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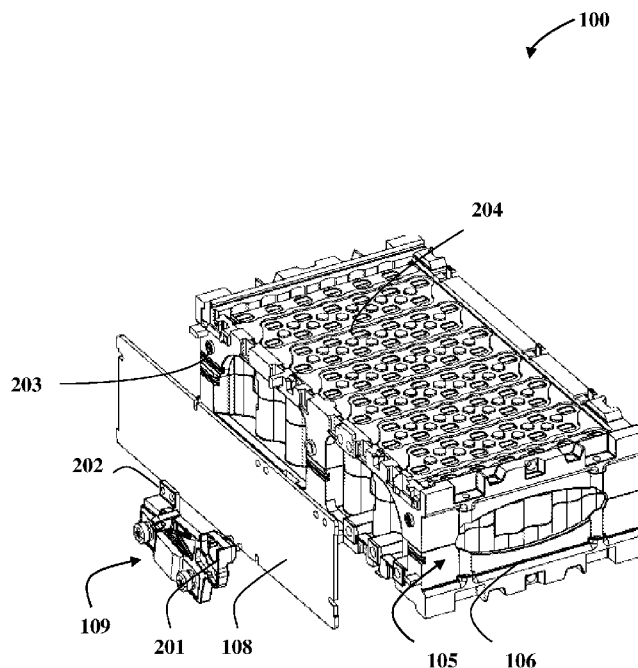


Fig. 2

(57) Abstract: A battery module (100, 700) for a powered device comprising cells enclosed in a casing (101, 701), at least one end cover (103, 702) securely attached to the casing (101, 701), and a BMS board (108, 806) positioned proximal to the at least one end cover (103, 702) is disclosed. The battery module (100, 700) also includes at least one end connection (109, 110, 111; 703a and 703b) removably attached to the BMS board (108, 806). A first end connection (109, 703a) corresponding to at least one power line of the battery module (100, 700) comprising at least one protection device (301, 1004) connected to the at least one power line for providing electrical protection to the battery module (100, 700). The end connections (109, 110, 111; 703a and 703b) avoid interference of the signal lines with the power lines and make the battery module (100, 700) waterproof and dust resistant.

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END CONNECTIONS OF A BATTERY MODULE

TECHNICAL FIELD

[0001] The present subject matter relates to battery modules. More particularly, end connections of the battery modules are disclosed in the patent application
5 number 202041010274 and the present subject matter offers an improvement over the subject matter as claimed in aforementioned patent application.

BACKGROUND

[0002] Existing research in battery technology is directed to rechargeable
10 batteries, such as sealed, starved electrolyte, lead/acid batteries, are commonly used as power sources in different applications, such as, vehicles and the like. However, the lead-acid batteries are heavy, bulky, and have short cycle life, short calendar life, and low turn around efficiency, resulting in limitations in applications.

15 [0003] Thus, in order to overcome problems associated with conventional energy storage devices including the lead-acid batteries, a lithium ion battery provides an ideal system for high energy-density applications, improved rate capability, and safety. Further, the rechargeable energy storage devices - lithium-ion batteries exhibit one or more beneficial characteristics which make it useable on powered
20 devices. First, for safety reasons, the lithium ion battery is constructed of all solid components while still being flexible and compact. Secondly, the energy storage device including the lithium ion battery exhibits similar conductivity characteristics to primary batteries with liquid electrolytes, i.e., deliver high power and energy density with low rates of self-discharge. Thirdly, the energy storage
25 device as the lithium ion battery is readily manufacturable in a manner that it is both reliable and cost-efficient. Finally, the energy storage device including the lithium ion battery is able to maintain a necessary minimum level of conductivity at sub-ambient temperatures.

[0004] In a known structure for an energy storage device, one or more energy
30 storage cells including lithium ion battery cells are disposed in at least one holder structure in series and parallel combinations using at least one interconnecting

structure. The interconnecting structure is adapted for electrically interconnecting the energy storage cells with a battery management system (BMS). An output voltage and an output current generated by the energy storage device is transmitted to one or more electronic and electrical components configured to be
5 powered by the energy storage device via end connections after being monitored and regulated by the BMS. The design of the end connections is critical to the safety, serviceability, and maintainability of the energy storage device.

BRIEF DESCRIPTION OF DRAWINGS

10 [0005] The detailed description is described with reference to the accompanying figures. The same numbers are used throughout the drawings to reference like features and components.

[0006] Figs. **1A-1B** exemplarily illustrate a perspective view and an exploded
15 view of a first embodiment of a battery module;

[0007] Fig. **2** exemplarily illustrates a partial exploded view of the battery pack showing the first end connection of the first embodiment of the battery module;

[0008] Fig. **3** exemplarily illustrates a perspective view of a first end connection of the first embodiment of the battery module;

20 [0009] Fig. **4** exemplarily illustrates an exploded view of the first end connection of the first embodiment of the battery module;

[00010] Fig. **5** exemplarily illustrates a plan view of at least one connector of the terminal holder of the first embodiment of the battery module;

[00011] Fig. **6** exemplarily illustrates a plan view of the terminal holder of
25 the first embodiment of the battery module;

[00012] Fig. **7** exemplarily illustrates a perspective view of a second embodiment of a battery module;

[00013] Fig. **8** exemplarily illustrates an exploded perspective view of the battery module exemplarily illustrated in Fig. **7**;

30 [00014] Figs. **9A-9B** exemplarily illustrate perspective views of a second end connection of the second embodiment of the battery module;

[00015] Figs. **10A-10C** exemplarily illustrate perspective views of a first end connection of the second embodiment of the battery module; and

[00016] Figs. **11A-11B** exemplarily illustrate a perspective sectional view of the second embodiment of the battery module with the first end connection and
5 the second end connection.

DETAILED DESCRIPTION OF THE INVENTION

[00017] The energy storage device is connected to subsequent energy storage devices, on-board or external chargers, and electrical and electronic loads
10 of a power supply system via a plurality of end connections. Typically, the output of the energy storage cells is connected to the battery management system (BMS) circuit board by means of wires and the output voltage and the output current from the end connections connect to the electronic and electrical loads in the power supply system by means of wires. Such interconnecting wires have a potential of
15 short circuit while assembly of the energy storage device.

[00018] To prevent occurrences of such untoward events, in the existing structures of the energy storage device, the end connections are molded into an end cover of the energy storage device. Such end connections are not removable, requiring replacement of the entire end cover in case of repair of the end
20 connections. In some other structures of the energy storage devices, the end connections are positioned on a printed circuit board (PCB) located in the energy storage device in addition to the BMS in the energy storage device. Such PCBs are inflexible and are under stress during the assembly of the energy storage device, leading to failure of the PCB in the energy storage device. Further,
25 additional components in the energy storage device increase the weight of the energy storage device and the cost associated with the manufacturing, servicing, and replacement of the energy storage device.

[00019] Further, the output of the cells of the energy storage device passes through a safety device, such as, a fuse to the end connection on the body of the
30 energy storage device. The assembly of the safety device needs to be performed prior to the mounting of the end cover of the energy storage device. Since, wires

are used to connect the cells to the end connection; the safety device is connected to the wires. In the assembly of the energy storage device, the fuse will be hanging from the wires and difficult to connect to the end connection in the end cover. The stated difficulty in assembly of the energy storage device and safety
5 protection on assembly of the energy storage device drives the need for an improved design of the energy storage device.

[00020] There exists a need for an improved design of an energy storage device with end connections that ensure safety during assembly, maintainability, and serviceability of the energy storage device overcoming all problems disclosed
10 above as well as other problems of known art.

[00021] The present subject matter discloses an energy storage device, that is, a battery module comprising an improved and simplified design of end connections for facilitating connection of the battery module to a battery controller, a charging unit, or subsequent battery modules in a powered device, for
15 example, a vehicle. In an embodiment of the present invention, a battery module for a powered device is disclosed. The battery module comprises a plurality of cells enclosed in a casing, at least one end cover securely attached to the casing, and a battery management system (BMS) board positioned proximal to the at least one end cover in the casing. Further, the battery module comprises at least one
20 end connection removably attached to the BMS board. In an embodiment, the at least one end connection comprises a first end connection, corresponding to at least one power line of the battery module, comprising at least one protection device connected to the at least one power line for providing electrical protection to the battery module. The first end connection comprises one of a first terminal
25 holder and a second terminal holder removably attached to the battery management system board.

[00022] The first terminal holder comprises a base member with at least one connector attached to a bottom surface of the base member at predetermined locations and an attaching member at a first corner for removably attaching the
30 base member to the BMS board. The at least one protection device is attached to the at least one connector to form a positive terminal of the battery module.

[00023] In an embodiment, a first end of the at least one connector connects to positive terminals of the plurality of cells at one of the predetermined location through at least one interconnect sheet and a second end of the at least one connector connects to the at least one protection device. In an embodiment, a second end of the at least one connector connects to the at least one protection device and a first end of the at least one connector forms the positive terminal of the battery module. In an embodiment, the at least one connector is a metal connector with mounting provisions en-molded in the base member. In an embodiment, the terminal holder comprises at least one guiding means to route at least one cable on the BMS board. In an embodiment, the base member comprises at least one stiffener between the at least one connector and the at least one protection device for reinforcing the base member.

[00024] In an embodiment, the first end connection comprises the second terminal holder removably attached to the BMS board, a positive terminal stud and a negative terminal stud extending from the second terminal holder for connecting to external components, and the at least one protection device connected to the positive terminal stud in a path of current from the BMS board to the positive terminal stud. The positive terminal stud and the negative terminal stud project from the battery management system board through the at least one end cover. In an embodiment, the positive terminal stud and the negative terminal stud have different geometries.

[00025] The second terminal holder comprises a base member with at least one connector attached on a bottom surface of the base member at predetermined locations. One of the at least one connector connects the at least one protection device to the positive terminal stud. In an embodiment, the at least one end connection further comprises a second end connection corresponding to signal lines of the battery module.

[00026] The second end connection comprises at least one female signal connector comprising at least one hollow pin securely attached to the BMS board, and at least one corresponding male signal connector comprising at least one plug

removably engaged with the at least one hollow pin of the at least one female signal connector for connecting the battery module to a battery controller.

[00027] In an embodiment, the at least one male signal connector further comprises clips for secure and tight locking of the at least one plug with the at least one hollow pin of the at least one female signal connector. In an embodiment, the second end connection facilitates parallel connection of the battery module with other battery modules of similar type. The battery module further comprises a third end connection corresponding to negative terminals of the plurality of cells. In an embodiment, the at least one end connection on the BMS board is connected to an external connection on the at least one end cover of the battery module for charging, discharging, and controlling operation of the battery module. In an embodiment, the end cover further comprises guiding means and a holding clamper to route power cables and signal cables connected to the first end connection and the second connection respectively.

[00028] Another embodiment of a battery module for a powered device is disclosed. The battery module comprises a plurality of cells enclosed in a casing, at least one end cover, with an external connection, securely attached to the casing, and a BMS board positioned proximal to the at least one end cover in the casing. The battery module further comprises a first end connection comprising a first terminal holder and at least one protection device positioned on the BMS board, forming a positive terminal of the battery module, a second end connection positioned on the battery management system board, corresponding to signal lines of the battery module, and a third end connection positioned on the battery management system board, connecting to negative terminals of the plurality of cells. The first end connection, the second end connection, and the third end connection on the BMS board are connected to the external connection on the at least one end cover of the battery module for charging, discharging, and controlling operation of the battery module.

[00029] In this embodiment, the first terminal holder comprises a base member with at least one connector attached to a bottom surface of the base member at predetermined locations and an attaching member at a first corner for

removably attaching the base member to the battery management system board. The at least one protection device is fastened to the at least one connector to form a positive terminal of the battery module. In an embodiment, a first end of the at least one connector connects to positive terminals of the plurality of cells through at least one interconnect sheet at one of the predetermined fastening locations and a second end of the at least one connector connects to the at least one protection device. In another embodiment, a second end of the at least one connector connects to the at least one protection device and a first end of the at least one connector forms the positive terminal of the battery module. In an embodiment, the at least one connector is a metal connector with mounting provisions molded in the base member. The base member comprises at least one guiding means to route at least one cable on the battery management system board. In another embodiment, the base member comprises at least one stiffener between the at least one connector and the at least one protection device for reinforcing the base member.

[00030] The present subject matter is further described with reference to accompanying figures. It should be noted that the description and figures merely illustrate principles of the present subject matter. Various arrangements may be devised that, although not explicitly described or shown herein, encompass the principles of the present subject matter. Moreover, all statements herein reciting principles, aspects, and examples of the present subject matter, as well as specific examples thereof, are intended to encompass equivalents thereof.

[00031] Figs. **1A-1B** exemplarily illustrate a perspective view and an exploded view of a first embodiment of a battery module **100**. The battery module **100** comprises a plurality of cells forming a battery pack **105** housed within a casing. The external casing **101** encloses the battery pack **105** from top and bottom. The battery module **100** further comprises a first end cover **103** and a second end cover **104** that enclose the battery pack **105** from the rear and the front respectively. The cells **107** in the battery pack **105** are arranged in a particular sequence in a cell holder **106**. The cells **107** are electrically connected in series and/or parallel configuration to form an array of cells. Such arrays of cells are

electrically connected to a battery management system (BMS) board **108** within the battery module **100**. The BMS **108** is a printed circuit board with one or more integrated circuits integrally built on it as exemplarily illustrated in Fig. **1B**. The BMS board **108** is attached to one of the sides of the battery pack **105**. In an embodiment, the BMS board **108** is located between the battery pack **105** and the first end cover **103**.

[00032] The external casing **101** has mounting provisions for the second end cover **104** and the first end cover **103**. The second end cover **104** and the first end cover **103** are fastened to the external casing **101** using a plurality of attachment means, such as, fasteners. The battery pack **105** has mounting provisions for the BMS board **108**. The BMS board **108** is screwably attached to the cell holder **106** of the battery pack **105**.

[00033] An external connection **102** is mounted on the first end cover **103**. The external connection **102** of the battery module **100** facilitates connection of the battery module **100** for charging, discharging, series and parallel connection with other battery modules or controlling operation by a battery controller in the powered device. In an embodiment, the external connection **102** may be positioned in a mounting provision in the end cover **103** to facilitate the connection of the battery module **100** to external components in the powered device. The powered device may be a vehicle, be it a two-wheeled vehicle, a three-wheeled vehicle, multi-wheeled vehicle, etc.

[00034] The battery module **100** comprises power lines that provide the voltage and current output of the battery module **100** and signal lines that provide status of the battery module **100** to be used further by the external components in the powered device. As exemplarily illustrated, the battery module **100** comprises at least one end connection **109**, **110**, **111** removably attached to the BMS board **108**. The at least one end connection may be a first end connection **109**, a second end connection **110**, and/or a third end connection **111**. As exemplarily illustrated, all of the first end connection **109**, the second end connection **110**, and the third end connection **111** are removably attached to the BMS board **108**. In an embodiment, at least one of the first end connection **109**, the second end

connection **110**, and the third end connection **111** is removably attached to the BMS board **108**.

[00035] The first end connection **109** exemplarily illustrated in Fig. **1B** corresponds to at least one power line, that is, the positive terminal of the battery module **100**. The positive terminals of the cells **107** of the battery module **100** culminate in the first end connection **109** and the first end connection **109** corresponds to the positive terminal of the battery module **100**. The second end connection **110** corresponds to signal lines of the battery module **100**. The third end connection **111** corresponds to negative terminals of the plurality of cells **107**. The negative terminals of the cells **107** culminate in the third end connection **111**. The first end connection **109**, the second end connection **110**, and the third end connection **111** connect to the external connection **102** as shown. On the external connection **102**, the on-board charger, or components of the powered device are connected for charging, discharging, or controlling the battery module **100**.

[00036] Fig. **2** exemplarily illustrates a partial exploded view of the battery pack **100** showing the first end connection **109**. As exemplarily illustrated, the first end connection **109** is mounted onto the BMS board **108**. The first end connection **109** carries current from the BMS board **108** in and out of the battery module **100**. The current from the cells **107** in the battery pack **105** culminate into a positive terminal and a negative terminal on the BMS board **108** through the interconnect sheets **204**. The first end connection **109** comprises a first terminal holder **201** removably attached using at least one mounting provision **202** to the BMS board **108** of the battery module **100**. The BMS board **108** is mounted to the cell holder **106** using the mounting provisions, such as, **203**.

[00037] Fig. **3** exemplarily illustrates a perspective view of a first end connection **109**. As exemplarily illustrated, the first end connection **109** comprises the first terminal holder **201** and at least one protection device **301**. The first terminal holder **201** is a bus bar with mounting provisions **202a**, **202b** to mount the first end connection **109** onto the BMS board **108**. The positive terminals of the cells **107** connect to the first terminal holder **201** and the output terminal **303** of the first terminal holder **201** forms the positive terminal of the battery module

100. In an embodiment, the positive terminals of the cells **107** culminate on the BMS board **108** through the interconnect sheets **204** and the positive terminal of the BMS board **108** is connected to the first terminal holder **201**. The first terminal holder **201** comprises at least one guiding means **302** to route at least one
5 cable on the BMS board. The first terminal holder **201** comprises a base member **401** and at least one connector **202a**, **202b** as will be described in Fig. 4.

[00038] Fig. 4 exemplarily illustrates an exploded perspective view of the first end connection **109**. The terminal holder **201** of the first end connection **109** comprises the base member **401** onto which the protection device **301** is mounted.
10 At least one connector **202a**, **402** is attached to a bottom surface of the base member **401** at predetermined locations. The base member **401** comprises at least one attaching member **202b** at a first corner of the base member **401** on a top surface. The attaching member **202b** is a mounting provision for mounting the terminal holder **201** to the BMS board **108**. The base member **401** is made of a
15 polymeric material, for example, plastic. The protection device **301** is mounted on the base member **401** at predetermined locations using fasteners **403a**, **403b**, such as, screw and nut assemblies shown in Fig 4. The at least one protection device **301** on the terminal holder **401** is, for example, a fuse exposed to direct currents of a predetermined value. As per an embodiment, the predetermined value can be
20 70 Amperes. The fuse is a self-acting circuit break appliance for protection of the battery module **100** against excessive currents. Excessive currents in the battery module **100** could be due to incorrect wiring of the components within the battery module **100**, shorting of the positive terminal of the BMS board **108**, or overloading of the battery module **100**, etc. The fuse is located in close proximity
25 to the positive terminal of the BMS board **108** and connected to the positive terminal **303** of the battery module **100**. In case of fault between the fuse and the electrical load connected to the external connection **102**, the fuse blows and the current flow to the loads stops from the positive terminal **303** of the battery module **100**. The protection device **301** is mounted using the attachment means
30 **403a** and **403b**, for example, screws and nuts at the predetermined locations **404a** and **404b** on the base member **401**. In an embodiment, gaskets, such as, O-ring

seals are provided around the screws for tight sealing at the predetermined locations.

[00039] Fig. 5 exemplarily illustrates a plan view of at least one connector **202a**, **402** of the terminal holder **201**. The terminal holder **201** comprises two connectors **202a**, **402** fastened to the bottom surface of the base member **401** at predetermined locations. One of the connectors **202a** connects to the positive terminal of the BMS board **108** and also functions as a mounting provision to mount the terminal holder **201** to the BMS board **108**. A first end **501a** of the connector **202a** connects to the positive terminal of the cells **107** at a predetermined location on the BMS board **108** and a second end **501b** of the connector **202a** connects to the protection device **301**. A second end **502b** of the connector **402** connects to one end of the protection device **301** and a first end **502a** of the connector **402** forms the output terminal **303** of the terminal holder **201** and the positive terminal of the battery module **100**. The connectors **202a**, **402** have the protection device **301** connected between them and the free ends **501a**, **502a** of the connectors **202a**, **402** respectively form the input terminal of the terminal holder **201** and the output terminal **303** of the terminal holder **201**. The current from the cells **107** is passed to the metal connector **202a** at the end **501a** and then passed to the end **501b**. At the end **501b**, the protection device receives the current and if condition of the battery module is good, the protection device passes the current to the end **502b** of the connector **402**. From the end **502b**, the current passes to the end **502a** of the connector **402** to pass to the output terminal **303** of the terminal holder **201**.

[00040] In an embodiment, the connectors **202a**, **402** are metal connectors that are en-molded by the plastic base member **401**. The connectors **202a**, **402** are en-molded in a manner to expose the input terminal and the output terminal **303** of the terminal holder **201** and the predetermined locations for mounting the protection device **301**. In an embodiment, the connectors **202a**, **402** are made of a metal, such as, casted brass. In an embodiment, the connectors **202a**, **402** are made of sheet metal. The design of the connectors **202a**, **402** may be same or different. The contour of the connectors **202a**, **402** is made in the base member of

the terminal holder **201** for correct and guided positioning of the connectors **202a**, **402** in their respective locations.

[00041] Fig. **6** exemplarily illustrates a plan view of the terminal holder **201**. The attaching member **202b** at the first corner of the base member **401** on the top surface comprises metal hollow connectors with threads en-molded in the plastic base member **401**. In an embodiment, gaskets, such as, O-ring seals may be provided at all the predetermined locations for tight sealing. The gaskets provide a rugged sealed connection of the input terminal, the output terminal of the terminal holder **201** from water and dust for IP67 compliance of the battery module **100**. Further, the base member **401** comprises at least one stiffener, **601** such as, grooves, ridges, or any pattern between the connectors **202a**, **402** and the protection device **301** for reinforcing the base member **401**.

[00042] Fig. **7** exemplarily illustrates perspective view of a second embodiment of a battery module **700**. The battery module **700** comprises a plurality of cells arranged in a particular sequence in a cell holder. The cells are electrically connected in series and/or parallel configuration to form an array of cells. Such arrays of cells are electrically connected to a battery management system (BMS) within the battery module **700**. The BMS is a printed circuit board with one or more integrated circuits integrally built on it as exemplarily illustrated in Fig. **8**.

[00043] As exemplarily illustrated, the battery module **700** comprises an external casing **701** with a dovetail pattern that is vibration proof and shock resistant, a first end cover **702**, a second end cover (not shown), and a battery pack. The dovetail pattern of the external casing **701** facilitates easy mounting and un-mounting of the battery module **700** in the space in a device or powered product. The external casing **701** encloses the battery pack from top and bottom. The second end cover (not shown) and the front-end cover **702** enclose the battery pack from the rear and the front respectively.

[00044] The terminal studs of a plurality of end connections **703a** and **703b** extend from the first end cover **702** as exemplarily illustrated. The first end cover **702** further comprises guiding means **704** and a holding clasper **705** to route

power cables 706 and signal cables connected to the end connections **703a** and **703b** of the battery module **700**.

[00045] Fig. 8 exemplarily illustrates an exploded perspective view of the second embodiment of the battery module **700**. As exemplarily illustrated, the battery pack **804** is enclosed between the second end cover **803**, the external casing **701**, the first end cover **702**. The BMS board **806** is attached to one of the sides of the battery pack **804**. In an embodiment, the BMS board **806** is located between the battery pack **804** and the first end cover **702**. The end connections **703a** and **703b** (exemplarily illustrated in Fig. 7) are removably attached to the BMS board **806**. The external casing **701** has mounting provisions for the second end cover **803** and the first end cover **702**. The second end cover **803** and the first end cover **702** are fastened to the external casing **701** using a plurality of attachment means **802** and **809** respectively. As per a preferred embodiment, the attachment means can be fasteners. The battery pack **804** has mounting provisions for the BMS board **806**. The BMS board **806** is screwably attached to the cell holder **804a** of the battery pack **804**. Further, the end cover **803** has a vent plug **801** for release of by-product gases from the battery pack **804**.

[00046] The plurality of end connections **703a** and **703b** include a first end connection **703a** and a second end connection **703b**. The first end connection **703a**, exemplarily illustrated in Fig. 7, corresponds to the power lines of the battery module **700**. The first end connection **703a** is mounted on the BMS board **806**. The second end connection **703b** corresponds to signal lines of the battery module **700**. The second end connection **703b** is a two-part signal connector including a female signal connector **807** and a male signal connector **808** that is fastened to the BMS board **806**.

[00047] Figs. 9A-9B exemplarily illustrate perspective view of the second end connection **703b** of the battery module **700**. The second end connection **703b** comprises the female signal connector **807** and the corresponding male signal connector **808**. The female signal connector **807** comprises at least one hollow pin, such as, six hollow pins **901** centrally located on its body. The corresponding male signal connector **808** removably engages with the female signal connector

807. The female signal connector **807** is fastened on the BMS board **806** directly using fasteners **805** as exemplarily illustrated in Fig. **8**. The at least one hollow pins **901** are molded into the body of the female signal connector **807**. Corresponding to the hollow pins **901**, the BMS board **806** comprises
5 corresponding at least one mounting provisions, such as, holes **806a** as exemplarily illustrated in Fig. **8**, to removably attach the female signal connector **807** with the pins **901** to the BMS board **806** using fasteners **805** from the surface of the BMS board **806** that is in contact with the battery pack **804**. The male signal connector **808** comprises six banana plugs **902** protruding from a rear
10 surface **808a** to engage with the six pins **901** in the female signal connector **807**. The hollow pin **901** of the female signal connector **807** engages with the plug **902** of the male signal connector **808**. On a first surface **808b** of the male signal connector **808**, the six banana plugs **902** facilitate signal lines of the battery pack **804** to be accessed from outside.

15 **[00048]** Further, the male signal connector **808** comprises clips **903** on both sides for ease in mating and disengaging of the male signal connector **808** with the female signal connector **807**. For mating of the banana plugs **902** with the hollow pins **901**, the inner diameter of the hollow pins **901** are greater than or engageably conforming with the diameter of the banana plugs **902** and the banana plugs **902**
20 are inserted into the hollow space of the hollow pins **901** to achieve an operable & stable electrical contact cum connection. While mating the banana plugs **902** with the hollow pins **901**, the clips **903** are pressed, for example, inwards towards the banana plugs **902**. Once the banana plugs **902** are engaged with the hollow pins **901**, the clips **903** are released. The clips **903** ensure secure and tight locking of
25 the banana plugs **902** with the hollow pins **901**. To disengage the banana plugs **902** from the hollow pins **901**, the clips **903** are again pressed in a lateral direction towards each other and the banana plugs **902** are pulled out from the hollow pins **901**. The pins **901** correspond to the signals from the BMS board **806**. The second end connection **703b** facilitates parallel connection of the battery module **700** with
30 other battery modules of similar type. Also, the second end connection **703b** aids

in communication of the battery module **700** to the battery controller in the powered device, for example, a vehicle.

[00049] Figs. **10A-10C** exemplarily illustrate perspective views of the first end connection **703a** of the battery module **700**. The first end connection **703a** carries current from the BMS board **806** out of the battery module **700** to electrical loads. The current from the cells in the battery pack **804** culminate into a positive terminal and a negative terminal on the BMS board **806**. The first end connection **703a** comprises a second terminal holder **1001** removably attached using at least one mounting provision **1002a** and **1002b** to the BMS board **806** of the battery module **700**. As exemplarily illustrated, the second terminal holder **1001** is a bus bar with mounting provisions to mount at least one protection device **1004**, a positive terminal stud **1005a**, and a negative terminal stud **1005b** of the battery module **700**. The positive terminal of the BMS board **806** is connected to the positive terminal stud **1005a** and the negative terminal of the BMS board **806** is connected to the negative terminal stud **1005b**. Between the positive terminal stud **1005a** and the negative terminal stud **1005b**, the electrical loads of the battery module **700** or a charger of the battery module **700** to recharge the battery module **700** are connected. The positive terminal stud **1005a** and the negative terminal stud **1005b** protrude through the first end cover **702**. The positive terminal stud **1005a** and the negative terminal stud **1005b** are located in a depression (not shown) in the front-end cover **702** as exemplarily illustrated in Fig. 7.

[00050] The at least one protection device **1004** on the second terminal holder **1001** is, for example, a fuse exposed to direct currents of predetermined value. As per an embodiment, the predetermined value can be 70 Amperes. The fuse is a self-acting circuit break appliance for protection of the battery module **700** against excessive currents. Excessive currents in the battery module **700** could be due to incorrect wiring of the components within the battery module **700**, shorting of the positive terminal of the BMS board **806**, or overloading of the battery module **700**, etc. The fuse is located in close proximity to the positive terminal of the BMS board **806** and connected to the positive terminal. The

negative terminal is connected to the ground. In case of fault between the fuse and the electrical load, the fuse blows and as a result the current flow to the loads stops. The protection device **1004** is mounted using the attachment means **1003a** and **1003b**, for example, screws and nuts at the mounting provisions **1006a** and **1006b** on the second terminal holder **1001**.

[00051] The positive terminal stud **1005a** and the negative terminal stud **1005b** are securely attached to the terminal holder **1001** at designated locations on the second terminal holder **1001**. As per an embodiment, the positive terminal stud **1005a** is a bolt **1008a** in which a conductor from the positive terminal of the BMS board **806** is placed and fastened with a nut, such as, **1009** to the second terminal holder **1001**. Similarly, as per an embodiment, the negative terminal stud **1005b** is a bolt **1008b** in which a conductor from the negative terminal of the BMS board **806** is placed and fastened with a nut, such as, **1009** to the second terminal holder **1001**. Each of the positive terminal stud **1005a** and the negative terminal stud **1005b** is fastened to the second terminal holder **1001** using a fastener **1009**, for example, a screw and a washer from bottom of the second terminal holder **1001**. In an embodiment, each of the positive terminal stud **1005a** and the negative terminal stud **1005b** comprise gaskets **1007a** and **1007b**, such as O-ring seals for tight sealing at the positive terminal stud **1005a** and the negative terminal stud **1005b**. The gaskets **1007a** and **1007b** provide a rugged sealed connection of the terminal studs **1005a** and **1005b** from water and dust for IP67 compliance of the battery module **700**.

[00052] In an embodiment, the second terminal holder **1001** is a plastic base member **1011** to which metal connectors, such as, **1010**, **1012**, and **1013** are screwably attached or en-molded on a bottom surface of the plastic base member **1011** at predetermined fastening locations as exemplarily illustrated in Fig. **10C**. The metal connectors **1012** and **1013** facilitate detachably attaching the terminal holder **1001** to the BMS board **806**. The metal connectors **1012** and **1013** have the mounting provisions **1002a** and **1002b** to mount the plastic base member **1011** to the BMS board **806** of the battery module **700**. The metal connector **1010**

connects the fuse in series with the positive terminal of the BMS board **806** at the positive terminal stud **1005a**.

[00053] The positive terminal stud **1005a** and the negative terminal stud **1005b** extend from the plastic base member **1011** through the first end cover **702** for sourcing power to external loads. The positive terminal stud **1005a** and the negative terminal stud **1005b** form the first end connection **703a** exemplarily illustrated in Fig. 7. As per an embodiment, the positive terminal stud **1005a** and the negative terminal stud **1005b** have different geometries to avoid interchanging of polarities during manufacturing, assembly, or servicing of the battery module **700**. In an embodiment, the positive terminal stud **1005a** and the negative terminal stud **1005b** have anti-rotation feature for ensuring tight fastening of the positive terminal stud **1005a** and the negative terminal stud **1005b** to the terminal holder **1001**.

[00054] Figs. **11A-11B** exemplarily illustrate a perspective sectional view of the battery module **700** exemplarily illustrated in Fig. 7 with the first end connection **703a** and the second end connection **703b**. The battery pack **804** of the battery module **700** comprises a plurality of cells **1101** positioned on a cell holder structure **804a** and connected in series and parallel connections using an interconnecting sheet **1102** as exemplarily illustrated. The terminals of the cells **1101** are connected to the interconnecting sheet **1102** and connected to the BMS board **806**. An enlarged view of the sectional view of the second end connection **703b** is exemplarily illustrated in Fig. **11B**. In the second end connection **703b**, the at least one banana plug **902** of the male signal connector **808** engages with the at least one pin **901** of the female signal connector **807**. The male signal connector **808** comprises locking elements or clips **903** on both sides for ease in insertion and removal of the male signal connector **808** from mating and disengaging of the male signal connector **808** with the female signal connector **807**.

[00055] The positive terminal stud **1005a** and the negative terminal stud **1005b** extend from the BMS board **806** and protrude through the first end cover **702**. Eye terminals of the power lines of the battery pack **804** are screwed on the

terminal studs **1005a** and **1005b**. The signal lines of the battery pack **804** are soldered or crimped into the banana plugs **902**. The signal lines originate from at least one of a temperature sensor installed on the battery pack **804**, a current measurement of an individual cell in the battery pack **804**, or a voltage level
5 detector of an individual cell in the battery pack **804**, etc.

[00056] The first end cover **702** also includes guiding means **704** for guiding the cables **706** arising from the positive terminal stud **1005a** and the negative terminal stud **1005b** as exemplarily illustrated in Fig. 7. The guiding means **704** are located in depressions on the first-end cover **702** to guide the cable
10 through the depressions in the first end cover **702**. The first end cover **702** has projections over the positive terminal stud **1005a** and the negative terminal stud **1005b** beyond which the positive terminal stud **1005a** and the negative terminal stud **1005b** do not extend. The guiding means **704** and the projections ensure the cables **706** extending from the positive terminal stud **1005a** and the negative
15 terminal stud **1005b** are press fit into the guiding means **704** and do not bulge from the surface of the first end cover **702** avoiding stress and damage on the cables **706**, when the battery module **700** is to be compactly positioned in a powered device, for example, a vehicle. The holding clasper **705** holds the guided cables and prevents dangling of the cables **706** to avoid damage to the
20 cables **706**.

[00057] The end connections in the different embodiments of the battery module provide technical advancement in battery technology as follows: In the first embodiment of the battery module, such a first end connection ensures the positive terminals of the cells are routed separately to the external connection and
25 avoids interference with the negative terminals of the cells and the signal lines of the battery module. Also, the first end connection, the second end connection and the third connection are mounted on the BMS board and other internal components such as bus bars are avoided. The connection of the cells to the BMS board happens through the interconnect sheets in contact with the cells. The
30 common external connection of the battery module where the first end connection, the second end connection, and the third end connection converge ensures

simplicity in manufacture and use of the battery module. The components of the powered device interfacing with the battery module are all connected through the same external connection. The design of the first end connection includes guiding means for guiding cables on the BMS board and the stiffeners such as grooves to strengthen the base member of the terminal holder. The connectors to connect the protection device have different geometries and shapes to differentiate between them during the process of assembly and servicing of the battery module. Further, the presence of the protection device within the battery module protects the battery module from occurrence of any short-circuit, fluctuations, etc., within it and saves the powered device from any catastrophe.

[00058] In the second embodiment of the battery module with such first end connection and second end connection avoids interference of the signal lines with the power lines. The clampers guide the cables from the first end connection further, thereby avoiding crimping, stripping, and tangling of the cables. The first end connections and the second end connections are rugged in construction allowing multiple times of engagement and disengagement of the cables from the first end connections and the second end connections, improving durability and reliability of the battery module. The gaskets in the end connections prevent dust and water entry into the battery module through the end connections resulting in a waterproof and dust resistant battery module. The different geometries of the terminal studs in the first end connections prevents interchanging of the polarities of the terminal studs and eases assembly and servicing of the battery module, thereby saving man hours in assembly, servicing, and maintenance of the battery module.

[00059] Such different embodiments of the battery modules allow uninterrupted supply to drive the powered device as the end connections facilitate interconnection of multiple such battery modules. The mounting of the protection device on the BMS board reduces the chances of mounting of the protection device in the wrong terminal. Also, the losses due to wire lengths between the cells and the external connection are reduced. The assembly of the protection device and the terminals of the battery module can be safely performed.

Additionally, the positive terminal wire of the battery module is prevented to come in contact with the BMS board and its components by the terminal holder, while assembly of the battery module. The terminal holder also avoids direct transfer of stress to the surface of the BMS board by the wires originating from the cells. The terminal holder also ensures the interconnect sheets of the battery module are in position and fastened tightly. The fasteners, such as, screw and nut assembly, at the predetermined location on the end connections ensures firm fastening of the end connection to the BMS board and also ensures establishing robust electrical connections between the different parts of the end connections and the BMS board.

[00060] Improvements and modifications may be incorporated herein without deviating from the scope of the invention.

LIST OF REFERENCE NUMERALS

- 100- First embodiment of a Battery Module
- 101- Casing
- 102- External connection
- 5 103- First end cover
- 104- Second end cover
- 105- Battery pack
- 106- Cell holder
- 107- Cells
- 10 108-BMS board
- 109- First end connection
- 110-second end connection
- 111-third end connection
- 201- Terminal holder
- 15 202- Mounting provisions
- 202a-connector
- 202b-attaching member
- 203-mounting provisions on cell holder
- 204-interconnect sheet
- 20 301- Protection device
- 302-guiding means
- 303-positive terminal of battery module
- 401- Base member
- 402- Connector
- 25 403a, 403b- fasteners for fastening the protection device
- 404a, 404b- location of fastening the protection device
- 501a, 501b- ends of connector 202a
- 502a, 502b- ends of connector 402
- 601- stiffener
- 30 700- Second embodiment of battery module
- 701- Casing

- 702-first end cover
- 703a, 703b- end connections
- 704- Guiding means
- 705- Holding clamper
- 5 706- Cables
- 801- Vent plug
- 802, 809- attachment means for end covers
- 803- Second end cover
- 804- Battery pack
- 10 804a- cell holder
- 805- Fasteners for fastening the female signal connector
- 806- BMS board
- 806a- holes for fastening the female signal connector
- 807- Female signal connector
- 15 808- Male signal connector
- 808a, 808b- surfaces of the male signal connector
- 901-hollow pins
- 902- Banana plugs
- 903- Clips
- 20 1001- Second terminal holder
- 1002a, 1002b- mounting provisions
- 1003a, 1003b-attachment means
- 1004-protection device
- 1005a- positive terminal stud
- 25 1005b- negative terminal stud
- 1006a, 1006b-mounting provisions on second terminal holder
- 1007a, 1007b- gaskets
- 1008a, 1008b- bolt
- 1009- Nut
- 30 1010, 1012, 1013- connectors
- 1011- Base member

1101- Cells in cell holder

I/We claim:

1. A battery module (100, 700) for a powered device comprising:
 - a plurality of cells enclosed in a casing (101,701);
 - 5 at least one end cover (103, 702) securely attached to the casing (101, 701);
 - a battery management system board (108, 806) positioned proximal to the at least one end cover (103, 702) in the casing (101, 701); and
 - 10 at least one end connection (109, 110, 111; 703a and 703b) removably attached to the battery management system board (108, 806), wherein the at least one end connection (109, 110, 111; 703a and 703b) comprises:
 - 15 a first end connection (109, 703a) corresponding to at least one power line of the battery module (100, 700) comprising at least one protection device (301, 1004) connected to the at least one power line for providing electrical protection to the battery module (100, 700).
2. The battery module (100, 700) as claimed in claim 1, wherein the first end
20 connection (109, 703a) comprises one of a first terminal holder (201) and a second terminal holder (1001) removably attached to the battery management system board (108, 806).
3. The battery module (100) as claimed in claim 2,
 - 25 wherein the first terminal holder (201) comprises a base member (401) with at least one connector (202a, 402) attached to a bottom surface of the base member (401) at predetermined locations and an attaching member (202b) at a first corner for removably attaching the base member (401) to the battery management system board (108), and
 - 30 wherein the at least protection device (301) is attached to the at least one connector (202a, 402) to form a positive terminal (303) of the battery module (100).

4. The battery module (100) as claimed in claim 3, wherein a first end (501a) of the at least one connector (202a) connects to positive terminals of the plurality of cells (107) at one of the predetermined location through at least one interconnect sheet (204) and a second end (501b) of the at least one connector (202a) connects to the at least one protection device (301).
5. The battery module (100) as claimed in claim 3, wherein a second end (502b) of the at least one connector (402) connects to the at least one protection device (301) and a first end (502a) of the at least one connector (402) forms the positive terminal (303) of the battery module (100).
6. The battery module (100) as claimed in claim 3, wherein the at least one connector (202a, 402) is a metal connector with mounting provisions en-molded in the base member (401).
7. The battery module (100) as claimed in claim 3, wherein the terminal holder (201) comprises at least one guiding means (302) to route at least one cable on the battery management system board (108).
8. The battery module (100) as claimed in claim 3, wherein the base member (201) comprises at least one stiffener (601) between the at least one connector (202a, 402) and the at least one protection device (301) for reinforcing the base member (401).
9. The battery module (700) as claimed in claim 2, wherein the first end connection (703a) comprises:
- the second terminal holder (1001) removably attached to the battery management system board (806),
- a positive terminal stud (1005a) and a negative terminal stud (1005b) extending from the second terminal holder (1001) for connecting to external components, and
- the at least one protection device (1004) connected to the positive terminal stud (1005a) in a path of current from the battery management system board (806) to the positive terminal stud (1005a).

10. The battery module (700) as claimed in claim 9, wherein the positive terminal stud (1005a) and the negative terminal stud (1005b) project from the battery management system board (806) through the at least one end cover (702) and wherein the positive terminal stud (1005a) and the negative terminal stud (1005b) have different geometries.
11. The battery module (700) as claimed in claim 9,
wherein the second terminal holder (1001) comprises a base member (1011) with at least one connector (1010, 1012, 1013) attached on a bottom surface of the base member (1011) at predetermined locations, and
wherein one of the at least one connector (1010) connects the at least one protection device (1004) to the positive terminal stud (1005a).
12. The battery module (100, 700) as claimed in claim 1, wherein the at least one end connection (109, 110, 111; 703a and 703b) further comprises a second end connection (110, 703b) corresponding to signal lines of the battery module (100, 700).
13. The battery module (700) as claimed in claim 12, wherein the second end connection (703b) comprises:
at least one female signal connector (807) comprising at least one hollow pin (901) securely attached to the battery management system board (806), and
at least one corresponding male signal connector (808) comprising at least one plug (902) removably engaged with the at least one hollow pin (901) of the at least one female signal connector (807) for connecting the battery module (700) to a battery controller.
14. The battery module (700) as claimed in claim 13, wherein the at least one male signal connector (808) further comprises clips (903) for secure and tight locking of the at least one plug (902) with the at least one hollow pin (901) of the at least one female signal connector (807).

15. The battery module (700) as claimed in claim 12, wherein the second end connection (703b) facilitates parallel connection of the battery module (700) with other battery modules of similar type.
16. The battery module (100) as claimed in claim 1, further comprises a third end connection (111) corresponding to negative terminals of the plurality of cells (107).
17. The battery module (100) as claimed in claim 1, wherein the at least one end connection (109, 110, 111) on the battery management system board (108) is connected to an external connection (102) on the at least one end cover (103) of the battery module (100) for charging, discharging, and controlling operation of the battery module (100).
18. The battery module (700) as claimed in claim 1, wherein the end cover (702) further comprises guiding means (704) and a holding clasper (705) to route power cables and signal cables connected to the first end connection (703a) and the second connection (703b) respectively.
19. A battery module (100) for a powered device comprising:
- a plurality of cells (107) enclosed in a casing (101);
 - at least one end cover (103), with an external connection (102), securely attached to the casing (101);
 - a battery management system board (108) positioned proximal to the at least one end cover (103) in the casing (101);
 - a first end connection (109) comprising a first terminal holder (201) and at least one protection device (301) positioned on the battery management system board (108), forming a positive terminal of the battery module (100);
 - a second end connection (110) positioned on the battery management system board (108), corresponding to signal lines of the battery module (100); and
 - a third end connection (111) positioned on the battery management system board (108), connecting to negative terminals of the plurality of cells (107);

wherein the first end connection (109), the second end connection (110), and the third end connection (111) on the battery management system board (108) are connected to the external connection (102) on the at least one end cover (103) of the battery module (100) for charging, discharging, and controlling operation of the battery module (100).

20. The battery module (100) as claimed in claim 19,

wherein the first terminal holder (201) comprises a base member (401) with at least one connector (202a, 402) attached to a bottom surface of the base member (401) at predetermined locations and an attaching member (202b) at a first corner on a top surface of the base member (401) for removably attaching the base member (401) to the battery management system board (108), and

wherein the at least one protection device (301) is fastened to the at least one connector (202a, 402) to form a positive terminal (303) of the battery module (100).

21. The battery module (100) as claimed in claim 20, wherein a first end (501a) of the at least one connector (202a) connects to positive terminals of the plurality of cells (107) through at least one interconnect sheet (204) at one of the predetermined locations and a second end (501b) of the at least one connector (402) connects to the at least one protection device (301).

22. The battery module (100) as claimed in claim 20, wherein a second end (502b) of the at least one connector (402) connects to the at least one protection device (301) and a first end (502a) of the at least one connector (402) forms the positive terminal (303) of the battery module (100).

23. The battery module (100) as claimed in claim 20, wherein the at least one connector (202a, 402) is a metal connector with mounting provisions en-molded in the base member (401).

24. The battery module (100) as claimed in claim 20, wherein the base member (401) comprises at least one guiding means (302) to route at least one cable on the battery management system board (108).
- 5 25. The battery module as claimed in claim 20, wherein the base member (401) comprises at least one stiffener (601) between the at least one connector (202a, 402) and the at least one protection device (301) for reinforcing the base member (401).

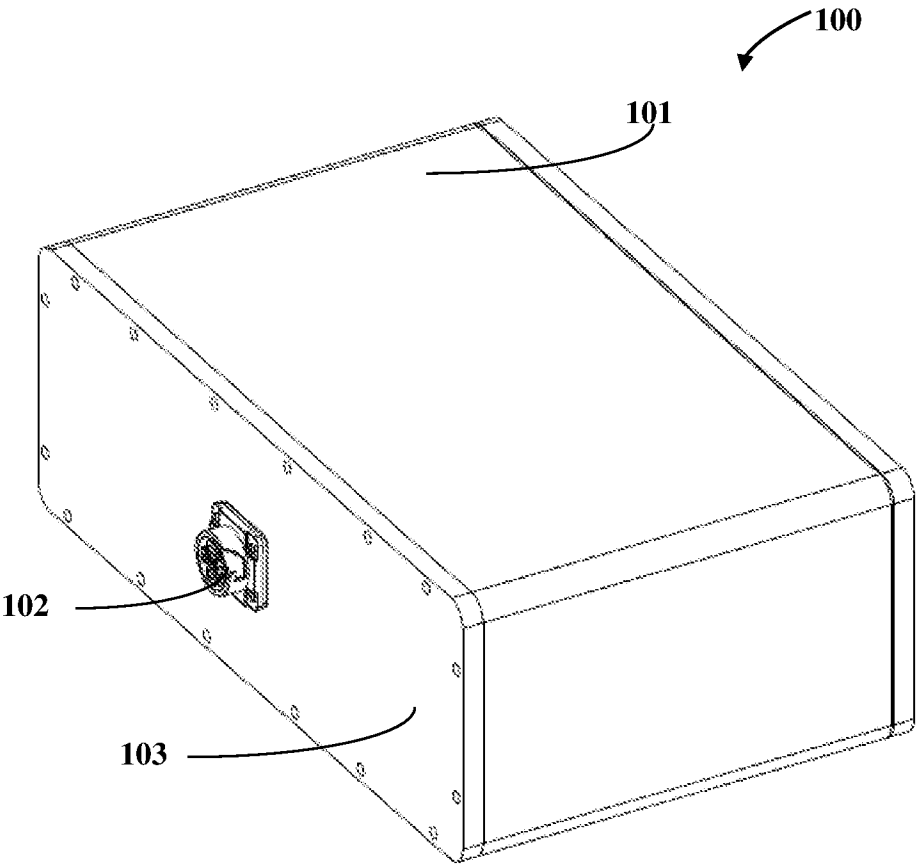


Fig. 1A

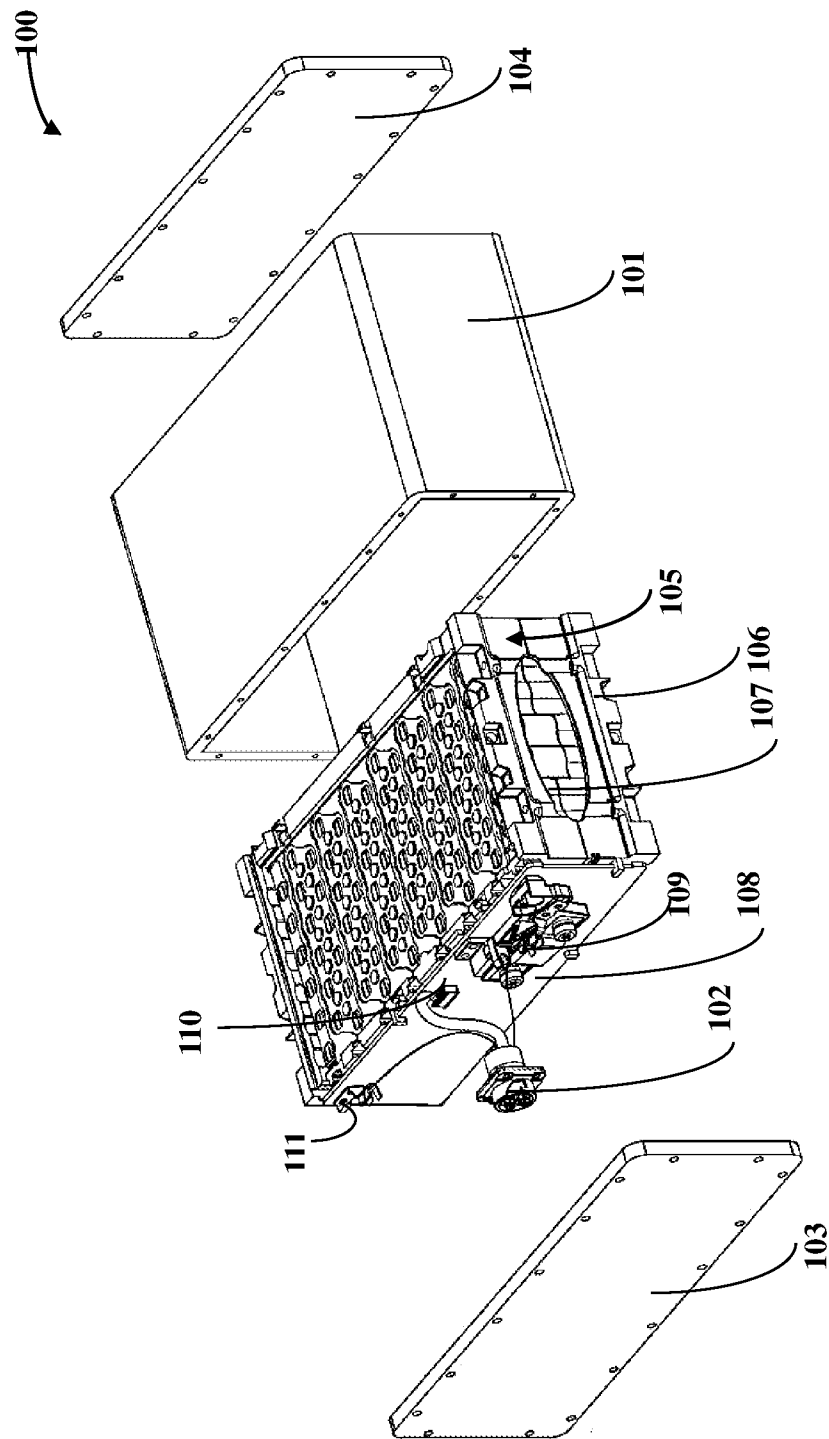


Fig. 1B

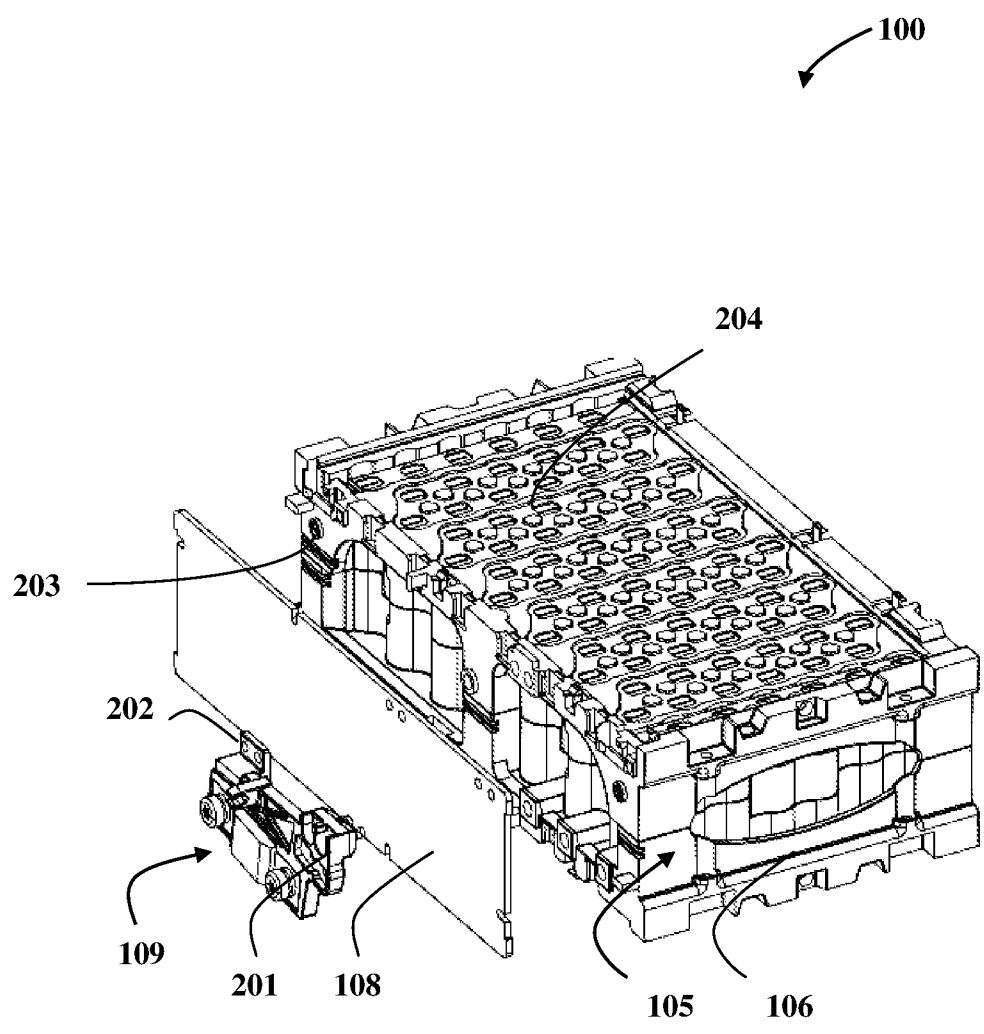


Fig. 2

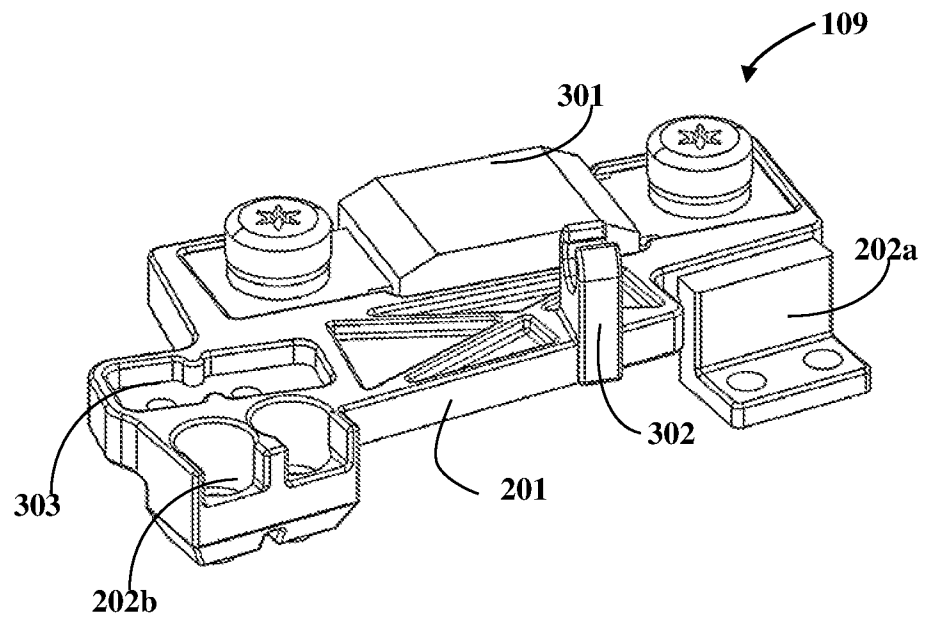


Fig. 3

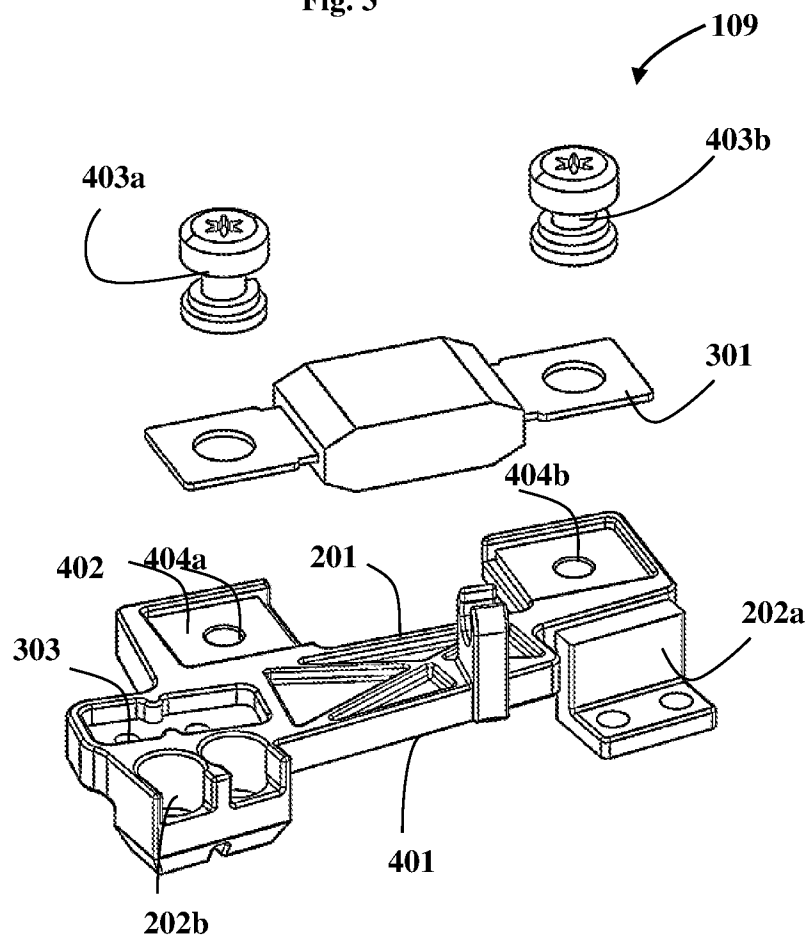


Fig. 4

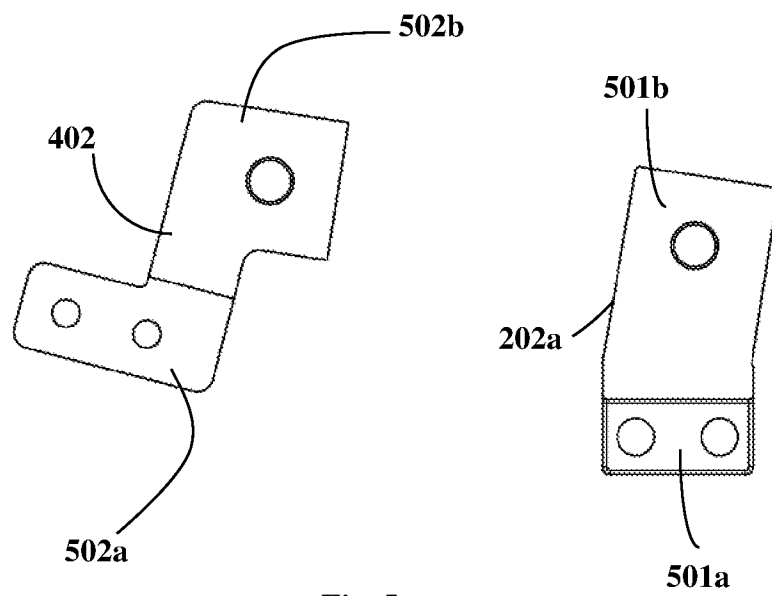


Fig. 5

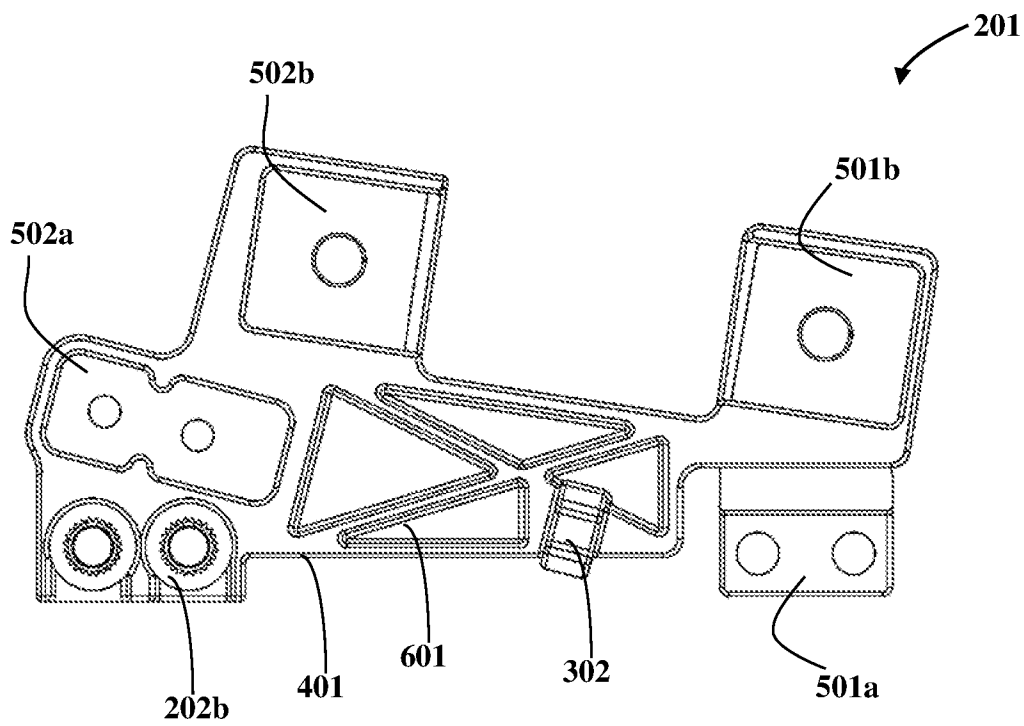


Fig. 6

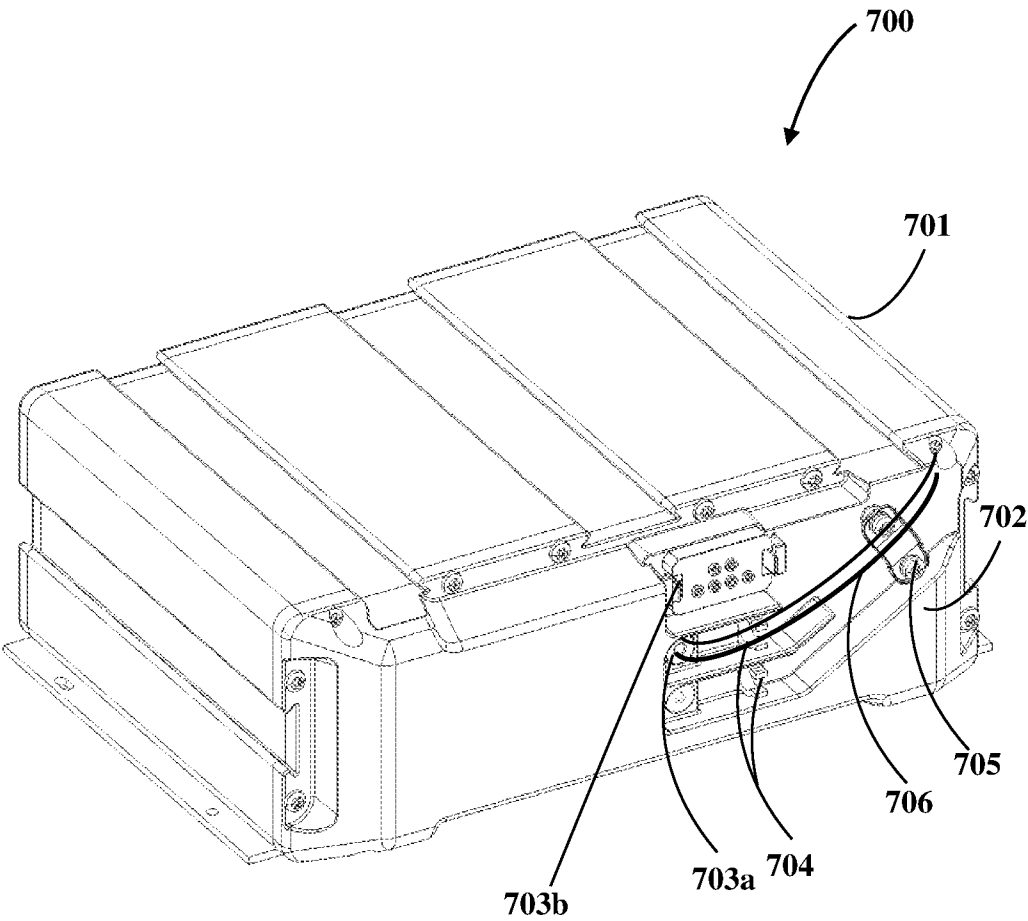


Fig. 7

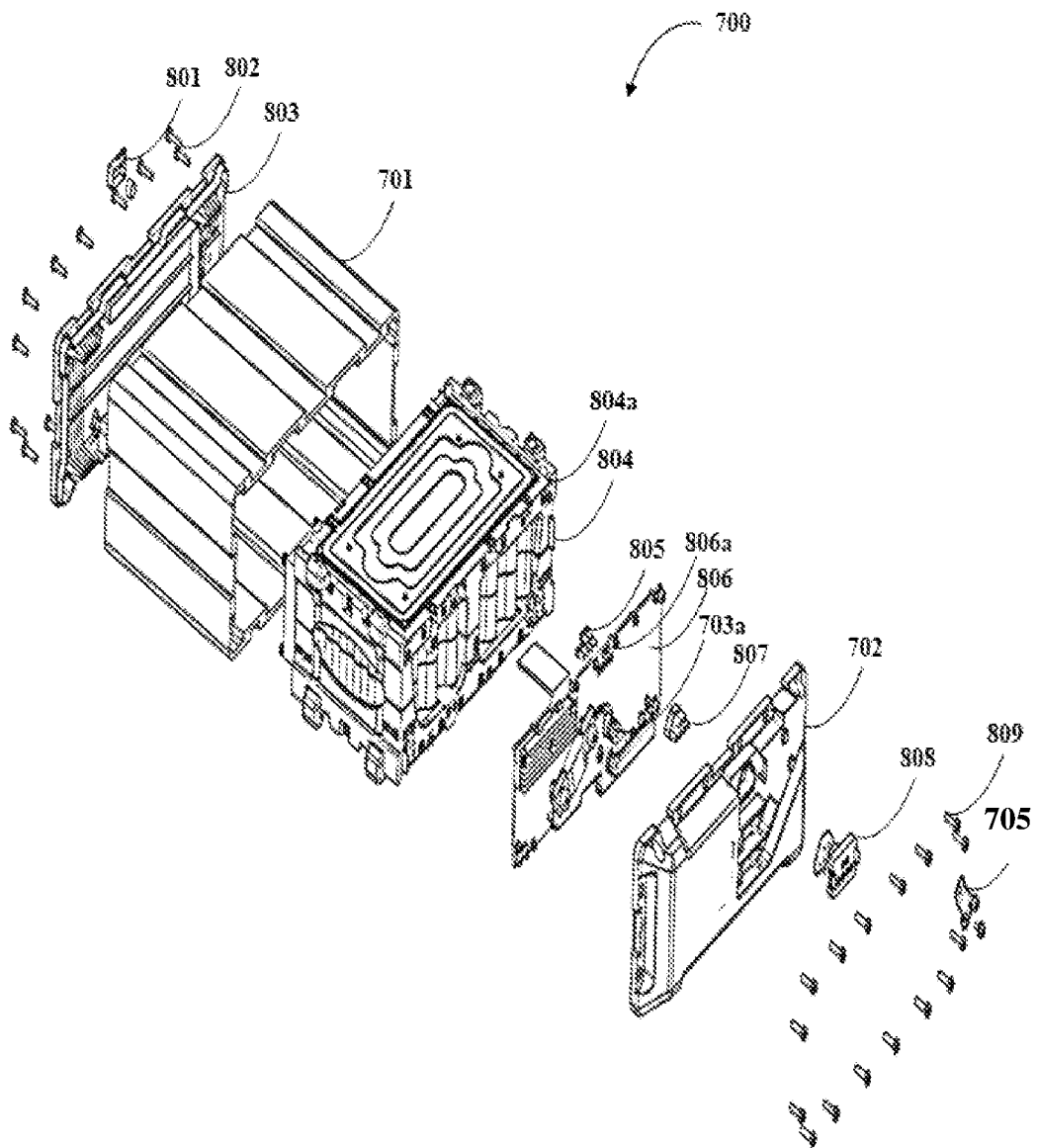


Fig. 8

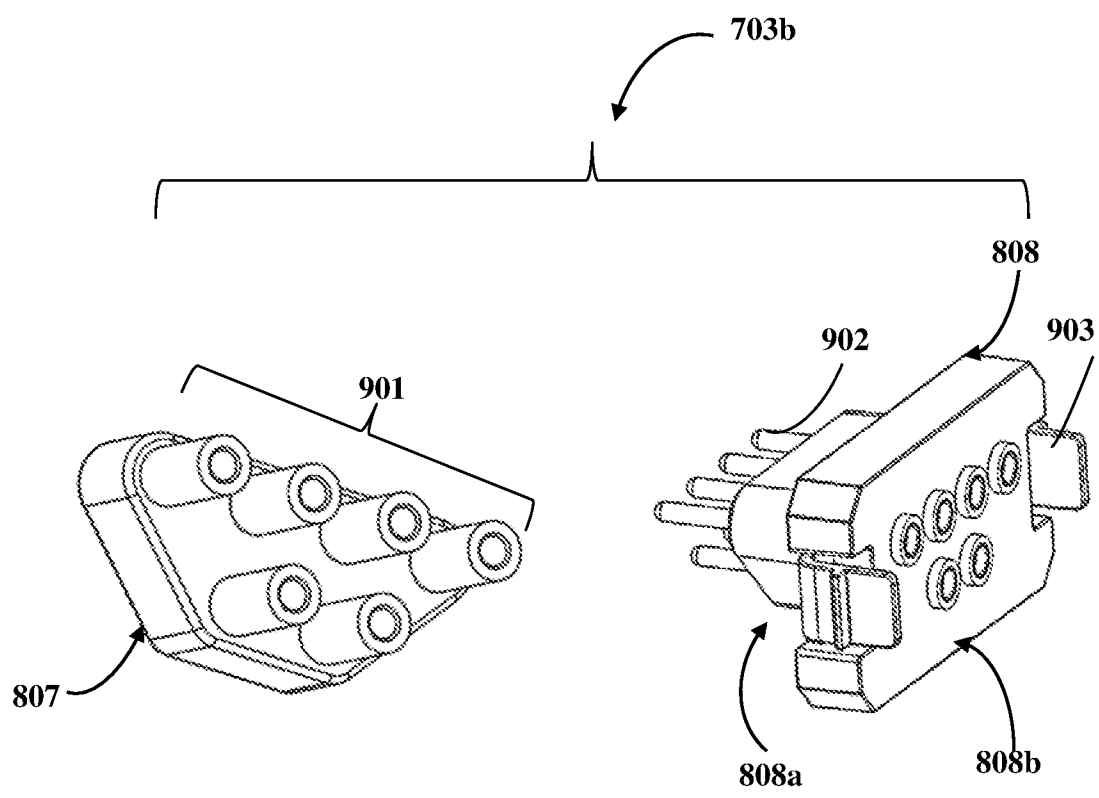
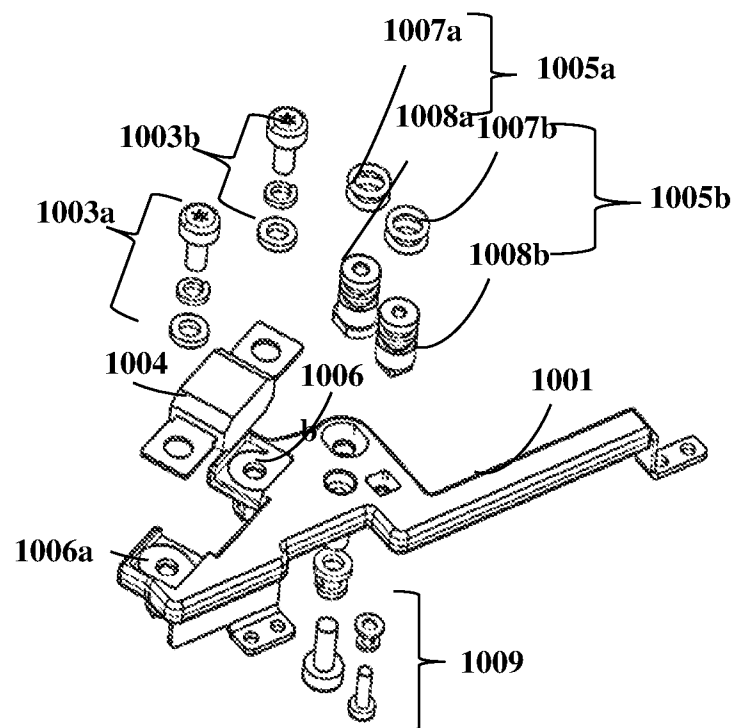
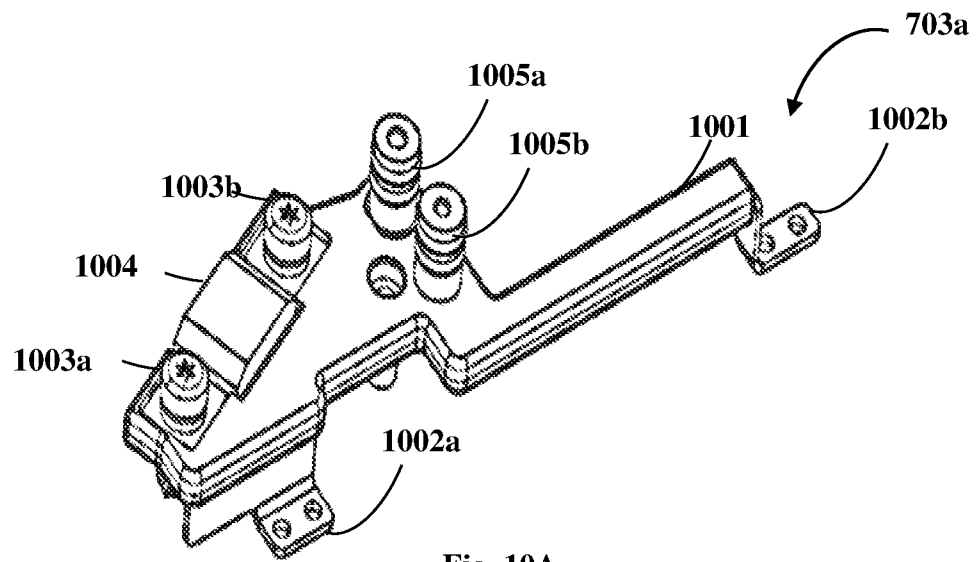


Fig. 9A

Fig. 9B



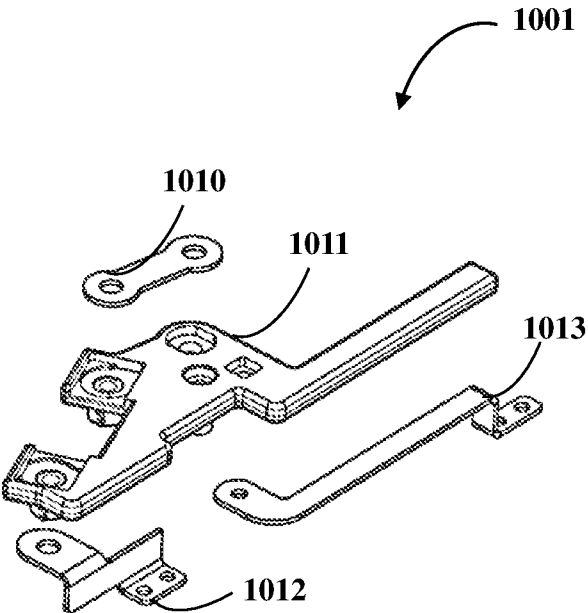


Fig. 10C

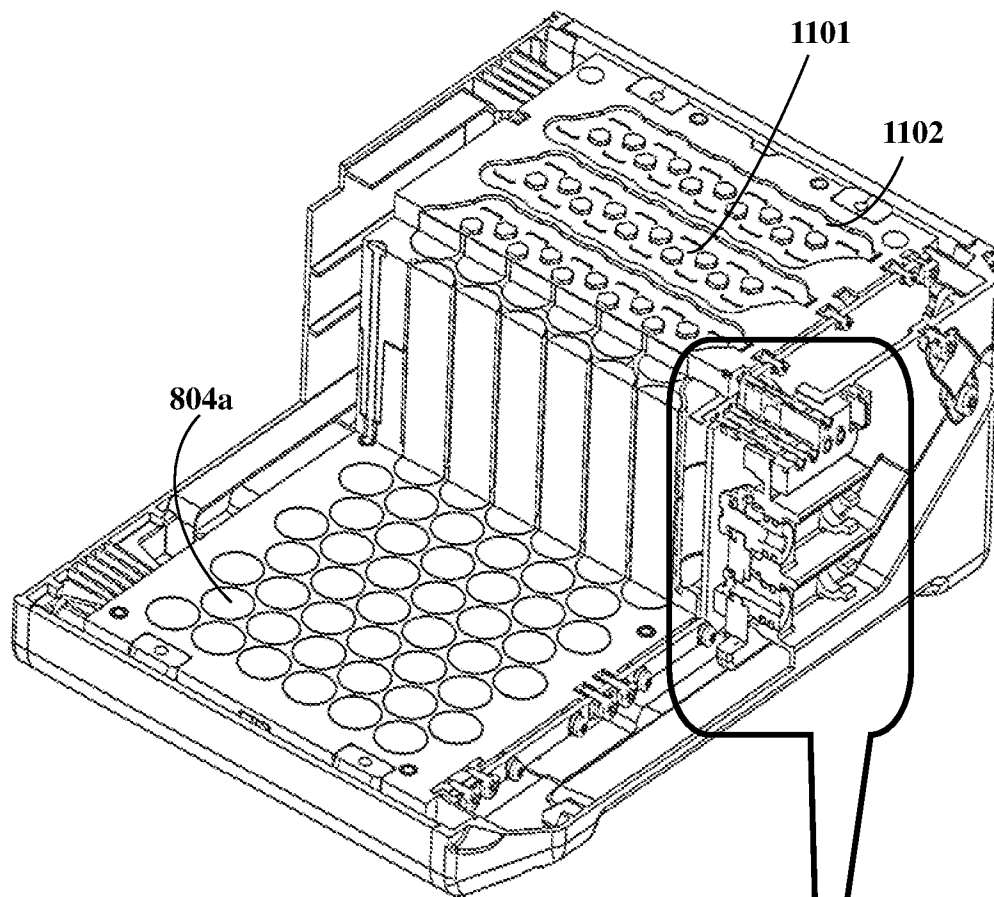


Fig. 11A

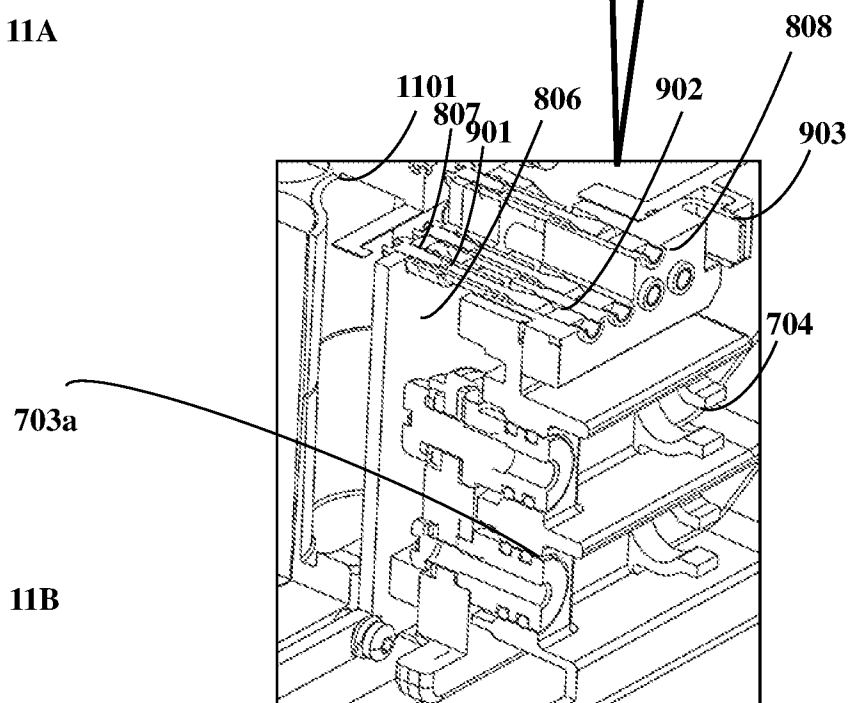


Fig. 11B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IN2021/050183

A. CLASSIFICATION OF SUBJECT MATTER
H01M10/48, H01M10/0525 Version=2021.01

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)

Databases: TotalPatent One, IPO Internal Database

Keywords: Battery module, End connections, Battery management system

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20130164567 A1 (SEEKTECH, INC.) 27 JUNE 2013 (27-06-2013), Figs. 1A, 1B, 2, 17B; Paragraphs [0043], [0085], [0099]-[0101], [0107], [0112], [0194]; Claim 1	1-18
Y	Whole document -----	19-25
Y	US 20150318582 A1 (CPS TECHNOLOGY HOLDINGS LLC) 05 NOVEMBER 2015 (05-11-2015), Whole document	19-25

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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"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)

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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

14-06-2021

Date of mailing of the international search report

14-06-2021

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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