



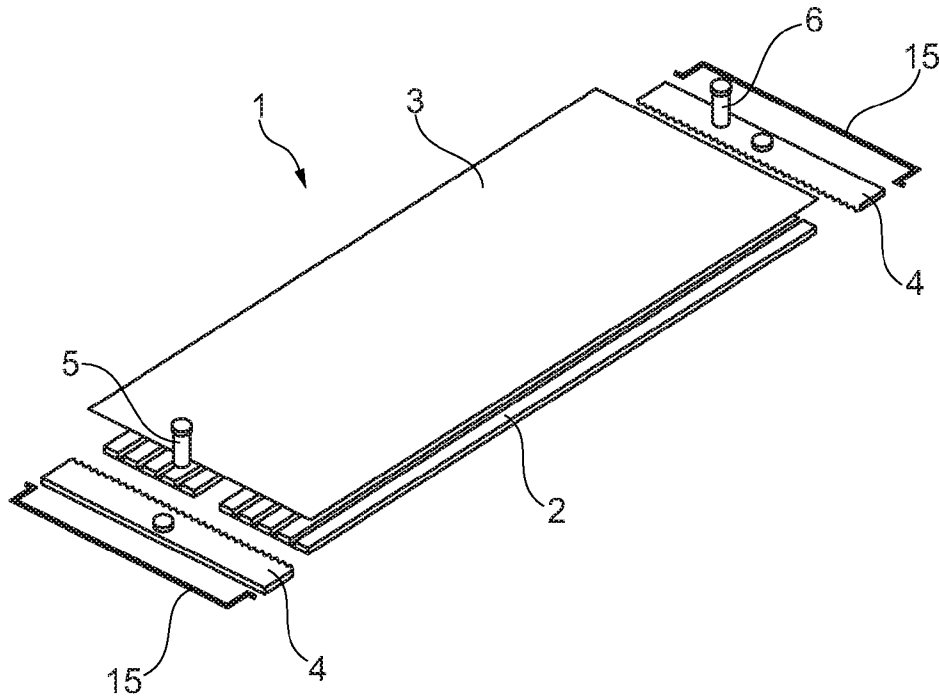
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(19) **United States**(12) **Patent Application Publication**
HIRSCH et al.(10) **Pub. No.: US 2016/0097598 A1**(43) **Pub. Date: Apr. 7, 2016**(54) **HEAT EXCHANGER**(71) Applicant: **MAHLE International GmbH**,
Stuttgart (DE)(72) Inventors: **Stefan HIRSCH**, Stuttgart (DE); **Florin**
MOLDOVAN, Stuttgart (DE)(73) Assignee: **MAHLE International GmbH**,
Stuttgart (DE)(21) Appl. No.: **14/884,824**(22) Filed: **Oct. 16, 2015****Related U.S. Application Data**(63) Continuation of application No. PCT/EP2014/
057689, filed on Apr. 16, 2014.(30) **Foreign Application Priority Data**

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F28D 1/053 (2006.01)(52) **U.S. Cl.**
CPC **F28D 1/05366** (2013.01)(57) **ABSTRACT**

A heat exchanger having a cover plate, a first manifold tube, a second manifold tube and at least one tube, wherein the tube is received at the ends in a respective opening of the first manifold tube and of the second manifold tube, wherein the cover plate is in contact with the manifold tubes and in thermal contact with the tube, wherein a fixing device is provided by which the cover plate can be fixed to at least one manifold tube and/or to at least one tube.



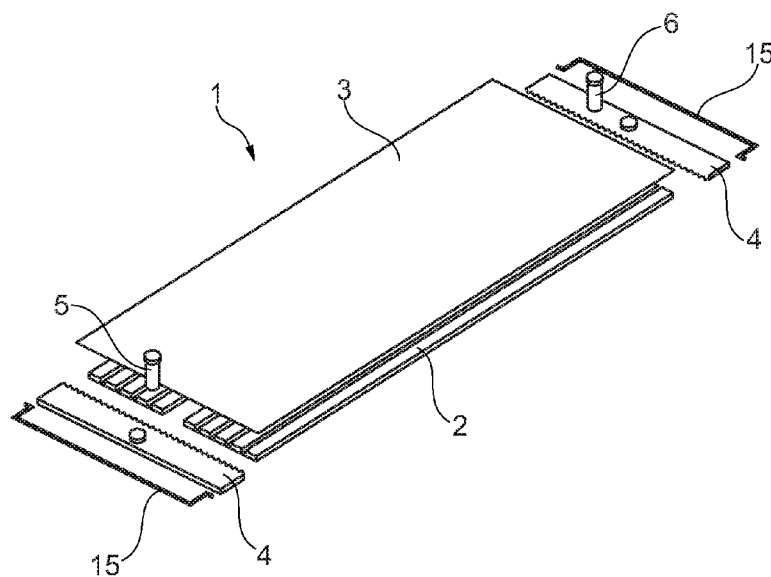


Fig. 1

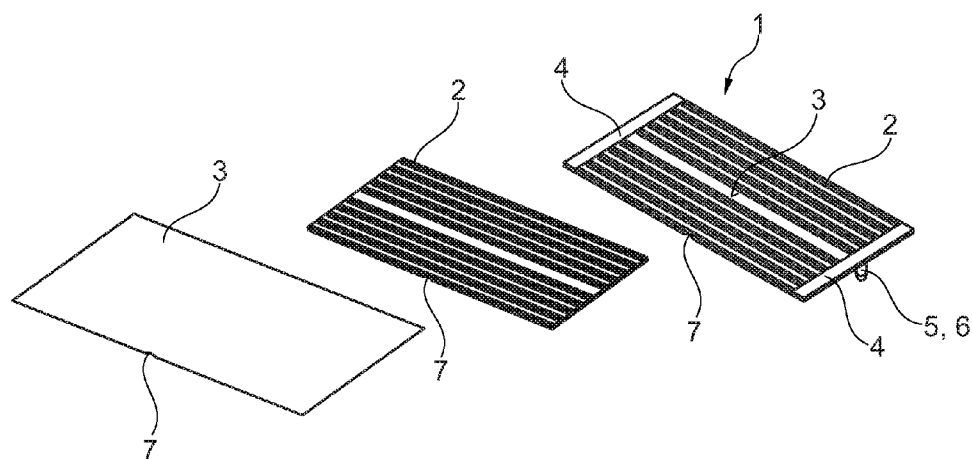


Fig. 2

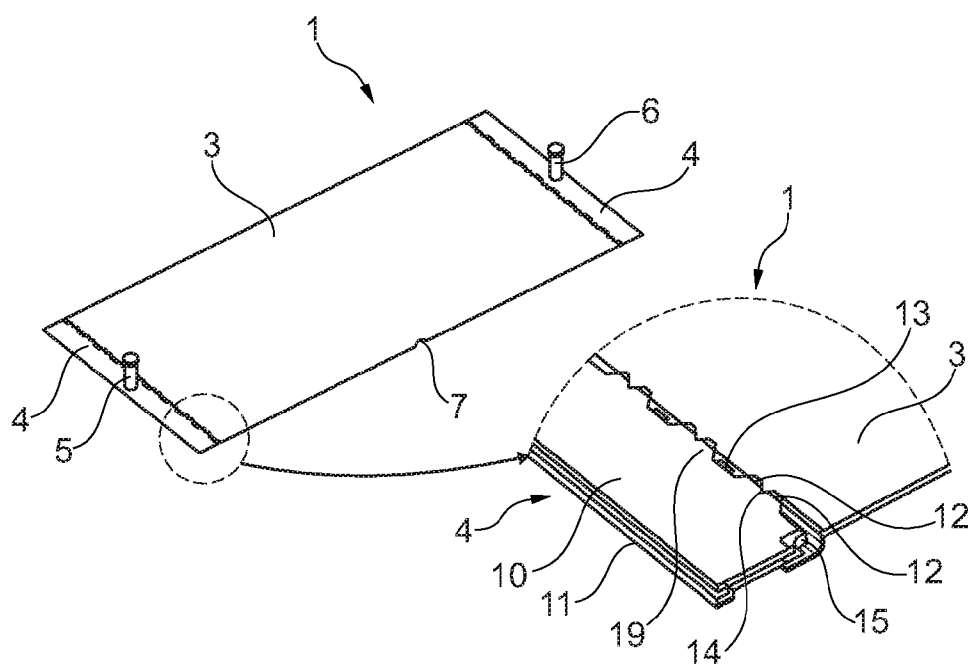


Fig. 3

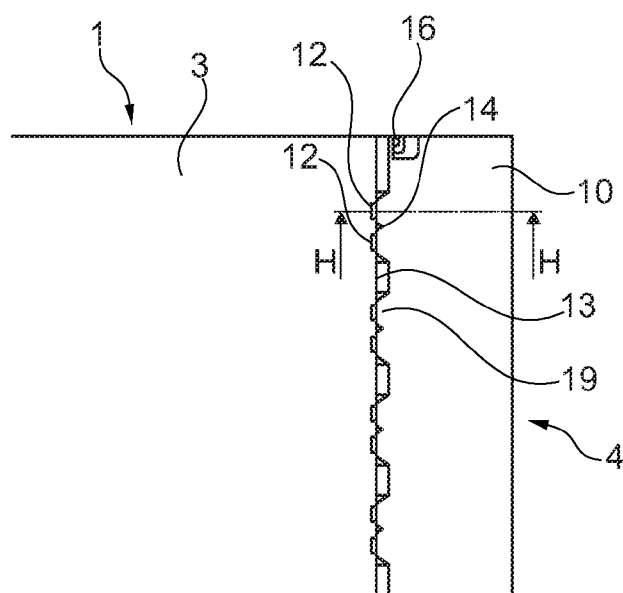


Fig. 4

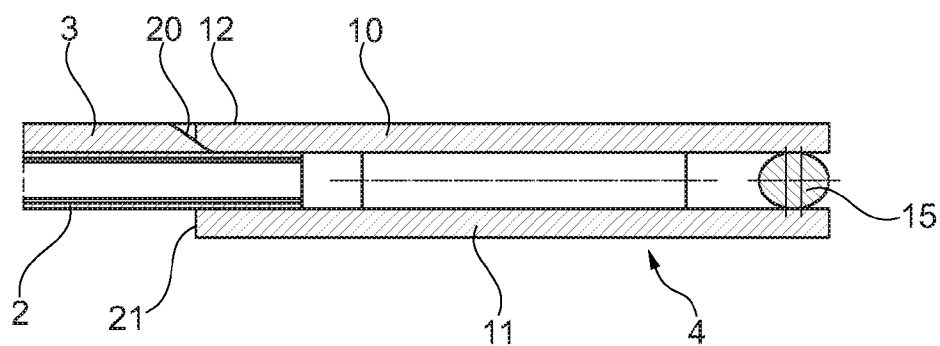


Fig. 5

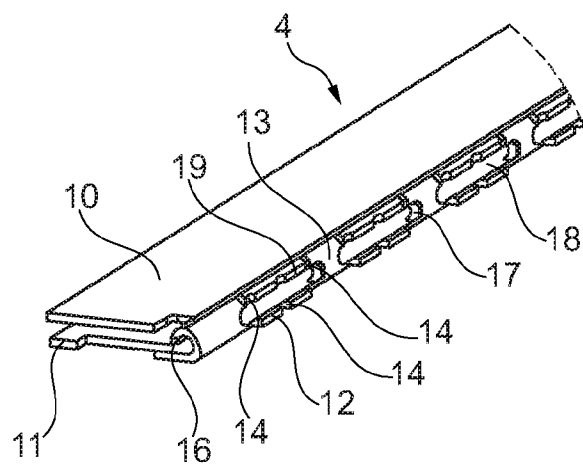


Fig. 6

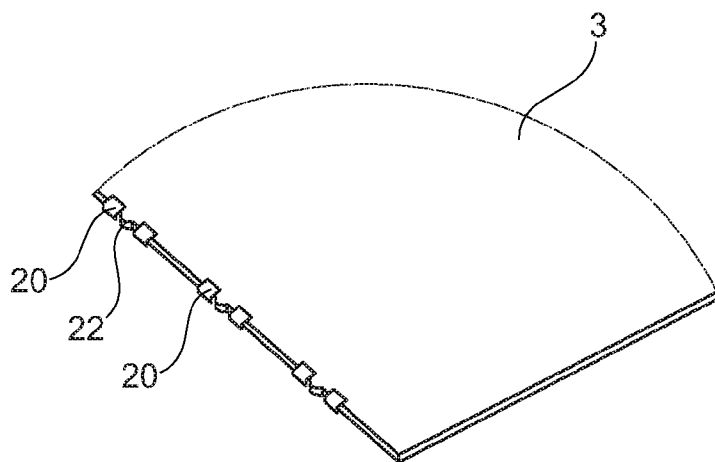


Fig. 7

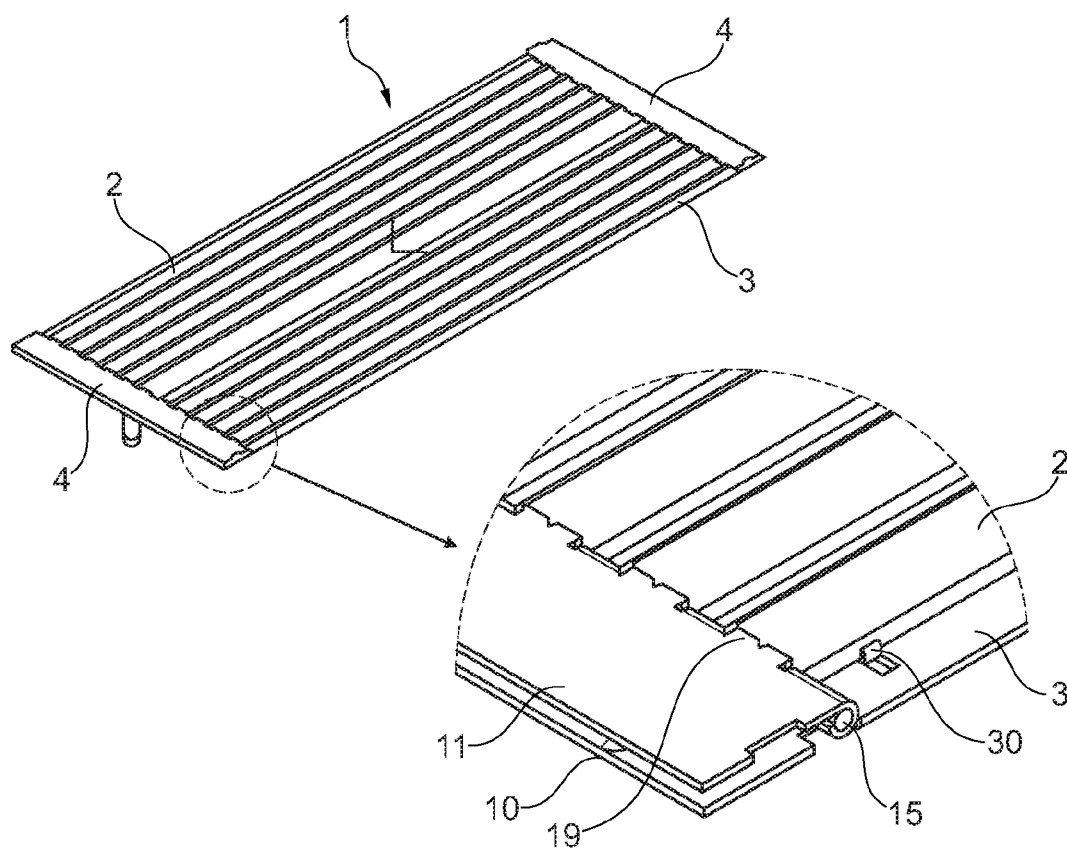


Fig. 8

HEAT EXCHANGER

[0001] This nonprovisional application is a continuation of International Application No. PCT/EP2014/057689, which was filed on Apr. 16, 2014, and which claims priority to German Patent Application No. 10 2013 207 375.5, which was filed in Germany on Apr. 23, 2013, and which are both herein incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a heat exchanger having a cover plate, a first header, a second header, and at least one tube, whereby the tube is received at the ends in a respective opening of the first header and of the second header, whereby the cover plate is in contact with the headers and in thermal contact with the tube.

[0004] 2. Description of the Background Art

[0005] Heat exchangers are used today for cooling various components. The cooling of battery components in particular has become increasingly important in recent years.

[0006] Batteries produce heat during charging and discharging which either heats the batteries or must be removed by suitable means. The recently favored lithium ion batteries in particular have a strong temperature dependence. The temperature dependence results inter alia in a more rapid aging of the individual battery cells due to high temperatures. In addition, excessive heating has a disadvantageous effect on the efficiency of the batteries. Suitable means for controlling the temperature of batteries must be provided, therefore, to be able to always operate the batteries within an optimal temperature range.

[0007] In order to enable a temperature transfer that is as great as possible between a cooling medium and the batteries, it is advantageous to provide as extensive a connection as possible of the heat exchanger to the batteries to be temperature controlled. Solutions to this problem are known in which the individual flat tubes are provided with a cover plate. The cover plate in this case serves as a surface for connecting the batteries.

[0008] The solutions in the existing art have the drawback in particular that the attachment of the cover plate to the heat exchanger has not been optimally solved thus far. The solutions in the existing art are not optimal especially in regard to the mountability of the heat exchanger having a cover plate and the simplicity of the connection.

SUMMARY OF THE INVENTION

[0009] It is therefore an object of the present invention to provide a heat exchanger which has an optimized connection of a cover plate in comparison with the solutions from the existing art.

[0010] An exemplary embodiment of the invention relates to a heat exchanger having a cover plate, a first header, a second header, and at least one tube, whereby the tube is received at the ends in a respective opening of the first header and of the second header, whereby the cover plate is in contact with the headers and in thermal contact with the tube, whereby a fixing device is provided by which the cover plate can be fixed to at least one header and/or to at least one tube.

[0011] A cover plate can be a substantially flat, essentially planar plate, which is in thermal contact with a single tube or with a plurality of tubes and/or with the headers and forms a

connecting surface for battery elements. The main task of the cover plate is to provide a heat transfer surface that is as large as possible.

[0012] A fixing device can be a device that prevent a relative movement of the cover plate in a direction running perpendicular to the main extension direction of the tubes. In particular, a falling off of the cover plate during the mounting and transport process is to be prevented in this way. This applies especially to a time at which the individual parts are still not permanently connected together by material bonding, for instance, by a soldering process.

[0013] It can be advantageous, moreover, if the fixing device is formed by retaining elements, which are disposed on the cover plate and/or on at least one header and serve to fix the cover plate to at least one header and/or to at least one tube, whereby the retaining elements are formed by at least one projection and/or at least one recess.

[0014] Positioning of the cover plate relative to the headers can be achieved via a projection and/or recess on a header and/or on the cover plate. In addition, a relative movement of the cover plate relative to the headers and the tubes can be prevented via the retaining elements. The projection and the recess are advantageously designed in this case such that they correspond to one another and can engage in one another.

[0015] The retaining elements in this case can be disposed on only one of the headers or equally on both headers.

[0016] In an embodiment of the invention, it can be provided that at least one opening of the headers has an edge region and the edge region has at least one insertion taper on a surface facing the center of the opening.

[0017] An insertion taper on a surface facing the center of the opening is advantageous to be able to insert the cover plate more easily into the opening. A surface facing the center can mean the inner walls of the opening. The insertion of a tube into the opening is also facilitated by such an insertion taper.

[0018] In an embodiment of the invention, it is provided in addition that the projection and/or recess on the header can be located on an edge region of an opening of the header, whereby the projection can have the insertion taper.

[0019] The projection and/or recess can be located on the edge region of the opening to achieve better guidance for the cover plate. The projection in this case can engage in a recess of the cover plate and/or partially overlap the cover plate. The projection and/or recess particularly during use of flat tubes are advantageously located on the longer sections of the edge regions of the opening.

[0020] In order to be able to receive both a cover plate on the top side of the tubes and also on the bottom side of the tubes, projections and/or recesses are disposed in each case on an opposing top and bottom edge region of the opening.

[0021] The projection in this case can be oriented such that it can merge flush with the header's top or bottom outer surface, which if flat tubes are used is oriented parallel to the broad side of the flat tubes.

[0022] An at least partially perimeter passage can be formed at the opening of the header by the projection and/or recess, whereby the passage is directed away from the interior of the particular header.

[0023] An at least partially perimeter passage can be produced by the projection. Both a tube and the cover plate can be inserted in this passage. The passage increases in particular the stability of the heat exchanger thereby. In addition, because of the passage a better material connection can be

created between the particular tube, the headers, and the cover plate, because the contact area can be increased overall.

[0024] It can be especially advantageous, furthermore, if the cover plate has a bevel on at least one edge region, as a result of which the material thickness of the cover plate increases from the edge.

[0025] The bevel is especially advantageous for inserting the cover plate into the opening of the header or into the passage. The bevel in this case is oriented such that the edge region of the cover plate has a sweep-back. The bevel in this case can extend over the entire edge region. Alternatively, the bevel can also extend only over one or more partial areas. In the inserted state, the bevel advantageously comes to lie on the insertion taper.

[0026] A clamping can be created between the tube and the header, as a result of which a cover plate, disposed on the tube and adjacent to the header, can be fixed.

[0027] A clamping between the particular header and the tube can lead to an advantageous fixing of the cover plate. This can be achieved particularly in that the cover plate with an end region, which has a bevel, is pushed into the clamping between the tube and the header. Alternatively, a clamping can also be produced between the tube, cover plate, and the header.

[0028] The clamping can be achieved in this case, for example, in that the cover plate is placed on the tubes, which are inserted, for example, in a mounting device, and then the header is pushed laterally onto the tube ends. The cover plate in this case is also inserted at least partially into the openings of the header or passages. The clamping arises thereby primarily because of the oversize of the tubes and cover plate in comparison with the opening or passage.

[0029] The edge region of the cover plate with the bevel can be inserted at least partially into an area between the passage and the tube and/or can be inserted into the opening of the header.

[0030] A clamping which effectively fixes the cover plate to the tubes and headers can be produced in this way.

[0031] An exemplary embodiment provides that the cover plate can have a bevel on each of two substantially opposing edge regions.

[0032] A bevel on two opposite edge regions of the cover plate is especially advantageous for being able to insert the cover plate in a simple way into both headers.

[0033] The insertion taper can be oriented such that the clear width of the opening decreases toward the interior of the header.

[0034] Such an orientation of the insertion tapers particularly facilitates the insertion of the cover plate into the opening. With an increased insertion depth, the orientation of the insertion taper and the bevel of the cover plate to one another in addition produces an increasing pressing between the tube, header, and cover plate, as a result of which the cover plate is fixed better.

[0035] A flush transition can be formed between the cover plate and at least one outer surface of a header, whereby the outer surface and the cover plate form a mutual planar surface.

[0036] An outer surface of the header can be an outer surface that runs substantially parallel to the plane in which the central axes of the tubes run.

[0037] For the case that the header is produced from a material strip by bending into a U-shaped structure, two substantially opposing legs arise which are connected to one

another via a narrow side of the tube. Each leg has an outer surface which runs parallel to the plane of the tubes. A flush transition of said outer surface into the surface of the cover plate is especially advantageous.

[0038] An enlarged planar surface, which can be used for connecting battery elements, can be produced overall by a flush transition. A smooth transition is especially advantageous in this case in order to be able to utilize the entire surface.

[0039] A plurality of tubes can be provided, whereby the tubes can be formed by flat tubes, which in each case have two opposing broad sides and two opposing narrow sides, whereby the central axes of the flat tubes and the respective broad sides are disposed in each case lying in a plane, whereby the cover plate lies on the plane formed by the broad sides.

[0040] Flat tubes are especially advantageous with respect to heat transfer, because the broad sides in particular form a larger heat transfer surface. An arrangement of the flat tubes in a plane has the result that a cover plate can be placed on the flat tubes and thereby is equally in thermal contact with all flat tubes. This is advantageous to achieve as great a heat transfer as possible.

[0041] The fixing device can be formed by at least one tab, which can be bent out of the plane of the cover plate and can be bent at least partially around a tube.

[0042] A tab bendable out of the cover plate is especially advantageous, because a connection between the cover plate and one or more tubes can be produced in a simple way. In this regard, only a single tab for each cover plate can be provided or a plurality of tabs, as a result of which the connection is improved overall.

[0043] Two cover plates can be provided, whereby one cover plate in each case lies against a plane formed by the broad sides.

[0044] Two cover plates are especially advantageous, when the heat exchanger is to be connected on both sides to elements to be cooled such as, for example, battery elements.

[0045] Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0046] The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus, are not limitative of the present invention, and wherein:

[0047] FIG. 1 shows a perspective view of a heat exchanger in an exploded illustration;

[0048] FIG. 2 shows a view, in sections, of the assembly process of the heat exchanger;

[0049] FIG. 3 in the left part shows a perspective view of a heat exchanger and in the right part a detailed view of the transition from the header to the cover plate of the heat exchanger;

[0050] FIG. 4 shows a view of the joint between the header and the cover plate;

[0051] FIG. 5 shows a sectional view through the joint between the header and the cover plate;

[0052] FIG. 6 shows a perspective view of the header looking toward the tube narrow side which has the openings;

[0053] FIG. 7 shows a perspective view of the edge region of a cover plate; and

[0054] FIG. 8 in the left part shows a perspective view of a heat exchanger with an alternative design of the fixing device for securing the cover plate to the tubes and in the right part a detailed view of the fixing device.

DETAILED DESCRIPTION

[0055] FIG. 1 shows a perspective view of a heat exchanger 1. Heat exchanger 1 is formed substantially of a plurality of tubes 2, which are received laterally in headers 4. Headers 4 have fluid connections 5 or 6, over which a fluid can be introduced into heat exchanger 1 or discharged from it, respectively.

[0056] Tubes 2 shown in FIG. 1 are formed by flat tubes, which have two opposing broad sides and two opposing narrow sides. In FIG. 1 flat tubes 2 are positioned such that the central axes of the tubes and the two opposing broad sides are disposed in each case in one plane.

[0057] Headers 4 have openings corresponding to flat tubes 2 into which the flat tubes can be pushed. Headers 4 are formed by a material strip which is bent into a U-shape and is closed on the side facing away from flat tubes 2 by a closing device 15, which can be formed, for example, by a shaped wire.

[0058] A cover plate 3 is placed on flat tubes 2. Said plate is in thermal contact with flat tubes 2 and headers 4. It forms a heat transfer surface and serves to connect components to be cooled such as, for example, batteries or the power electronics thereof.

[0059] FIG. 2 on the left shows a perspective view of cover plate 3. A positioning recess 7 is shown on the long side of cover plate 3.

[0060] The middle illustration in FIG. 2 shows an arrangement of cover plate 3 with flat tubes 2 placed thereon. Flat tubes 2 and cover plate 3 are placed in an assembly device, whereby the assembly device is not shown. Cover plate 3 is positioned in this regard in the assembly device such that positioning recess 7 grasps a bolt provided in the assembly device. Cover plate 3 is securely positioned thereby within the assembly device.

[0061] The right part of FIG. 2 shows a heat exchanger 1, as it was already shown in FIG. 1. In the right part of FIG. 2, heat exchanger 1 is shown in the final assembled state. To this end, headers 4 are pushed laterally onto flat tubes 2 or cover plate 3.

[0062] FIG. 3 shows a view of heat exchanger 1 looking toward cover plate 3. Side headers 4 with fluid connections 5 or 6 can also be seen. Cover plate 3 also has positioning recess 7. A detailed view of the transition from one of headers 4 to cover plate 3 is shown in the right part of FIG. 3.

[0063] It can be seen in the detailed view that header 4 is formed by a material strip bent into a U-shape. The material strip forms a bottom leg 11 and a top leg 10 by the U-shaped bending. The two legs 10 or 11 are connected to one another via a tube narrow side 13. Shaped wire 15 is indicated in the interior of header 4. Shaped wire 15 is fixed within header 4 by means of a tab 16, which is bent out of top leg 10.

[0064] The shown elements, such as tubes, cover plate, headers, and shaped wire, are permanently connected in a

step following the assembly using a material connection method such as, for instance, soldering.

[0065] Top leg 10 of header 4 furthermore has passages 19 formed by two projections 12, which are separated by a recess 14. Passages 19 in this case are directed outwardly and are disposed on the edge region of the openings of headers 4, which openings are not shown in FIG. 3. Reference is made to the following FIG. 5 or 6 for the precise structure of header 4.

[0066] FIG. 4 shows a view of the transition between header 4 and cover plate 3 of heat exchanger 1. As already indicated in FIG. 3, shaped wire 15 is fixed by tab 16, bent out of leg 10, in the interior of header 4. Passages 19, formed by projections 12, protrude over tube narrow side 13, connecting top leg 10 to bottom leg 11.

[0067] Cover plate 3 engages with its own projection in recess 14, located between projections 12. Passages 19 or projections 12 thereby partially overlap cover plate 3.

[0068] FIG. 5 shows a section along the cut indicated in FIG. 4, labeled with the capital letters H-H.

[0069] Top leg 10 and bottom leg 11 in particular can be seen in the cut through header 4, and additionally shaped wire 15, which closes the header to the side facing away from flat tubes 2.

[0070] Cover plate 3 on one of its edge regions has a bevel 20, as a result of which a sweep-back of cover plate 3 arises. The material thickness of cover plate 3 increases thereby from the edge region. Projections 12 above and below flat tube 2 each have an insertion taper 21 on the inwardly directed surface. Due to insertion taper 21, the clear width of the opening decreases toward the center of header 4.

[0071] In the example shown in FIG. 5, bevel 20 and insertion taper 21 come to lie on top of one another in the assembled state. A clamping forms between top leg 10 of cover plate 3, flat tube 2, and bottom leg 11 of header 4. Cover plate 3 is also fixed to header 4 in this way in the not yet soldered state.

[0072] In an alternative embodiment, a second cover plate can also be provided, which is connected to the heat exchanger below the tubes via a connection analogous to the first cover plate.

[0073] Cover plate 3 is substantially impeded by the clamping, shown in FIG. 5, from falling off heat exchanger 1 in a direction running perpendicular to the main extension direction of flat tubes 2. To prevent a shift of cover plate 3 in a direction transverse to the main extension direction of flat tubes 2, the projections and recesses shown in FIGS. 3 and 4 are provided, which engage in one another such that a relative movement transverse to the main extension direction of flat tubes 2 is prevented. A relative movement of the cover plate in the direction of the main extension direction of the flat tubes is hampered by the joint between top leg 10 of header 4 and cover plate 3.

[0074] Cover plate 3 is secured thereby against an unintentional falling out of heat exchanger 1 particularly in a state in which a material connection between the individual elements had not yet been created. This facilitates the assembly in particular and simplifies the transport process, as well as the entire fabrication process of heat exchanger 1.

[0075] FIG. 6 shows a perspective view of header 4. Header 4, as already described, is produced by bending a flat material strip into a U-shaped form. In so doing, top leg 10 and bottom leg 11 are formed, which are substantially parallel to one another. The two legs 10, 11 are connected together via tube narrow side 13.

[0076] FIG. 6 shows furthermore a plurality of openings 18 which are provided in tube narrow side 13. Openings 18 are adapted in their contour to the outer contour of flat tubes 2. Opening 18 thus has two long sides lying parallel to surfaces 10 or 11 and two transverse sides standing perpendicular to surfaces 10 or 11. The long sides of opening 18 are longer than the transverse sides. The transverse sides of openings 18 are rounded.

[0077] It can be seen furthermore in FIG. 6 that passages 17, which are oriented inwardly, are located on the transverse sides of opening 18. It can also be seen that the outwardly oriented passages 19 each have two projections 12, which are separated from one another in each case by a recess 14. Said recesses 14 act as positioning aids for cover plate 3.

[0078] Preferably, the outwardly oriented passages 19 or projections 12 are present both on the top and bottom side of opening 18.

[0079] The outwardly oriented passages 19 are made as two parts. Projections 12 are formed identical and are separated from one another by recess 14. Recess 14, as just described, serves to receive a projection of cover plate 3 to assure a secure positioning of the cover plate relative to the header.

[0080] The outwardly oriented passages 19 have a recess 14 both in the middle and also on their respective left and right end regions. In addition, the outwardly oriented passages 19 or projections 12 have insertion tapers 21, which are intended to make the insertion of cover plate 3 easier. Insertion tapers 21 have already been illustrated in the sectional view of FIG. 5.

[0081] FIG. 7 shows a detailed view of cover plate 3. Projections 22 and bevels 20 are located on the left edge region of cover plate 3. Projections 22 are designed such that they can engage with an accurate fit in recesses 14 on header 4. Bevels 20 are designed such that they correspond to insertion tapers 21 on the outwardly oriented passages 19 or projections 12 of header 4. Projections 22 or bevels 20 in this case are disposed at the same distance to one another as openings 18 of headers 4.

[0082] In alternative embodiments, the bevels can also be made over a wider area of the edge region of the cover plate. Basically, the arrangement of bevels 20 or projections 22 is oriented toward the areas of headers 4, which areas are formed by openings 18 or the outwardly oriented passages 19 and projections 12.

[0083] FIG. 8 shows a further perspective view of a heat exchanger 1 looking toward flat tubes 2 disposed below cover plate 3.

[0084] In FIG. 8, cover plate 3 is fixed to flat tubes 2 by an alternative embodiment of the fixing device. In this regard, a detailed view is shown in the right part of FIG. 8. Cover plate 3 is attached here to a flat tube 2 via a tab 30 bent out of the flat plane of cover plate 3. Flat tube 2 in this case is at least partially grasped by tab 30. In addition to tab 30 shown in FIG. 8, further tabs can be disposed along cover plate 3. In alternative embodiments, the tabs can grasp flat tubes 2 more or less greatly than shown in FIG. 8. Falling of plate 30 off flat tubes 2 during assembly or transport should be substantially prevented by tab 30.

[0085] The exemplary embodiments shown in FIGS. 1 to 8 are only exemplary in nature. They have no limiting effect and can be combined with one another.

[0086] The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and

scope of the invention, and all such modifications as would be obvious to one skilled in the art are to be included within the scope of the following claims.

What is claimed is:

1. A heat exchanger comprising:

a cover plate;

a first header;

a second header; and

at least one tube that is received at ends in a respective opening of the first header and of the second header,

wherein the cover plate is in contact with the headers and in thermal contact with the tube, and

wherein a fixing device is provided by which the cover plate is fixed to at least one header and/or to at least one tube.

2. The heat exchanger according to claim 1, wherein the fixing device is formed by retaining elements, which are disposed on the cover plate and/or at least on one header and fix the cover plate to at least one header and/or to at least one tube, and wherein the retaining elements are formed by at least one projection and/or at least one recess.

3. The heat exchanger according to claim 1, wherein at least one opening of the headers has an edge region and the edge region has at least one insertion taper on a surface facing a center of the opening.

4. The heat exchanger according to claim 1, wherein the projection and/or the recess on the header are located on an edge region of an opening of the header, and wherein the projection has an insertion taper.

5. The heat exchanger according to claim 4, wherein an at least partially perimeter passage is formed at the opening of the header by the projection and/or recess, and wherein the passage is directed away from the interior of the header.

6. The heat exchanger according to claim 1, wherein the cover plate has a bevel on at least one edge region, as a result of which the material thickness of the cover plate increases from the edge.

7. The heat exchanger according to claim 1, wherein a clamping is created between the tube and the header, as a result of which a cover plate disposed on the tube and adjacent to the header is fixed.

8. The heat exchanger according to claim 7, wherein the edge region of the cover plate with the bevel is inserted at least partially into an area between the passage and the tube and/or is inserted into the opening of the header.

9. The heat exchanger according to claim 1, wherein the cover plate has a bevel on each of two substantially opposing edge regions.

10. The heat exchanger according to claim 1, wherein the insertion taper is oriented such that the clear width of the opening decreases toward the interior of the header.

11. The heat exchanger according to claim 1, wherein a flush transition is formed between the cover plate and at least one outer surface of a header, and wherein the outer surface and the cover plate form a mutual planar surface.

12. The heat exchanger according to claim 1, wherein a plurality of tubes are provided, wherein the tubes are formed by flat tubes, which, in each case, have two opposing broad sides and two opposing narrow sides, wherein central axes of the flat tubes and respective broad sides are disposed in each case lying in a plane, and wherein the cover plate lies on the plane formed by the broad sides.

13. The heat exchanger according to claim 1, wherein the fixing device is formed by at least one tab, which is bent out of the plane of the cover plate and bent at least partially around a tube.

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