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WO 2009/057894 A **WO 2006/101343 A**
WO 2006/101342 A **US 20020000786 A**

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(54) Title of the Invention: **Modular battery with exchangeable cell elements**
Abstract Title: **Modular battery with exchangeable cell elements**

(57) The present disclosure relates to a method for manufacturing and to a method for replacing pouches of a secondary battery. The present invention also relates to a rack or base 100 for a secondary battery. The base comprises a plurality of pouch reception portions wherein each one of the plurality of reception portions 133 comprises a fastening element 40 for receiving and mechanically supporting at least one of a plurality of pouches. A pair of electrical contact elements is provided for contacting the electrochemical cell in the pouch.

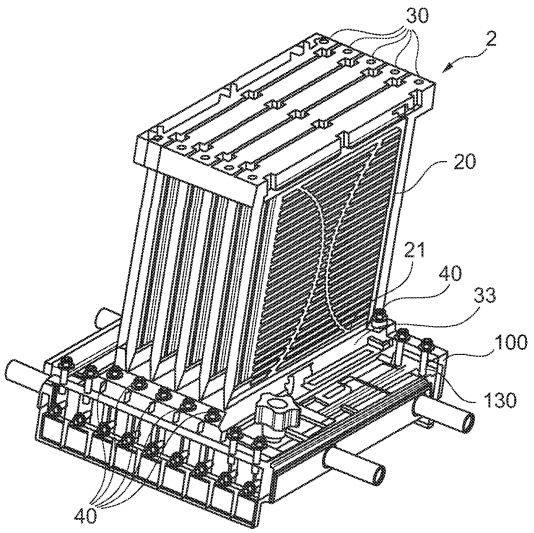

Fig. 1

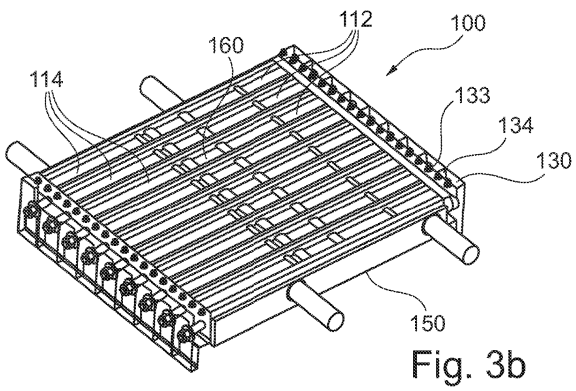

Fig. 3b

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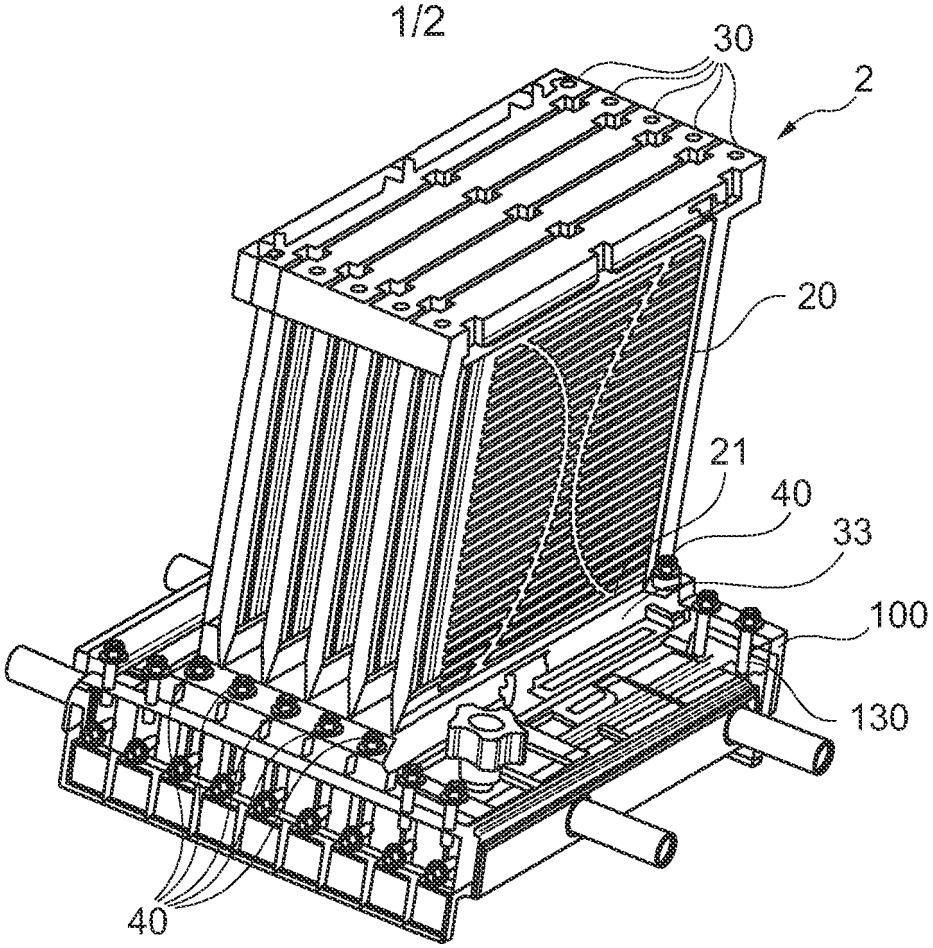

Fig. 1

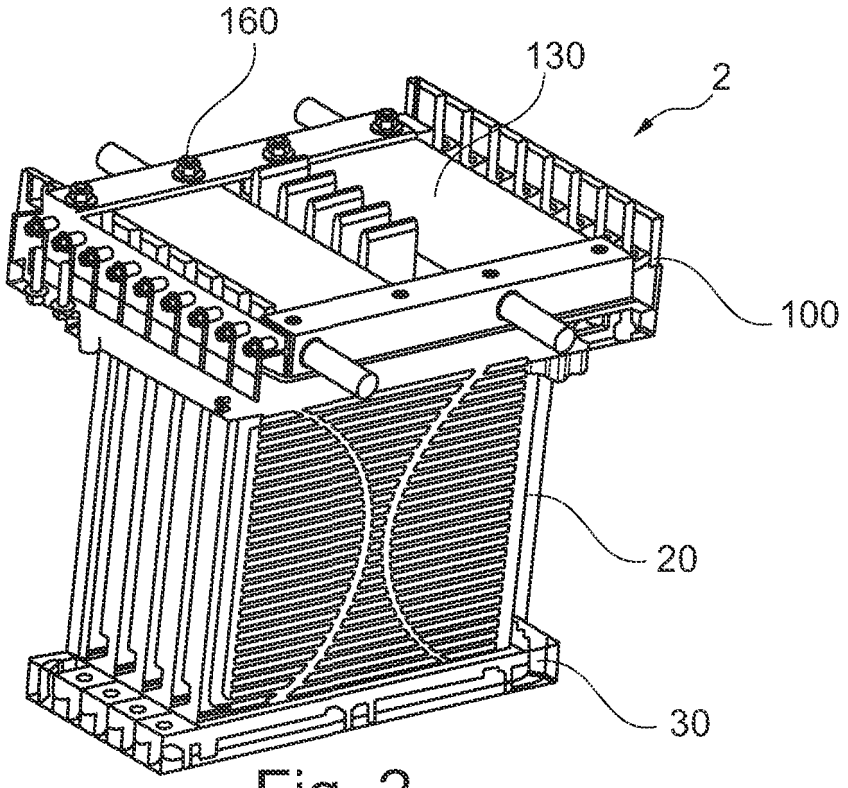

Fig. 2

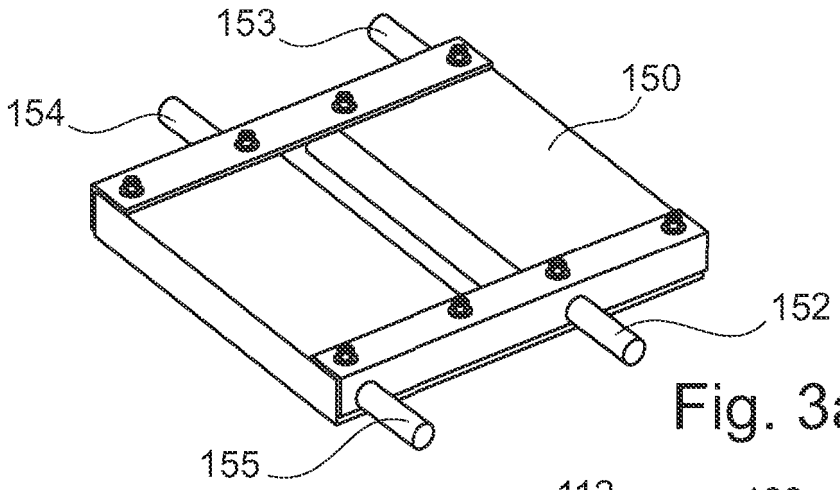

Fig. 3a

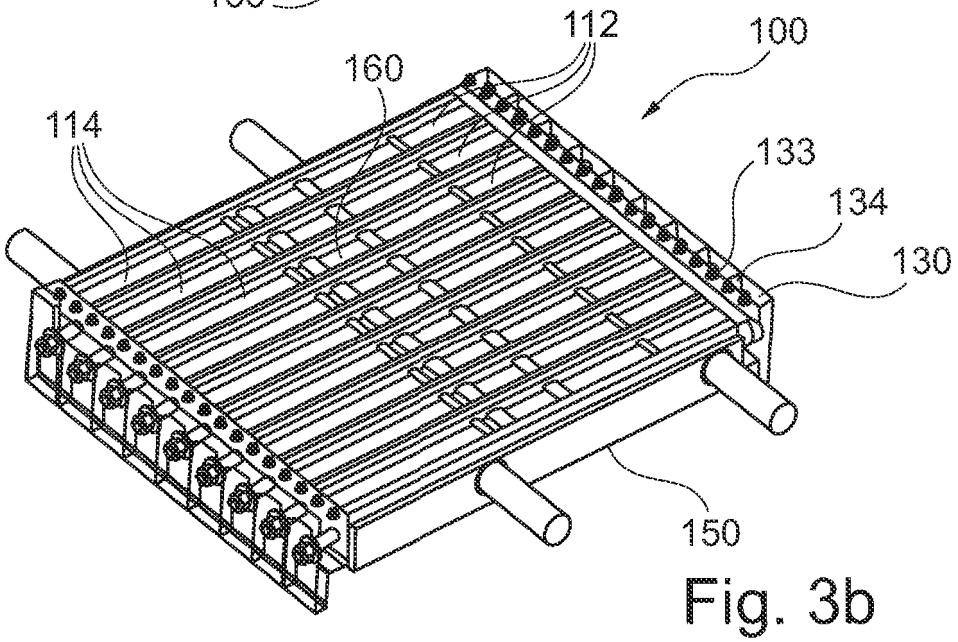

Fig. 3b

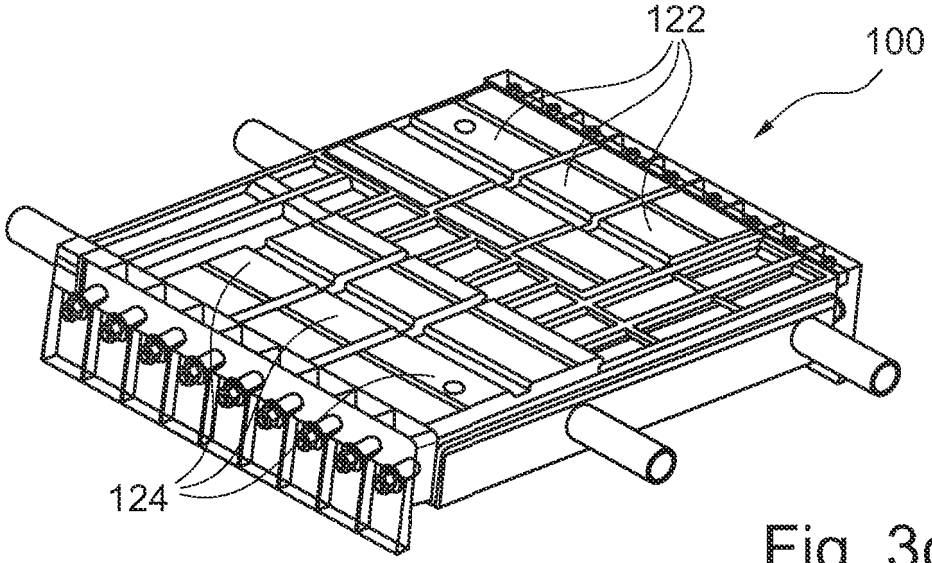

Fig. 3c

Description

[0001] The present disclosure relates to components for a battery, to a method for manufacturing batteries and to a battery manufactured therewith. In particular the present invention relates to serviceable secondary batteries and to a method for assembling and for exchanging components of the secondary battery.

Introduction and Related Art

[0002] Secondary batteries are becoming increasingly important for energy storage in mobile applications as well as buffer systems for electric grids and are an increasingly important part of modern energy technology. Today, high capacities secondary batteries are comparatively expensive and have a limited lifetime which limit the applications of secondary batteries. Increasing lifetime of secondary batteries is therefore one of the main interests of research and development in the field.

[0003] Secondary batteries usually consist of a plurality of electrochemical cells that are stacked together to achieve the desired battery capacity and/or the desired electrical voltage. Each electrochemical cell comprises at least two electrodes, a cathode and an anode which are electrically separated from each other, for example by a separator.

[0004] The electrodes, cathode and anode, each comprise a current collector and at least an electrochemically active electrode material. Many different electrochemically active electrode materials are known in the art which can be used either as electrochemically active cathode material or as electrochemically active anode material. The electrochemically active electrode materials are selected depending on the electrolyte used and on the application of the battery.

[0005] A plurality of electrochemical cells are assembled in a stack and are mounted in a battery case. Additional components such as a heat sink, cooling and electronics are added to control the status and the function of the batteries.

[0006] Lithium based batteries are often based on pouch type cells, wherein a plurality of thin and flexible electrochemical cells are packed and preassembled in a sealed pouch. The pouch usually has a negative electrode and a positive electrode contact. The pouches are mechanically deformable and are usually fixed in a battery case.

[0007] In state of the art manufacturing processes, stacks of electrochemical cells or pouches are placed in a battery case or battery module and the heat sinks, cooling systems and electronic modules are attached to the battery stacks before the battery housing is closed.

[0008] WO 2009/073225 describes a method and a system for stacking electrochemical cells, wherein a plurality of pouches containing electrochemical cells are stapled in support frames. The pouches in the frames are mounted into a battery case and are thermally and electrically connected.

[0009] These known manufacturing methods allow a fast assembly of the battery but a replacement of battery cells is not possible.

[0010] It is an object of the present invention to overcome the disadvantages of prior art.

Summary of the invention

[0011] The disclosure proposes a battery rack for a battery for supporting a plurality of pouches. Each one of the plurality of pouches contains at least one electrochemical cell. The battery rack comprises a plurality of pouch receiving sections, wherein each one of the plurality of the pouch receiving sections comprises a releasable fastening element for releasably fixing and mechanically supporting at least one of the plurality of pouches. The battery rack also comprises at least one pair of electrical contact elements for electrically contacting the at least one electrochemical cell in the at least one of the plurality of

pouches, when the pouch is positioned in the respective pouch receiving section. The fastening element is releasable for reversibly attaching the at least one pouch. The fastening element allows releasing and replacing one or more of the pouches in a simple and effective manner enabling a serviceable battery. This is particularly advantageous for secondary batteries. Pouches containing defect electrochemical cells or pouches containing celsl at the end of their cycle-lifetime can be easily replaced. The fastening element may be a click-in mechanism or may comprise screws or other releasable mounting or fixation means. The battery rack comprising the plurality of receiving sections may be considered a base enabling the mechanical support of the pouches. The battery rack provides in the same time a mechanical support, alignment and an electrical contact to the at least one pouch.

[0012] The pouches may be battery packs or packs of electrochemical cells as generally known in the art, in particular of lithium ion secondary batteries. The present disclosure is particularly useful with foil-type pouches, i.e. pouches comprising electrochemical cells with current collector and/or electrode foils.

[0013] The pouches may be arranged in a pouch support frame or in another support structure that gives the pouches mechanical stability. This is in particular useful if electrochemical cells made from foil material are used that are not by themselves mechanically stable. The use of support frames as such is known in the art. If a pouch support frame is used, the fastening element may be adapted to receive and mechanically support the pouch support frame. In this case the pouches can be reversibly or irreversible fixed in the pouch support frame.

[0014] If the pouches are mechanically supported by the support frame, the battery rack aligns and mechanically supports the support frame, thereby in turn supporting the pouch. The fastening element may be adapted to receive and mechanically support the support frame which in turn mechanically supports the pouch. A support frame can be used to support a single pouch or a plurality of pouches. Support frames for a single pouch and the support frames for two pouches are per se known in the art.

[0015] Alternatively, the use of support frames can be omitted and the pouches can be directly supported by the battery rack.

[0016] The battery rack may be made from a rigid structure and can be made of different materials such as plastics or metals or other or a combination of different materials. The battery rack may comprise a heat sink and the heat sink may come into thermal contact with the at least one pouch. The heat sink allows effective heat transport and cooling of the electrochemical cells in the pouch.

[0017] The heat sink may be made from a rigid structure and may give the battery rack a rigid structure for mechanically supporting the plurality of pouches. In this case, the reception portion may be made from a lightweight material with a structure that is in itself not rigid and stable enough to mechanically and stably support the plurality of pouches.

[0018] The battery rack may further comprise an electronic circuit to control the at least one electrochemical cell in the at least one pouch. The electronic circuit may involve at least one of charging and de-charging control of the electrochemical cell, temperature control and the control of other parameters. One electronic circuit per pouch may be provided or an electronic circuit to control all or a plurality of pouches may be used.

[0019] The battery rack may further comprise a plurality of contact elements for contacting the plurality of pouches. The contact elements may be adapted to contact two or more electrode contacts of different pouches This allows connecting the pouches in series or in parallel to adjust the configuration of the battery depending on the needs. The electrical contact elements may reversibly contact the electrode contacts, i.e. the anode contact or the cathode contact. This may also allow modifying the battery if the application of the battery is changed.

[0020] The electrical contact elements may be implemented as bus bars. The electrical contact element may be in thermal contact with a heat sink. This allows an effective heat transfer from the electrical contact element and thereby from an electrode of the

electrochemical cells in order to keep the electrochemical cells in a certain temperature range.

[0021] The battery rack may further comprise one or more sensors for controlling the temperature of the electrochemical cells and the pouches or other parameters of the battery.

[0022] The present invention also relates to secondary battery comprising such a battery rack. The secondary battery further comprises a plurality of pouches fastened to the battery rack. The pouches are releasably fastened and can be easily exchanged. This provides a modularly battery system that can also be designed for a plurality of battery racks.

[0023] The secondary battery may comprise a housing in which the battery rack and the plurality of pouches is protected.

[0024] The present disclosure also relates to a method for manufacturing a secondary battery. The manufacturing method comprises providing a pre-assembled battery rack and attaching at least one pouch to the battery rack in a reversibly manner. The pouch is not fixedly connected to the battery rack and can be easily removed to increase serviceability of the battery rack.

[0025] The reversible attachment of the at least one pouch may comprise placing the at least one pouch in a frame and reversibly attaching the at least one frame to the battery rack.

[0026] The present invention also relates to a method for replacing a pouch of a secondary battery. The replacing method comprises releasing a pouch containing the electrochemical cell to be replaced from the battery rack to which the pouch is reversibly attached, and attaching a replacement pouch to the battery rack. The pouch to be replaced and the replacement pouch may be supported by a pouch support frame.

Brief description of the drawings

Figure 1 shows an assembly with a rack according to the present invention.

Figure 2 shows the rack of figure 1 from an opposite view.

Figure 3a – 3c show the assembly of a rack according to the invention.

Detailed description

[0027] The invention will now be described on the basis of the drawings. It will be understood that the embodiment and aspects of the invention described herein are only examples and do not limit the protective scope of the claims in any way. The invention is defined by the claims and their equivalence. It is understood that the features of one aspect or embodiment of the invention can be combined with a feature of different aspects and/or examples of the invention.

[0028] Figure 1 shows a battery module 2 that can be used alone or in combination with other battery modules in a primary or secondary battery. The battery module 2 is in use arranged in a housing to protect the battery cells and the electronics. The housing may be a standard battery housing and is not shown in the figures.

[0029] The battery module 2 comprises a battery rack or base 100 to which a plurality of pouches 20 are mounted. Each pouch 20 is mounted in a pouch support frame 30. In the example shown in figure 1, in total five pouch support frames 30 each comprising one pouch 20 are mounted to the rack 100. This number of support frames is only shown for illustrative purposes and a different number of pouches and pouch support frames 30 can be mounted to the rack 100. Typical numbers for pouches attached to a base 100 range from a single pouch to about a few hundred pouches. The number of pouches actually used depends on the application of the battery and the required properties. The pouches may be selected to provide final voltages of up to about 1000 V and 300 A currents. The number of pouches and cells, however may be easily multiplied by a factor of 2, 4, 6, or more.

[0030] The pouches 20 comprise a plurality of electrochemical cells, each cell comprising at least one anode, a cathode and a separator. The pouches 20 comprising the electrochemical cells are per se known in the art and any conventional pouches can be used

with the present disclosure. Instead of pouches, other types of battery packs or electrochemical cells may be used.

[0031] Each pouch 20 has at least two electrical electrode contacts, a positive electrode contact 12 and a negative electrode contact 14 electrically contacting the respective electrodes of the electrochemical cells. In the example shown both electrical electrode contacts 12, 14 are arranged on the same rack facing side 21 of the pouch 20. The electrical electrode contacts can also be arranged in other configurations, for example on opposite sites of the pouch.

[0032] The pouch support frame 30 surrounds the pouch 20 and at least 4 sides and holds the pouch 20 mechanically stable. In this way, the pouch is protected from deflections and other mechanical forces or damages. The support frames 30, however, may be arranged differently and only cover a certain portion of the pouch 20. Furthermore, the support frames 30 may be adapted to the shape of the pouch. The support frames 30 may or may not comprise electrical contacts. In the examples shown, the support frames 30 provide mechanical stability to the pouches 20 and do not contain any electrical contact or control.

[0033] Each support frame 30 is inserted into a pouch receiving section 133 of a rack element 130 of the battery rack 100. The rack element 130 has a plurality of pouch receiving sections 133, wherein in each pouch receiving section 133 can take-up one and fix one support frame 30. The pouch receiving sections 133 have a complementary shape to a fitting portion 33 of the support frames 30. Screws 40 may be used as fastening elements to fix the support frames 30 containing the pouches 20 to the rack element 130. By releasing the screws 40, a corresponding frame 30 can be removed from the rack 100 and a replacement frame with a replacement pouch 20 can be inserted in the corresponding receiving section 133 and fastened using the screws 40. In this way, a defect pouch 20 can be easily replaced. Other releasable fastening elements than screws 40 can be used for attaching the pouches 20 to the rack 100. For example notches or snap hinges may be used.

[0034] In the shown example, the pouch support frames 30 and the pouches 20 are aligned in parallel and are essentially perpendicular to the rack 100. Other arrangements of the pouches 20 with respect to the rack 100 are, however, possible.

[0035] Figure 2 shows the battery module 2 of figure 1 from the opposite side showing electronics 160 and a heat sink 150, as will be described in more detail with respect to figure 3a – 3c.

[0036] Figure 3a shows a heat sink or cooling device 150 that can be used with the present disclosure. The heat sink 150 has thermal connections 152, 153, 154, 155 for connecting heat sink to heat transport means. The thermal connections 152, 153, 154, 155 may comprise fluid connectors for a cooling medium such as refrigerant that can flow through the heat sink 150. Alternatively, the contacts 152, 153, 154, 155 are metal contacts for the heat transport of heat generated by the electrochemical cells in use. The heat sink 150 forms a rigid backbone for the base or rack 100. A receiving section 130 with a plurality of receiving elements 133 is arranged on the heat sink 150 forming the rack 100. Each one of the receiving elements 133 has guiding means 135 for guiding and mechanically supporting and positioning frames 30 on the rack 100. Furthermore, the plurality of electronic circuits 160 is arranged on the rack 100. The electronics may serve for controlling for example temperature, current, voltage and other parameters of the electrochemical cells. Other functions may be implemented in the electronics 160.

[0037] Figure 3c shows a plurality of electrical contact elements or bus bars 122, 124 arranged on the rack 100 of figure 3b. The bus bars 122, 124 may be arranged in the rack element 130 and form an electrical contact with the electrode contact elements 12 and 14 of the pouches. The bus bars 122, 124 may additionally in thermal contact with the heat think 150. An electrically isolating and thermally conductive material may be used between the heat think 150 and the bus bars 122, 124 to avoid an electric potential on the heat think, while an efficient cooling of the electrochemical cells can be obtained.

[0038] The bus bars 122, 124 can have different sizes and can be arranged to electrically contact the pouches 20 in series or in parallel depending on the arrangement of the bus bars

122, 124. Any combination of contacting the electrical electrode contacts 12, 14 of the pouches in series and/or in parallel can be adjusted depending on the needs of the final battery. For example, it can be useful to group a certain number of pouches 20 and to electrically connect all pouches 20 of the group in parallel to increase the capacity. Several groups of pouches may then be connected in series to increase the nominal tension of the battery according to the requirements. The bus bars 122, 124 can be used for any configuration of connecting the pouches 20. It is also possible to group and to electrically connect all pouches 20 of the group in series in order to increase the nominal voltage or to connect the ouches in any combination of series and parallel. If the requirement or application of the battery changes during the lifetime of the battery, the bus bars may be rearranged to a different configuration if needed. In this way, the battery can be adapted to different applications and different nominal voltages can be obtained.

[0039] It is an advantage that the pouches 20 can be removed to readjust or exchange items of the rack 100. This allows a serviceable battery module wherein each part can be easily exchanged extending the lifetime of secondary batteries. It is also possible to exchange all pouches of a battery, for example at the end of the life time and to reuse the base with new pouches.

[0040] Each pouch receiving section 133 of the rack element 130 comprises openings 112, 114 that con be used for fixation of the bus bars 122, 124. A snap-in mechanism, screws or other reversible fixation means can be used to arrange the bus bars 122, 124 on the rack element 130.

[0041] While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only and not imitation. It really would be apparent to a person skilled in the art that various changes and form in detail can be made therein without departing from the scope of the invention. Thus, the present invention should not be limited by any of the above described exemplary embodiments, but should be defined only in accordance with the following claims at their equivalence.

Claims

1. A battery rack (100) for supporting a plurality of pouches (20) , containing at least one electrochemical cell, the rack comprising:
   - a plurality of pouch receiving sections (133) with releasable fastening elements (40) for releasably fixing and supporting the respective pouch (20);
   - at least one pair of electrical contact elements (122, 124) for electrically contacting the at least one electrochemical cell in the at least one of the plurality of pouches (20), positioned within the pouch receiving section (133).

2. The battery rack (100) according to claim 1, wherein the pouch (20) is arranged in a pouch support frame (30), and wherein the fastening element (40) is adapted to receive and mechanically support the pouch support frame (30).

3. The battery rack (100) according to claim 1 or 2, wherein the battery rack (100) comprises a heat sink (150) in thermal contact with at least one electrode of the at least one electrochemical cell in the at least one of the plurality of pouches (20)) when the pouch is attached to the battery rack (100).

4. The battery rack (100) according to claim 3, wherein the rack element (130) and the heat sink (150) together form a rigid structure.

5. The battery rack (100) according to any one of the preceding claims, wherein the battery rack (100) comprises at least one electronic circuit (160) for controlling the at least one electrochemical cell.

6. The battery rack (100) according to any one of the preceding claims, wherein at least one of the electrical contact elements (122, 124) is in electrical contact with the at least one electrochemical cell of at least two of the plurality of pouches.

7. The battery rack (100) according to any one of the preceding claims, wherein the battery rack (100) further comprises at least one sensor.

8. A secondary battery comprising
    a. at least one battery rack (100) according to any one of the preceding claims; and
    b. a plurality of pouches (20) fastened to the at least one battery rack (100).

9. The secondary battery of claim 8, further comprising a housing in which the at least one battery rack (100) and the plurality of pouches (20) are arranged inside the housing.

10. A method for manufacturing a secondary battery, the method comprising:
    a. providing a pre-assembled battery rack (100) according to any one of claims 1 to 7;
    b. reversibly attaching at least one pouch (20) to the battery rack (100).

11. The method for manufacturing a secondary battery of claim 10, wherein the reversibly attaching the at least one pouch (20) to the battery rack (100) comprises placing the at least one pouch (20) in a pouch support frame (30) and reversibly attaching the at least one pouch support frame (30) to the battery rack (100).

12. The method for manufacturing a secondary battery of claim 10 or 11, wherein the reversibly attaching the at least one pouch (20) to the pre-assembled battery rack (100) comprises at least one of establishing of an electrical contact, a thermal contact and mechanically supporting the at least one pouch by the batter rack (100).

13. The method for manufacturing a secondary battery of any one of claims 10 to 12, further comprising arranging at least one electrical contact element electrical contact elements (122, 124) such that it is in electrical contact with two or more electrode contacts (12, 14) of two or more pouches (20).

14. A method for replacing an electrochemical cell of a secondary battery, the method comprising:
    a. releasing a pouch (20) containing the electrochemical cell to be replaced from a battery rack (100) according to any one of claims 1 to 7, to which the pouch is reversibly attached;
    b. attaching a replacement pouch to the battery rack (100).

15. The method for replacing an electrochemical cell of claim 14, wherein the at least one pouch (20) and the replacement pouch (20) are placed in a pouch support frame (30), the pouch support frame (30) comprising a releasable mechanical fixation.

Application No:	GB1109503.1	**Examiner:**	Tony Martin
Claims searched:	All Claims	**Date of search:**	22 June 2011

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1,8,10 and 14 at least	WO2006/101343 A SK Corporation see paragraph 65
X	" "	WO2006/101342 A SK Corporation see paragraph 66
X	" "	US2002/0000786 A Choi see claim 1 and Fig 5A
X	" "	WO2009/057894 A SK Energy see Claim 1 and Fig 9

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[X] :

Worldwide search of patent documents classified in the following areas of the IPC

The following online and other databases have been used in the preparation of this search report

International Classification:

Subclass	Subgroup	Valid From
H01M	0002/10	01/01/2006