

A LITHIUM BATTERY

Field of the Invention

- 5 The present invention relates to a lithium battery and a method for managing the lithium battery.

Background

- 10 Portable batteries currently available typically are lead acid batteries. Lead acid batteries are currently ubiquitous and in use in nearly every application which requires either a portable or a scalable power source.

- However, the ready availability of lead acid batteries does not indicate that they do not
15 have issues. For example, lead acid batteries have a relatively short lifespan, require regular maintenance, have a relatively high mass, and so forth.

- Consequently, lithium ion batteries are increasing being used to replace lead acid batteries due to some advantages over lead acid batteries. However, current lithium
20 ion batteries also have issues, such as, for example, battery management issues, combustibility issues, safety issues and so forth.

- It is evident that there are still areas to improve for lithium ion batteries before they can be used for large scale replacement of lead acid batteries.

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Summary

- In a first aspect, there is provided a lithium battery comprising:
a plurality of lithium cells;
30 an S board configured to ensure the connectivity of the plurality of lithium cells,
the S board including a first balancer configured to maintain a balance in each of the

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plurality of lithium cells;

a management board coupled to the S board; and

a battery management system coupled to the management board, the battery management system including a second balancer.

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It is advantageous that the management board and the S board are maintained on separate boards to enable modularity.

It will be appreciated that the broad forms of the invention and their respective features
10 can be used in conjunction, interchangeably and/or independently, and reference to separate broad forms is not intended to be limiting.

Brief Description of the Drawings

15 A non-limiting example of the present invention will now be described with reference to the accompanying drawings, in which:

FIG 1 is an exploded view of an embodiment of a lithium battery of the present invention;

20 FIG 2 is a perspective view of the lithium battery of FIG 1, with a cut-away of both top and bottom cases;

FIG 3 is a top view of the lithium battery of FIG 1;

FIG 4 shows a configuration of the lithium battery of FIG 1 in an emergency mode;

FIG 5 shows the lithium battery of FIG 1 being used singularly;

25 FIG 6 shows a plurality of lithium batteries of FIG 1 being used in a parallel assembly;

FIG 7 shows a plurality of lithium batteries of FIG 1 being used in a first series assembly;

FIG 8 shows a plurality of lithium batteries of FIG 1 being used in a second series assembly;

30 FIG 9 shows a plurality of lithium batteries of FIG 1 being used in configurations which reduces a footprint of the plurality of lithium batteries;

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FIG 10 shows a top view of a BMS used in the lithium battery of FIG 1;
FIG 11 shows a permanent attachment of a busbar to the lithium battery of FIG 1;
FIG 12 shows a close up side view of the attached busbar of FIG 11; and
FIGs 13(a) and 13(b) show EVA protective foam used with the lithium battery of FIG
5 1.

Detailed Description

The present invention provides a lithium battery with a built-in battery management
10 system that allows the lithium battery to be a safe and durable power source. The
lithium battery is advantageously able to last an extended duration without any
maintenance, and can be deployed in multiple configurations to provide varying power
supply requirements. The lithium battery can also be deployed in different applications
due to its robustness.

15 For the purpose of illustration, it is assumed that the lithium battery as described is
one possible embodiment, and other embodiments are possible. It should be noted
that all advantages should be consistent for all embodiments.

20 Referring to FIG 1, there is provided an exploded view of a preferred embodiment of
a lithium battery 100. Respective components of the battery 100 are shown to be
assembled in a stacked configuration, but other configurations to assemble the
components of the battery are also possible, and can be dependent on a particular
application of the battery 100, for example, if a large footprint is desired, if a lower
25 height is desired, and so forth.

The battery 100 includes a bottom case 105, the bottom case 105 should be made
from a non-conductive material such as, for example, ABS. It should be noted that the
bottom case 105 should be robust and should be able to withstand impact forces and
30 drops from height so that components of the battery 100 located within the bottom
case 105 are adequately protected during use.

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A base 103 of the bottom case 105 should be configured to enable placement of at least on damping structure 110. The damping structure 110 is configured to support movement of components of the battery 100 located within the bottom case 105, and
5 to damp forces at the base 103. The damping structure 110 can be made from EVA foam, or any similar material.

A lithium cell 115 is located on the damping structure 110. Typically, at least two lithium cells 115 are included in the battery 100. The number of cells 115 in the battery 100
10 can vary depending on a power and energy capacity rating of the battery 100. A plurality of lithium cells 115 are mounted and electrically coupled to an S board (SPCB) 120, the SPCB 120 being sufficiently rigid to maintain an orientation of the plurality of lithium cells 115, and to ensure that the plurality of lithium cells 115 remained electrically coupled to each other. The SPCB 120 enables the plurality of lithium cells
15 115 to be electrically coupled to each other either in a series or parallel configuration, depending on a circuit design of the SPCB 120. The SPCB 120 includes an active balancer 125 to aid in monitoring a capacity of each of the lithium cells 115 and transfers energy amongst the lithium cells 115 in order to maintain a balance in the lithium cells 115 to ensure longevity of the lithium cells 115. In some embodiments,
20 the active balancer 125 can be replaced with a passive balancer.

The SPCB 120 is electrically coupled to a management board (m-board) 135 via electrical connectors 130. For example, the electrical connectors 130 can be gold-plated coupling plug connectors or any other high current electrical connector which
25 ensures permanent electrical connectivity even when the battery 100 experiences any impact forces. The m-board 135 is also mounted to the SPCB 120 such that both the SPCB 120 and the m-board 135 are fixedly located with respect to one another. The mounting of the m-board 135 to the SPCB 120 can be with use of the electrical connectors 130 or by other means.

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The m-board 135 includes a connector 150, for example an eight pin connector, to enable a battery management system (BMS) 145 to be connected to the m-board 135. The BMS 145 is configured to control parameters for each lithium cell 115, such as, for example, minimum voltage, maximum voltage, current limits, temperature limits
5 and the like. The BMS 145 is configured in a manner to ensure safety and longevity of the lithium cells 115 in the battery 100. Furthermore, the BMS 145 also includes a passive balancer which operates with the active balancer 125 to ensure a balance among the lithium cells 115 in the battery 100 by discharging a lithium cell 115 with a
10 highest voltage level to the level of other lithium cells 115. Moreover, the passive balancer is configured to protect the lithium cells 115 when the BMS 145 is bypassed, for example, during activation of a reserve charge when the battery 100 is drained. In some embodiments, the passive balancer can be replaced with an active balancer. In order to reduce impedance losses, the BMS 145 is bolted directly to a battery terminal bus and not mounted using soldering and cables. FIG 10 shows a top view of the BMS
15 145. The BMS 145 is configured to provide, for example, current protection, over-voltage protection, high temperature protection, over-charging protection, and over-discharge protection.

It is preferable that the m-board 135 and the SPCB 120 are maintained on separate
20 boards to ensure a degree of modularity for each battery 100, which advantageously enables ease of assembly and servicing for the lithium cells 115. For example, the battery 100 can be separable to a bottom module including the lithium cells 115 and the SPCB 120, and a top module including the m-board 135 and a display module 165. The bottom and the top modules can then be readily connectable using gold-plated coupling connectors or any other high current electrical connector.
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The m-board 135 also includes a gasket 140, the gasket 140 being for lining a perimeter of the m-board 135. It is preferable that the gasket 140 is able to prevent damage to the m-board 135 when a top case 155 is coupled with the bottom case 105
30 such that the battery 100 is sealed. An appropriately positioned gasket 140 also prevents ingress of dust and liquids into the battery 100.

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The top case 155 includes a plurality of terminal contacts 160, the plurality of terminal contacts 160 being removable, and made from an electrically conductive material like zinc. The removable terminal contacts 160 aid in packing and transportation of the battery 100 as the removal of the terminal contacts 160 enables the battery 100 to maintain a substantially cuboidal shape that can be stacked for storage and/or transportation even without any packaging. When the battery 100 is packed, it can be packed with EVA fire retardant foam to prevent transportation damage. The EVA foam can also be used when the battery 100 is in use. The use of EVA retardant foam when the battery 100 is in use ensures that the battery 100 is protected in high temperature environments (for example, engine bay) and is protected from impact damage. In addition, the use of the EVA retardant foam also protects the usage environment in the event of battery issues.

The top case 155 also includes a display module 165, and a defined mode actuator 170. For example, the defined mode is an emergency mode. The display module 165 is configured to indicate battery usage parameters such as, for example, state of charge, voltage level, operation temperature, and so forth. The display module 165 is coupled to the plurality of terminal contacts 160, and includes a built-in temperature sensor which is configured to determine a temperature of the battery 100, specifically within the bottom case 105. The defined mode actuator 170 is coupled to a brass alloy busbar 153 which connects to one of the terminal contacts 160 when activating the defined mode. The brass alloy busbar 153 allows some flexibility which facilitates the connection to the terminal contacts 160. The brass alloy busbar 153 is a separate accessory usable when the emergency mode is required. In some embodiments, the brass alloy busbar 153 can be permanently installed during battery installation once it is decided which of two negative terminals contacts 160 will be used for a main connection, such that a second one will be used to connection to the brass alloy busbar 153. Permanent installation is possible due to a design of the top case 155 being 1mm higher the terminal contact 160 as shown in FIG 12. Permanent installation of the brass alloy busbar 153 is shown in FIG 11.

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In some embodiments, as shown in FIGs 4 and 11, a butterfly screw is used to deform the brass alloy busbar to activate the emergency mode. The butterfly screw can be stored within the EVA foam when the emergency mode is not required as shown in
5 FIG 13.

Another busbar made from copper is usable when connecting a plurality of the battery 100 in parallel or series connection as shown in FIGs 6-9.

10 The top case 155 is secured to the bottom case 105 using a snap-fit coupling configuration. Once the top case 155 is secured to the bottom case 105, the battery 100 has an appearance as shown in FIG 2, although both the top case 155 and the bottom case 105 are in an incomplete form in order to show internals of the battery 100. FIG 3 shows a top view of the battery 100.

15 It should be noted that while the shape of the battery 100 should not be constrained to the shape as shown in FIGs 2 and 3.

It should be noted that the battery 100 can be used to provide flexible power sources
20 in accordance with user requirements.

For the sake of illustration, FIG 5 shows a single battery 100 which can have the rating of 12V, 40AH, and either 120A/1.5KW or 240A/3.0KW. FIGs 6 to 9 show various configurations of multiple batteries being connected together to fulfil different power
25 supply requirements.

It can be appreciated that the battery 100 is able to provide a consistent, durable, zero maintenance power source that can be used in a variety of applications, such as, for example, land vehicles, water borne vessels, aircraft, charging stations, portable
30 generators, traction batteries, UPS batteries and so forth. Furthermore, the balancing

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of the energy levels in the lithium cells ensures cell longevity and less environmental issues from processing lithium.

Throughout this specification and claims which follow, unless the context requires
5 otherwise, the word “comprise”, and variations such as “comprises” or “comprising”, will be understood to imply the inclusion of a stated integer or group of integers or steps but not the exclusion of any other integer or group of integers.

Persons skilled in the art will appreciate that numerous variations and modifications
10 will become apparent. All such variations and modifications which become apparent to persons skilled in the art, should be considered to fall within the spirit and scope that the invention broadly appearing before described.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A lithium battery comprising:
 - a plurality of lithium cells;
 - 5 an S board configured to ensure the connectivity of the plurality of lithium cells, the S board including a first balancer configured to maintain a balance in each of the plurality of lithium cells;
 - a management board coupled to the S board; and
 - a battery management system coupled to the management board, the battery
 - 10 management system including a second balancer,
 - wherein the management board and the S board are maintained on separate boards to enable modularity.
2. The battery of claim 1, further comprising:
 - 15 a gasket configured to line a perimeter of the management board, the gasket being for preventing damage from moisture and dust to the management board;
 - a plurality of terminal removable contacts;
 - at least one display module coupled to the plurality of terminal removable contacts; and
 - 20 a defined mode actuator.
3. The battery of either claim 1 or 2, wherein the second balancer is configured to operate with the first balancer to maintain a balance among the plurality of lithium cells.
- 25 4. The battery of either claim 1 or 2, wherein the first balancer is configured to protect the plurality of lithium cells when the battery management system is bypassed.
5. The battery of any of claims 1 to 4, wherein the battery management system is
- 30 bolted directly to a battery terminal bus to reduce impedance losses.

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6. The battery of any of claims 1 to 5, wherein the modularity is for a top module and a bottom module.

7. The battery of any of claims 1 to 6, wherein the defined mode actuator is
5 coupled to a busbar to enable activation of a defined mode.

8. The battery of claim 7, wherein the busbar is removable.

9. The battery of claim 7, wherein the busbar is non-removable.
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10. The battery of any of claims 1 to 9, wherein the first balancer is configured to prevent over-charging and over-discharging for each of the plurality of lithium cells.

11. The battery of any of claims 1 to 10, wherein the first balancer is an active
15 balancer.

12. The battery of any of claims 1 to 10, wherein the first balancer is a passive balancer.

20 13. The battery of any of claims 1 to 10, wherein the second balancer is an active balancer.

14. The battery of any of claims 1 to 10, wherein the second balancer is a passive
25 balancer.