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(54) **Title:** HEAT EXCHANGER ASSEMBLY

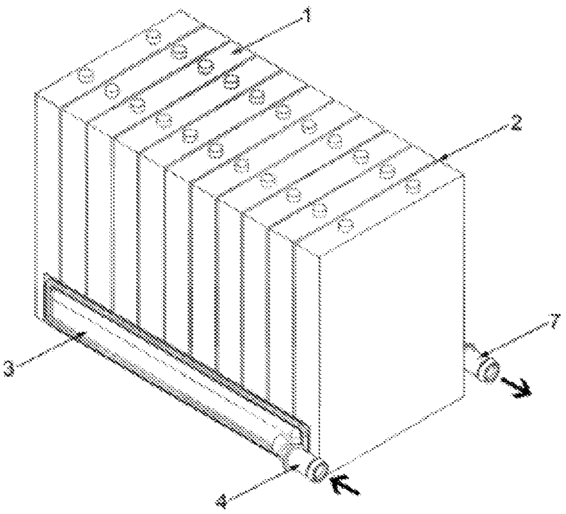

Fig. 1

(57) Abstract: A heat exchanger assembly for thermal regulation of battery cells or modules for electric vehicles including a heat exchanger inner circuit, an inlet port (4) for supplying a heat transfer medium to the heat exchanger inner circuit, an outlet port (7) for discharging the heat transfer medium from the heat exchanger inner circuit, and at least one battery cell (1) or battery module (17). The heat exchanger assembly comprises a shaped seal (2) of an elastomeric material, wherein at least a portion of the heat exchanger inner circuit is defined by two parallel surfaces and the shaped seal (2) for the flow of the heat transfer medium, wherein at least one of the parallel surfaces is the surface of the battery cell (1) or battery module (17), and the at least a portion of the heat exchanger inner circuit is linked by its first end to the inlet port (4) and, by its second end, to the outlet port (7).

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Heat exchanger assembly

Technical field

The invention relates to the field of heat exchangers, in particular for cooling or heating battery cells (accumulators), which are arranged side by side or on top of each other to form a battery module, which is used, for example, in electric vehicles as an energy source.

More specifically, it relates to a heat exchanger assembly comprising battery cells or battery modules arranged in a row, between which a seal is placed defining a space through which a thermally regulated medium flows, the supply and discharge of which is provided by manifolds placed on the sides of the battery cells or battery modules.

Background of the Invention

Currently, aluminum heat exchangers are used for thermal regulation of prismatic battery cells and their assemblies into battery modules. These heat exchangers are composed of several pairs of pressed plates connected to each other by inlet and outlet tubes, which complete and close the heat exchanger inner circuit in which the heat transfer medium, usually a liquid, flows. The cooling plates are placed between the individual battery cells or battery modules, or one cooling plate with an inlet and outlet port is placed under the battery modules.

The required functionality of the heat exchanger and the efficiency of heat transfer between the cooling plates and the cooled battery cells or modules depend on their permanent contact and the size of the heat transfer area. As a result of vibration, thermal and compressive stresses during operation, cracks form in depressions on the plate and tubular connections between the individual plates, which subsequently leak the cooling medium that causes a critical failure of the entire system.

In order to ensure sufficient heat transfer area and constant contact, high demands are placed on the precision of the production of the cooling plates and all cooled components, resulting in increased production costs. The different thermal expansion of the individual components located close to the heat exchanger can temporarily cause a loss of contact of the heat transfer areas or, in the opposite case, an undesired deformation of the heat exchanger and subsequent formation of a crack and leakage of the medium. The use of aluminum heat exchangers causes an undesirable significant increase in the weight and footprint dimensions of the battery modules.

All components made of electrically conductive materials and in areas with a risk of a short-circuit of the battery module must be provided with electrical insulation, which increases production costs, weight, and footprint dimensions and reduces heat transfer efficiency.

The purpose of this invention is to create a compact heat exchanger assembly that will have a higher heat transfer efficiency and thus higher thermal performance with the ability to efficiently absorb vibration and thermal expansion of the individual components without the need for additional electrical insulation of the individual components. At the same time, weight, footprint dimensions, and production precision requirements are reduced.

Summary of the Invention

The above described task is achieved by a heat exchanger assembly comprising a heat exchanger inner circuit, an inlet port for supplying a heat transfer medium to the heat exchanger inner circuit, an outlet port for discharging the heat transfer medium from the heat exchanger inner circuit, and at least one battery cell or battery module, the essence of which is a shaped seal made of an elastomeric material, wherein at least a portion of the heat exchanger inner circuit is defined for the flow of the heat transfer medium by two parallel surfaces and shaped seal, wherein at least one of the parallel surfaces is a battery cell or battery module surface and the at least portion of the heat exchanger inner circuit is linked by its first end to the inlet port and by its second end to the outlet port.

Shaped seals are placed between prismatic battery cells, battery modules, or between a battery module and an area of any component, e.g., a battery pack carrier shell, which in combination with the cooled area of the individual prismatic battery cells, battery modules, or component area forms a cooling circuit. The cooling circuits thus formed are linked to a common inlet and outlet manifold or media supply and discharge chamber, which are provided with a seal and are placed on sides perpendicular to the cooled sides of the battery cells or battery modules. The idea is to efficiently utilize the areas of the components requiring thermal management to create a higher-level heat exchanger assembly without the need to duplicate individual shells in the assembly, thus saving on heat exchanger production material.

The inlet and outlet manifolds can preferably be replaced by a single double manifold with two media supply and discharge integrated channels if the shape of the seal is adapted to this solution. The manifolds can be made of plastics and their composites without the need for additional electrical insulation. The manifolds can be provided with a bleed valve to facilitate filling of the heat exchanger with the medium, or sensors for measuring the medium.

The cooled areas of the battery cells and battery modules are in direct contact with the heat transfer medium. This results in immediate direct heat transfer over the maximum possible area and increase in the thermal regulation efficiency by significantly reducing heat loss outside the cooled areas.

Shaped seals provide efficient absorption of thermal expansion of the battery cells or battery modules, which results in greater compression of the seals, reducing the profile of the flow channel, resulting in increased flow rate and overall thermal performance. Shaped seals absorb vibration and eliminate their transfer between the individual components, increasing the life of all battery cell and battery module fixed connections.

This creates a heat exchanger assembly for prismatic battery cells and battery modules with significantly lower weight, production costs, and space savings that can be used to increase the number of the battery cells.

Description of Drawings

The invention will be further clarified using examples of possible embodiments of the heat exchanger assembly for prismatic battery cells and battery modules.

Alternative no. 1:
Fig. 1. – an axonometric view of a possible embodiment of the heat exchanger assembly.
Fig. 2. – a transverse section through the center of the shaped seal.

Fig. 3. – a longitudinal section through the centers of the inlet and outlet manifold.

Alternative no. 2:
Fig. 4. – an axonometric view of a possible embodiment of the heat exchanger assembly.
Fig. 5. – a transverse section through the center of the shaped seal.
Fig. 6. – a longitudinal section through the center of one of two integrated channels of the double manifold.

Alternative no. 3:
Fig. 7. – an axonometric view of a possible embodiment of the heat exchanger assembly.
Fig. 8. – a longitudinal section through the center of the shaped seal.

Alternative no. 4:
Fig. 9. – an axonometric view of a possible embodiment of the heat exchanger assembly.
Fig. 10. – a longitudinal section through the center of the shaped seal.

Alternative no. 5:
Fig. 11. – an axonometric view of a possible embodiment of the heat exchanger assembly.
Fig. 12. – a longitudinal section through the center of the shaped seal.

Alternative no. 6:
Fig. 13. – an axonometric view of a possible embodiment of the heat exchanger assembly.
Fig. 14. – a longitudinal section through the center of the shaped seal.

Exemplary Embodiment of the Invention

The heat exchanger assembly shown in Fig. 1 comprises eleven prismatic battery cells 1 arranged in a single row behind each other, between which ten shaped seals 2 are inserted to form ten cooling circuits, which are linked in parallel on one side of the prismatic battery cells to an inlet manifold 3 provided with an inlet port 4 and a seal 5 and, on the other side of the prismatic battery cells, to an outlet manifold 6 provided with an outlet port 7 and a seal 8.

The linkage of one of the ten cooling circuits to the inlet manifold 3 and outlet manifold 6 is shown in a transverse section in Fig. 2, supplemented by an enlarged detail of the linkage point of the outlet manifold 6 with the cooling circuit formed by the shaped seal 2 and the two attached prismatic batteries 1 by means of the seal 8 inserted in a groove on the outlet manifold 6, which is provided with the outlet port 7. The linkage of the inlet manifold 3, which is provided with the inlet port 4 and the seal 5, is identical to the linkage of the outlet manifold 6. On the bearing areas of the inlet manifold 3, the outlet manifold 6 and the prismatic battery cells 1, a connection is formed, e.g., by gluing, welding, or mechanical locking.

The parallel linkage of the ten cooling circuits to the inlet manifold 3 and outlet manifold 6 is shown in a transverse section in Fig. 3, where each of the ten shaped seals 2 defines a cooling circuit between two cooled areas of the prismatic battery cells 1. The seal 5 and the seal 8 provide the linkage between the inlet manifold 3 provided with the inlet port 4, the prismatic battery cells 1 and the outlet manifold 6 provided with the outlet port 7 in combination with the formed connection, e.g., by gluing, welding, or mechanical locking.

In Fig. 4, a similar type of the heat exchanger assembly is shown, which consists of eleven prismatic battery cells 1 arranged in a single row behind each other, between which ten shaped seals 16 are inserted, thus forming ten cooling circuits which are linked in parallel on only one side of the prismatic battery cells to a double manifold 9 provided with the inlet port 4, outlet port 7 and seal 10.

The linkage of one of the ten cooling circuits to the double manifold 9 is shown in a transverse section in Fig. 5, supplemented by an enlarged detail of the linkage point of the double manifold 9 with the cooling circuit formed by the shaped seal 16 and the two attached prismatic batteries 1 by means of the seal 10 inserted in a groove on the double manifold 9, which is provided with the inlet port 4 and outlet port 7. On the bearing areas of the double manifold 9 and the prismatic battery cells 1, a connection is formed, e.g., by gluing, welding, or mechanical locking.

The parallel linkage of the ten cooling circuits to the double manifold 9 is shown in a transverse section in Fig. 6, where each of the ten shaped seals 16 defines a cooling circuit between two cooled areas of the prismatic battery cells 1. The seal 10 provides a linkage between the double manifold 9 provided with the inlet port 4 and outlet port 7 and the prismatic battery cells 1 in combination with a formed connection, e.g., by gluing, welding, or mechanical locking.

In Fig. 7, a second similar type of the heat exchanger assembly is shown, which consists of an area of the component 12, on which a shaped seal 18 is placed, on which a battery module 17 is placed, which is provided with an inlet chamber 19 having an inlet port 4 and an outlet chamber 20 having an outlet port 7. The inlet chamber 19 and the outlet chamber 20 are linked to the battery module 17 e.g., by gluing, welding, soldering, or mechanical locking to form a single cooling circuit. The desired compression of the shaped seal 18 may be achieved by loosely fitting the battery module 17 on the shaped seal 18, assuming sufficient weight of the battery module 17, or by forming an additional connection between the area of the component 12 and the battery module 17, e.g., by mechanical locking or welding.

The linkage of the cooling circuit to the inlet chamber 19 and the outlet chamber 20 is shown in a longitudinal section in Fig. 8, where the shaped seal 18 extends past the edge of the battery module 17 to link the inlet chamber 19 and the outlet chamber 20. The inlet chamber 19 provided with the inlet port 4 and the outlet chamber 20 provided with the outlet port 7 may be placed arbitrarily on the sides of the battery module 17, if the shaped seal 18 is adapted to this solution.

In Fig. 9, a third similar type of the heat exchanger assembly is shown, which consists of an area of the component 12, on which a shaped seal 21 is placed, on which the battery module 17 is placed, which is provided with a double chamber 13 having the inlet port 4 and the outlet port 7. The double chamber 13 is linked to the battery module 17 by means of five screws 14, which can be replaced e.g., by mechanical locking or welding, and a seal 15. The desired compression of the shaped seal 21 may be achieved by loosely fitting the battery module 17 on the shaped seal 21, assuming sufficient weight of the battery module 17, or by forming an additional connection between the area of the component 12 and the battery module 17, e.g., by mechanical locking or welding.

The linkage of the cooling circuit to the double chamber 13 is shown in a longitudinal section in Fig. 10, supplemented by an enlarged detail of the linkage point, where the shaped seal 21 extends past the edge of the battery module 17 to link the double chamber 13, which is provided with the inlet port 4, the outlet port 7, and the seal 15. The double chamber 13 may be placed arbitrarily on the sides of the battery module 17 if the shaped seal 21 is adapted to this solution.

In Fig. 11, a fourth similar type of the heat exchanger assembly is shown, which consists of an area of the component 12, on which a shaped seal 22 is placed, on which a battery module 23 is placed, the outer shell of which is extended on the bottom cooled side by shaped elements for linking the inlet port 4 and the outlet port 7. The desired compression of the shaped seal 22 may be achieved by loosely fitting the battery module 23 on the shaped seal 22, assuming sufficient weight of the battery module 23, or by forming an additional connection between the area of the component 12 and the battery module 23, e.g., by mechanical locking or welding.

The linkage of the cooling circuit through the shaped elements on the battery module 23 to the inlet port 4 and the outlet port 7 is shown in a longitudinal section in Fig. 12, where the shaped seal 22 does not extend past the edge of the battery module 23 at any point. The shaped elements on the battery module 23 may be placed arbitrarily on the sides of the battery module 23 if the shaped seal 22 is adapted to this solution.

In Fig. 13, a fifth similar type of the heat exchanger assembly is shown, which consists of eleven prismatic battery cells 1 arranged in a single row behind each other, between which ten shaped seals 27 are inserted, thereby forming ten cooling circuits. The shaped seal 27 on both sides of the prismatic battery cells 1 extends past the edges of the cooled surfaces to create a space for parallel linkage to the inlet and outlet manifolds. The inlet manifold is composed of one plug 25, nine manifold cells 24, and an inlet chamber 26 provided with the inlet port 4. The outlet manifold is composed of one plug 25, nine manifold cells 24, and an outlet chamber 28 provided with the outlet port 7. Each component of the inlet and outlet manifold can be provided with a groove with a seal for linking to the battery cell. All components of the input and output manifolds may be replaced by components forming a single double manifold with two or more integrated channels, wherein these components are placed on one and the same side of the battery cells in the same manner. All components of the manifolds can be incorporated into the production process of the shell of the battery cells or battery modules, making them an integral, integrated part of them.

The linkage of one of the ten cooling circuits to the inlet manifold via the inlet chamber 26 and the outlet manifold via the outlet chamber 28 is shown in a transverse section in Fig. 14, where the inlet chamber 26 is provided with the inlet port 4 and the outlet chamber 28 is provided with the outlet port 7. On the bearing areas between the chambers 26, 28 and the prismatic battery cell 1, a connection is formed, e.g., by gluing, welding, or mechanical locking. The linkage of the cooling circuits by means of the manifold cells 24 and the plug 25 and the formation of the manifold, thereby completing the cooling circuit, is identical to the linkage of the chambers 26 and 28.

Claims

1. A heat exchanger assembly comprising a heat exchanger inner circuit, an inlet port (4) for supplying a heat transfer medium to the heat exchanger inner circuit, an outlet port (7) for discharging the heat transfer medium from the heat exchanger inner circuit, and at least one battery cell (1) or battery module (17), **characterized in that** it comprises a shaped seal (2) made of an elastomeric material, wherein at least a portion of the heat exchanger inner circuit is defined for the flow of the heat transfer medium by two parallel surfaces and the shaped seal (2), wherein at least one of the parallel surfaces is a battery cell (1) or battery module (17) surface and that the at least a portion of the heat exchanger inner circuit is linked by its first end to the inlet port (4) and, by its second end, to the outlet port (7).

2. The heat exchanger assembly of claim 1, **characterized in that** the shaped seal (2) extends, by a portion thereof, past the edge of at least one of the two parallel surfaces, wherein through this extending portion of the shaped seal (2), a portion of the heat exchanger inner circuit is linked to the inlet port (4) or the outlet port (7).

3. The heat exchanger assembly of claim 1 or 2, **characterized in that** it comprises at least two manifolds (3) and at least two battery cells (1) or battery modules (17), wherein at least two different portions of the heat exchanger inner circuit are composed of two parallel surfaces and the shaped seal (2), wherein the two parallel surfaces forming at least one of these portions of the heat exchanger inner circuit together with the shaped seal (2) are both surfaces of the battery cell (1) or battery module (17), and that the different portions of the heat exchanger inner circuit are linked in parallel by their first end to the inlet port (4) via the first manifold (3) and, by their second end, to the outlet port (7) via the second manifold (3).

4. The heat exchanger assembly of claim 3, **characterized in that** the shaped seals (2) extend, by a portion thereof, past the edge of the two parallel surfaces, and at least one manifold (3) is composed of a plurality of components including at least one manifold cell (24), a plug (25), and an inlet chamber (26) linked to the inlet port (4) or an outlet chamber (28) linked to the outlet port (7), wherein all the individual extending portions of the shaped seal (2) are located between different pairs of adjacent components of the manifold (3), wherein the individual portions of the heat exchanger inner circuit are connected at their ends by the manifold (3) and linked to one inlet port (4) or outlet port (7).

5. The heat exchanger assembly of claim 1, **characterized in that** it comprises at least one chamber (19), wherein a portion of the heat exchanger inner circuit is linked by one end thereof to the inlet port (4) or outlet port (7) via the chamber (19).

6. The heat exchanger assembly of claims 1 to 5 of the preceding claims, **characterized in that** the shaped seal (2) is attached to the surface with which it forms at least a portion of the heat exchanger inner circuit by gluing or by a groove in the surface, or the surface of the bearing area for the shaped seal (2) has an increased roughness.

7. The heat exchanger assembly of claims 1 to 6, **characterized in that** the shape seal (2) comprises a shape element for changing the flow rate and flow manner, e.g., from laminar to turbulent flow, in a defined portion of the heat exchanger inner circuit.

8. The heat exchanger assembly of claims 3 to 7, **characterized in that** the chamber (19) or the manifold (3) is provided with a bleed valve.

9. The heat exchanger assembly of claims 1 to 8, **characterized in that** the battery cell (1) or the battery module (17) comprises a shape element, wherein the shape element is in contact with the shaped seal (2) and forms a portion of the surface of the battery cell (1) or the battery module (17) forming a portion of the heat exchanger inner circuit, wherein through the shape element, at least a portion of the heat exchanger inner circuit is linked to the inlet port (4) or the outlet port (7).

10. The heat exchanger assembly of claims 1 to 9, **characterized in that** the components of the heat exchanger assembly, which form parallel areas defining together with the shaped seal (2) a portion of the heat exchanger inner circuit, are connected to each other, wherein this connection provides compression of the shaped seal (2) between them.

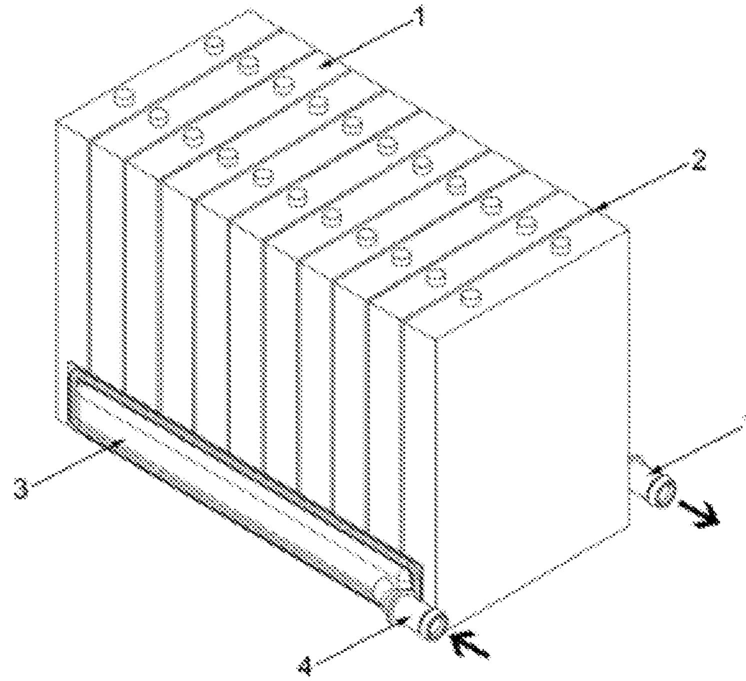

Fig. 1

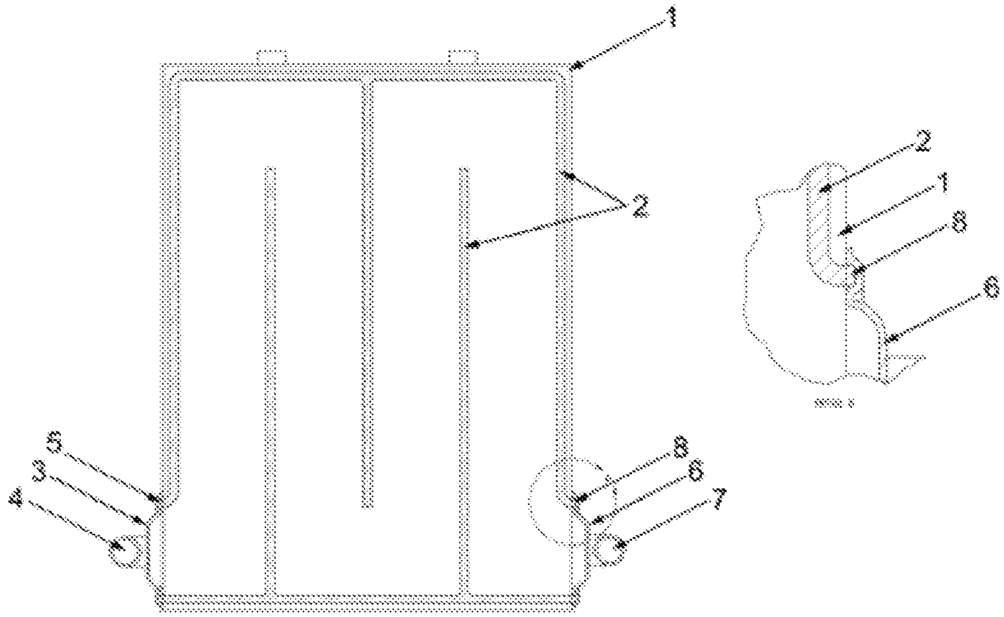

Fig. 2

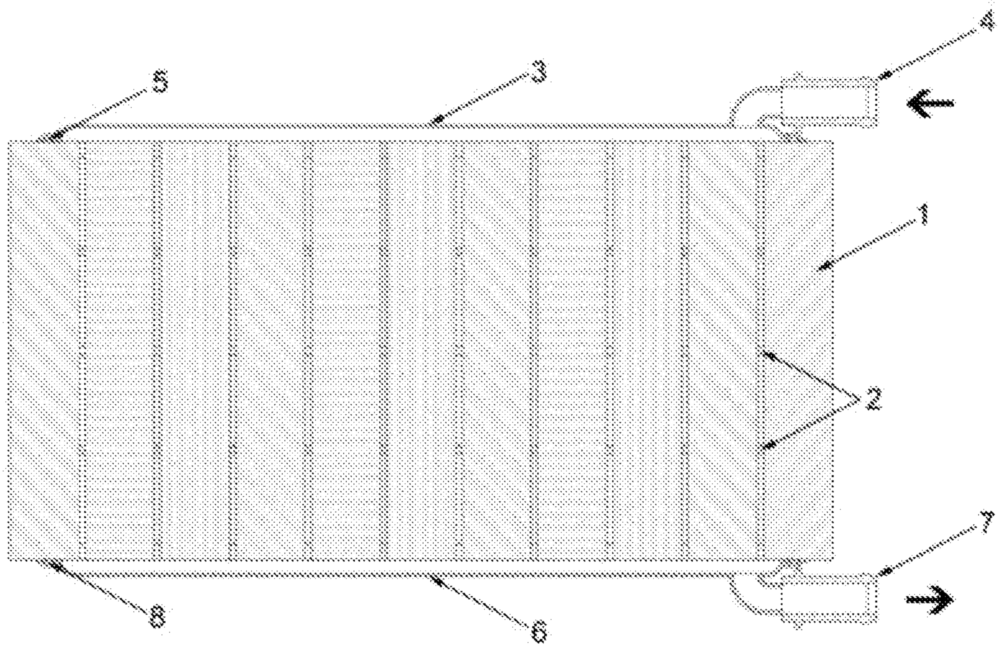

Fig. 3

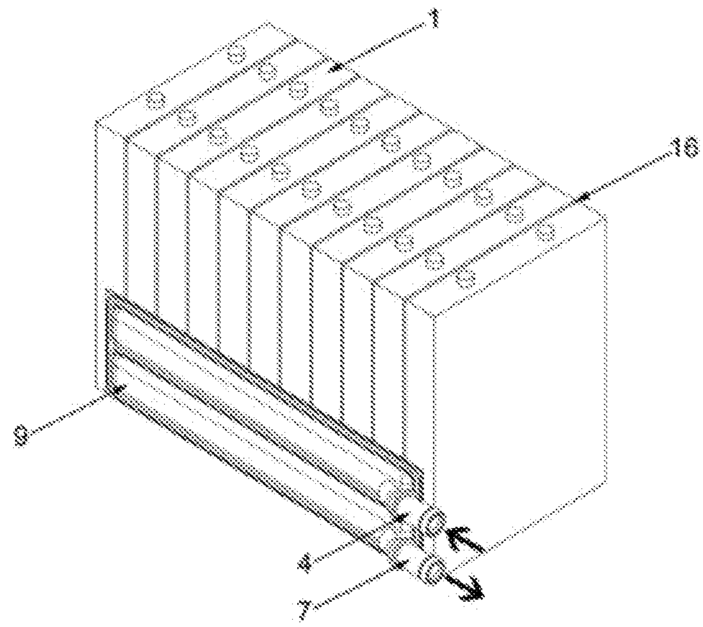

Fig. 4

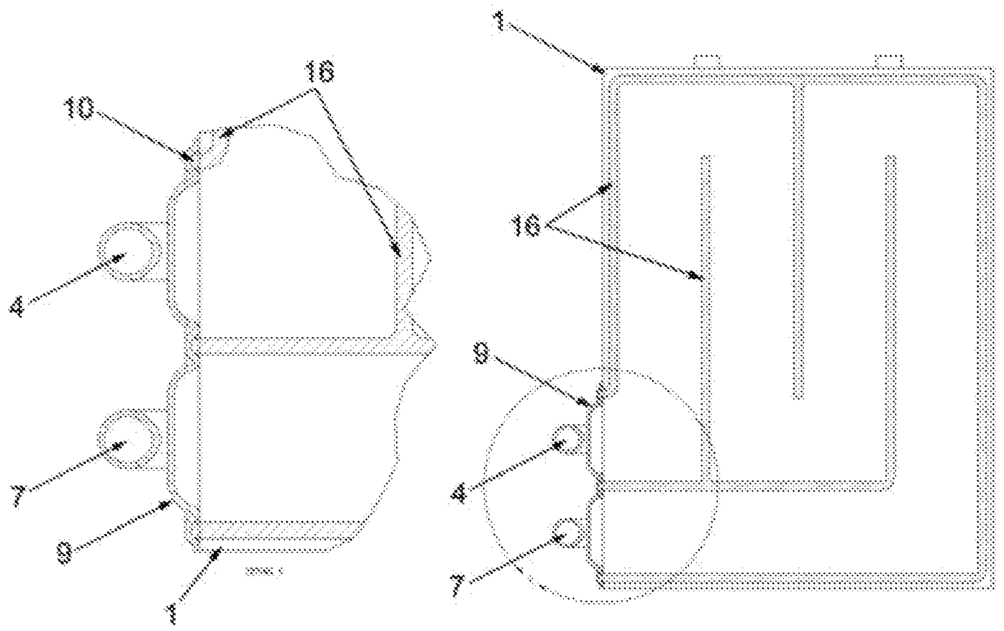

Fig. 5

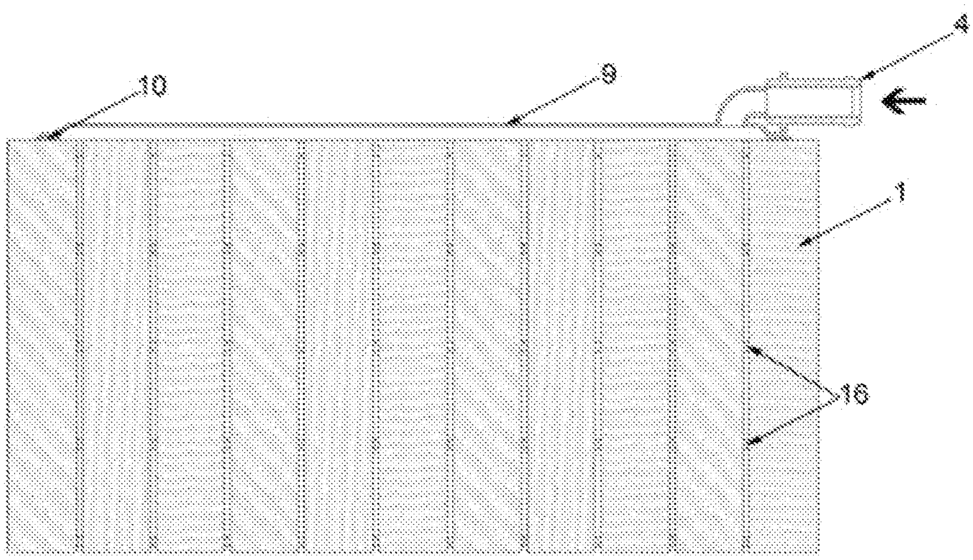

Fig. 6

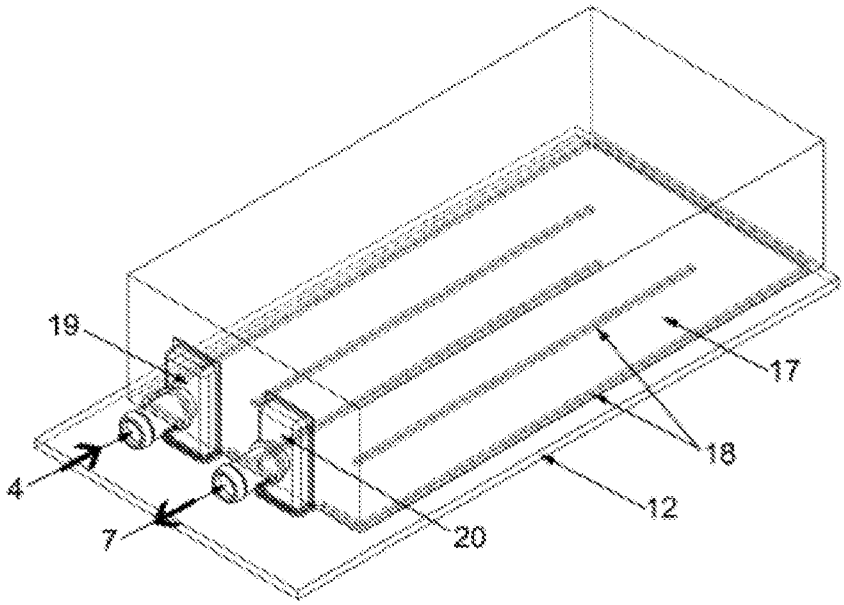

Fig. 7

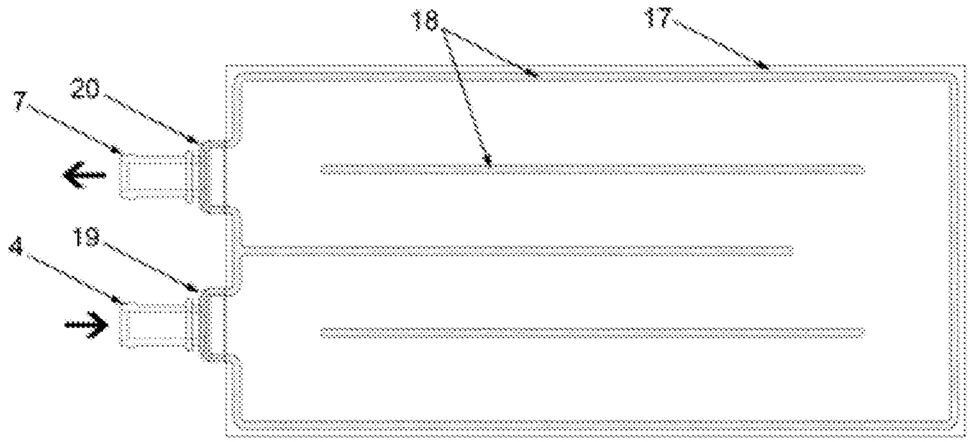

Fig. 8

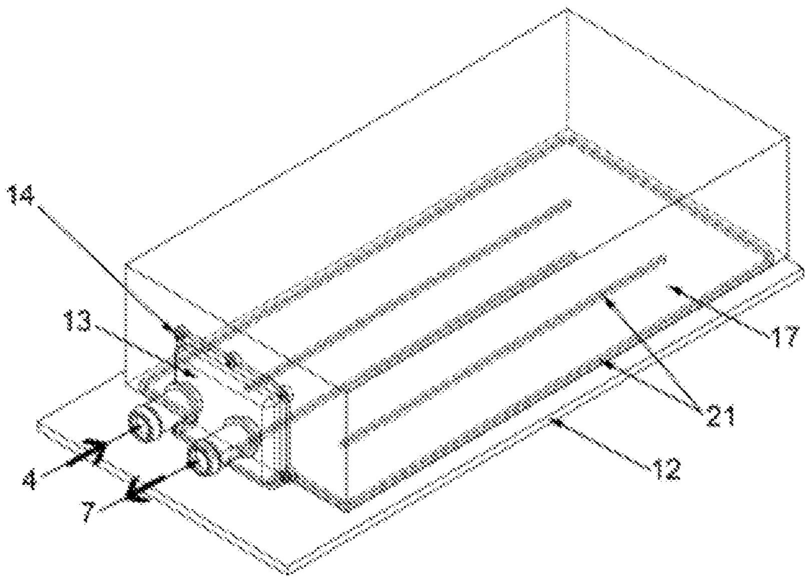

Fig. 9

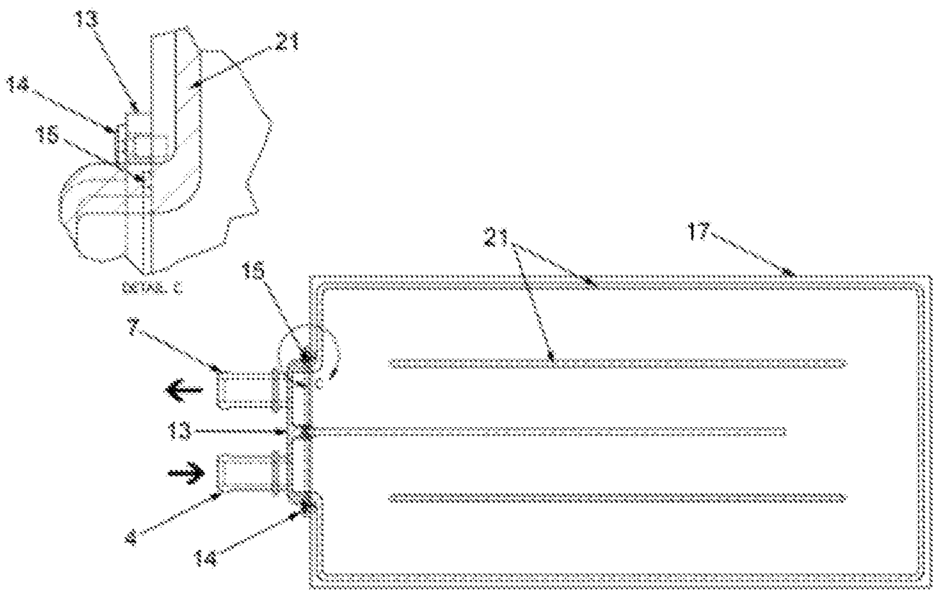

Fig. 10

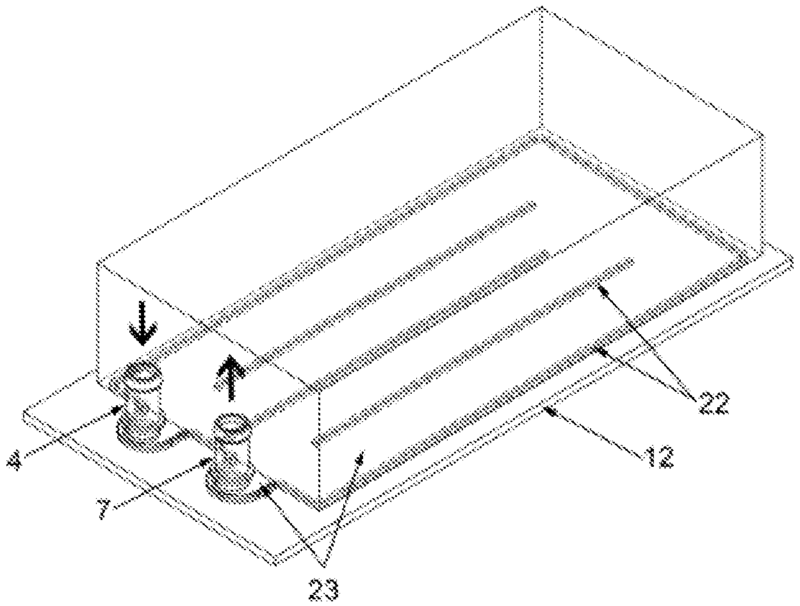

Fig. 11

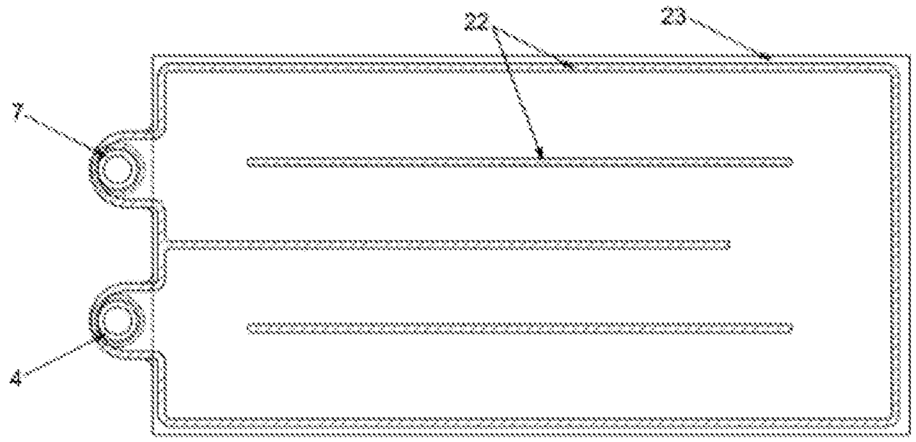

Fig. 12

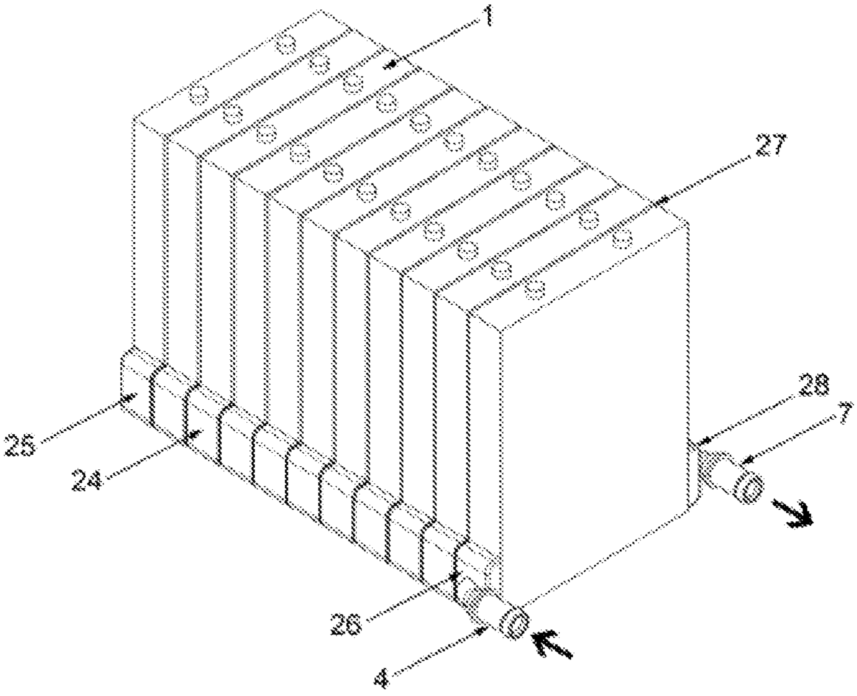

Fig. 13

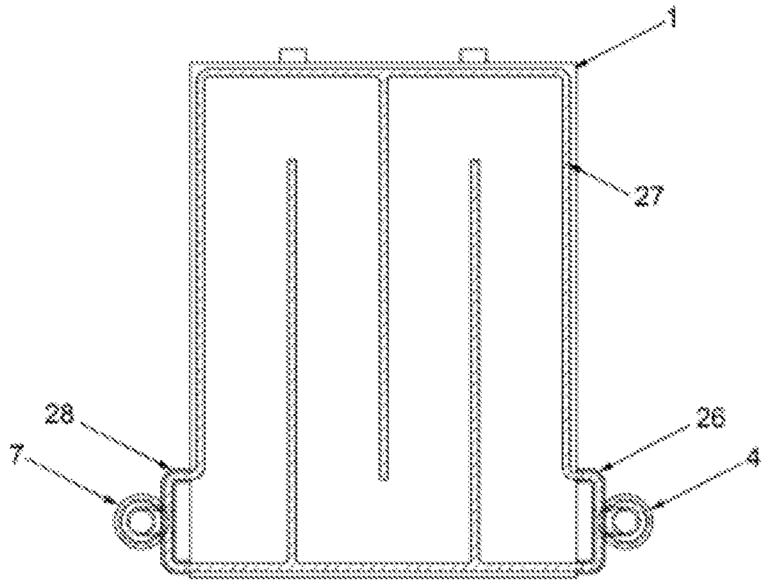

Fig. 14

INTERNATIONAL SEARCH REPORT

International application No
PCT/CZ2021/050078

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01M10/6556 H01M10/6557
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	US 2017/125858 A1 (MILLER DANIEL [US] ET AL) 4 May 2017 (2017-05-04) paragraphs [0036], [0039] - [0043]; claim 7; figures 4-11 -----	1-10
X	US 2011/206968 A1 (NISHIMURA KATSUNORI [JP] ET AL) 25 August 2011 (2011-08-25) paragraphs [0065], [0077]; figures 3-9 -----	1,3,5-7, 10
X	DE 10 2018 221477 A1 (BOSCH GMBH ROBERT [DE]) 18 June 2020 (2020-06-18) paragraph [0041]; figures 1-11g -----	1,6,7,9, 10

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

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
11 October 2021	22/10/2021

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Maître, Jérôme

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

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