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(54) Title: A BATTERY MODULE

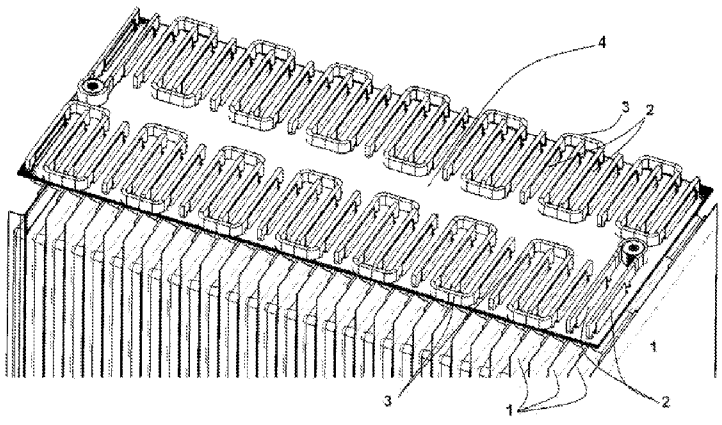

Figure 1

(57) Abstract: A battery module is provided with plurality of battery cells, each having cell tabs for connecting and sourcing the power supplied to and from the cell tabs. The cell tabs are arranged into a first set and a second set of battery cells. A plurality of busbars acting as connecting members are provided for connecting the cell tabs of the battery cells. The battery cells in each set are connected in series and the battery cells of one set are spaced apart by arranging the battery cells of other set in-between. A plate substrate with a plurality of elements for the battery management is disposed above the battery cells. This arrangement makes possible that electrically connected cell tabs are not assembled adjacent to another, and the assembly incorporates one electrically connected cell tab in-between the other electrically connected cell tabs. This improved arrangement provides advantages in terms of increased safety against propagation, redundant power sourcing, volumetric packaging efficiency, electrical properties and manufacturability.

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A BATTERY MODULE

FIELD OF INVENTION

The present invention generally relates to a battery module, and more particularly to a battery module with a two string architecture.

BACKGROUND OF INVENTION

Multiple cell batteries, especially Lithium-ion (Li-ion) batteries are widely used due to its high energy density, high specific energy, long life cycle and flexible and lightweight design. Generally a multiple cell lithium-ion battery includes a battery case and a set of cells grouped in the battery case as battery modules. Each of these battery cells includes a positive electrode having a positive lead and a negative electrode having a negative lead. In construction these positive leads and negative leads are connected in series or in parallel, or in combination to meet different requirements of voltage and energy on battery level.

Normally a battery includes a busbar, which is a metallic conductor having low impedance and high current carrying capacity and connects electrodes in the required arrangement. The busbar is generally used as a conductor to distribute electric power to several points of the battery. The busbar is electrically connected to a printed circuit board (PCB) having control and measurement elements, which is spaced apart from the busbar at a predetermined distance , such that the voltage of the busbar, is transmitted to the PCB and to the control elements in order to enable the battery control. The busbars are usually provided as a separate attachment to enable connection between the electrodes of the battery cells. The battery modules having plurality of Lithium-ion cells are electrically interconnected with the busbars through the cell contact leads to achieve the desired architecture in order to meet the required level of voltage and energy.

The printed circuit board (PCB) includes various power elements such as fuses, measurement elements and control components to have the required control

over the battery. The battery cells which are arranged in modules, busbar elements and the PCB with its components are all packed together to form a battery unit which serves as a power supply unit. The battery cells are electrically interconnected through the busbars and are placed adjacent to one another, and due to this adjacent placement of cells the heat energy developed in one cell is transferred to other cells in close proximity.

In order to maintain the thermal propagation at a safe level, the battery cells arrangement is adapted in various structures and the busbars are modified with various designs in order to meet the voltage and energy level requirements. The conventional design of battery cell arrangement structure and the busbar design will impact the battery performance and result in higher impedance.

The US 7762848 patent describes an interconnect device for battery cells assembly which includes multiple electrical contact members having multiple contact portions. The interconnect device couples a first set of electrodes at a first polarity in series with a second set of electrodes at a second polarity in a battery module. The interconnect device provides a technical effect coupling a first set of electrodes at a first polarity in series with a second set of electrodes at a second polarity, while providing substantially equal current flow through electrical contact members of the interconnect device. This arrangement stacks the cells in a co-connectivity fashion and thus providing only a single power source and does not yield any added advantages in times of obstruction in the power supply from the battery.

The WO 2010081085 document describes a battery system comprising a plurality of battery cells arranged in a sequence, each cell having a first and a second voltage terminal, wherein the first voltage terminals of the plurality are arranged in a row; and a bimetallic busbar having a first segment joined to a second segment. The first segment includes a u- shaped bend defining a first channel into which the first voltage terminal of one of the plurality of cells is positioned. This arrangement stacks the battery cells one adjacent to another and this results in unwanted level of propagation and affects the life of battery.

These combinations of row and series arrangement of cells are made in order to achieve a target voltage and energy for the cell architecture. Though the configuration allows the battery module and the individual cells to get arranged in combination of rows and in series, the conventional arrangements have several problems. The level of propagation has to be maintained in a safe level so that the specific energy level can be maintained and the lifetime of the battery will be improved.

As the propagation can spread due to the placement of one cell adjacent to other cells which are electrically inter connected, and the heat can be transferred over the busbars, the conventional design suffers in terms of required safety level of propagation. With this conventional arrangement, any faulty cell can impact the behavior of the whole battery module, and thus obstruction in the power supply from the battery to the vehicle.

The assembly of the busbar and printed circuit board PCB provided in the conventional structure increases number of assembly parts, and makes the battery bigger in size. Further the space required for mounting the related components for PCB and busbar in the conventional design is more, and this increases the size of the entire battery unit and manufacturing cost.

Therefore, it is desirable to provide an improved battery arrangement which provides an improved level of propagation with simple construction, and a structure capable to address and overcome the above disadvantages.

SUMMARY OF INVENTION

The object of the present invention is to provide an improved battery arrangement with increased level of propagation safety and a system which is simple in construction.

Another object of the present invention is to provide an improved battery arrangement, which functions without any interruption in power supply and increase in battery life.

Further object of the present invention is to provide an improved battery arrangement structure which allows advantages in terms of manufacturability and electrical properties.

According to the present invention, a battery arrangement is provided with plurality of battery cells such as lithium-ion cells, each having cell tabs for connecting and sourcing the power supplied to and from the cell tabs. The battery cells are stacked asymmetrically to form plurality of battery modules, and the battery modules are accorded with two string cell tab architecture, such that one set of connected cell tabs is placed in-between the other set of connected cell tabs. This arrangement makes possible that electrically connected cell tabs are not assembled adjacent to another, and the assembly incorporates one connected cell tab in-between the other electrically connected cell tabs.

The battery arrangement includes connecting members (busbars) to connect the cell tabs, where the busbars are placed parallel to the cell tabs stacked in the battery module. The busbar connects the module terminals in a non-crossing arrangement, such that the module end terminals, connecting to the next modules can be split into two positive (+ve) and two negative (-ve) on each side of the battery module, and thereby maintaining the two-string approach throughout the whole battery pack.

Further, a printed circuit board (PCB) is placed on the top of the battery modules between the busbar and cell top portion. The cell tabs are extended through the PCB and projected above the PCB to connect with the busbar elements as one possible method to interconnect busbars with PCB. Pluralities of recesses are provided on the PCB for fixing the busbar connecting legs. The PCB carries the busbars in such way that the busbars are welded to the cell tabs and stands perpendicular at the top surface of the PCB. The present invention allows the cell tabs

of the battery cells to pass through the defined slits provided in the PCB and the busbars with connecting legs soldered on top of the PCB are connect to the cells tabs.

Another embodiment of the present invention is to provide PCB strip placed in between the two rows of cell tabs. The PCB strip is situated in between the two rows of cell tabs, in accordance to another embodiment of the present invention. The plate substrate acting as a PCB strip is disposed above the battery cells to accommodate the busbars for making electrical connections between the cell tabs.

The cell tabs are assembled such that the battery assembly incorporates one connected cell tab in-between the other electrically connected cell tabs. The cell tabs are arranged into a first set and a second set of battery cells, and the battery cells in each set are connected in series and the battery cells of one set are spaced apart by arranging the battery cells of other set in-between. The plate substrate PCB for the battery disposed above the battery cells such that the plate substrate PCB strip is situated in between the two rows of cell tabs of the battery cell arrangement.

In addition, the PCB accommodates the battery management system BMS components such as voltage measurement unit, temperature sensors, etc, and all these electronic components can be connected to the printed conductor in the PCB along with the busbars, thus enabling the PCB to perform double function.

As the PCB is placed on the top of the battery modules it provides a good access for welding equipment, and thereby achieving advantages in terms of manufacturability for the battery unit. One possible method of joining busbars and cells tabs is selective soldering, to make electrical and mechanical connectivity.

This two string cell tab arrangement made for connecting the battery modules, allows for achieving a double power source directly from this battery arrangement and enables a full redundant source of power supply to the consumer. The electrically connected cell tabs are not assembled one adjacent to another, and the assembly incorporates one cell tab in-between the other electrically connected cell tabs, and hence improving the propagation safety level for the battery.

The busbar interconnects the battery cells with a specific non crossing busbar design that makes various advantages in terms of manufacturability and electrical properties with higher level of propagation safety. In addition, it allows for using the PCB for electronic components for the battery management system increasing volumetric packaging efficiency.

The present invention of battery arrangement allows the cell tabs to get stacked asymmetrically to form plurality of battery modules, and the battery modules are accorded with two string cell tab architecture and thus providing double power source directly to the consumer. This unique battery module architecture enables cost efficient battery module architecture with improved safety, manufacturability and electrical properties.

BRIEF DESCRIPTION OF DRAWINGS

Referring now to the drawings wherein the showings are for the purpose of illustrating a preferred embodiment of the invention only, and not for the purpose of limiting the same.

FIG. 1 shows a schematic diagram of an improved battery module in accordance with an exemplary embodiment of the present invention.

FIG. 2 shows a schematic diagram of a busbars provided for the battery module, in accordance to the present invention.

FIG. 3 illustrates a schematic arrangement of a printed circuit board PCB having busbars welded together on the top surface of PCB for the battery module, in accordance to the present invention.

FIG. 4 shows a schematic diagram of printer circuit board PCB having defined slits and recesses for stacking the cell tabs and connects with busbars, in accordance to the present invention.

FIG. 5 illustrates various views of busbar with legs for connecting the cell tabs, in accordance to the present invention.

FIG. 6 illustrates a PCB strip situated in between the two rows of cell tabs, in accordance to another embodiment of the present invention.

FIG. 7 illustrates a two string arrangement to connect the battery cells into a battery module, in accordance to the present invention.

DETAILED DESCRIPTION

The present invention, which achieves the objectives, relates to battery modules, in which battery cells are stacked asymmetrically in two string architecture and are connected with a specific busbar design that brings advantages in terms of manufacturability and electrical properties. The battery assembly generally comprises plurality of battery modules connecting in parallel with each other, and each of the battery modules consisting of battery cells connecting in series and plurality of connecting members disposed respectively on the top of the battery module to make the electrical and mechanical connection between the battery cells.

FIG. 1 shows a schematic diagram of an improved battery module, in accordance to the present invention. A battery arrangement is provided with a plurality of battery cells 1 such as lithium-ion cells, each having cell tabs 2 for connecting and sourcing the power supplied to the battery cells. The battery cells 1 act as power storage units to store and supply the electrical energy. The battery cells 1 according to the present invention are arranged in a simple structure that makes capable of easily accomplishing the electrical and mechanical connection between the cell tabs 2 of the battery cells 1.

The assembly of the proposed battery arrangement is simply carried out by stacking the battery cells 1 in an asymmetrical fashion to form plurality of battery modules in a specific connectivity between the cell tabs 2. Connecting members 3 are provided for connecting the cell tabs 2 through a plate substrate 4 placed on the top of the battery cells 1.

FIG. 2 shows a schematic diagram of busbars provided for the battery module, in accordance to the present invention. The cells tabs 2 are generally protruding upwards from the battery cells 1 and allow making the connection at the top of the battery modules. A connecting member, usually a busbar 3, connects the protruding cell tabs 2 to make the electrical and mechanical connectivity of the battery modules to source and supply the electrical energy to and from the battery assembly. The busbar 3 connects the cell tabs 2 in specific arrangement to bring advantages in accordance to the improved battery arrangement.

As shown in the figure, the cells are arranged into a first set (la) and a second set (lb) of battery cells, and the battery cells in each set are connected in series and the adjacent battery cells in each set are spaced apart by arranging a battery cell of other set in-between. The arrangement is such that the module end terminals, connecting to the next module can be split into two positive +ve (9,10) or ~~and~~ two negative -ve (9',10') on each side of the battery module, and thereby maintaining the two-string approach throughout the whole battery pack. The busbars 3 connects the cell tabs 2 of battery cells 1 in each set in a non-crossing or non-overlapping arrangement with respect to the other set. This two string cell tab arrangement made for connecting the battery modules, allows for achieving a double power source directly from this battery arrangement and enables a full redundant source of power supply to the consumer.

FIG. 3 illustrates a schematic arrangement of a plate substrate 4 with busbars 3 soldered on the top surface, in accordance to the present invention. A plate substrate 4 having defined slits 5 is placed on the top of the storage cells 1 in the battery

arrangement for enabling connection between the cell tabs 2 of the battery cells 1 and the busbars 3. The plate substrate 4 placed on the top of the storage cells serves as a platform for enabling connectivity between the battery cells 1 and accommodating control elements for the battery. The cell tabs are extended through the slits 5 of the plate substrate 4 and make the connection with the busbars 3 carried by the plate substrate 4. Here the plate substrate is a printed circuit board (PCB) to accommodate elements of battery management system. Alternatively, it is also possible that the cell tab 2 electrically and mechanically connected to the PCB 4 and further the cell tabs are connected by busbars 3 for sourcing the power supply (not shown).

The battery assembly includes busbars 3 as connecting members, each having preferably a U- shape/C-shape and connects to the cell tabs 2 at the vertical surface of the cell tab. The busbar 3 has two connecting ends for connecting two different cell tabs 2 spaced apart in same row of cell tabs and an intermediate portion. The intermediate portion is located along the sides of the cell tabs to place the busbar surface parallel to the surface of the cell tab in a non - crossing or non-overlapping arrangement with another busbar.

The busbar has connecting legs 6 extended from the busbar bottom surface to locate in the corresponding recesses 7 on the PCB to connect the busbar and PCB mechanically and electrically. Busbars can be connected directly or through a resistor to lower the number of voltage pickup points in order to save cost. It is of great importance that this connection has a low thermal transfer rate to ensure the preservation of the enhanced propagation properties.

The busbars 3 acting as connecting members are provided in the battery arrangement for connecting the cell tabs 2 of the battery cells. The busbars in the battery module are arranged in a non-overlapping manner and connected to the vertical surface of the cell tabs 2 of the battery cells. To achieve this non-overlapping configuration, the adjacent busbars are positioned on the opposite sides of the cell tabs.

FIG. 4 shows a schematic diagram of printed circuit board (PCB) with defined slits 5 for stacking the cell tabs 2 of battery cells, in accordance to the present invention. The printed circuit board (PCB) 4 is a plate substrate with PCB body placed on the top of the battery modules in the battery arrangement and includes a plurality of defined slits 5 for accommodating the cell tabs and extending to the top surface of the PCB for enabling connection between the cell tabs 2 and the busbars 3. The PCB 4 carries the busbars 3 in such way that the busbars stand perpendicular along its length and assembled at the top surface of the PCB. The cell tabs extend through the corresponding slits 5 in the printed circuit board PCB 4 and make connection between the cell tabs 2 and busbars 3. The cell tabs 2 of the battery cells 1 are connected with the busbars 3 by soldering to provide the electrical connection between the battery cells 1 in the battery modules.

FIG. 5 illustrates various views of busbar with connecting legs for making connection with PCB and cell tabs, in accordance to the present invention. The busbar 3 connecting the battery modules are coupled to the corresponding cell tabs 2 of battery cells. The connecting legs 6 of busbar are located in the recess 7 on the PCB and joined by any suitable joining technique (e.g., soldering) 8 thereby connecting PCB and busbar mechanically and electrically. The battery cells are located below the PCB and cell tabs 2 are extended through the slit 5 of the PCB to project above the PCB surface for connecting to the busbar 3. The busbar 3 and cell tabs are connected by any suitable joining technique (e.g., soldering). The connecting legs of busbars allow the cells tabs connection much simpler. The material of the busbar 3 is made of special conductive material to achieve the required level of thermal propagation and improve the battery life.

The PCB accommodates elements of battery management system such as voltage measurement unit, temperature sensors, etc, and all these electronic components are connected to the printed conductor in the PCB along with the busbars, thus enabling the PCB to perform double function. As the PCB is placed on the top of the battery modules it provides a good access for welding equipments, and thereby achieving advantages in terms of manufacturability for the battery unit. The busbars

and the cell tabs are connected by special process such as selective soldering to make electrical and mechanical connectivity.

FIG. 6 illustrates a PCB strip situated in between the two rows of cell tabs, in accordance to another embodiment of the present invention. The plate substrate acting as a PCB strip 4` is situated in between the two rows of cell tabs 2` and disposed above the battery cells to accommodate the busbars 3` for making electrical connections between the cell tabs 2`. This improved arrangement provides advantages in terms of manufacturability and electrical properties. In this embodiment at least one connecting end portion of the busbar is extended to the surface of the PCB and connected 6' to PCB in the recesses provided therein.

The cell tabs 2` are arranged into a first set and a second set of battery cells, and the battery cells in each set are connected in series and the adjacent battery cells of each set are spaced apart by arranging a battery cell of other set in-between. As shown in the figure 6, the busbar 3' is arranged in overlapping relation with another busbar to connect the alternate cells and to facilitate busbar connection with the PCB at one side.

FIG. 7 illustrates a two string arrangement to connect the battery cells into a battery module, in accordance to the present invention. The battery cells 1 are stacked in two string architecture to form a battery module and offer an improved arrangement, such that no battery cells 1 from the same string have direct contact and thereby limiting the thermal runaway within the module. During the thermal event, the heat transfer will not be limited to the cells in physical contact or to the electrically connected cell by bus bars 3. In this way, heat can be distributed to multiple cells. The increased length of the busbar will also limit the heat transfer through the busbar.

With this arrangement, in case of failure or high impedance in one string, the power can be supplied by another string, thus providing an improved arrangement and obtaining double power source from the module. The arrangement also allows for achieving design of multiple strings and obtains various advantages in terms for

powers source and battery life. If such architecture is adapted in which two electrically connected cells are adjacent to each other, the electrical connection should be established using the connectors with low thermal transfer rate, e.g., via PCB or a thin wire.

According to present invention the battery modules are accorded with two string cell tab architecture, such that one set of connected cell tabs is placed in-between the other set of connected cell tabs. This special arrangement makes the battery arrangement possible that electrically connected cell tabs are not assembled one adjacent to another, and the battery assembly incorporates one connected cell tab in-between the other electrically connected cell tabs.

The battery assembly according to the present invention allows the cell tab to be accommodated directly on the PCB and the busbar soldered PCB utilized to connect the cell tabs through soldering, and this provides a good access for welding equipments, and thereby achieving advantages in terms of manufacturability for the battery unit. This improved arrangement enables the battery assembly to achieve increased level of propagation safety and obtain enhanced battery life.

The two-string architecture of the present invention provides electrical interconnection between the cell tabs through the busbars and ensures one set of connected cell tabs is placed in-between the other two set of connected cell tabs, and this allows to pack more number of cell tabs and obtain high output voltage with less number of battery modules. This design permits to obtain high voltage without the need of double up on box level in a battery pack, thus achieving a simple battery construction and lowering the manufacturing cost.

The electrically connected cell tabs are not assembled one adjacent to another, and the assembly incorporates one cell tab in-between the other electrically connected cell tabs, and hence improving the propagation safety level for the battery. The busbar interconnects the battery cells with a specific non crossing busbar design that makes

advantages in terms of manufacturability and electrical properties with higher level of propagation safety.

The busbars consume less metal compared to that of the busbars used in traditional architecture, and hence improving the electrical connectivity and reducing the cost and weight of busbars. The PCB accommodates the control elements such as temperature sensors and voltage measurements in the printed conductor and no external wiring for analogue signals are required between the control elements in the battery management systems.

The busbars are assembled in the printed conductor of the PCB and provide connections between the cell tabs by direct soldering, this simple design enables for lowering short circuits during the battery assembly and allows for delivering the PCB and busbars elements as one single unit, and thereby achieving advantages such as high grade of automation and manufacturing cost of the battery. The present invention accomplishes an improved battery arrangement with the busbars and thus enabling a low impedance and weight saving design for the battery arrangement.

With improved accessible features for making contact between the busbars and the battery modules, the present invention allows for many possible contacting techniques such as resistance welding, laser welding and ultrasonic welding, and thereby enabling a scalable production for both low and high volume application.

The present invention of battery arrangement provides a fully redundant power source and enables simultaneous charging and discharging with provision of supplying power for two consumers independently from one power source, thus achieving cost efficient battery module architecture with improved safety, manufacturability and electrical properties.

The foregoing description is a specific embodiment of the present invention. It should be appreciated that this embodiment is described for purpose of illustration only, and that numerous alterations and modifications may be practiced by those

skilled in the art without departing from the spirit and scope of the invention. It is intended that all such modifications and alterations be included insofar as they come within the scope of the invention as claimed or the equivalents thereof.

We claim:

1. A battery module comprising,

a plurality of battery cells with cell tabs arranged into a first set and a second set of battery cells, and a plurality of busbars for connecting the cell tabs of said battery cells;

wherein said battery cells in each set are connected in series and said battery cells of one set are spaced apart by arranging said battery cell of other set in-between.

2. The battery module as claimed in claim 1, wherein a plate substrate with a plurality of elements for said battery management is disposed above said battery cells.

3. The battery module as claimed in claim 2, wherein said cell tabs are accomodated in said plate substrate through corresponding slits therein.

4. The battery module as claimed in claim 3, wherein said cell tabs are electrically and mechanically connected to said plate substrate.

5. The battery module as claimed in claim 3, wherein said cell tabs are extended through said slits and connected to said busbars.

6. The battery module as claimed in either claim 2 or claim 5, wherein said busbars are carried by said plate substrate.

7. The battery module as claimed in claim 6, wherein said busbar having at least one connecting leg.

8. The battery module as claimed in any one of the claims 6 to 7, wherein said plate substrate has plurality of recesses for locating the connecting legs of said busbars and joining by suitable method.

9. The battery module as claimed in any one of the preceding claims, wherein said plate substrate is a printed circuit board (PCB).

10. The battery module as claimed in any one of the claims 5 to 9, wherein said busbars are electrically connected to said plate substrate.

11. The battery module as claimed in any one of the preceding claims, wherein said busbars are arranged in a non-overlapping or overlapping manner and connected to the vertical surface of the cell tabs of said battery cells.

12. The battery module as claimed in claim 8, wherein said busbars are placed on the surface of said plate substrate and the connecting legs projecting from the side of said busbar located in the recesses.

13. The battery module as claimed in claim 12, wherein said connecting legs are soldered to said plate, in the recesses provided therein.

14. The battery module as claimed in claim 6, wherein said busbar is connected to said plate substrate through a resister.

15. A battery module comprising, a plurality of battery cells arranged into a first set and a second set of battery cells; a plurality of connecting members for connecting the cell tabs of said battery cells;

wherein said battery cells in each set are connected in series and a battery cell of said first set is arranged adjacent to a battery cell of said second set in a row;

wherein said connecting members are carried by a plate substrate accommodating the elements of said battery management system.

16. The battery module as claimed in claim 15 wherein said connecting members are electrically and mechanically connected to said plate substrate.

17. The battery module as claimed in claim and 16, wherein said plate substrate is placed in between the cell tabs of said battery cell.

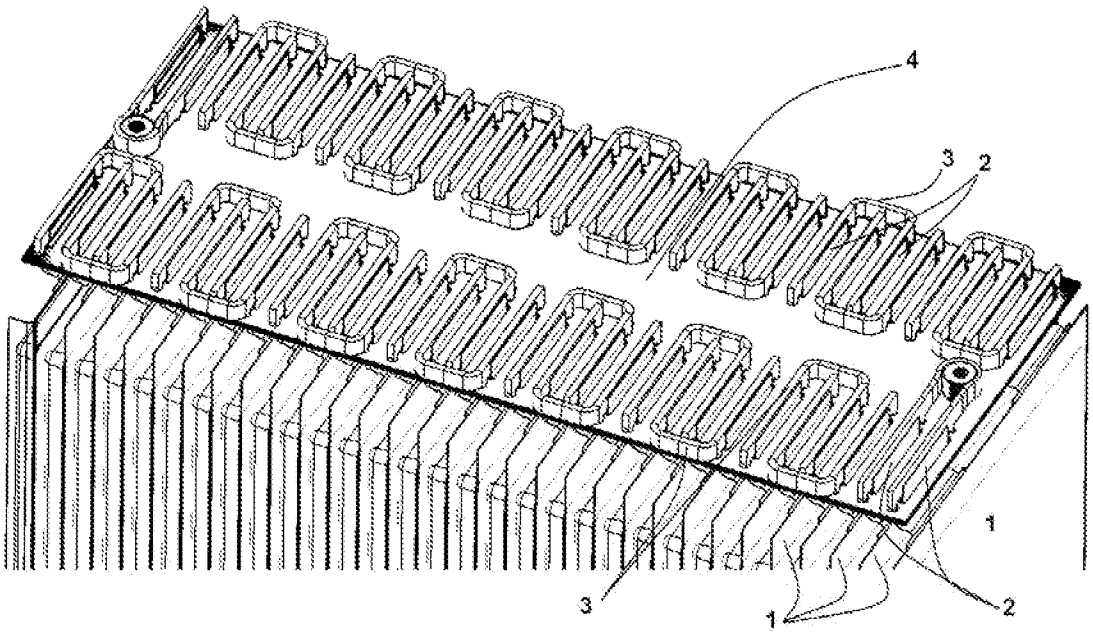

Figure 1

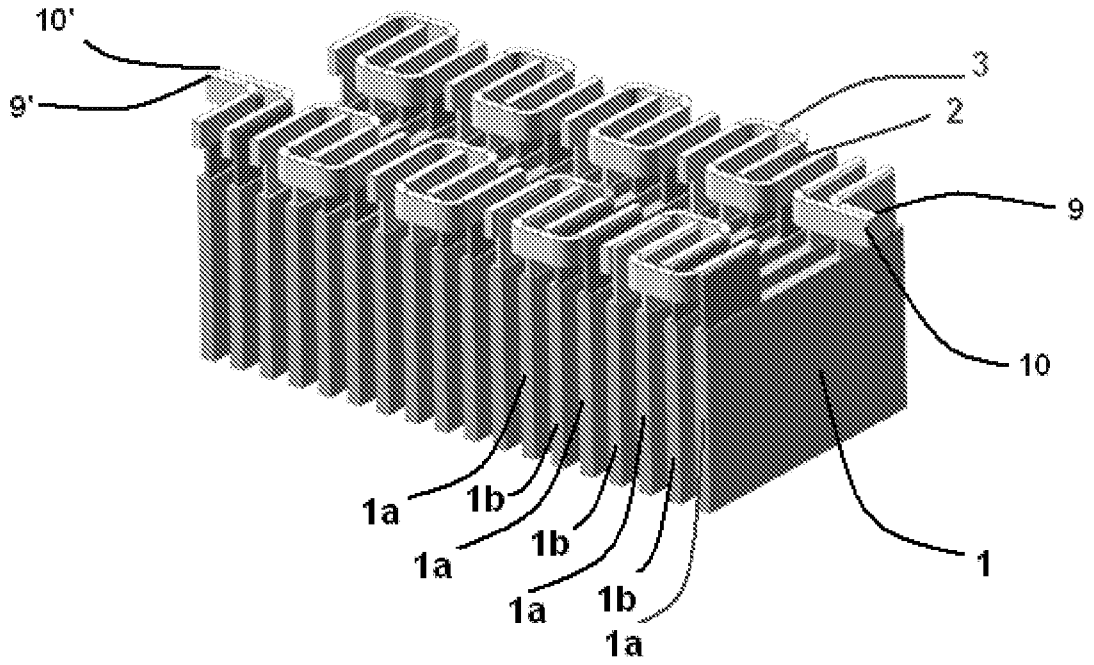

Figure 2

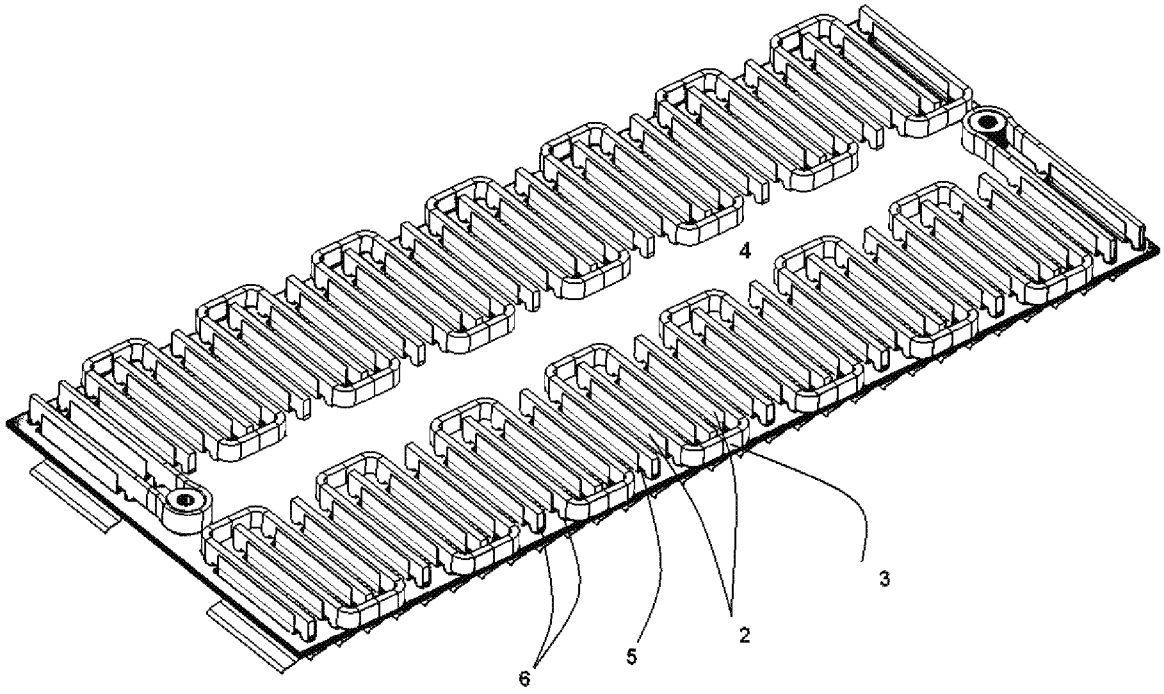

Figure 3

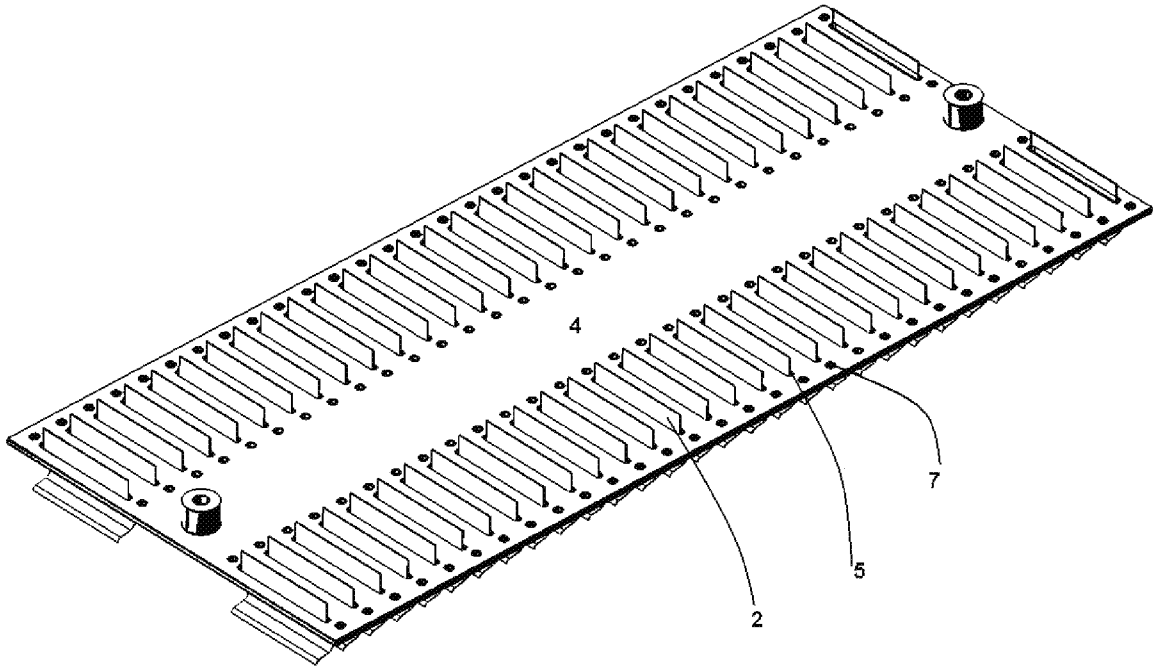

Figure 4

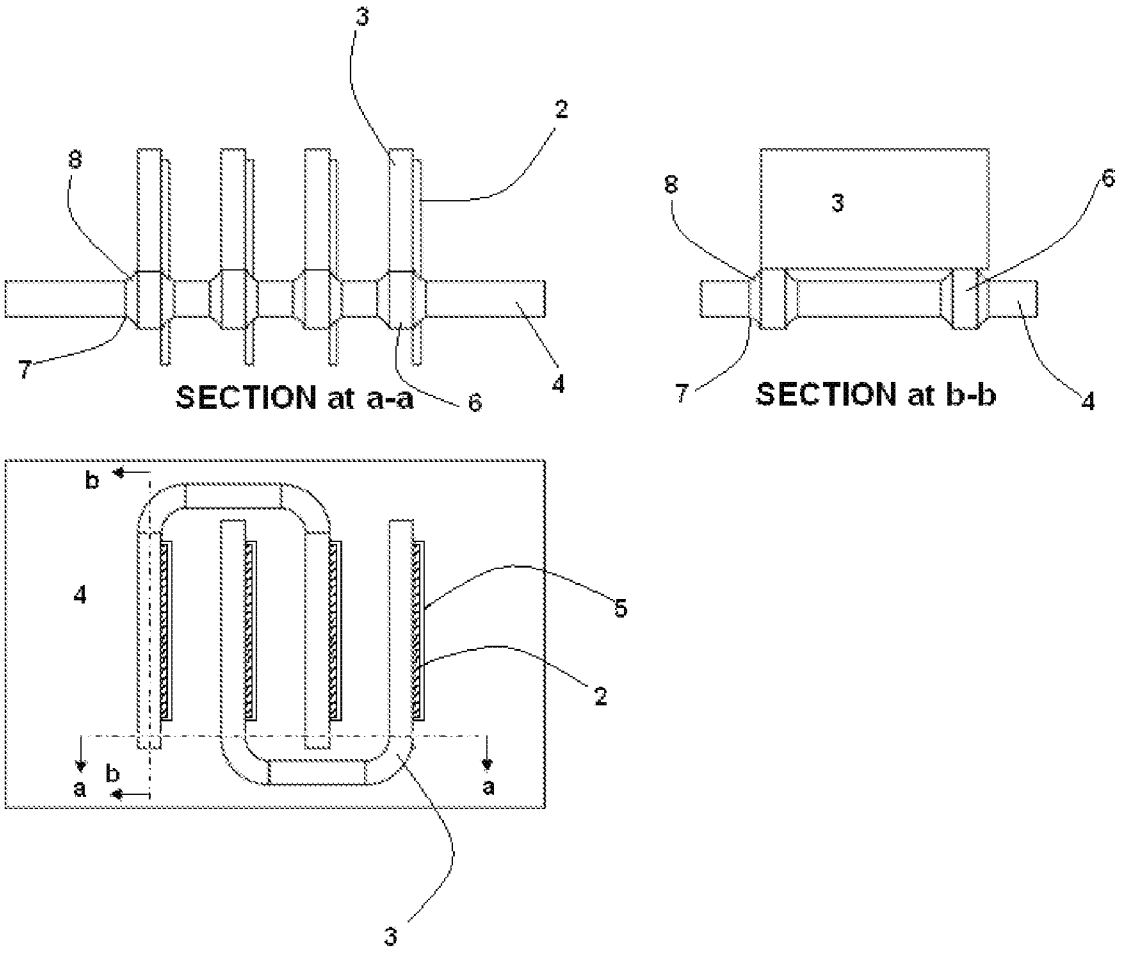

Figure 5

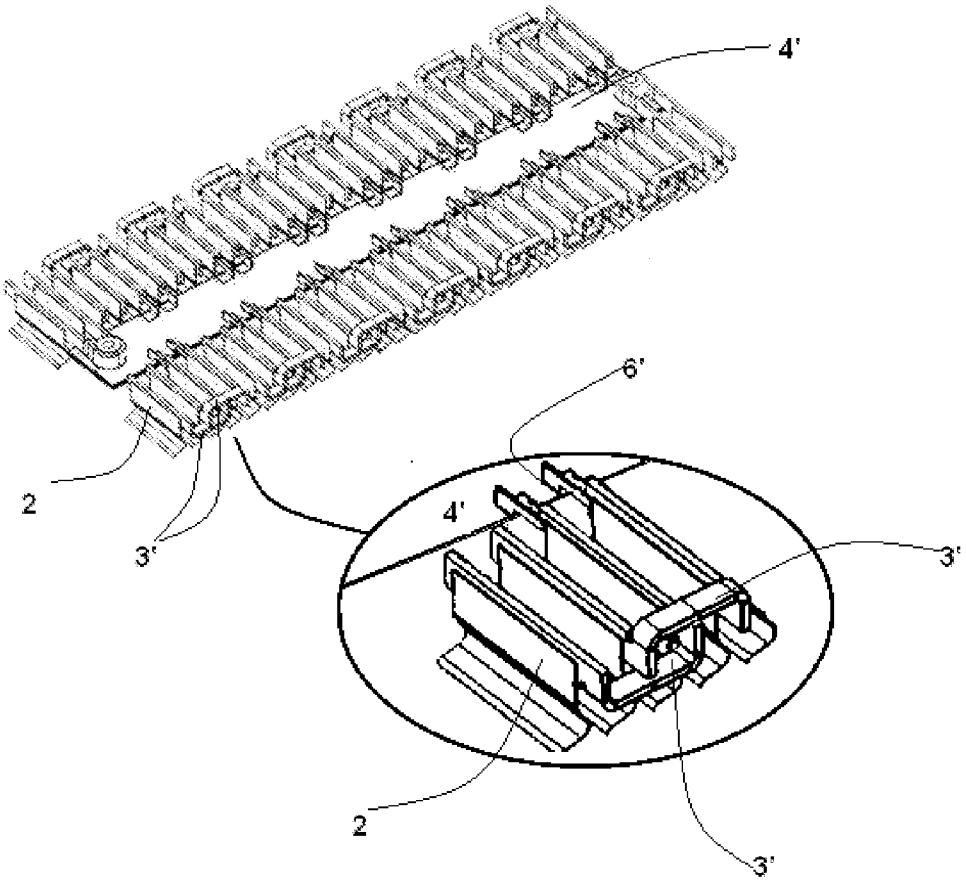

Figure 6

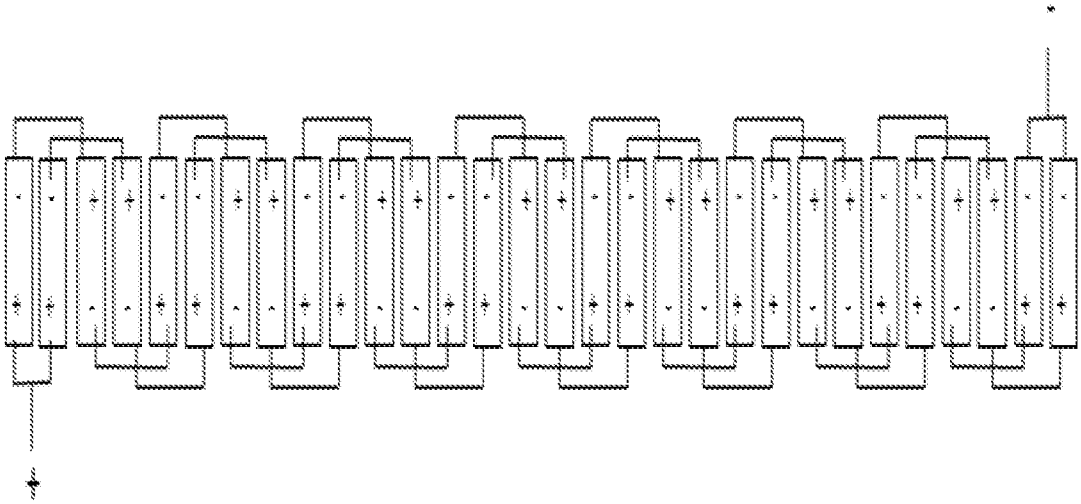

Figure 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2012/056788

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01M2/20 H01M2/10
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 445 807 A2 (DELPHI TECH INC [US]) 11 August 2004 (2004-08-11) figure 10 pages 26,41-46	1,11
X	US 2011/293992 A1 (HSU CHIH-CHENG [US] ET AL) 1 December 2011 (2011-12-01) figure 2 paragraphs [0018] , [0019] , [0023] , [0026]	1,11
X	WO 2006/052063 A1 (LG CHEMICAL LTD [KR]) 18 May 2006 (2006-05-18) figure 3 page 9, line 5 - page 11, line 3	1,11

-/- .

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 April 2013	03/05/2013

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2012/056788

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 2011/076521 A1 (SHIMIZU HIDEO [JP] ET AL) 31 March 2011 (2011-03-31) figures 3,4,8,9,10,11,13,25,27 paragraphs [0048], [0054], [0058] - [0061], [0064] - [0070], [0074], [0101] - [0103]	1-14
X	US 2005/285567 A1 (KIM TAE-Y0NG [KR]) 29 December 2005 (2005-12-29) figures 1-3 paragraphs [0027], [0028], [0042], [0045], [0049], [0050]	15-17
X	W0 2008/074034 A1 (JOHNSON CONTROLS SAFT ADVANCED [US]; WOOD STEVEN J [US]; H0UCHIN-MI LLE) 19 June 2008 (2008-06-19) figures 2,6,7 paragraphs [0024], [0029], [0034]	15-17

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