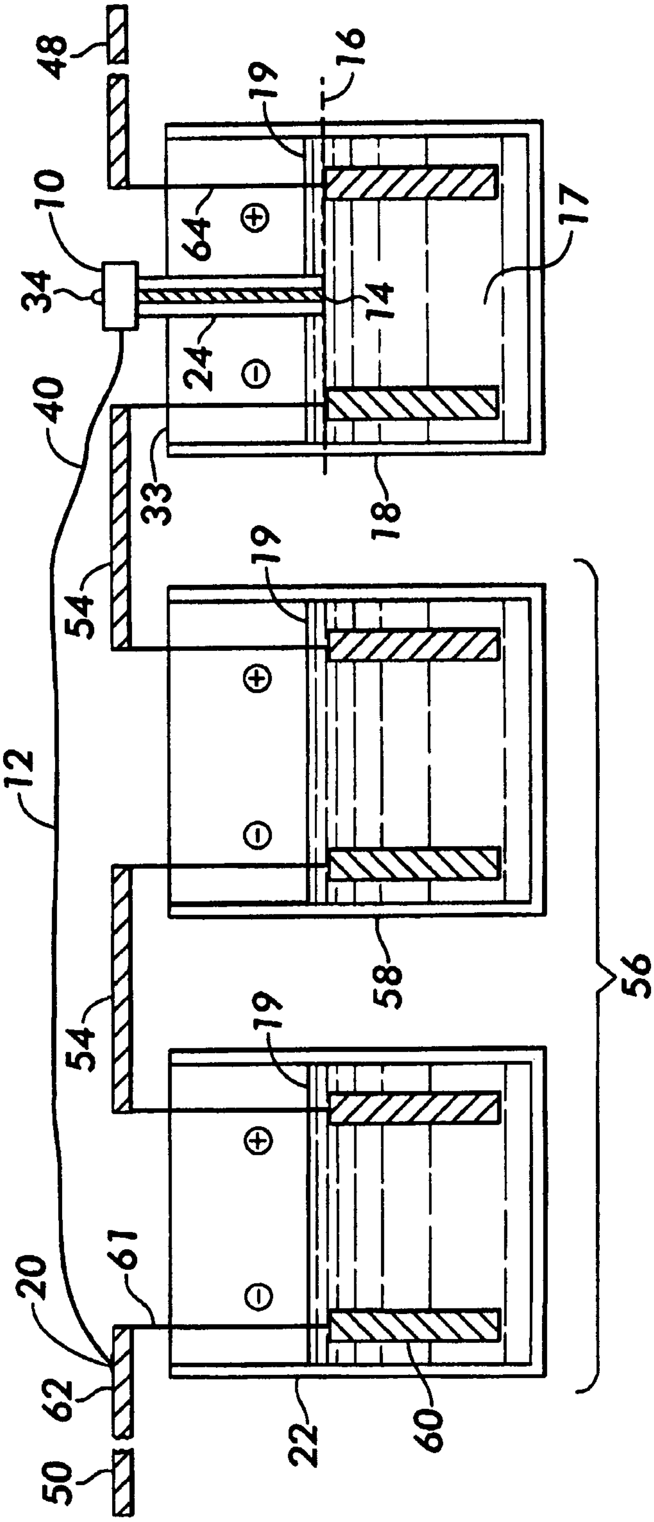

48
10
34
40
12
20
62
50
19
16
64
14
24
33
18
17
54
19
58
56
54
19
61
22
60

FIG. 4

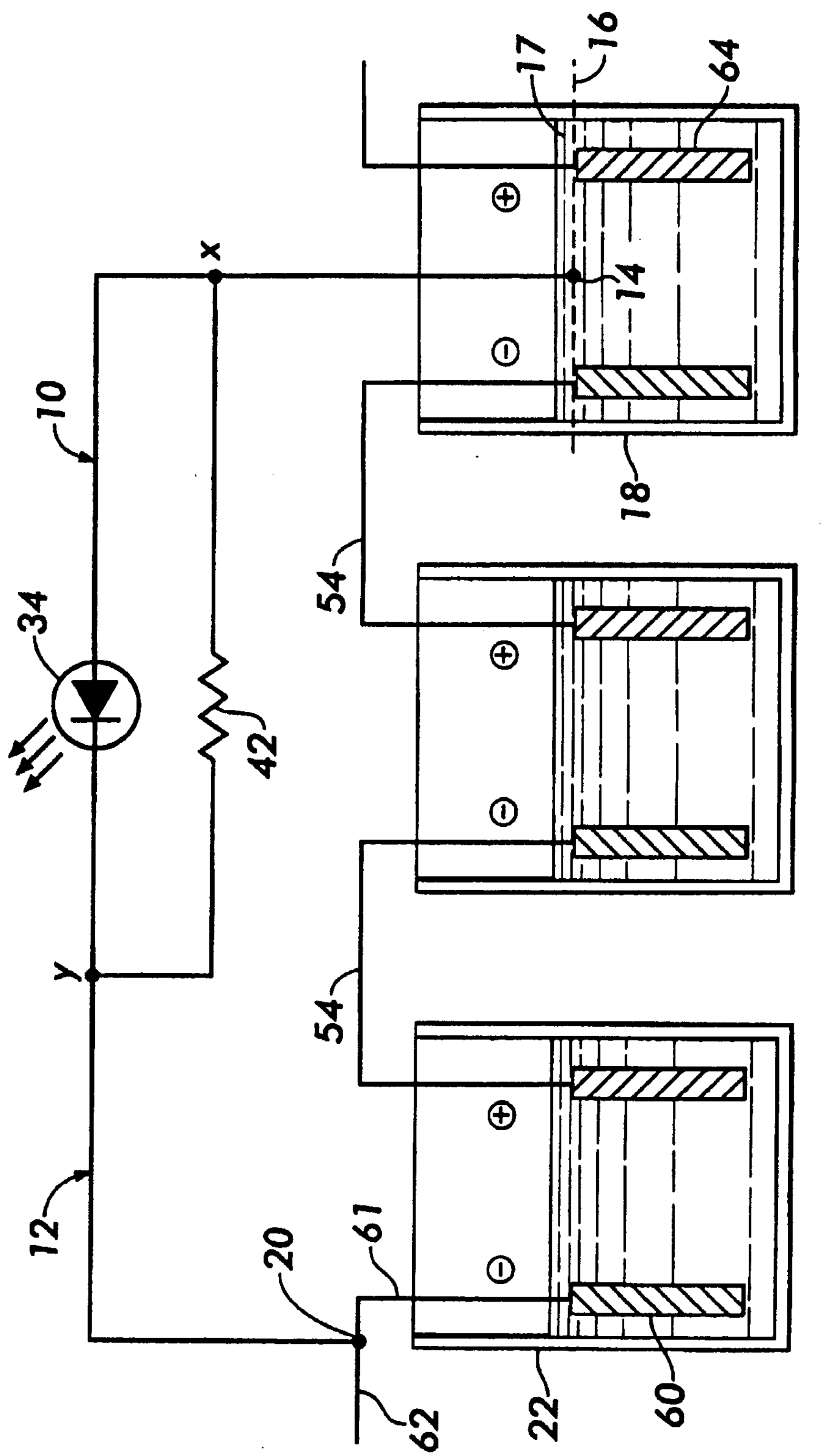


FIG.5

BATTERY ELECTROLYTE LEVEL MONITOR

BACKGROUND

1. Field of the Invention

The present invention relates to devices for monitoring the level of electrolyte in rechargeable aqueous electric storage batteries. More particularly, the present invention relates to a device for providing a positive indication that the minimum acceptable level of electrolyte is present in a battery cell.

2. Background of the Invention

Rechargeable or secondary electric storage batteries often contain an aqueous electrolyte, such as a dilute sulfuric acid in lead acid systems. These batteries have multiple cells connected in series and are widely used in many applications such as electric vehicles.

During normal use, the water in the electrolyte solution is depleted by the electrolysis that accompanies the charging process and for other reasons such as charge inefficiencies. This water loss needs to be replaced before a low electrolyte level results in damage to the battery cells. Thus, such batteries are typically "topped off" or replenished with water before permanent damage to the battery components result.

A long recognized problem in the industry has been the determination of when to add additional water. The actual point of time when topping off is required is not easily determinable as battery utilization varies greatly with each application. Regular visual monitoring, such as looking into the battery cell, is typically required. Nevertheless, a main cause of battery failure is due to the lack of water. Furthermore, too frequent watering without proper visual monitoring can lead to overfilling and spilling of electrolyte.

Various devices are known in the art for monitoring electrolyte levels. Some of these units are deficient in that they are not fail safe. These units provide a positive indication, such as a light, only when the electrolyte liquid level falls below the minimum acceptable level. Such units are not capable of differentiating between a low electrolyte level and a failed monitor device. If no indication is given, it could mean that the electrolyte level is okay, or it could be that the unit has failed, in which case reliance on the monitor could result in a damaged battery.

More recently, supposedly fail safe monitors have been introduced. Such monitors are placed within the battery cell and positioned at a predetermined minimum acceptable electrolyte level to contact the electrolyte and give a positive indication when the electrolyte is just at the minimum acceptable level or higher. Such systems would have the advantage that a positive signal means that the liquid level is acceptable. If no indication were given, either the liquid level is low or the monitor is not working. In either event, the lack of a positive indication would mean that something is wrong and that further investigation is required.

These supposed fail safe devices, however, have in reality failed. It has been found that such devices can give a false signal indicating that the electrolyte level is acceptable when in fact the electrolyte is below the minimum acceptable level.

Accordingly, one object of the present invention is to provide a monitoring device which provides a positive indication when the electrolyte is at the minimum acceptable level.

Another object is to provide a monitor that is fail safe and not prone to false indications.

A further object of the present invention is to provide a simple and reliable monitoring device that has no moving parts to fail and that is virtually maintenance free.

Another object of the present invention is to provide a monitoring device that does not require a separate power source which can be depleted or fail.

Additional objects, advantages and novel features of the invention will be set forth in the description which follows, and in part should become apparent to those skilled in the art upon examination of the following or may be learned by practice of the invention.

SUMMARY OF THE INVENTION

In making the present invention, the inventors believe they have solved a problem previously unappreciated by others in the art. As the battery cell ages, oils are liberated from materials within the battery. These oils form an oil film that coats all exposed surfaces within the cell. This film is conductive and can provide a weak short circuit from the electrolyte to any device or item within the battery cell. The inventors have determined that this is likely the reason why previous fail safe monitoring devices give false signals. A weak short circuit from the electrolyte to the monitoring device can give a false indication of electrolyte level.

The inventors have developed a novel monitor which overcomes this problem, and which provides a true fail safe device. In broad terms, the monitor provides an electric circuit having a first terminal which is positioned in one of the cells of the battery at a minimum acceptable electrolyte level. The electric circuit has a second terminal which is electrically connected to a second cell of the battery to impress a potential across the circuit when the electrolyte in the one cell to be monitored contacts the first terminal of the circuit. An indicator that is responsive to a flow of current is electrically connected in series between the first and second terminals of the circuit. Connected electrically in parallel with the indicator is a resistor. When the electrolyte level contacts the first terminal of the circuit, current flows through the circuit and a positive indication of the current is given. When the electrolyte level falls below the desired electrolyte level the circuit is opened, and no indication is given indicating that either the electrolyte level is low or that the electrolyte level monitor has failed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a preferred embodiment of an electrolyte monitor in accordance with the present invention;

FIG. 2 is a sectional view of the electrolyte monitor of FIG. 1;

FIG. 3 is a top view of a battery of sixteen cells having an electrolyte monitor of the embodiment shown in FIG. 1;

FIG. 4 is a schematic view of the completed circuit of the electrolyte monitor of FIG. 1 shown connected across a driving cell string of two cells; and

FIG. 5 is a schematic diagram of a monitor circuit of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment illustrated is not intended to be exhaustive or to limit the invention to the precise form disclosed. It is chosen and described to best explain the principle of the invention and its application and practical use and to enable others skilled in the art to best utilize the invention.

Illustrated in FIGS. 1, 2 and 5 is an electrolyte monitor 10 of the present invention. The monitor 10 comprises an electric circuit 12 having a first terminal 14 to be positioned to contact the electrolyte 17 at a minimum acceptable electrolyte level 16 in a cell 18 which has been selected to be monitored (see FIG. 4) (this monitored cell is alternately referred to as the pilot cell), and a second terminal 20 to be electrically connected to a second cell 22 (see FIG. 4) to impress a potential across the circuit 12 as further discussed below.

In the illustrated embodiment, a probe 24 electrically connected to the circuit 12 is inserted into the cell 18 for contacting the electrolyte 17. The probe 24 has an electrically conductive sensor member 26 comprising a rod of lead (Pb), such as a lead alloy, which is compatible with the sulfuric acid used in lead acid batteries. The sensor member 26 has an exposed face 28 at an end of the probe 24 which defines the first terminal 14 and which is positioned to contact and sense the electrolyte 17 at the predetermined minimum acceptable electrolyte level 16.

The probe 24 also has a non-conductive shell 30 within which the sensor member 26 is fixed. The shell 30 structurally reinforces the sensor member 26 which, comprising lead, is soft and weak. The shell 30 also electrically insulates the sensor member 26, other than the exposed face 28, to prevent false indications due to accidental contact between the probe 24 and other battery parts within the cell 18. The shell 30 preferably comprises a tubular structure made of a phenolic material compatible with the electrolyte 17. A non-corrosive, electrically insulating epoxy 32 fills the void between the sensor member 26 and the shell 30 to fix the sensor member 26 therein. The length of the probe 24 is chosen to extend through the cell cover 33 (FIG. 4) of the cell 18 and to position the exposed face 28 at the minimum acceptable electrolyte level 16.

Electrically connected in series to the circuit 12 between the first and second terminals 14, 20 is an indicator 34 that is responsive to the flow of current through the circuit 12. In the illustrated embodiment, the indicator comprises a light emitting diode (LED) which provides a visual indication of current flow. A blinking LED is preferable as it is easy to see.

One lead 36 of the LED indicator 34 is electrically connected to the sensor member 26 of the probe 24 as known in the art, such as by solder. The other lead 38 of the LED is connected through an insulated copper wire 40 to the second terminal 20 of the circuit 12, which, in the illustrated embodiment, comprises a ring terminal 41 which can be physically connected with a screw to an intercell connector as further discussed below.

A resistor 42 is electrically connected in parallel with the indicator 34. The resistor 42 reduces the sensitivity of the LED to low level currents in a manner known in the art.

A head cap 44 encloses the LED indicator 34, resistor 42, and the top end of the probe 24 to protect these from the environment.

With further reference to FIGS. 3 and 4, utilization of the monitor 10 is now described. Illustrated in FIG. 3 is a battery 46 having a positive terminal 48 and a negative terminal 50. The battery 46 is made up of sixteen cells 52 connected in series by intercell connectors 54. Each of the sixteen cells 52 has its own electrolyte level 19. The battery 46 of sixteen cells is for illustration purposes, it being understood that the present invention is readily applied to batteries made up of any number of cells in series that have a driving cell string for the monitor 10 as described below.

The monitor circuit 12 is powered by some of the cells of the battery 46 itself, and does not require an external power source. Each cell 52 of a typical battery provides a potential of about 2.2 volts. A suitable number of cells 52 in series adjacent to the monitored cell 18 serves as a driving cell string 56 to impress a potential across the circuit 12 (see FIG. 4). The LED indicator 34 of the present embodiment requires a potential of about 3–5 volts to turn on. Thus a driving cell string 56 of the two cells 22 and 58 in series is used to provide about 4.4 volts to operate the monitor 10.

As seen in FIGS. 3, 4, and 5, the first terminal 14 (exposed face 28 of probe 24 in the preferred embodiment) is placed in the pilot cell 18 in which the electrolyte 17 has been selected to be monitored. The first terminal 14 is fixed at the level 16 below which water should be added to the pilot cell 18.

The second terminal 20 of the circuit 12 is connected to the second cell 22 to impress a potential across the circuit 12 from the drive cell string 56. The second terminal 20 of the circuit 12 is connected in electrical contact with the negative terminal 61 of the cell 22, and preferably in such contact by being physically connected to the intercell connector 62. It is understood that electrical contact with the intercell connector 62 or the negative plate 60 of the cell 22 is in fact being in electrical contact with the negative terminal 61. Connecting the second terminal 20 of the circuit 12 to the intercell connector 62 on the outside of the cell 22 protects the second terminal 20 from the corrosive effects of the electrolyte within the cells. The ring terminal 41 allows the second terminal to be readily connected to the intercell connector 62 with a screw. The screw and terminal 41 can be coated with epoxy to protect them from external corrosion.

The monitored cell 18 is not believed to add any potential to that of the driving string 56 as the cell 18 is not included in the closed circuit. As shown in FIGS. 3 and 4, the circuit 12 is oriented so that the second cell 22 is positioned electrically between the first cell 18 having the first terminal 14, and the negative terminal 50 of the battery 46, i.e., the current flows through the circuit 12 in the same direction as the current flow through the battery 46—from positive (first terminal 14) to negative (second terminal 20). This orientation is preferable since the reverse orientation, placing the first terminal 14 in the cell 22 and the second terminal 20 of the circuit 12 to the positive terminal 64 of cell 18 would cause the lead material of probe 24 to be consumed by the electrochemical process.

Referring to FIG. 3, it is preferable to select a pilot cell 18 for monitoring from one of the inner rows of the cells 52. Surrounded by other cells, the inner cells tend to run hotter than the cells along the outer perimeter of the battery 46, and therefore are likely to have a lower electrolyte level at any given time. In this manner, the pilot cell 18 is indicative of all the cells of the battery which should be topped off at the same time cell 18 is topped off.

It is seen that the present invention provides a fail safe monitor of electrolyte level. As illustrated in FIG. 4, when the electrolyte 17 contacts the first terminal 14 a current flows through the circuit 12 causing the LED indicator 34 to illuminate. As long as the level of the electrolyte 17 remains in contact with the first terminal 14, at or above the level 16, the LED will remain lit. When the level of the electrolyte 17 drops below the level 16, contact with the first terminal 14 is broken, and the LED goes off. The device is fail safe in that a positive indication is given to indicate that the electrolyte level is at or above the minimum acceptable level 16. Lack of an indication means that the electrolyte level is low or that the monitor is not working properly. In either case an investigation of the battery is required.

The LED requires only a minimal current at a specific voltage to operate. Stray currents within a cell have been found to provide the minimal current necessary to give a positive indication in prior art monitoring devices even when the electrolyte level is below the minimum acceptable level. This problem is believed to have been previously unappreciated by those in the art.

The inventors recognized that a short circuit path from the electrolyte to the probe may develop within the cell 18. As a battery ages and is repeatedly cycled, oils are leeched from the separators within the cell such as those made of certain plastics. Aided by the gassing and splashing within the cell, these oils may mix with dirt and form an oily film that coats all exposed surfaces within the cell. This film is conductive and sustains a weak short circuit from the electrolyte, up the walls and onto the top cover of the battery cell, and to a probe device to give a false indication of an acceptable electrolyte level even though the actual level is below the minimum acceptable level.

Having recognized this problem, the inventors further developed a novel solution. The addition of a resistor 42 in parallel with the LED indicator 34 lowers the current through LED 34 for a given voltage across nodes X and Y, thereby requiring a higher current into node X to turn on the LED. By sizing the resistor 42 for the particular driving cell string voltage and LED utilized, the current required by the circuit 12 to light the LED can be made higher than that delivered through the oil film, thereby avoiding a false or impartial (dim) lighting of the LED.

In the illustrated example, the LED used is a blinking green, size T 1¾, having an input voltage of 3 V (Luminex part number SSL-LX5093BGD); the resistor used is an 82.5 Ohm, 1% metal film fixed resistor, ¼watt; for use with the two cell driving string 56.

The inventors have found that use of the present monitor has additional advantages. The industry recognizes that batteries should not be operated below 80% discharge which coincides with about an average voltage of 1.70 V per cell. To do so could damage the battery as well as the motor driven by the battery as the motor draws a higher current to compensate for the drop in voltage.

It has been found that around the discharge point of 80%, the monitor of the preferred embodiment stops working. This is believed to be when the voltage in each of the cells drop to about 1.7 volts. Thus, in the fail safe nature of this monitor 10, a lit LED indicates the electrolyte level is at or above the minimum acceptable level; while a non-lit LED indicates that an investigation is warranted and that there are at least three potential problems: 1) a low electrolyte level; 2) an improperly working monitor 10; or 3) the battery has discharged to the point that the battery should be recharged.

While the embodiment illustrated herein is designed as an after market device for installation in existing batteries, those in the art will recognize that similar and suitably modified devices can be incorporated in the battery during manufacture. It is understood that the foregoing description is intended to describe the preferred embodiment of the present invention and is not intended to limit the invention in any way. This invention is to be read as limited only by the appended claims.

What is claimed is:

1. A device for monitoring electrolyte level in a multi-celled battery, said device comprising:

an electric circuit having a first terminal capable of being fixed within one of the battery cells at a minimum acceptable electrolyte level, and a second terminal capable of being electrically connected to a second of the battery cells;

a probe having an electrically conductive sensor member, said sensor member connected electrically to said circuit and having an exposed face defining said first terminal to contact the electrolyte;

an indicator electrically connected to said circuit between said probe and said second terminal, said indicator being responsive to a flow of current through said circuit; and

a resistor electrically connected in parallel with said indicator.

2. A device in accordance with claim 1 wherein said probe further comprises a nonconductive outer shell within which is fixed said sensor member.

3. A device in accordance with claim 1 wherein said electrical circuit is closed so as to allow current to flow through said indicator when said electrolyte is at a level sufficient to contact said first terminal, whereby a positive indication of sufficient electrolyte is given.

4. A device in accordance with claim 2 wherein said indicator comprises a light emitting diode (LED).

5. A device in accordance with claim 4 wherein said sensor member comprises a rod including lead.

6. A device in accordance with claim 5 wherein said outer shell comprises a phenolic.

7. A device in accordance with claim 4 wherein said LED is fixed on top of said probe.

8. A device in accordance with claim 3 wherein said exposed face is positioned at an end of said probe.

9. A device in accordance with claim 4 wherein said LED has a rated input voltage of between about 3 and about 4 volts, and said resistor has an impedance of between about 79 and about 86 ohms.

10. An electrolyte level monitoring device, comprising:

an electric circuit having a first terminal positionable at a minimum acceptable electrolyte level within one battery cell and a second terminal for electrical connection to a second battery cell;

a probe having an electrically conductive sensor member and a nonconductive shell, said sensor member electrically connected to said circuit and having an exposed face defining said first terminal for contacting the electrolyte;

an LED electrically connected in series between said first terminal and said second terminal; and

a resistor electrically connected in parallel with said LED.

11. A battery having an electrolyte level monitor, said battery comprising:

a negative terminal;

multiple cells connected electrically in series to one another;

an electrical circuit having a first terminal positioned at a minimum acceptable electrolyte level in a one of said cells to contact the electrolyte at said level, and a second terminal electrically connected to a second of said cells to impress a potential across said circuit when the electrolyte in said one cell contacts said first terminal;

an indicator electrically connected in series between said first and second terminals, said indicator being responsive to a flow of current through said circuit; and

a resistor electrically connected in parallel with said indicator.

12. A battery in accordance with claim 11 wherein said second terminal of said circuit is in electrical contact with a negative terminal of said second cell.

13. A battery in accordance with claim 12 wherein said negative terminal is electrically connected in series to another of said cells through an intercell connector, said second terminal of said circuit being physically connected to said intercell connector.

14. A battery in accordance with claim 12 wherein said second cell is positioned electrically between said one cell and the negative terminal of the battery.

15. A battery in accordance with claim 14 further comprising a driving cell string which comprises two of said multiple cells in series to impress a potential across said circuit.

16. A battery in accordance with claim 11 wherein said indicator comprises an LED.

17. A battery in accordance with claim 16 wherein said LED comprises a blinking LED.

18. A battery in accordance with claim 11 further comprising a probe electrically connected to said circuit, said probe having a sensor member comprising lead and an exposed face defining said first terminal.

19. A battery in accordance with claim 18 wherein said probe comprises a nonconductive outer shell within which said sensor member is fixed.

20. A battery in accordance with claim 13 further comprising an insulated wire electrically connected in series between said LED and said second terminal of said circuit.

21. A battery in accordance with claim 18 wherein said one of said cells includes a cell cover, said probe being supported by and extending through said cover into said one cell.

22. A battery in accordance with claim 11 further comprising a probe electrically connected to said circuit, said probe having an end defining said first terminal.

23. A device for monitoring electrolyte level in a battery having multiple cells, said device comprising:

an electric circuit having a probe capable of being positioned within one of said battery cells, said probe comprising an electrically conductive material and having a first terminal positionable at a minimum acceptable electrolyte level within said one of said battery cells;

a second terminal electrically connected to said electric circuit for electrical connection to a second one of said battery cells;

an indicator electrically connected in series between said first and said second terminals, said indicator being responsive to a flow of current through said circuit; and

a resistor electrically connected in parallel with said indicator.

24. A device in accordance with claim 23 wherein said indicator comprises a light emitting diode (LED).

25. A device in accordance with claim 24 wherein said probe further comprises a nonconductive outer shell within which is said conductive material.

* * * * *

EXHIBIT B

US007812613B2

(12) **United States Patent**
Jones et al.

(10) **Patent No.: US 7,812,613 B2**
(45) **Date of Patent: Oct. 12, 2010**

(54) **SYSTEM AND METHOD FOR MONITORING ELECTROLYTE LEVELS IN A BATTERY**

(75) Inventors: **Duncan Jones**, Manchester (GB); **John Worthingdon**, Rochdale (GB)

(73) Assignee: **Philadelphia Scientific**, Montgomeryville, PA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 480 days.

(21) Appl. No.: **10/866,862**

(22) Filed: **Jun. 14, 2004**

(65) **Prior Publication Data**

US 2005/0001628 A1 Jan. 6, 2005

Related U.S. Application Data

(60) Provisional application No. 60/477,989, filed on Jun. 12, 2003, provisional application No. 60/484,855, filed on Jul. 3, 2003.

(51) **Int. Cl.**
G01N 27/41 (2006.01)
G08B 21/00 (2006.01)
H01M 10/48 (2006.01)

(52) **U.S. Cl.** **324/426**; 324/425; 429/91; 429/61; 340/620

(58) **Field of Classification Search** 320/112, 320/132; 324/425, 426, 429, 437; 429/89, 429/91, 61; 340/620
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,891,465 A * 6/1975 Muto et al. 429/61
4,053,686 A * 10/1977 Oxenreider 429/91
4,184,011 A * 1/1980 Strazewski 429/91
4,247,811 A * 1/1981 Findl 320/134
4,353,245 A * 10/1982 Nicolai 73/49.2
4,388,584 A * 6/1983 Dahl et al. 320/126
4,536,757 A * 8/1985 Ijntema 340/636.15
4,562,127 A * 12/1985 Mangone 429/89
4,768,377 A 9/1988 Habelmann
5,394,344 A * 2/1995 Lippmann et al. 702/50

(Continued)

FOREIGN PATENT DOCUMENTS

DE 200 14 429 U1 1/2001

(Continued)

OTHER PUBLICATIONS

European Search Report Dated Jan. 2, 2007 for related EP application 04 776 510.2-2207.

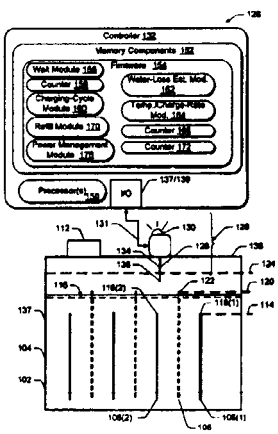
(Continued)

Primary Examiner—Edward Tso
Assistant Examiner—Alexis Boateng
(74) *Attorney, Agent, or Firm*—Fox Rothschild LLP

(57) **ABSTRACT**

A measuring device is used in conjunction with a programmable controller for monitoring electrolyte levels in the battery. According to one implementation, the measuring device is located in a battery and is configured to detect when the electrolyte level in the battery falls below a particular level. The controller is in electrical communication with the electrolyte detection device. The controller is configured to: (i) receive a signal from the electrolyte level detection device indicating when the electrolyte level in the battery has fallen below the particular level; (ii) introduce a wait-period after the signal is received; and (iii) enable an indicator to indicate that the electrolyte level in the battery should be refilled when the wait-period expires.

17 Claims, 4 Drawing Sheets



U.S. PATENT DOCUMENTS

5,422,822	A *	6/1995	Toyota et al.	702/63
5,773,962	A	6/1998	Nor et al.	
5,841,357	A *	11/1998	Henry et al.	340/636.13
5,936,382	A *	8/1999	Jones et al.	320/132
6,313,611	B1 *	11/2001	Mowry et al.	320/136
6,653,843	B2 *	11/2003	Whitchurch	324/446

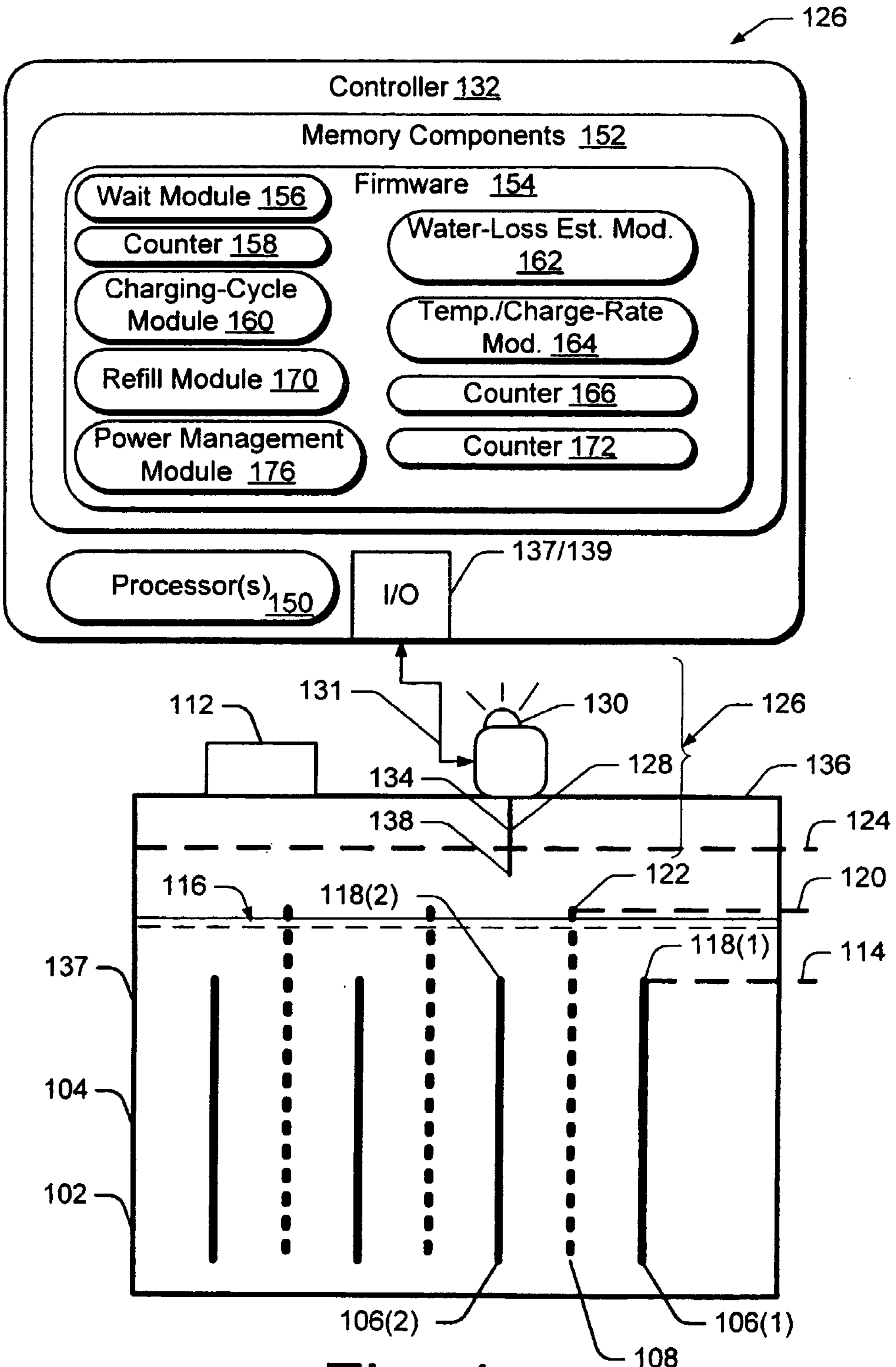
FOREIGN PATENT DOCUMENTS

DE	10038792	1/2002
EP	0791809	8/1997
GB	2055208	2/1981
JP	58 059568	4/1983
JP	58059568	8/1983
WO	00/35040	6/2000

OTHER PUBLICATIONS

Communication dated Feb. 20, 2006 issued in related European application.

* cited by examiner



126
Controller 132
Memory Components 152
Firmware 154
Wait Module 156
Counter 158
Charging-Cycle Module 160
Refill Module 170
Power Management Module 176
Water-Loss Est. Mod. 162
Temp./Charge-Rate Mod. 164
Counter 166
Counter 172
Processor(s) 150
I/O
137/139
112
131
130
126
128
136
134
138
124
122
120
116
118(2)
118(1)
114
137
104
102
106(2)
106(1)
108

Fig. 1

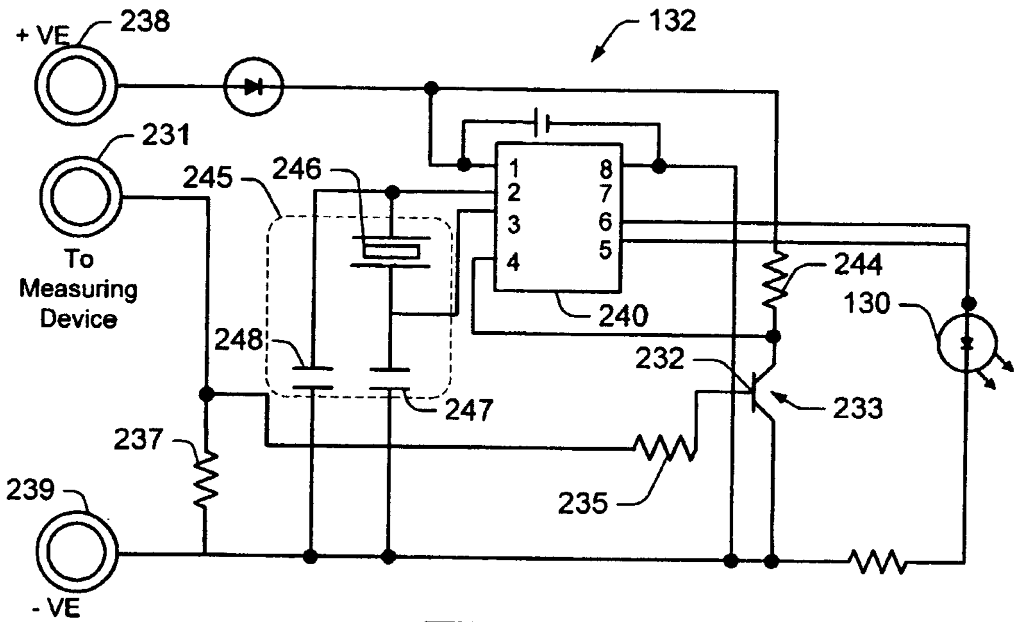

+ VE
238
132
231
245
246
1
2
3
4
8
7
6
5
To
Measuring
Device
244
130
240
248
232
233
247
237
235
239
- VE

Fig. 2

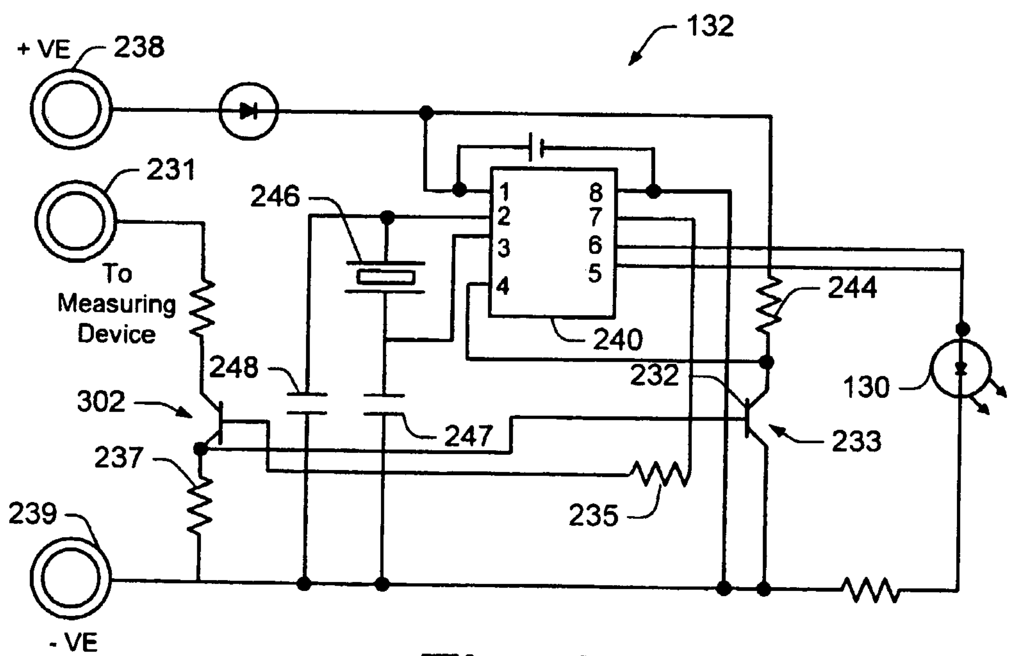

+ VE
238
132
231
246
1
2
3
4
8
7
6
5
To
Measuring
Device
244
240
232
248
130
302
247
233
237
235
239
- VE

Fig. 3

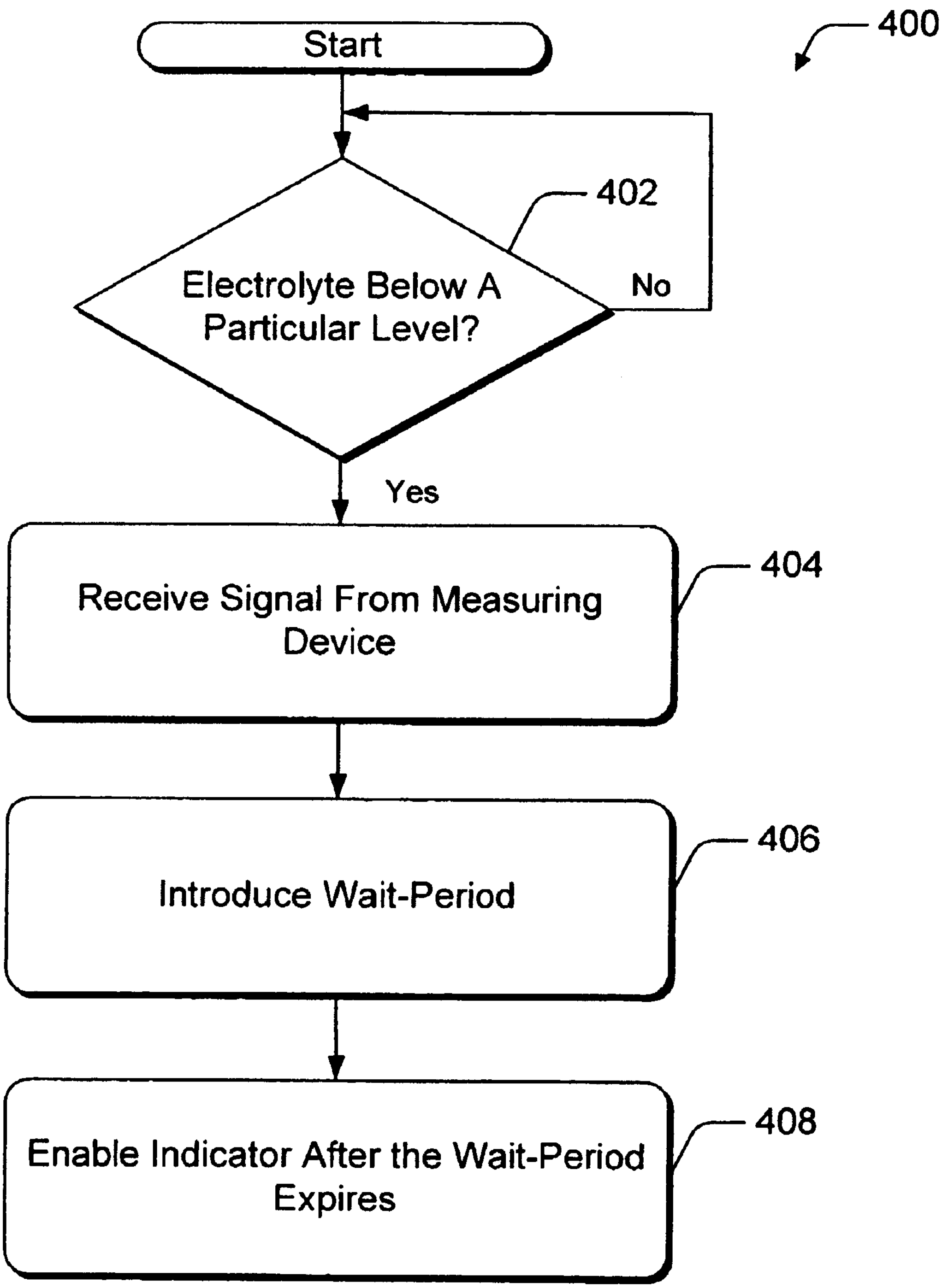

400
Start
402
Electrolyte Below A Particular Level?
No
Yes
Receive Signal From Measuring Device
404
Introduce Wait-Period
406
Enable Indicator After the Wait-Period Expires
408

Fig. 4

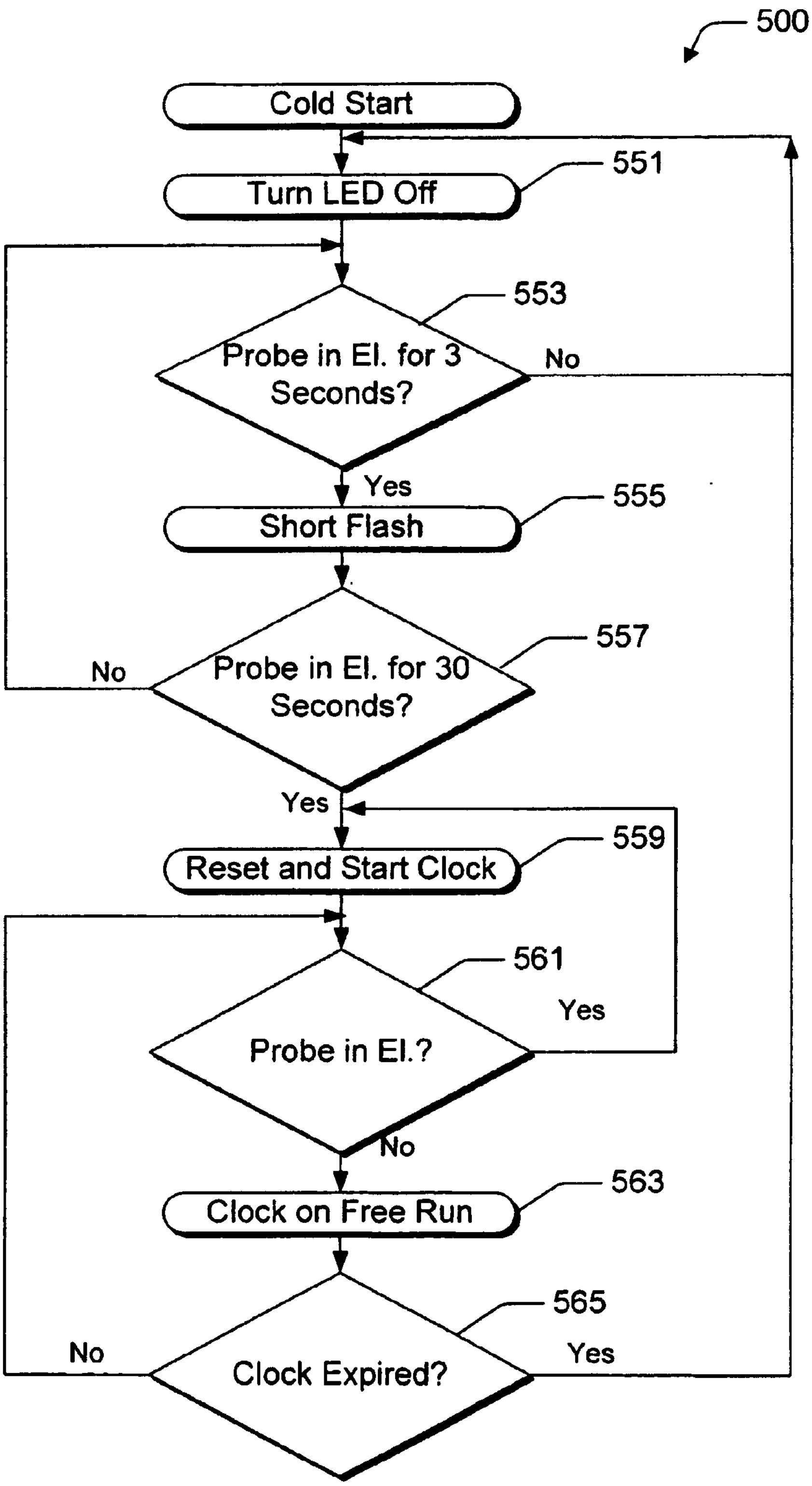

500
Cold Start
Turn LED Off
551
553
Probe in El. for 3 Seconds?
No
Yes
Short Flash
555
557
Probe in El. for 30 Seconds?
No
Yes
Reset and Start Clock
559
561
Yes
Probe in El.?
No
Clock on Free Run
563
565
Clock Expired?
No
Yes

Fig. 5

SYSTEM AND METHOD FOR MONITORING ELECTROLYTE LEVELS IN A BATTERY

CROSS-REFERENCE TO RELATED APPLICATIONS

The present patent application claims benefit of U.S. Provisional Application Ser. Nos. 60/477,989 and 60/484,855 filed on Jun. 12, 2003 and Jul. 3, 2003, respectively. The contents of the aforementioned applications are fully incorporated by reference herein.

TECHNICAL FIELD

The present invention relates to batteries, and more specifically, to monitoring electrolyte levels in batteries.

BACKGROUND

Many industrial batteries, for example fork truck batteries, contain an electrolyte solution used for storing and conducting electrical power. Over time water in the electrolyte solution evaporates from the battery causing the electrolyte solution level (the "electrolyte level") to fall. If the electrolyte level falls below a minimal acceptable level in a battery, serious problems can occur to the battery such as reduced electrical power output and/or permanent damage. For example, if the electrolyte level drops below the top edge of a negative plate in the cell of a battery, the negative plate is exposed to air, which rapidly causes the negative plate to oxidize.

To address this problem, numerous devices have been proposed for monitoring the electrolyte level in the battery to ensure that the water is replenished before the electrolyte level drops below the minimal acceptable level. For instance, devices mounted outside the cell of a battery that indicate when the electrolyte level is low are now in common use, see e.g., U.S. Pat. No. 5,936,382, entitled Battery Electrolyte Level Monitor, issued Aug. 10, 1999, incorporated herein by reference. The common principle for most of these devices is a metal probe inserted through the cover of a pilot cell in the battery. Typically, when the tip of the probe touches the electrolyte, the probe sends a signal (via electrical circuitry) to an indicator, such as an alarm or a light, indicating that the electrolyte level in the battery is satisfactory. On the other hand, when the electrolyte level drops below the tip of the probe, it sends another signal to the indicator that the time for re-watering the battery is imminent.

One drawback with these probe-based devices is they cannot easily read the electrolyte level below the top edges of battery separators. Separators are porous plastic sheets that keep the plates apart electronically, but permit ionic current flow between them. If the metal tip of the probe should touch the wet separator in general, or have any ionic contact with the separator whatsoever, for example through a droplet of electrolyte, or tarry substance, or wet particulate matter, etc., then this may cause the probe to continue sending a signal indicating that the electrolyte level is satisfactory, even though the electrolyte may have fallen below the acceptable level. In other words, the probe causes the indicator to illicit a false indication that the electrolyte level is satisfactory, when in fact, it is too low.

As a result, most battery manufacturers have kept their probe tips above the separators and require watering more frequently than is actually needed. However, now there is a demand for batteries that are designed for very low maintenance, i.e., very long watering intervals. That is, there is a

desire to allow the electrolyte levels to drop to a level that is well below the level of the separators, such as to the tops of the plates.

To make the probes more accurate at measuring the electrolyte levels below the separators without touching them, a mechanical "spreader" or shield is used to wedge the separators apart so that the probe can descend between them without touching them or having any ionic tracking paths to the separators.

One limitation with this mechanical solution is the tight tolerances involved. For example, the separators even in a large battery cell may be only a few millimeters apart, and much less on smaller cells. Therefore, the risk of ionic contact with the separators is quite high, which results in a false signal.

Still another limitation with spreader designs is that a hole must be provided in the cell's cover which is aligned perfectly above the positive plate; otherwise, the probe will not fit precisely and may damage the separators. Existing punch-out holes in many batter cell covers, used routinely for level probes—generally do not line up with the plates and cannot be used in conjunction with the spreader designs. The result is a second set of holes must be drilled into the cell covers, which adds labor cost and inconvenience. Thus, there is currently no inexpensive and accurate way to measure electrolyte levels in batteries once the electrolyte levels fall below the top of the separators.

Another drawback associated with current probe designs is their failure to recognize when the electrolyte level in a battery cell falls below the level of the probe. Many times an indirect current path can still exist from the tip of the probe, along the length of the probe, around the inside of a battery cell and finally down the cell wall to the lowered electrolyte level. Although this path is of a higher resistance than a direct current path from the probe tip submerged in the electrolyte, the indirect current path may still cause a false indication.

SUMMARY

A system and method for monitoring electrolyte levels in a battery is described. According to one implementation, the system comprises a measuring device and a controller. The measuring device is located in a battery and is configured to detect when the electrolyte level in the battery falls below a particular level. The controller is in electrical communication with the measuring device. The controller is configured to: (i) receive a signal from the measuring device indicating when the electrolyte level in the battery has fallen below the particular level; (ii) introduce a wait-period after the signal is received; and (iii) enable an indicator to indicate that the electrolyte level in the battery should be refilled after the wait-period expires.

The following description, therefore, introduces the broad concept of using a measuring device, such as a probe-based system, in conjunction with a programmable controller for monitoring the electrolyte level in a battery. The controller is configured to introduce a wait-period after receiving a signal from a measuring device indicating that the electrolyte level in a battery cell has fallen below a particular level, e.g., a level above one or more separators in the battery cell. The wait-period is intended to coincide with an approximate time it takes the electrolyte level to fall from the particular level above the separators to a level below the separators but above the top of plates in the battery cell. The controller introduces the wait-period without having to physically measure the electrolyte level, after the electrolyte level drops below the top of the separators in the battery cell. Accordingly, the

controller waits for the wait-period to expire before enabling an indicator (e.g., an alarm, a light, a message, etc.) to indicate that the battery should be refilled.

The controller also eliminates the need to physically insert a measuring device below the separators where there is a high likelihood of touching the separators or making ionic contact with them. That is, the novel systems and methods described herein are able to provide an indication of the electrolyte level below the separators without a risk of touching the separators or making ionic contact with them. As such, a probe can be inserted in standard punch-out holes provided in the casing of the battery. No drilling or lining-up of the probe with the plates is required, reducing labor costs and inconveniences associated with painstakingly attempting to insert the probe between the separators as may be the case with conventional solutions as described above in the Background.

According to another implementation, the electrolyte level in a battery is monitored when fluid is being added to the battery, i.e., the battery is being refilled. When the electrolyte level rises to a particular level a refill-wait-period is introduced. If the electrolyte level is detected to remain at the particular level for the duration of the refill-wait-period, then an indicator is enabled indicating that the electrolyte level in the battery has reached at least a desired level. The refill-wait-period is programmable duration that may be used to account for accidental splashing of fluids on a measuring device that performs level detection of the electrolyte when refilling the battery with fluid.

According to still another implementation, the electrolyte level is monitored in a battery to detect when the electrolyte level falls below a particular level. A first wait-period is introduced when the electrolyte level in the battery is detected to have fallen below the particular level. The electrolyte level is then monitored to detect whether it rises back above the particular level during the first wait-period. If the electrolyte level in the battery does rise above the particular level during the first wait-period, then the first wait-period is reset. However, if the electrolyte level in the battery does not rise above the particular level during the first wait-period, then a second wait-period is introduced after the first wait-period expires. When the second-wait period expires, an indicator is enabled indicating that the electrolyte level in the battery should be refilled.

The first wait-period may account for situations when the battery probe temporarily emerges from the electrolyte, such as when the battery is in motion or tilted on an angle. To ensure that this does not cause a false indication that the battery needs to refilled, the first wait-period is continually reset each time the probe reenters the electrolyte. Only after the first wait-period expires before being reset, i.e., when the probe remains emerged from the electrolyte for the duration of the first-wait period, is the second-wait period initiated.

According to yet another implementation, a power management system is used to control power supplied to a probe. The system selectively energizes and de-energizes the probe over time. When the probe is energized, a high current is supplied to the probe to reduce the probability of a false connectivity indication that the probe is submerged in electrolyte, when in fact the electrolyte is below the probe. Periodically, switching between the energized and non-energized states enables the overall average current draw to remain relatively low over time despite supplying a high current to the probe. The relatively high current enables the current draw between direct and indirect paths to be large and easily distinguishable, increasing the accuracy of electrolyte level detection without incurring a penalty for using a higher current.

This and other implementations will be described below when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The detailed description is described with reference to the accompanying figures. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears.

FIG. **1** illustrates a cross-sectional view of an exemplary aqueous battery in which it is desirous to monitor electrolyte levels therein.

FIG. **2** illustrates a schematic diagram of an exemplary implementation of a controller shown in FIG. **1**.

FIG. **3** illustrates an alternative schematic diagram of another exemplary implementation of the controller shown in FIG. **1**.

FIG. **4** illustrates an exemplary method for monitoring electrolyte levels in a battery.

FIG. **5** illustrates a more detailed exemplary method for monitoring electrolyte levels in a battery.

DETAILED DESCRIPTION

Exemplary Battery

FIG. **1** illustrates a cross-sectional view of an exemplary aqueous battery **102**, such as a lead acid or nickel-cadmium battery, in which it is desirous to monitor electrolyte levels therein. Battery **102** includes: a container **104**, a negative plate **106(1)**, a positive plate **106(2)**, a separator **108**, and a vent **112**. It is to be appreciated that additional components (not shown) can be included in battery **102**. For example, additional plates, separators, vents, and so forth may be included in battery **102**. Additionally, battery **102** may comprise additional cells that are not necessarily located in the same container **104**. It is assumed that those skilled in the art are familiar with the basic components as well as the operational principles of an aqueous battery.

During charging of battery **102**, water is electrolyzed to hydrogen and oxygen gases which exit container **104** via vent **112**. The result is a gradual lowering of the electrolyte level in battery **102**.

Exemplary Monitoring System

Accordingly, connected to battery **102** is a novel monitoring system **126** for monitoring the electrolyte level in battery **102**. In the exemplary implementation, monitoring system **126** comprises a measuring device **128**, an indicator **130**, and a controller **132**.

In one implementation, monitoring system **126** monitors three levels of electrolyte (electrolyte levels) in battery **102**: a lowest electrolyte level **114**, an interim level **120**, and a highest level **124**. The lowest electrolyte level **114** is the lowest safe level for electrolyte solution should be allowed to reach, which coincides to the tops **118(1)** and **118(2)** of the plates **106(1)** and **106(2)**. Interim level **120** coincides with the top **122** of separator **108** and highest level **124** represents a maximum electrolyte height recommended by the manufacturer of the battery and is usually the level after the battery **102** has been refilled with water or some other type of solution. Other levels may also be monitored by the monitoring system **128**.

Measuring device **128** may be any type of device configured to detect when the electrolyte level in the battery falls below a particular level. For example, in one implementation measuring device **128** comprises a probe **134** inserted through a hole (not shown) in the top **136** of container **104**. Probe **134** senses whether its tip **138** is submerged in the electrolyte or the electrolyte level is below the tip **138** of probe **134**. In other words, probe **134** is configured to detect whether the electrolyte level is above or below the particular level coinciding with tip **138**, which in one implementation also coincides with the interim level **120**. It is also possible that the particular level may coincide with other levels in the battery, higher than the interim level or potentially lower than the top **122** of separator **108**.

In alternative implementations, probe **134** may be inserted from the side **137** of container **104** instead of the top **136**. Additionally, it is also possible to have multiple probes located in battery **102** (whether from the side or top), for measuring the electrolyte levels in different cells and/or different electrolyte levels. It should be appreciated to those skilled in the art that the measuring device **128** may take various other forms, such as a strip, an optical sensor, or some other type of measuring device capable of sensing whether the electrolyte level falls below a particular level.

Indicator **130** is a device capable of providing an indication to people that the battery may need to be serviced. For instance, in one implementation, indicator **130** is a light that remains illuminated when the electrolyte level is satisfactory, and is turned-OFF, i.e., extinguished or deactivated, signaling that the time for refilling the battery is imminent. Alternatively, the light may be illuminated when it is time for refilling and deactivated when the electrolyte level is satisfactory.

In other implementations, it is also possible for the indicator to be configured to provide different types of indications as the electrolyte level approaches the lowest recommended electrolyte level **114**. For example, the indicator **130** may provide a forewarning indication of a different color, such as yellow, indicating that the electrolyte level is quickly approaching the lowest recommended electrolyte level **114**. A red light may then be illuminated when the electrolyte level actually reaches the lowest safe level, which coincides to the tops **118(1)** and **118(2)** of the plates **106(1)** and **106(2)**.

In alternative implementations, indicator **130** may take various forms including: an audio alarm, a message displayed on a display device such as a user-interface on a dashboard, a message indicating whether the electrolyte level is satisfactory or not such as an e-mail message sent over a network, multiple lights having various potential colors, an analog or digital gauge showing a full and recommended refilling levels, a combination of any of the aforementioned formats, and other potential indicators.

Controller **132** is a control module that controls the operation of monitoring system **126**, such as when to enable indicator **130** to signal (i.e., indicate) that the electrolyte level in the battery should be refilled. In one implementation, controller **132** is connected to measuring device **128** and indicator **130** via a link **131**, such as a wired or wireless link. Accordingly, controller **132** is in "electrical communication" with measuring device **128** and indicator **130**.

In one implementation, controller **132** includes one or more processor(s) **150** that can be configured to implement the inventive techniques described herein. Processor(s) **150** process various instructions to control the operation of the monitoring system **126** and possibly to communicate with other electronic and computing devices.

Controller **132** may also include one or more memory components **152** such as volatile or non-volatile memory (also collectively referred to as computer readable media). For example, controller **132** may include a firmware component **154** that is implemented as a permanent memory module stored in memory components **152**. Firmware **154** is programmed and tested like software, and may be distributed with battery **102** (or separately on a disk or over the Internet

such as in the form of an update). Firmware **154** can be implemented to coordinate operations monitoring system **126** such as controlling the indicator **130**, and contains programming constructs used to perform such operations.

Thus, memory components **152** may store various information and/or data such as configuration information, operating parameters about the battery, charging information, and other information. For example, contained within memory components **152** are modules that contain code, such as in the form of firmware **154** and/or logic, used by controller **132** to monitor whether the electrolyte level is above or below a particular level.

It is to be appreciated that the components and processes described with reference to controller **132** can be implemented in software, firmware, hardware, or combinations thereof. By way of example, a programmable logic device (PLD) or application specific integrated circuit (ASIC) could be configured or designed to implement various components and/or processes discussed herein.

Controller **132** may include an input **137**, which is one or more variety of components such as pin(s) on a microprocessor chip configured to receive one or more signals from measuring device **128**. The signals indicate whether the electrolyte level in the battery is above or below a particular level, such as interim level **120**. The signals themselves may be logical signals such as logical "one" indicating that the electrolyte level has dropped below the particular level and logical "zero" indicating that the electrolyte level is above a particular level, or vice versa.

Controller **132** may also include an output **139** configured to transmit a signal to indicator **130** to induce indicator **130** to provide an indication (visual and/or auditory) whether the electrolyte level in the battery **102** should be refilled or not and potentially other indications. Like input **137**, output **139** represents one or more variety of components such as pin(s) on a microprocessor chip configured to transmit one or more signals.

Having introduced the various components of a exemplary battery and monitoring system **126**, it is now possible to describe specific functionality provided by monitoring system **126**.

Wait Period

Controller **132** receives a signal (either active high or active low) from measuring device **128** indicating when the electrolyte level in battery **102** has fallen below the interim level **120**. At this point after the signal is received, controller **132** introduces a wait-period. The wait-period is intended to coincide with an approximate time it takes the electrolyte level to fall from the particular level above the separators to a level below the separators but above the tops **118(1)** and **118(2)** of the plates **106(1)** and **106(2)**. Controller **132** introduces the wait-period without having to physically measure the electrolyte level, after the electrolyte level drops below the top **122** of separator **108**. Accordingly, controller **132** waits for the wait-period to expire before enabling indicator **130** (e.g., an alarm, a light, a message, etc.) to indicate that the time for refilling the battery should be performed.

Controller **132** when used in conjunction with a measuring device eliminates the need to physically insert measuring devices below a separator **108** where there is a high likelihood of touching the separator **108** or making ionic contact with it. That is, monitoring system **126** provides an indication of the electrolyte level below a separator without risking touching the separators or making ionic contact with them. As such, a probe can be inserted in standard punch-out holes provided in the container **104** of battery **102**. No drilling or lining-up of a measuring device **128** (such as a probe) with plates **106** is required, reducing labor costs and inconveniences associated with painstakingly attempting to insert the probe between the separators as may be the case with conventional solutions as described above in the Background.

Using a programmable controller **132** also facilitates providing an extremely low maintenance battery, i.e., a battery with very long watering intervals. The extra increment of time gained between water operations attained by introducing the wait-period in accordance with the novel implementations described herein, reduces the water intervals and adds commercial value to the battery. By allowing the electrolyte level to drop to the top of the plates **106**, well below the tops of one or more separators, extends the water maintenance interval time over that of most batteries with conventional probe-based detection systems. In essence the battery is considered to be a lower maintenance battery.

In one implementation, controller **132** includes a wait-module **156** configured to introduce the wait-period after the signal is received from the measuring device **128** indicating that the electrolyte level in the battery has fallen below a particular level, such as the interim level **120**.

In one implementation, the wait-period is a programmable period of time that may be predetermined and programmed into controller **132**. The wait-period may include any period of time, but typically ranges from hours-to several days. For example, for most batteries it is anticipated that the wait-period will range from one or more days to about 50 days or more, before controller **132** enables indicator **130** to indicate that the time for refilling battery **102** has arrived.

Wait-module **156** may determine the wait-period several different ways. For instance, in one implementation, the wait-period is a programmable period of time. Controller **132** may comprise a counter **158** configured to countdown the programmable period of time to determine the wait-period.

According to another implementation, controller **132** may comprise a charging-cycle module **160**, which is configured to monitor how many cycles of charging the battery experiences as a function of determining the wait-period, i.e., the period of time used by counter **158** to countdown. According to this implementation, controller **132** would be configured keep track of charging cycles.

According to another implementation, controller **132** may comprise a water-loss estimation module **162**, configured to estimate a rate of electrolyte loss for the battery as a function of the age of the battery, and adjust the wait-period (i.e., the period of time used by counter **158** to countdown) accordingly. For example, water-loss estimation module **162** may take into account variable water consumption rates of old versus new batteries containing antimonial grids.

According to yet another implementation, controller **132** may comprise a temperature/charge-rate compensation module **164** to further estimate a wait-period.

Thus, the wait-period may be preset or be dynamically adjusted to account for various parameters, such as the age of the battery, temperatures, charging cycles, water-rate-loss, etc.

First and Second Wait Periods

According to still another implementation, controller **132** monitors the electrolyte level battery **102** to detect when the electrolyte level falls below a particular level, such as interim level **120**. This time another wait-period is introduced called, a "first wait-period" when the electrolyte level in the battery is detected to have fallen below the particular level. The electrolyte level is then monitored to detect whether it rises back above the particular level during the first wait-period. If the electrolyte level in the battery does rise above the particular level during the first wait-period, then the first wait-period is reset (a counter is reset). However, if the electrolyte level in the battery does not rise above the particular level during the first wait-period, then a second wait-period (typically a longer "wait-period" such as described above) is introduced after the first wait-period expires. When the second-wait period expires, controller **132** enables indicator **130** to indicate that the electrolyte level in the battery should be refilled.

The first wait-period is designed to account for situations when measuring device **128** temporarily emerges from the electrolyte, such as when the battery is in motion or tilted on an angle. To ensure that this does not cause a false indication that the battery needs to refilled, the first wait-period is continually reset each time the probe reenters the electrolyte. Only after the first wait-period expires before being reset, i.e., when the measuring device **128** remains emerged from the electrolyte for the duration of the first-wait period, does the controller **132** initiate the second-wait period.

In one implementation, the first wait-period is a programmable period of time that may be predetermined and programmed into controller **132**. The first wait-period may include any period of time, but typically ranges for only a few seconds to several minutes. For example, the first wait period may be set to start after about three seconds, and if the measuring device **128** does not remain the electrolyte for about 30 continuous seconds, then the second wait-period will be initiated.

Wait-module **156** may determine the "first wait-period" several different ways. For instance, in one implementation controller **132** may comprise a counter **166** configured to countdown the programmable period set for the first wait-period. For instance, counter **166** counts may be set to start after about three seconds (another counter, not shown, may be used to start the initial count period) and if the measuring device **128** does not remain the electrolyte for about 30 continuous seconds, then the second wait-period will be initiated. Otherwise, counter **166** will be reset if the measuring device **128** is re-immersed in electrolyte before reaching the end of the 30 second countdown period (i.e., the first wait-period).

Refill Wait-Period

According to another implementation, monitoring system **126** also monitors the electrolyte level in battery **102** when fluid is being added to battery **102**. When the electrolyte level rises to a particular level, controller **132** introduces a refill-wait-period. If the electrolyte level is detected to remain at the particular level for the duration of the refill-wait-period, then controller **132** enables indicator **130** to indicate that the electrolyte level in the battery **102** has reached at least a desired level.

The refill-wait-period is programmable for a duration that may be used to account for accidental splashing of fluids on measuring device **128** when refilling the battery with fluid. For instance, a mere splash of acid onto a probe could reset the logic in controller **132** and enable the indicator **130** to indicate that the battery **102** is full. This may cause a maintenance operator servicing the battery to think that the cell(s) of the battery are full when they are not, which may cause confusion. Accordingly, an appropriate time delay (the refill-wait-period) configured in controller **132**, ensures that the indicator does not indicate that cell(s) of battery **102** are full until measuring device **128** makes continuous contact with the electrolyte for the period of the time delay.

For instance, in one implementation controller **132** may also include a refill module **170** configured to introduce the refill-wait-period. In one implementation, the refill wait-period may be set for several seconds, i.e., such as two to ten seconds or enough to account for accidental splashing. A counter **172** may countdown the re-fill period to ensure that the electrolyte level makes continuous contact with the measuring device **128** before enabling controller **132** to enable indicator **130**.

Power Management

According to yet another implementation, controller **132** may comprise a power management module **176** to control power supplied to the measuring device **128**. That is, controller **132** selectively energizes and de-energizes the measuring device **128** over time. When the measuring device **128** is energized, a high current is supplied to the measuring device to reduce the probability of a false connectivity indication that the measuring device **128** is submerged in electrolyte, when in fact the electrolyte is below the electrolyte detection device. Periodically, switching between the energized and non-energized states enables the overall average current draw (or voltage draw) to remain relatively low over time despite supplying a high current (or voltage) to the measuring device device. Whereas, the relatively high current enables the current draw between direct and indirect paths to be large and easily distinguishable, therefore increasing the accuracy of electrolyte level detection without incurring a higher current draw.

In one implementation, the high current supplied to the measuring device is about approximately 100 milliamperes, however, the high current could also be greater or smaller. For instance, the high current could be less than 100 milliamperes, so long as the high current is distinguishable from the indirect current paths.

In one implementation, controller **132** selects (i.e., switches) between a test mode and a non-test mode. During the test mode, controller **132** energizes measuring device **128** to enable the measuring device **128** to ascertain whether the electrolyte level is above or below a particular level. During the non-test mode controller **132** deactivates (or de-energizes power to) measuring device **128**. In one implementation, controller switches between the test mode and non-test mode about every second. However, during the period of the test mode controller **132** only requires a few milliseconds to determine the status of the measuring device **128**, i.e., whether the electrolyte level is above or below the measuring device **128**. Thus, energizing the measuring device **128** for only a few milliseconds before de-energizing it, allows current draw over time to remain on average at about five milliamperes, or equivalent to constantly energizing the measuring device **128** with a smaller current.

Although controller **132** is shown to include various distinct functional blocks (a wait module **156**, a water-loss estimation module **162**, a refill module **170**, etc.), it is understood that when actually implemented in the form of computer-executable instructions, logic, firmware, and/or hardware, that the functionality described with reference to each block may not exist as separate identifiable modules. Controller **132** may also be integrated with other components or as a module in a larger system.

Exemplary Implementations of Control Module

FIG. **2** illustrates a schematic diagram of an exemplary implementation of the controller **132** shown in FIG. **1**. Referring to FIG. **2**, an input **231** of the controller **132** is coupled to a measuring device **126** (FIG. **1**). Input **231** is coupled to the base **232** of transistor **233** across resistor **235** and is also coupled across resistor **237** to terminal **239**, which is coupled to −VE potential of battery **102**.

Resistor **237** serves as a current to voltage translator, creating a voltage drop across resistor **237** when current flows from input **231** to terminal **239**. Resistor **235** serves to limit the amount of current that flows to base **232** of transistor **233**.

When measuring device **128** (FIG. **1**) is immersed in the electrolyte contained in container **104** (FIG. **1**), the electrolyte functions to close the circuit between first input **231** and terminal **239**. This creates a voltage drop across resistor **235** sufficient to drive transistor **233** into saturation. When transistor **233** is on, the circuit path from terminal **238** to terminal **239** is closed through resistor **244**. This results in causing a low level logic or logical zero being applied to pin **4** of a microcontroller **240**.

When measuring device **126** is not immersed in the electrolyte, the circuit between input **231** and terminal **239** is opened. This causes the potential between the base **232** of transistor **233** and the drain of terminal of transistor **233** to become zero and transistor **233** turns off. This will cause pin **4** of microcontroller **240** to realize an input voltage equal to terminal **238** i.e., +VE. This is equivalent of a logical one provided to pin **4**.

Microcontroller **240** is programmed to recognize the change from a logical zero to a logical one on pin **4** as an indication that the measuring device **126** is no longer immersed in the electrolyte in battery **102**, and control indicator **130** (which in this implementation comprises two LEDs), which is coupled to microcontroller **240** after one or more wait-periods according to preprogrammed set of conditions.

In the exemplary implementation illustrated in FIG. **2**, microcontroller **240** is a 12F629 chip manufactured by Microchip of Chandler, Ariz., USA. It is, however, understood that one of skill in the art would appreciate that numerous chips and/or other devices could be used in place of this specific microcontroller **240**.

A clock circuit **245** comprising a crystal controlled clock **246** and a set of capacitors **247** and **248** facilitate control of indicator **130** by microcontroller **240**. Clock circuit **245** provides the time mechanism required to allow microcontroller **240** to control indicator **130** in accordance with preprogrammed conditions.

FIG. **3** illustrates an alternative schematic diagram of another exemplary implementation of controller **132** shown in FIG. **1**. FIG. **3** includes the addition of a switch **302** coupled to both the microcontroller **240** and measuring device **128**. Microcontroller **240** operates in a selectable test mode and non-test mode. When microcontroller **240** selects the test mode, microcontroller **240** enables power to be supplied to measuring device **128**. That is, the microcontroller **240** causes the switch **302** to couple the power supply +VE/−VE to measuring device **128** when the microcontroller is in the test mode, which energizes the measuring device and allows microcontroller **240** to determine the electrolyte level in the battery is above or below a particular level. When in the non-test mode, microcontroller **240** disconnects (decouples) measuring device **128** enabling the measuring device **128** to be de-energized. Repetitively switching between the test mode and the non-test mode causes the measuring device to be energized and de-energized repetitively over time, which allows a high current to be supplied to the measuring device **128**, when in the test mode.

Methods of Operation

FIG. **4** illustrates an exemplary method **400** for monitoring electrolyte levels in a battery. Method **400** enables the electrolyte levels to be monitored below the tops of separators in a battery without having to actually insert a sensor below the separators. Method **400** includes blocks **402**, **404**, **406** and **408** (each of the blocks represents one or more operational acts). The order in which the method is described is not to be construed as a limitation, and any number of the described method blocks can be combined in any order to implement the method. Furthermore, the method can be implemented in any suitable hardware, software, firmware, or combination thereof.

In a decisional block **402**, the electrolyte level in the battery is monitored to detect whether it falls below a particular level. For example, controller **132** (FIG. **1**) detects whether tip **138** (FIG. **1**) of probe **134** (FIG. **1**) is submerged in the electrolyte or the electrolyte level is below the tip **138** (FIG. **1**), which generally coincides with a level the top **122** (FIG. **1**) of separator **108** (FIG. **1**) in battery **102** (FIG. **1**). If the electrolyte level is not below the particular level, then according to the NO branch of decisional block **402**, method **400** loops back and continues to monitor the electrolyte level. If the electrolyte level falls below the particular level, then according to the YES branch of decisional block **402** method **400** proceeds to block **404**.

In block **404**, if the electrolyte falls below the particular level a signal is received by the controller **132** (FIG. **1**) indicating that electrolyte level is below the particular level.

In block **406**, a wait-period is introduced when the electrolyte level in the battery **102** is detected to have fallen below a particular level. For example, controller **132** starts a counter **158** that counts down a particular period of time.

In block **408**, a warning is made that the electrolyte level in the battery should be refilled after the wait-period expires. For example, controller **132** sends a signal to indicator **130** enabling it to indicate (light, sound an alarm, display a message, etc.) that water should be added to battery **102**.

FIG. **5** illustrates a more detailed exemplary method for monitoring electrolyte levels in a battery. Method **500** includes blocks **551**, **553**, **555**, **557**, **559**, **561**, **563** and **565** (each of the blocks represents one or more operational acts). The order in which the method is described is not to be construed as a limitation, and any number of the described method blocks can be combined in any order to implement the method. Furthermore, the method can be implemented in any suitable hardware, software, firmware, or combination thereof.

In block **551** an indicator is turned-OFF (in this example when the indicator is turned-OFF it is actually enabled—meaning that the electrolyte level needs to be refilled). In a decisional block **553** a determination is made whether a measuring device has been in the electrolyte for a short period time, such as several seconds. If according to the YES branch of decisional block **553**, the measuring device has been immersed in the electrolyte for the short period of time (e.g., three seconds), method **500** proceeds to block **555**. If according to the NO branch of decisional block **553**, the measuring device has not been immersed in the electrolyte for the short period of time, then method **500** proceeds back to block **551**.

In block **555** an indicator is enabled. For example, a light (e.g., light emitting diode) is turned-ON, meaning the indicator is actually indicating that the electrolyte level is satisfactory and does not need to be refilled.

In a decisional block **557**, a determination is made whether the measuring device remains immersed in the electrolyte for another short duration of time. For example, a determination is made whether the measuring device **128** (FIG. **1**) remains in the electrolyte for thirty continuous seconds. If according to the NO branch of decisional block **557**, if the measuring device does not remain in the electrolyte, method **500** proceeds to block **553**. If according to the YES branch of decisional block **557**, if the measuring device does remain the electrolyte, method **500** proceeds to block **559**.

In block **559** a timer for a clock is initiated, i.e., a counter starts counting down the wait-period. However, according to the YES branch of decisional block **561**, if the measuring device remains in the electrolyte the counter will either be reset or will not count-down, and method **500** returns to block **559**.

If according to the NO branch of decisional block **561**, if the measuring device does not remain in the electrolyte, method **500** proceeds to block **563** and the counter counts down the wait-period, (whether predetermined or dynamically chosen depending on various parameters such as age of the battery, charging cycles, water loss rate, etc.).

Once the wait-period expires, e.g., counter finishes counting down the wait-period, method **500** proceeds to block **551** and turns-off indicator **130** (e.g., enables indicator to indicate that aqueous solution should be added to battery **102** because the electrolyte level has most likely reached the tops of the battery plates.

Although the invention has been described in language specific to structural features and/or methodological acts, it is to be understood that the invention defined in the appended claims is not necessarily limited to the specific features or acts described. Rather, the specific features and acts are disclosed as exemplary forms of implementing the claimed invention.

What is claimed is:

1. A system for monitoring the electrolyte level in a battery having one or more separators between positive and negative plates in a cell of the battery, the one or more separators having a top which is at a level that is higher than a top of the plates, said system comprising:

a measuring device, suitable to be located in said battery, configured to detect when the electrolyte level in the battery falls below a first level which is above the tops of the separators in said battery; and

a controller, in electrical communication with the measuring device, configured to (i) receive a signal from the measuring device indicating when the electrolyte level in the battery has fallen below said first level, (ii) introduce a wait-period after the signal is received, and (iii) enable an indicator to indicate that the electrolyte in the battery should be refilled after the wait-period expires;

wherein said wait-period represents an appropriate time it takes the electrolyte level to fall from said first level to a second level which is below the tops of said separators and above the tops of said plates.

2. The system as recited in claim **1**, wherein during the wait-period the controller is further configured to enable the indicator to indicate that the electrolyte level in the battery is approaching said second level as a forewarning to actually providing the indication that the electrolyte level in the battery should be refilled.

3. The system as recited in claim **1**, wherein the wait-period is a programmable period of time.

4. The system as recited in claim **1**, wherein the controller comprises a counter configured to count down a programmable period of time comprising the wait-period.

5. The system as recited in claim **1**, wherein the controller comprises a charging-cycle module configured to monitor the number of cycles of charging the battery experiences after said signal is received and wherein said wait-period is a function of said number of cycles of charging.

6. The system as recited in claim **1**, wherein the controller comprises a water-loss estimation module, configured to estimate a rate of electrolyte loss for the battery as a function of the age of the battery, and adjust the wait-period accordingly.

7. The system as recited in claim 1, wherein the indicator is one or more lights that are activated to signify that the electrolyte level in the battery should be refilled.

8. A battery, comprising:

one or more cells having disposed therein positive and negative plates, a separator disposed between said positive and negative plates, and a liquid electrolyte within said cells having an electrolyte level, said separator having a top which is at a level above a top of said positive and negative plates;

a probe, located in at least one of said battery cells, configured to detect when said electrolyte level falls below a first level which is above the tops of said separators;

an indicator; and

a controller, in electrical communication with the probe, configured to (i) receive a signal from the probe indicating when the electrolyte level in the battery has fallen below said first level, (ii) introduce a wait-period after the signal is received, and (iii) enable the indicator to signify that the electrolyte in the battery should be refilled when the wait-period expires;

wherein said wait-period is chosen to allow the electrolyte level to fall from said first level to a second level which is below the tops of said separators and above the tops of said positive and negative plates.

9. The battery as recited in claim 8, further comprising an electrical circuit connecting the controller to the probe, the electrical circuit configured to enable the signal to be sent to the controller when the probe detects that the electrolyte level is below said first level.

10. The system as recited in claim 1, further comprising:

means for receiving the signal from the measuring device indicating whether the electrolyte level in the battery is above or below the measuring device; and

means for repetitively energizing and de-energizing the measuring device over time.

11. The system as recited in claim 10, wherein the means for repetitively energizing and de-energizing the measuring device over time comprises the controller.

12. The system as recited in claim 10, wherein the means for receiving the signal from the measuring device is an input terminal of the controller.

13. The battery as recited in claim 8, further comprising:

means for receiving the signal from the probe indicating whether the electrolyte level in the battery is above or below the probe; and

means for repetitively energizing and de-energizing the probe over time.

14. The battery as recited in claim 13, wherein the means for repetitively energizing and de-energizing the probe over time comprises the controller.

15. The battery as recited in claim 13, wherein the means for receiving the signal from the probe is an input terminal of the controller.

16. A system for monitoring the electrolyte level in a battery having one or more separators between positive and negative plates in a cell of the battery, the separator having a to that is at a level which is higher than a to of the plates, said system, comprising:

a measuring device for detecting when an electrolyte level in the battery falls below a first level which is above said top of said one or more separators, said measuring device comprising a probe positioned at said first level; and

a controller, in electrical communication with the measuring device, configured to (i) receive a signal from the measuring device indicating when the electrolyte level in the battery has fallen below said first level, (ii) introduce a wait-period after the signal is received, the wait-period being chosen to allow the electrolyte level to continue to fall to a second level which is below the tops of said separators and above the tops of said plates, and (iii) enable an indicator to indicate that the electrolyte in the battery should be refilled after the wait-period expires.

17. A system for monitoring the electrolyte level in a battery having a separator between positive and negative plates in a cell of the battery and a lowest recommended electrolyte level which is above the positive and negative plates, the separator having a top which is at a level that is higher than the lowest recommended electrolyte level, said system comprising:

a measuring device, located in said battery, configured to detect when the electrolyte level in the battery falls below a first level which is above the to of said separator;

a controller, in electrical communication with the measuring device, configured to (i) receive a signal from the measuring device indicating when the electrolyte level in the battery has fallen below the first level, (ii) introduce a wait-period after the signal is received, and (iii) enable an indicator to indicate that the electrolyte in the battery should be refilled after the wait-period expires; and

wherein said wait-period is chosen to allow the electrolyte level to fall from said first level to a second level which is below the top of said separator and no lower than said lowest recommended electrolyte level.

* * * * *

EXHIBIT C

Battery Watering Technologies

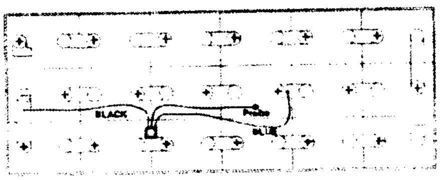
Installing the i-Lite Sensor
Part # BSVA-1000
Intended for Installation by Qualified Personnel

This package contains:
1 - i-Lite BSVA-1000 Sensor
1 - Grommet
2 - Self tapping screws
3 - Cable ties

Tools required for installation
- Towel to wipe down the top of the battery
- Drill
- Phillips screwdriver bit
- 1/2" (12 mm) drill bit
- Insulated wirecutters

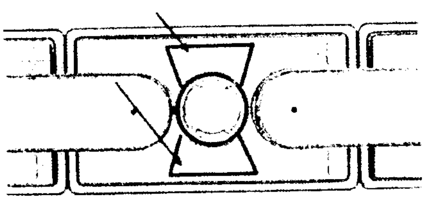
- **Always wear personal protective equipment (goggles, gloves, etc.) to protect yourself from sulfuric acid.**
- **Be sure the battery is disconnected from the charger to ensure the cells are not gassing before proceeding.**
- **Not recommended for use with battery additives.**
- **Read instructions in entirety before beginning the installation.**

STEP 1: PLAN
The electrolyte probe must be at least 4 cells to the positive side of the negative (black) wire connection. Take this into consideration when planning your installation. The sensor needs 8-12 volts to function properly.

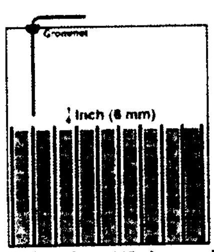


Example of 18 Cell Installation

STEP 2: DRILL
Choose a cell where the level probe will be inserted. **(Reminder: you must have at least 4 cells to the positive from the black (negative) wire.)** Drill a 1/2" hole in the cover of the level probe cell. The hole should be drilled between the vent opening and the edge of the cell to avoid cell internals. Do not drill into the battery plates.

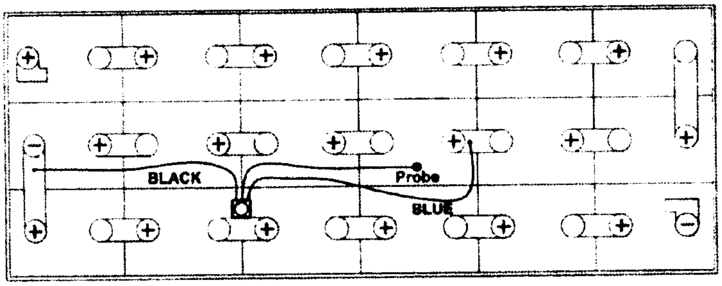

Example of Drill Zone

STEP 3: TRIM PROBE
Cut the probe to length. When fully inserted, the tip of the probe should be approximately 1/4" above the plates or moss shield. Insert the grommet into the hole and then insert the probe through the hole in the grommet.


Trim end of probe 1/4" above plates or moss shield

STEP 4: CONNECT

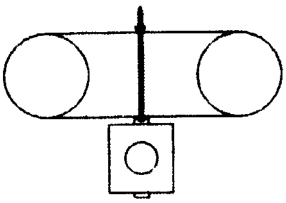
Connect the BLUE wire to the POSITIVE side of the cell that the probe is installed into. Count four (4) cells in the direction of the main negative post, including the cell the probe is installed in and connect the BLACK wire to the NEGATIVE side of the fourth cell.



Example of where to make connections on an 18 cell battery

STEP 5: SECURE HOUSING

Secure the sensor light housing using cable ties supplied. The example shows a method of attaching the housing to an intercell connector using the supplied cable tie. Make sure wires are secured so they cannot be snagged or pulled.



Tie down example for electronic housing

LED COLOR CODES

Solid green - Battery is OK
Solid red - Add water
Blinking red - Electrolyte level has been below the probe for more than ten (10) days.

To find out the number of days the system has been low on water, simply disconnect (BLUE-POWER) wire for five (5) SECONDS and then reconnect. The device will go into RESET MODE. Count the number of blinks to determine how many days / months the battery was low on water. A fast blink indicates how many days it was without water, a slow blink indicates how many months.

Reset Mode:
Fast blink - days
Slow blink - months

P: 336-714-0448
F: 336-714-0449
T: 877-522-5431
www.batterywatering.com
SensorInstall_BSVA1000_Rev. 1112

Battery Watering Technologies

EXHIBIT D

Battery Watering Technologies

The leader in battery watering technology

STANDARD WARRANTY

Battery Watering Technologies is a division of FourShare, LLC herein referred to as BWT, located in Clemmons, North Carolina. BWT makes only those warranties to original buyer as are contained in sales invoice or other written materials provided by BWT, if any. Equipment and accessories not manufactured by BWT are warranted only to the extent of the original manufacturer's warranty, if any. BWT's liability for or arising out of any defective or nonconforming equipment, service, or accessories is limited to repair or replacement or return of purchase price, FOB BWT Sales Office in Clemmons, North Carolina, USA, which is agreed to be buyer's sole and exclusive remedy.

All BWT valves, floats, and gaskets are warranted to be free of defects in workmanship and materials for a period of five (5) years from date of shipment. If BWT valves, floats or gaskets are determined to be the cause of a battery cell failure, BWT will repair or replace the damaged battery or cell within the warranty period at the discretion of BWT. Warranty date will be determined by valve date and/or invoice date. If defects in workmanship or materials are found within that period, the valve, float, and gasket will be replaced.

Buyer acknowledges that the limitations and disclaimers herein described are conditions of sale and that they constitute the entire agreement between the parties regarding warranty or any other liability.

All BWT items other than valves, floats, and gaskets are warranted to be free of defects in workmanship and materials for a period of one (1) year from date of shipment. If defects in workmanship or materials are found within that period, the BWT items will be repaired or replaced.

No warranty whatsoever will apply if and when our operating and maintenance instructions are not complied with or a change is made to the system or parts are exchanged or consumables are used which are not in compliance with our original specifications or recommendations.

The customer must notify us in writing of any defect without delay, but no later than within one (1) week from receipt of the supplied item. The customer is obligated to take random samples of each delivery. Defects that cannot be ascertained within such period of one (1) week through careful inspection and despite the random tests must be notified to us in writing immediately after discovery thereof.

Any defective products will be repaired or exchanged by us at no cost during the warranty period or we will issue a respective credit note to you. The customer will, however, be entitled to claim rescission of the contract or reduction of the purchase price if and to the extent that repair or replacement fail.

In the event of notification of a product defect by the customer, the product complained about must be sent to us for inspection. The preceding paragraphs contain our warranty for our deliveries in a final manner and exclude any other warranty claims of any kind whatsoever.

These warranties are subject to the following terms and conditions:

1. Copy of original sales invoice to user is required.
2. Defective part to be returned to BWT to determine the true warranty cause.
3. Proper operating pressure and installation and maintenance instructions must be followed.
4. BWT products must be installed by an authorized Representative of BWT who has been trained in the proper installation and filling techniques.
5. BWT products must be used with compatible BWT filling device(s) or used within proper pressure ranges as stated in BWT's operating instructions.
6. Labor rate charge on warranty claims will be $50 per hour.

EXHIBIT E

Apply this label to your battery after installing your electrolyte level indicator.

The label should be applied to a clean surface on the battery close to where the monitor is mounted. It can be placed on the cover or on the side of the battery where the watering system input coupling comes off the battery.

Do not cover existing labels.

i-Lite™ Watering Monitor *Monitor de Agua i-Lite™*

Green	Red
Verde	*Roja*
Water Level is OK	**Water Level is Low**
Nivel de agua adecuado	*Nivel de agua bajo*

If light is blinking red, battery has been without water for 10 days or longer. Call for more information.

Si la luz roja parpadea, la batería ha estado sin agua durante 10 o más días. Llame para más información.

Battery Watering Technologies

Faster.
Safer.
Better.

EXHIBIT F

Battery Watering Technologies ®

Call Now : 1-877-522-5431

i-Lite™ Sensor

The smartest, safest, and most accurate way to know when your batteries

need water

The technologically advanced i-Lite™ Sensor improved battery maintenance by alerting operators with the brightest L.E.D visual indication when it is time to water the batteries.

If the indication is ignored, the sensor is so smart, it can tell the operator how long the battery went without water. This unique feature is only available with the Battery Watering Technologies i-Lite™ Sensor. The most intelligent solution to a complex problem!


Green light indicates electrolyte level is okay.


Red light indicates water is needed.

EXHIBIT G

Battery Electrolyte Level Sensor

BSVA-1000 (Standard) and BSVA-2000 (Remote Dash Mount)

Battery Watering Technologies

The smartest, safest, and most accurate way to know when your batteries need water.

The technologically advanced i-Lite™ Sensor improves battery maintenance by alerting operators with the brightest L.E.D. visual indication when it is time to water the batteries. If the indication is ignored, the sensor is so smart, it can tell the operator how long the battery went without water. This unique feature is only available with the Battery Watering Technologies i-Lite™ Sensor. The most intelligent solution to a complex problem!

Easy to See and Use

- Solid green light means electrolyte level is okay
- Solid red light means water is needed
- Blinking red light means the battery has had low electrolyte level for 10 days or longer
- Re-set mode allows user to determine exactly how many days / months the battery has had low electrolyte level
- Probe can be mounted in the center of the battery and the light placed where it is easy to see
- EPDM Grommet ensures perfect seal between the probe and cell
- No calibration necessary!

Superior Design and Manufacturing

- Light is 1/2" in diameter, very bright visual indication
- Sensor cannot be damaged by electro-magnetic interference
- Low current draw won't drain the battery
- Probe is made from lead so it won't harm the battery
- Low profile reduces damage from battery cables as they move across the top of the battery

Guaranteed Performance

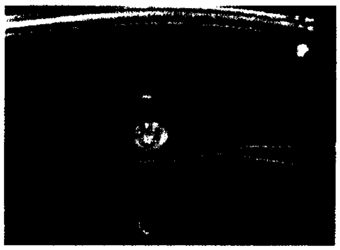
- One-year limited warranty
- The i-Lite™ sensor protects your battery investment and is designed to last the life of your battery

Technical Specifications

Operating Voltage	8 - 16 V Nominal
Current Consumption	30 mA
Acceptable Exposure Range	-20˚F to 160˚F (-29˚C to 71˚C)

Safest Sensor Available

- Electronic housing is separate from the sensor probe
- Multiple fuses - Eliminates any possibility of unrestricted current flow in any direction
- Sensor is protected against transient voltages and incorrect polarity
- Eliminates the need for battery room attendants to peer into vent wells to check electrolyte levels



Electrolyte level is OK

Water is needed

Sensor probe

Faster

Reduce filling time by 90%

Safer

Keep battery area safe and clean

Better

Improve battery life and performance

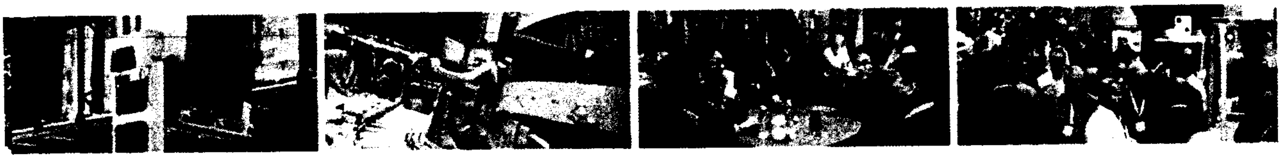
The leader in battery watering technology.™

T: 877-522-5431 P: 336-714-0448 F: 336-714-0449 www.batterywatering.com Sensor_0612

EXHIBIT H

PROMAT 2013

McCormick Place, Chicago
January 21 - 24, 2013



Battery Watering Technologies introduces the i-Lite™ Water Monitor

Battery Watering Technologies
(Booths: 431 5345)

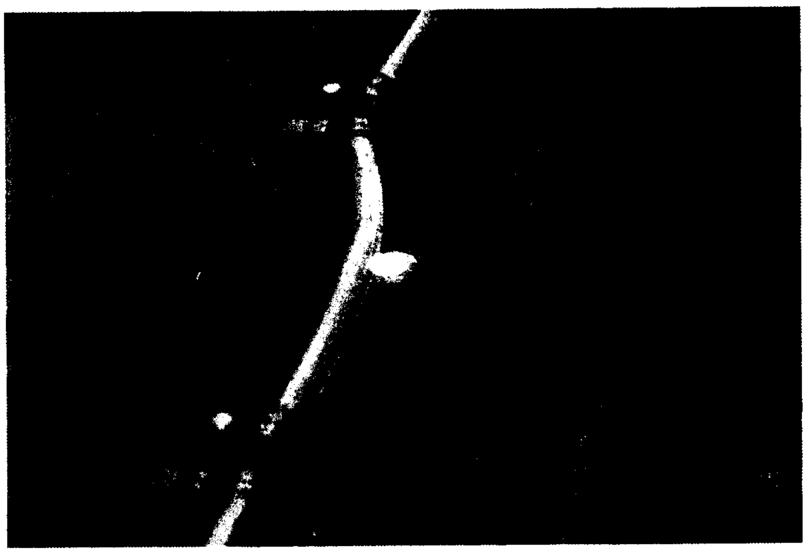
Battery Watering Technologies introduces the i-Lite™ Water Monitor for industrial and golf car batteries. The i-Lite water monitor alerts operators with the brightest L.E.D. visual indication when it is time to water the batteries. A solid green light means the electrolyte level is okay. A solid red light means water is needed. If the red light indication is ignored, the sensor is so smart, it can tell the operator how long the battery went without water.

In addition to this unique feature, the probe can be mounted in the center of the battery and the light can be placed on the battery where it can most easily be seen.

From a safety standpoint, the electronic housing is separate from the sensor probe, making it the safest monitor available. It has multiple fuses, which eliminates the possibility of unrestricted current flow in any direction. The sensor is protected against transient voltages and incorrect polarity.

Battery Watering Technologies brings expertise designing water delivery technology and sets the standard for quality and performance with our new i-Lite™ Water Monitor.

Battery Watering Technologies is comprised of industry leaders in the engineering, manufacturing, and marketing of battery watering systems and water delivery items. For more information: www.batterywatering.com or 1-877-522-5431.



For more information please contact:

Julie Elliott
Battery Watering Technologies
Jelliott@batterywatering.com

« Back to Press Releases