(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
24 December 2014 (24.12.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/204649 A1

(51) International Patent Classification: *H01M 10/48* (2006.01)

(21) International Application Number: PCT/US2014/040997

(22) International Filing Date: 5 June 2014 (05.06.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/836,233 18 June 2013 (18.06.2013) US

(71) Applicant: **ROCKETSHIP, INC.** [US/US]; 110 South 300 East, Provo, UT 84601 (US).

(72) Inventors: **HORITO, Michael, S.**; 381 East 400 South, Provo, UT 84606 (US). **BOMSTA, Zack, D.**; 993 East 200 North, Provo, UT 84606 (US).

(74) Agent: **SCOTT, Russell, C.**; 324 Limestone Trail, Austin, TX 78737 (US).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
— *of inventorship (Rule 4.17(iv))*

Published:
— *with international search report (Art. 21(3))*

(54) **Title**: BATTERY MANAGEMENT SYSTEM

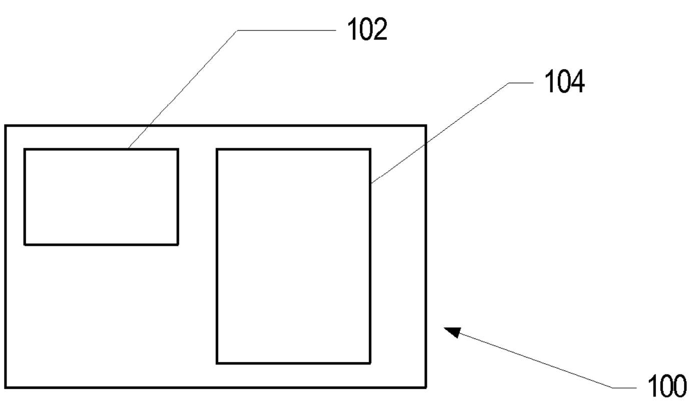

FIG. 1

(57) **Abstract**: A battery management system (BMS) of a rechargeable battery system. The battery system includes both the BMS and a battery bank. The battery bank has rechargeable battery cells that are connected to the BMS in a way that allows these battery cells to be charged or discharged in an intelligent, life enhancing manner when the rechargeable battery system is in operation. Other embodiments are also disclosed.

WO 2014/204649 A1

Battery Management System

PRIORITY CLAIM

[0001] This application claims the benefit of U.S. Provisional Application No. 61/836,233, filed June 18, 2013, entitled "Battery Management System," which is hereby incorporated by reference herein in its entirety.

BACKGROUND OF THE INVENTION

1. Technical Field

[0002] The present invention relates generally to batteries, and more specifically to management of battery cells within a rechargeable battery.

2. Description of the Related Art

[0003] Battery management systems are commonly found in rechargeable batteries. Rechargeable batteries typically include one or more battery banks. The battery banks are also sometimes referred to as battery packs and are each made up of multiple rechargeable battery cells.

[0004] When using a rechargeable battery for a desired application, users often have three main concerns: protecting battery cells from damage, prolonging battery cell life, and maintaining battery cells in the state in which the battery cells were intended to be used in an application. Battery cell damage can result in danger to users, so safety may also be a concern when using rechargeable batteries.

[0005] One way to distinguish contemporary rechargeable batteries from older dry cell batteries is to compare the newer power cell batteries to the older energy cell batteries. Power cell batteries allow massive amounts of current to be provided with only a small amount of stored energy. Alternatively, dry cell batteries, such as an old truck battery, are able to supply a small amount of current for a long period of time because the dry cells hold a large amount of energy.

[0006] Contemporary rechargeable batteries are commonly replaced in one of two ways: first, on a schedule, possibly based on the rechargeable battery’s expected life span; and second, subsequent the life of the rechargeable battery. Replacing a battery on a schedule and possibly prior to its expiration, or waiting until the death of a battery is often a costly approach.

[0007] To address this concern, a battery management system (BMS) was developed. A BMS monitors a number of parameters that affect performance of a rechargeable battery. The BMS typically monitors the rechargeable battery cells of the rechargeable battery’s battery pack. The function of the BMS is to monitor the battery cells and to measure their state of charge (SOC), their state of health (SOH), and their internal and ambient battery temperatures.

[0008] Battery packs often operate with one of three battery cell technologies. These include Nickel-Cadmium (NiCd), Nickel-Metal Hydride (NiMH), and Lithium-Ion (Li-Ion). Each of these different battery cell technologies has their pros and cons. For example, on the one hand, Li-Ion battery cells have low weight and high energy, but are relatively expensive. On the other hand, NiCd and NiMH battery cells are less expensive for an equivalent weight, but will hold less energy than the Li-Ion battery cells.

[0009] A single Li-Ion battery cell within a standard battery pack typically provides an output voltage of around 3.7V. This output voltage commonly has a narrow range of safe operating voltages between 3V and 4.2V. Operation outside of this range can result in irreparable damage to the cells of a battery pack, which in turn can limit the life of the battery pack. Thus the need for a BMS.

[0010] BMS improvements are welcome by rechargeable battery users. However, significant improvements to existing BMS technology have become rare.

SUMMARY

[0011] It has been discovered that what is needed to resolve the aforementioned challenges is an improved BMS that better meets objectives of the users of contemporary rechargeable batteries. The present disclosure addresses these concerns.

[0012] In one embodiment, the rechargeable battery system of the present invention includes a battery system that has a battery bank and a battery management system (BMS). The battery bank has rechargeable battery cells that are connected in a way that allows the battery cells to be discharged when the battery system is in operation.

[0013] The BMS is connected to the battery bank to allow communications therebetween. The BMS is configured to perform cell balancing within the battery bank. Cell balancing allows each of the rechargeable battery cells to be maintained in a similar electrical state.

[0014] In addition, the BMS includes isolation circuitry. The isolation circuitry allows the BMS to provide electrical isolation of the battery bank from the load across the battery.

[0015] In another embodiment, the BMS may include data management circuitry to collect battery system information for each of the rechargeable battery cells of the battery bank. This data management circuitry may work with communications circuitry to transmit selected battery system information, and this communication may be performed through wired or wireless communications circuitry. In one embodiment, for example, the wired communications circuitry may be performed through Ethernet communication circuitry.

[0016] In still other embodiments, the BMS can include short circuit damage protection circuitry. The short circuit damage protection circuitry can be configured to isolate the battery bank when a threatening electrical system short circuit is detected within or even outside of the battery system. Further, the BMS can include data collection circuitry that is configured to collect and analyze battery system information from each of the rechargeable battery cells of the battery bank. Finally, the BMS can have global positioning system communications circuitry or even universal serial bus system communications circuitry.

[0017] In another preferred embodiment, a battery system is designed where the battery system has a battery pack with a rechargeable battery cell and a BMS connected to the battery pack. The BMS includes isolation circuitry which allows the BMS to be configured to allow electrical isolation of the battery pack. Also included in the battery system is data management circuitry that collects battery system information from the rechargeable battery cell of the battery pack.

[0018] In addition, the battery system includes cell balancing circuitry that is configured to perform cell balancing when more than one rechargeable battery cell is present in the battery pack.

[0019] Finally, in this preferred battery system embodiment, communications circuitry is also included that is configured to transmit selected system information such as health metrics, location, use logs, and other battery system information. The communications circuitry includes wireless communications circuitry to transmit the selected battery system information to a site remote from the BMS.

[0020] Upon viewing the present disclosure, one of ordinary skill in the art will appreciate that variations to the above disclosed system and method could be contemplated.

[0021] The foregoing is a summary and thus contains, by necessity, simplifications, generalizations, and omissions of detail; consequently, those skilled in the art will appreciate that the summary is illustrative only and is not intended to be in any way limiting. Other aspects, inventive features, and advantages of the present invention, as defined solely by the claims, will become apparent in the non-limiting detailed description set forth below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The present invention may be better understood, and its numerous objects, features, and advantages made apparent to those skilled in the art by referencing the accompanying drawings.

[0023] **Figure 1** illustrates a block diagram showing a general embodiment of a battery system according to principles of the present invention;

[0024] **Figure 2** illustrates a block diagram showing the BMS of Fig. 1 in greater detail;

[0025] **Figure 3** illustrates another block diagram of the BMS of Fig.2 wherein certain aspects of the BMS are focused upon;

[0026] **Figure 4** is a more detailed block diagram of communication circuitry of the BMS of Fig. 2 wherein battery system information may be shared in various manners; and

[0027] **Figure 5** is a table of exemplary battery system indicators that are to be monitored and shared by the communication circuitry of Fig. 4.

DETAILED DESCRIPTION

[0028] The following is intended to provide a detailed description of examples of the invention and should not be taken to be limiting of the invention itself. Rather, any number of variations may fall within the scope of the invention, which is defined in the claims following the description.

[0029] **Figure 1** illustrates a block diagram showing a general embodiment of a battery system **100** according to principles of the present invention. Battery system **100** includes a BMS **102** and a battery pack **104.** Battery pack **104** is also sometimes known as a battery bank and includes a number of rechargeable Li-Ion battery cells. In general, unlike the prior art, BMS **102** uses battery pack **104** in ways that prior art BMSs do not.

[0030] BMS **102** monitors and controls cell balancing within battery pack **104.** Cell balancing assists in storage and/or delivery of power (Watts) to or from battery pack **104.** Energy (Joules) is the power that is delivered over time.

[0031] In other words, the amount of energy that battery system **100** accumulates or dissipates is the amount of power that is transferred during a set amount of time. BMS **102** monitors individual cells of battery pack **104** to determine appropriate times to activate balancing and/or protection circuitry to help prevent damage to battery system **100.** For example, damage to battery pack **104** may occur when corrective actions are not taken after BMS **102** detects unsafe energy transfer levels.

[0032] By monitoring such parameters, BMS **102** is able to prolong the life of battery pack **104** and to more efficiently utilize energy consumption and production in battery pack **104.**

[0033] **Figure 2** illustrates a block diagram showing BMS **102** in greater detail. Specifically shown are a communication circuitry **202,** a data management circuitry **204,** an isolation circuitry **206,** a short circuit protection circuitry **208,** and a cell balancing circuitry **210.**

[0034] In one embodiment, unlike a prior art battery pack and BMS, BMS **102** of battery system **100** can be used in a vehicle such as a truck where BMS **102** is configured to allow battery pack **104** to reliably perform.

[0035] In general, communication circuitry **202** of BMS **102** is configured to communicate battery system indicators to interested parties. These battery system indicators are sometimes referred to herein as health indicators and are things such as a battery cell threshold voltage, a battery current threshold, battery charge and discharge rates, number of detected short circuits, and general health of BMS **102.** The interested parties that may receive these communications can be located on site or even remotely to BMS **102.**

[0036] A primary function of data management circuitry **204** is to collect battery health indicators. These battery health indicators are discussed in greater detail herein. The collection of such information is sometimes referred to as data logging.

[0037] Isolation circuitry **206** is designed to provide a way to isolate battery pack **104** such that ameliorative actions may be taken in relation to battery system **100** when BMS **102** detects problems that could adversely affect battery life in battery system **100.** In certain embodiments, through wireless or other means, isolation circuitry **206** can be programmably or manually changed to be active or inactive during use.

[0038] In addition, short circuit protection circuitry **208** is available to detect and protect battery system **100** from a short circuit. The short circuit could occur anywhere in the entire electrical system that may adversely affect battery system **100.** Unlike short circuit protection circuitry of the prior art, short circuit protection circuitry **208** is configured to distinguish between an actual short circuit and a burst of electrical current on the order of hundreds to thousands of amps that might be needed for battery system **100** to start something like a large semi truck.

[0039] Finally, cell balancing circuitry **210** allows for more predictable, safe and prolonged operation of battery system **100.**

[0040] **Figure 3** illustrates another block diagram of BMS **102** wherein certain aspects of BMS **102** are focused upon, specifically data management circuitry **204,**

isolation circuitry **206**, cell balancing circuitry **210**, and short circuit protection circuitry **208**.

[0041] Data management circuitry **204** provides for the management of data as it relates to battery system **100**. Data relevant to battery system **100** is periodically collected over the life of battery system **100**. This data is then available to be used to make decisions on how to handle the different states that battery system **100** may enter while in operation or at rest.

[0042] In order to monitor health of battery system **100**, the collected data is analyzed and compared to expected values based on usage of battery system **100**. This data is also known as battery health data.

[0043] In addition, data management circuitry **204** is configured to allow the battery health data to be accessed by communications circuitry **202** as described in detail in relation to Fig. 4.

[0044] Battery health data is also sometimes referred to as battery health indicators. Some battery health indicators, such as battery cell threshold voltage, offer multiple parameters to be monitored where different actions can be taken to protect the life of battery system **100**.

[0045] Battery cell threshold voltage provides three potential battery health indicators. Battery cell threshold voltage is the point at which user action should occur to assist in maintaining the health of battery pack **104**. If action is taken when a threshold voltage is indicated, damage to the life of battery system **100** is likely to be prevented.

[0046] The threshold voltages are (1) reserve voltage, (2) low voltage lock-out, and (3) critical voltage.

[0047] Reserve voltage means that there is only enough energy remaining in battery pack **104** to be used one more time; for example, one more time to start a truck. The indication is a prompt to force some sort of user intervention to again use battery pack **104** for the purpose it has been designed to be used.

[0048] In other words, the reserve voltage threshold is analogous to a reserve gas tank on a vehicle. The vehicle may run out of gas, but the driver can then switch to the reserve gas tank to have enough fuel to start the vehicle and drive to the nearest gas station to completely fill up the gas tank.

[0049] An example of battery pack **104** reserve voltage is 30% remaining energy in battery system **100**. At this point, manual intervention is required to use battery system **100** one more time before battery system **100** must be fully recharged.

[0050] The second threshold voltage is low voltage lock-out. Low voltage lock-out occurs when battery system **100** is discharged below the reserve voltage. For example, if battery pack **104** is discharged to 5% energy remaining, low voltage lock-out triggers BMS **102** to temporarily prevent a user from using battery pack **104** of battery system **100**.

[0051] Of note, 5% remaining energy would mean that a jump start is required to start up a vehicle. When low voltage lock-out is indicated, battery pack **104** is protected because BMS **102** disables circuitry that would allow a user to even attempt to start the vehicle. Rather, the user would need to isolate the load for recharging of battery pack **104** to a “safe” level before attempting a current discharge that would be required to sustain load requirements across battery system **100**.

[0052] Disconnecting battery system **100** is also known as isolating the load and is discussed in greater detail hereinafter.

[0053] In this manner, damage to battery system **100** is more likely to be prevented because battery pack **104** is not allowed to reach the third threshold, critical voltage.

[0054] As stated, critical voltage is the third battery cell threshold voltage. If critical voltage is detected by BMS **102**, battery pack **104** begins to lose a lot of its health. Because of this danger, when critical voltage is detected, hibernation mode is commonly entered.

[0055] Hibernation mode is that mode where current consumption from battery pack **104** is reduced by a factor on the order of a hundred times. In other words, current consumption is much less than would otherwise be consumed. This mode is similar to hibernation mode in a laptop computer and can also be referred to as a “low power draw” mode for battery system **100**.

[0056] Of note, hibernation mode can be entered at times other than after detecting a critical voltage threshold. For example, similar to a common computer, after detecting a period of non-use in battery system **100**, to preserve energy of battery system **100**, hibernation mode can be entered.

[0057] In addition to hibernation mode of battery system **100**, isolation circuitry **206** is designed to respond to certain battery system **100** conditions. For example, isolation circuitry **206** can respond when certain threshold voltages are detected or a problem such as a short circuit is discovered in or around battery system **100**. The response may include corrective actions that are often based on data analysis of data that has been collected by data management circuitry **204**. If the collected data shows that a short circuit has occurred within battery system **100**, then short circuit protection circuitry **208** would likely be activated.

[0058] Short circuit protection circuitry **208** includes various types of circuitry. As previously described, battery system **100** is equipped with BMS **102** that allows battery pack **104** to distinguish between a short circuit and a needed current surge to start something like a truck engine.

[0059] During operation of battery system **100**, short circuit protection circuitry **208** interacts with isolation circuitry **206** to allow large current surges that, unlike a short circuit, may be needed. In prior art BMSs, these large current surges would be handled like a short circuit whether or not the surge was needed. In the case of an actual short circuit, isolation circuitry **206** prevents any further discharge of battery system **100** for any reason at all until the short circuit is removed.

[0060] Also unlike BMSs of the prior art, BMS **102** provides functionality that allows battery pack **104** to be shut off electronically. This functionality is made possible by designing BMS **102** such that the size of the magnetic field that is generated around a bus bar is monitored to detect current flow levels within battery pack **104** and to take battery action based on the current flow.

[0061] Prior art BMSs are known to diagnose and report a short circuit. A short circuit is commonly reported when current levels flowing from the battery pack are detected to have risen into the 100 mA range for an extended period of time (on the order of milliseconds). When a short circuit is reported by the prior art BMS, the prior art BMS simply shuts down its accompanying battery pack.

[0062] In the prior art, since short circuits are reported when only 100 mA flows for too long, in the event that a current level of 100 A is detected flowing from the battery pack, the prior art BMS reports a short circuit after an even shorter period of time.

[0063] In these prior art BMSs, when a potentially damaging current flow is detected, current flow from the battery pack is terminated to protect the battery pack. However, if a battery pack is to be used to successfully start, for example a truck, an even higher level of current flow is required for an even longer period of time.

[0064] Advantageously, BMS **102** is configured to recognize the difference between an undesirable short circuit and a necessary current surge for starting something like a semi truck. Because of short circuit protection circuitry **208**, BMS **102** is able to detect and allow current levels on the order of 2200 A for time periods of approximately .5 s. These amperage levels are programmable and may be set for different applications of battery pack **104**.

[0065] As described in relation to the threshold voltage of low-voltage lock-out, BMS **100** may isolate a load through circuit isolation. Circuit isolation is also sometimes referred to as lock-out. Lock-out may be accomplished with a number of different design techniques.

[0066] A first design technique that accomplishes the lock-out result is through trace design on a PC-Board. Typically, the PC-Board used for lock-out is the same PC-Board that holds BMS **102**, and trace-matching allows lock-out to occur based on slightly different transistor activation time.

[0067] Other trace design techniques to accomplish isolation are with the use of split columns or with a heat-tied arrangement. Slow speed transistor switching accomplishes a similar result with MOSFET transistor types.

[0068] A second design technique to accomplish lock-out is through customized circuitry such as an analog to digital converter, a reserve lock-out, a low-voltage lock-out, a user initiated lock-out, a temperature lock-out, or a short circuit lock-out.

[0069] Another design technique to accomplish lock-out uses circuit adaptation. This circuit adaptation is enabled when battery system **100** shows a low power draw such as hibernation mode.

[0070] Finally, under certain conditions, semi-conductor switches are programmed to toggle to provide lock-out options.

[0071] **Figure 4** is a more detailed block diagram of BMS communication circuitry **202** wherein battery system information may be shared in various ways. Firmware dictates utilization of available hardware for such sharing. Thus, the battery system information may be shared in a variety of manners.

[0072] As briefly described previously, battery communication circuitry **202** may be configured to report battery health indicators to a remote site. This can be accomplished in a number of ways. As illustrated, a USB (Universal Serial Bus) connection **402**, an Ethernet connection **404**, a GSM (Global System for Mobile Communications) **406**, or Wi-Fi hotspot functionality **408**.

[0073] Further, a GPS (Global Positioning System) **410** can be included in battery communication circuitry **202** to assist in determining an exact location of battery pack **104**. This is particularly useful if battery system **100** happens to be lost, located in a stolen vehicle, or has some other need to retrieve its exact global coordinates.

[0074] In this manner, battery health indicators may be monitored by allowing battery communication circuitry **202** to send the information to a remote location. For example, fleet headquarters may be interested in monitoring a number of different trucks where each truck uses its own battery pack **104**.

[0075] In this way, truck drivers may be given a warning to take action to maintain health of their personal battery system **100**. This function is similar to the function of a check engine light, but relating to battery pack health where more than just the driver is provided with the battery heath information.

[0076] **Figure 5** is a table of exemplary battery system indicators **500** that are to be monitored and shared by battery communication circuitry **202**. These include battery health indicators that allow a user of battery system **100** to better understand the health of battery pack **104** and to know when to take action that may assist in prolonging the life of battery system **100**.

[0077] These health indicators **500** allow a user to know when battery system **100** is nearing the end of its useful life.

[0078] Along with battery charge and discharge rates **502**, **504** of battery system **100** (for example short circuit detection), threshold voltages **506** are available as health indicators.

[0079] In addition, BMS health **508** is an indicator that triggers when service may be required for battery system **100**.

[0080] As discussed in detail with regard to Fig. 3, BMS **102** allows individual cells of battery pack **104** to be charged and discharged at about the same rate so that no single cell will be stressed. In this way, cell lifetimes may be maximized and, thus, lifetime of battery pack **104** is maximized. However, if BMS health **508** is indicated as needing service, all other health indicators become in question until BMS **102** is addressed concerning any health issues.

[0081] Functional descriptive material is information that imparts functionality to a machine. Functional descriptive material includes, but is not limited to, computer programs, instructions, rules, facts, definitions of computable functions, objects, and data structures.

[0082] It is to be understood that the invention is defined by the appended claims. It will be understood by those with skill in the art that if a specific number of an introduced claim element is intended, such intent will be explicitly recited in the claim, and in the absence of such recitation no such limitation is present.

WHAT IS CLAIMED IS:

1. A battery system comprising:

at least one battery bank having a plurality of rechargeable battery cells, the plurality of rechargeable battery cells being connected such that the rechargeable battery cells may be discharged when the battery system is in operation;

a battery management system (BMS) communicatively coupled to the at least one battery bank, the BMS being configured to perform cell balancing within the at least one battery bank wherein each of the rechargeable battery cells of the at least one battery bank are maintained in a similar electrical state; and

said BMS further including isolation circuitry wherein the BMS is configured to allow electrical isolation of the at least one battery bank.

2. The battery system of claim 1 wherein the BMS further includes data management circuitry to collect battery system information for each of the rechargeable battery cells of the at least one battery bank.

3. The battery system of claim 2 wherein the BMS further comprises communications circuitry to transmit selected battery system information.

4. The battery system of claim 3 wherein the communications circuitry further comprises wireless communications circuitry.

5. The battery system of claim 3 wherein the communications circuitry further comprises Ethernet communication circuitry.

6. The battery system of claim 1 wherein the BMS further comprises short circuit damage protection circuitry, the short circuit damage protection circuitry being configured to isolate the at least one battery bank when a short circuit is detected within the battery system.

7. The battery system of claim 1 wherein the BMS further comprises data collection circuitry being configured to collect and analyze existing battery system information from each of the plurality of rechargeable battery cells of the at least one battery bank.

8. The battery system of claim 1 wherein the BMS further comprises global positioning system communications circuitry.

9. The battery system of claim 1 wherein the BMS further comprises universal serial bus system communications circuitry.

10. A battery system comprising:

at least one battery bank having a plurality of rechargeable battery cells, the plurality of rechargeable battery cells being connected such that the battery cells may be discharged when the battery system is in operation;

a battery management system (BMS) communicatively coupled to the at least one battery bank, the BMS being configured to perform cell balancing within the at least one battery bank wherein each of the rechargeable battery cells of the at least one battery bank are maintained in a similar electrical state; and

said BMS further including isolation circuitry wherein the BMS is configured to allow electrical isolation of the at least one battery bank, data management circuitry to collect battery system information for each of the rechargeable battery cells of the at least one battery bank, and communications circuitry to transmit selected battery system information; and

said communications circuitry further comprising wireless communications circuitry.

11. The battery system of claim 10 wherein the BMS further comprises short circuit damage protection circuitry, the short circuit damage protection circuitry being configured to isolate the at least one battery bank when a short circuit is detected within the battery system.

12. The battery system of claim 10 wherein the BMS further comprises data collection circuitry being configured to collect and analyze existing battery system information from each of the plurality of rechargeable battery cells of the at least one battery bank.

13. The battery system of claim 10 wherein the BMS further comprises global positioning system communications circuitry.

14. The battery system of claim 10 wherein the BMS further comprises universal serial bus system communications circuitry.

15. A battery system comprising:

a battery pack having at least one rechargeable battery cell;

a battery management system (BMS) communicatively coupled to the battery pack, the BMS including isolation circuitry wherein the BMS is configured to allow electrical isolation of the battery pack;

data management circuitry to collect battery system information from the at least one rechargeable battery cell of the battery pack;

cell balancing circuitry configured to perform cell balancing of the at least one rechargeable battery cell of the battery pack; and

communications circuitry being configured to transmit selected battery system information from the BMS, said communications circuitry further comprising wireless communications circuitry to transmit the selected battery system information to a site remote from the BMS.

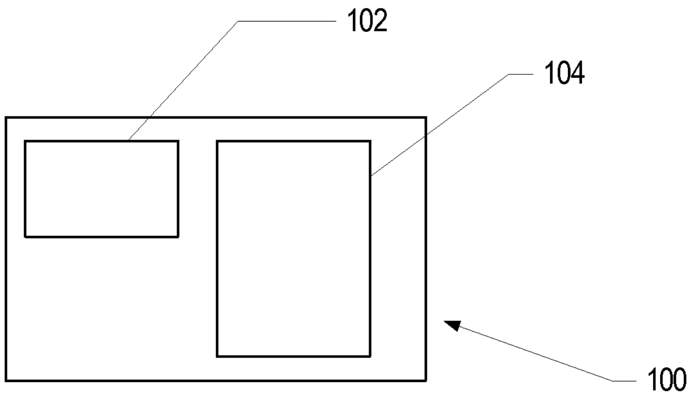

FIG. 1

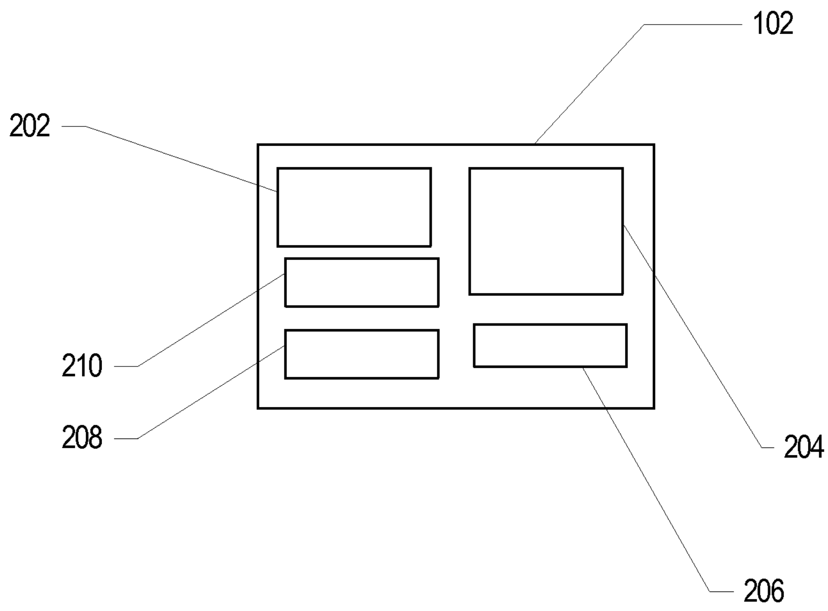

FIG. 2

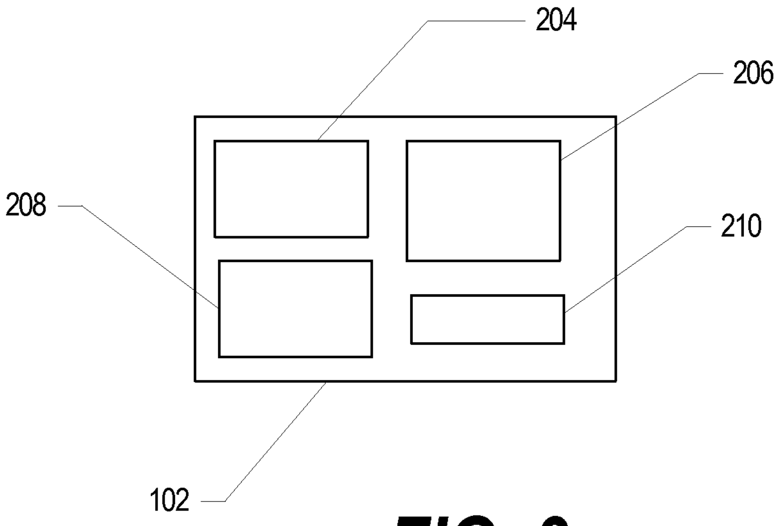

FIG. 3

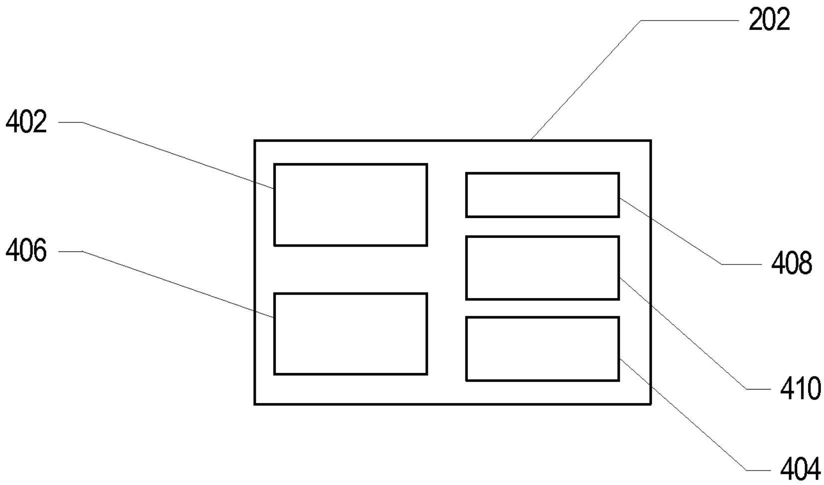

FIG. 4

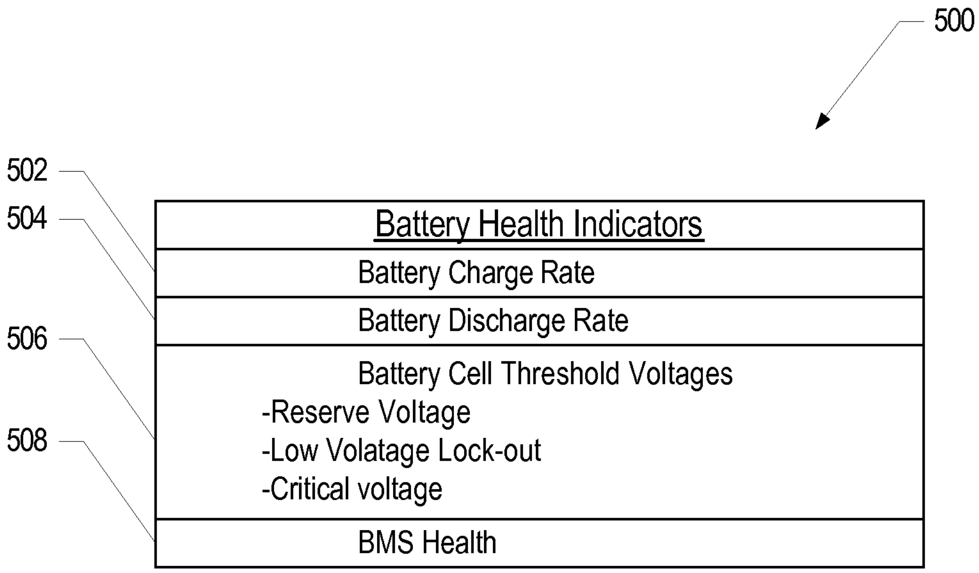
500
502
504
506
508
Battery Health Indicators
Battery Charge Rate
Battery Discharge Rate
Battery Cell Threshold Voltages
-Reserve Voltage
-Low Volatage Lock-out
-Critical voltage
BMS Health

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 14/40997

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H01M 10/48 (2014.01)
CPC - B60L 3/12; B60L 2240/545
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - H01M 10/48 (2014.01)
CPC - B60L 3/12; B60L 2240/545

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
IPC(8) - H01M 10/48 (2014.01)
CPC - B60L 3/12; B60L 2240/545; G01R 31/3624; USPC - 320/134 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Patbase, Google Patents, Google Scholar, Google web
Search terms used: Battery management Balancing Isolation Rechargeable Secondary Banks Cells charged

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2003/0139888 A1 (Burns) 24 July 2003 (24.07.2003), para [0002], [0004], [0013], [0014], [0036], [0045], [0050], [0086], [0081]	1-4, 7, 10, 12, 15 --- 5, 6, 8, 9, 11, 13, 14
Y	US 2013/0086409 A1 (Lu et al.) 04 April 2013 (04.04.2013), para [0010], [0219]	5, 9, 14
Y	US 2009/0167312 A1 (Keates at al.) 02 July 2009 (02.07.2009), Figs. 2-4; para [0018], [0021]	6, 11
Y	US 2008/0299938 A1 (Meshenberg) 04 December 2008 (04.12.2008), Fig. 1, para [0021]	8, 13
A	US 2010/0052615 A1 (Loncarevic) 04 March 2010 (04.03.2010), Figs 1-13, para [0003], [0004], [0005], [0011], [0034]	1-15

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 August 2014 (26.08.2014)	03 OCT 2014

Name and mailing address of the ISA/US
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450
Facsimile No. 571-273-3201

Authorized officer:
Lee W. Young
PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774