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(54) A HEAT EXCHANGER

(57) A heat exchanger (100) includes a housing (10) and a plurality of channel tubes (20). The housing (10) includes at least one first panel (10a), at least one second panel (10b) and a pair of spaced apart header plates (10c) that are disposed abutting each other to define an enclosure. The first panel (10a) is formed with a bend (12a), thereby inherently creating gap G at the at least one triple point formed at the interface between the first panel (10a) and the corresponding header plate (10c). The micro-channel tubes (20) are received in openings (12c) formed on the header plates (10c) and are disposed between the header plates (10c) to define fluid communication between end manifolds corresponding header plates (10c). The at least one of the panels (10a) and (10b) and the header plate (10c) is formed with at least one depression (50) along the bend (12a).

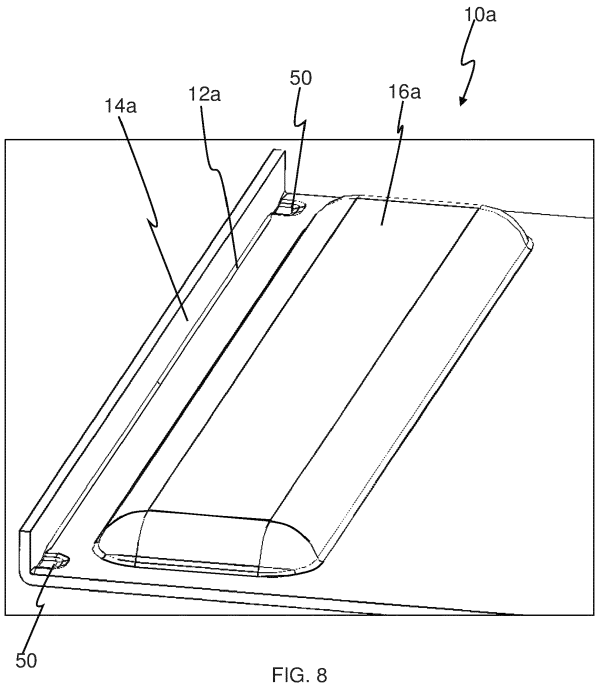


FIG. 8

EP 4 417 925 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a vehicle heat exchanger, more particularly, the present invention relates to a chiller for a use in vehicular environment.

BACKGROUND

[0002] Generally, a conventional heat exchanger, for example, a conventional water chiller, particularly, a R744 type water chiller includes a housing, a plurality of channel tubes disposed within the housing. The housing is formed of a plurality of panels that are assembled together and joined to each other by a joining process, such as for example, but not limited to brazing to define an enclosure. Particularly, the housing is formed by assembling one pair of opposite first panels, one pair of opposite second panels and a pair of header plates formed with openings. More specifically, one set of the first panel, the second panel and the header plate are disposed orthogonal to each other to form a portion of the housing. Another set of the first panel, the second panel and the header plate disposed orthogonal to each other forms the remaining portion of the housing. The first panel is formed with water boxes to configure u-flow within the housing. The housing includes an inlet and an outlet for ingress and egress of fluid to be cooled, for example, water with respect to the housing. The headers support the channel tubes there-between, refrigerant distributed to the channel tubes by a manifold flows through the channel tubes, such configuration enables heat exchange between the water flowing around the channel tubes and the refrigerant flowing through the channel tubes, thereby causing cooling of the water.

[0003] Generally, the first panel is bended at extreme ends thereof to form a rib or lip portion to increase surface contact between abutting first panel and the corresponding header plate to form robust connection between the two. The bend includes a fillet formed at the corner thereof to avoid stress concentrations. However, such bend forms a triple point at the interface of the first panel, the second panel and the header plate that are orthogonally arranged with respect to each other. The triple point inherently defines a gap "g" between the first panel and the header plate at the interface thereof along the bend line, thereby leading to insufficient contact between the first panel, the second panel and the header plate at the interface. The insufficient contact between the panels renders the joint between the panels ineffective or weak. The ineffective or weak joint between the panels forming the housing can cause leakage through the housing, thereby reducing the efficiency and performance of the heat exchanger. The reduced efficiency and performance of the heat exchanger, for example, the R744 type water chiller will result in inefficient cooling of elements, for example, the batteries intended to be cooled by insufficiently cooled fluid supplied by the heat exchanger, thereby leading to battery failure due to overheating of the batteries.

[0004] Accordingly, there is a need for a heat exchanger that obviates the drawbacks associated with the conventional heat exchanger due to modular configuration of the housing formed by joining panels, particularly, problems arising due to gap "g" at the at least one triple point formed at the interface between the first panel, the second panel and the corresponding header plate along the bend. Further, there is a need for a heat exchanger formed with a robust and leak-proof connection between the panels and the spaced header plates configuring the housing thereof.

[0005] In the present description, some elements or parameters may be indexed, such as a first element and a second element. In this case, unless stated otherwise, this indexation is only meant to differentiate and name elements which are similar but not identical. No idea of priority should be inferred from such indexation, as these terms may be switched without betraying the invention. Additionally, this indexation does not imply any order in mounting or use of the elements of the invention.

SUMMARY

[0006] A heat exchanger is disclosed in accordance with an embodiment of the present invention. The heat exchanger includes a housing and a plurality of channel tubes. The housing includes at least one first panel, at least one, second panel and a pair of spaced apart header plates formed with openings. At least one of the first panel and the second panel is formed with a bend. The at least one first panel, the at least one second panel and the pair of header plates are disposed abutting each other to define an enclosure, thereby, inherently creating gap G at the at least one triple point formed at the interface there-between along the bend. The plurality of channel tubes are received in the openings and are disposed between the header plates to define fluid communication between end manifolds corresponding to the pair of header plates. The at least one of the first panel, the second panel and the header plate is formed with at least one depression along the bend and configured to at least fill the gap G. The heat exchanger of the present invention addresses problems arising due to gap at the at least one triple point formed at the interface between the first panel, the second panel and the corresponding header plate. The heat exchanger of such configuration is robust in construction and the joint between the panels and the spaced header plates forming the housing of the heat exchanger is watertight.

[0007] Generally, the bend is formed on the first panel and a lip portion formed on the first panel due to the bending of the first panel abuts against the header plate.

[0008] Particularly, at least a portion of the at least one depression extends to the lip portion.

[0009] Specifically, the first panel, the second panel

and the header are all disposed orthogonal to each other.

[0010] More specifically, the first panel, the second panel and the header are joined by brazing.

[0011] Particularly, first panel extends beyond the second panel with an overhang portion extending beyond the second panel.

[0012] Generally, the at least one depression extends along the length of the bend.

[0013] More specifically, the at least one depression are intermittently formed along the length of the bend.

[0014] Particularly, the depression is formed proximal to four corners of the first panel.

[0015] Generally, the depression pushes material of the panel or the header plate to at least partially fill the gap G.

[0016] Further, the first panel is formed with a water box extending along the lip portion, the depression being offset from the water box.

[0017] A method of assembling a heat exchanger is disclosed in accordance with an embodiment of the present invention. The method includes the step of pre-assembling at least one first panel, at least one second panel and pair of spaced apart header plates in an abutting manner with respect to each other to define an enclosure, wherein at least one of the first panel and the second panel is formed with a bend. Thereafter the method includes the step of receiving a plurality of channel tubes in openings formed on the oppositely disposed header plates to define fluid communication between end manifolds corresponding to the pair of header plates. The method further includes step of forming at least one depression along the bend for at least partially filling a gap G created at the at least one triple point formed at the interface of the corresponding first panel, the second panel and the header plate. The method finally includes the step of joining the different elements, such as the at least one first panel, the at least one second panel and the pair of header plates by brazing for configuring the housing.

[0018] Preferably, the step of forming at least one depression is performed before the at least one first panel, the at least one second panel and the pair of header plates are joined by brazing to improve surface contact between these elements for improved connection therebetween.

[0019] Other characteristics, details and advantages of the invention can be inferred from the description of the invention hereunder. A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying figures, wherein:

FIG. 1 illustrates an isometric view of a conventional heat exchanger, for example, a water chiller, particularly, a R744 type of water chiller;

FIG. 2 illustrates a side view of the conventional heat exchanger of FIG.1 ;

FIG. 3 illustrates an enlarged view of a portion of the conventional heat exchanger of FIG. 1 depicting gap created at the at least one triple point formed at the interface of corresponding first panel, second panel and header plate thereof;

FIG. 4 illustrates an isometric view of a heat exchanger, for example, a water chiller, particularly, a R744 type of water chiller in accordance with an embodiment of the present invention configured with least one depression formed on the first panel along a bend of the first panel;

FIG. 5 illustrates a side view of the heat exchanger of FIG. 4 depicting the depression formed on the four corners of the first panel;

FIG. 6 illustrates an isometric view of a portion of the heat exchanger of FIG. 4, wherein the first panel thereof is formed with the depressions, also is depicted an enlarged view depicting depressions at opposite side corners of the first panel;

FIG. 7 illustrates a sectional view along a plane passing through the depression depicting material of panel pushed towards the gap to fill the gap created at the at least one triple point;

FIG. 8 illustrates an enlarged view of a portion of the side plate of the heat exchanger of FIG. 4; and

FIG. 9 illustrates a block diagram depicting the various steps involved in assembling a heat exchanger.

[0020] The present invention is explained with example of a water chiller, particularly, a R744 type of water chiller. The water chiller includes a housing formed by assembling and joining panels and headers. At least one of a first panel and a second panel is formed with a bend. The at least one first panel, the at least one second panel and the pair of header plates are disposed abutting each other and joined to define an enclosure that receive a second fluid, particularly water from inlet formed on the housing. The water received inside the housing egresses from the housing through the outlet formed on the housing after undergoing heat exchange with a first fluid flowing through channel tubes disposed inside the housing. Since the housing receives and holds water, the housing is required to be leak-proof. The abutting panels and the header plates inherently create gap "G" at the at least one triple point formed at the interface there-between, particularly, along the bend. At least one of the first panel, the second panel and the header plate is formed with at least one depression along the bend. Particularly, the first panel is formed with the bend and depression along

the bend. The formation of the depression pushes material of the panel or the header plate configured with the depression towards the gap G to at least partially fill the gap G, thereby improving the contact surface for creating robust joint between the panels and the header plates during the joining, for example, during the brazing. Although, the present invention is explained with example of R744 type of water chiller for use in a vehicle. However, the present invention is also applicable for any heat exchanger, particularly housing of the heat exchanger or any enclosed structure used in vehicular or non-vehicular environment, wherein the housing or enclosed structure is formed by assembling and joining panels. Particularly, the present invention is applicable for enclosed structure, wherein it is required to ensure sufficient contact between abutting panels to form robust connection between panels configuring the enclosed structure to render the enclosed structure leak-proof. More specifically, the present invention is applicable for any enclosed structure used in vehicular or non-vehicular environments, wherein it is required to fill the gap at the at least one triple point formed at the interface between panels configuring the housing or enclosed structure to enable sufficient contact during the joining and robust connection between the panels configuring the enclosed structure by the joining.

[0021] The FIG. 1 - FIG. 3 illustrates different views of a conventional heat exchanger, for example, a water chiller, particularly, a R744 type water chiller that includes a housing 2, a plurality of channel tubes 4 disposed within the housing 2. The housing 2 is formed of a plurality of panels 2a and 2b that are assembled together and connected to each other by a joining process, such as for example, brazing to define an enclosure. Particularly, the housing 2 is formed by assembling one pair of opposite first panels 2a, one pair of opposite second panels 2b and a pair of header plates 2c formed with openings. The first panel 2a is bended at extreme ends thereof to form a rib or lip portion that increases surface contact between abutting first panel 2a and the corresponding header 2c to form robust connection between the two. The bend includes a fillet formed at the corner thereof to avoid stress concentrations. However, such bend forms a triple point at the interface of the first panel 2a, the second panel 2b and the header plate 2c that are orthogonally arranged with respect to each other. The triple point inherently defines a gap "g" between the first panel 2a and the header plate 2c at the interface thereof along the bend line, thereby leading to insufficient contact between the first panel 2a, the second panel 2b and the header plate 2c at the interface. The insufficient contact between the panels renders the joint between the panels ineffective or weak. The ineffective or weak joint between the panels forming the housing 2 can cause leakage through the housing 2, thereby reducing the efficiency and performance of the chiller 1.

[0022] Referring to the FIG. 4 of the accompanying drawings, a heat exchanger, for example a water chiller, particularly, a R744 type of water chiller 100 in accordance with an embodiment of the present invention is illustrated. FIG. 5 illustrates a side view of the heat exchanger 100. The heat exchanger 100 includes a housing 10 and the plurality of channel tubes 20 received in the housing 10 and depicted in FIG. 5. Each of the channel tube 20 includes multiple channels and is formed by extrusion. The housing 10 includes at least one first panel 10a, at least one, second panel 10b and a pair of spaced apart header plates 10c formed with openings 12c. In accordance with a preferred embodiment, two first panels 10a, also referred to as the side panels 10a are spaced apart from each other and disposed opposite to one another. Similarly, the two second panels 10b, also referred to as closing panels 10b are spaced apart from each other and disposed opposite to each other. The spaced apart first panels 10a, the spaced apart second panels 10b in conjunction with the header plates 10c define an enclosure when joined together along the abutting edges. The panels 10a and 10b and the header plates 10c are disposed orthogonal to each other. In accordance with an embodiment of the present invention, the first panel 10a extends beyond the second panel 10b with an overhang portion 10d extending beyond the second panel 10b. At least one of the first panel 10a and the second panel 10b is formed with a bend 12a, 12b to configure a lip portion 14a that enhances surface contact between the panels 12a, 12b and the header plate 12c. The at least one first panel 10a, the at least one second panel 10b and the pair of header plates 10c are disposed abutting each other to define an enclosure, thereby inherently creating gap "G" at the at least one triple point formed at the interface there-between along the bend 12a. Generally, the first panel 10a, the second panel 10b and the header 10c are joined at the interface thereof by a joining process, for example, brazing. However, the present invention is not limited to any particular joining process for joining the first panel 10a, the second panel 10b and the header 10c with respect to each other. However, the gap "G" formed at least one triple point formed at the interface causes insufficient contact between the panels 10a, 10b and the header plate 10c, thereby leading to weak connection between the panels 10a, 10b and the header plate 10c when these are joined at the interface thereof by a joining process. In order to avoid such problems, the gap "G" is required to be at least partially filled to ensure sufficient contact between the panels 10a, 10b and the header plate 10c to configure robust connection there-between.

[0023] In accordance with an embodiment, the first and second panels 10a and 10b are L-shaped panels, accordingly, the two L-shaped panels 10a and 10b in conjunction with the header plates 10c configure the enclosed structure of the housing 10.

[0024] In accordance with an embodiment of the present invention, the bend 12a is formed along a lateral side of the first panel 10a and a lip portion 14a formed on the first panel 10a due to the bending of the first panel 10a abuts against the header plate 10c. FIG. 6 illustrates

the bend 12a and the lip portion 14a formed on the first panel 10a and the lip portion 14a abutting against the header plate 10c. Such configuration of the lip portion 14a enhances the surface contact between the abutting first panels 10a and corresponding header plates10c to form robust connection there-between

[0025] The plurality of channel tubes 20 are received in the openings 12c and are disposed between the header plates 10c to define fluid communication between end manifolds corresponding to the pair of header plates 10c. The channel tubes 20 can be arranged inside the housing to configure either I-flow or U0flow. In accordance with an embodiment of the present invention, the channel tubes 20 define fluid communication between a first manifold corresponding to a first header plate 10c and an intermediate manifold corresponding to a second header plate 10c opposite to the first header plate 10c. With such configuration the extruded channel tubes 20 are supported in a spaced apart configuration with respect to each other with second fluid around the channel tubes 20 for heat exchange between first fluid flowing, particularly, the refrigerant through the channel tubes 20 and second fluid around the channel tubes 20. In case the channel tubes are configuring u-flow of the refrigerant inside the housing 10, the first manifold 30a includes a first portion 32a and a second portion 32b. The first portion distributes refrigerant to either a first set of extruded channel tubes 20a or a portion 20a of the same extruded channel tube 20 to define a first pass for the refrigerant flow. The refrigerant collected in the intermediate manifold 30b is directed to a second set of extruded channel tubes 20b or remaining portion 20b of the same extruded channel tube 20 to define a return pass of the refrigerant, thereby defining the u-flow path of the refrigerant. In such case the refrigerant flows from the first set of extruded channel tubes to the second set of extruded micro-channel tubes, the first and the second set of channel tubes are disposed along the same plane. The refrigerant after flowing through the return pass is collected in the second portion. Such arrangement defines the refrigerant flow path within the heat exchanger 100. The housing 10 further includes an inlet 40a and outlet 40b, wherein the inlet 40a is for ingress of the refrigerant into the first portion 32a that distributes the refrigerant to the channel tubes 20 of the heat exchanger 100 for heat exchange with the water in the housing 10. The outlet 40b is for the egress of the refrigerant from the second portion 32b that collects refrigerant from the channel tubes 20 of the heat exchanger 100 after heat exchange with the water in the housing 10.

[0026] The housing 10 further includes an inlet port 10e and an outlet port 10f for ingress of water around the channel tubes 20 received inside the housing 100. The water received in the housing 10 and flowing around the extruded channel tubes 20 rejects thermal energy to the refrigerant flowing through the extruded channel tubes 20 and is cooled in the process. Particularly, the hot water enters through the inlet port 10e, the water flows around the channel tubes 20, cools down and cooled water egresses through the outlet port 10f.

[0027] The at least one of the first panel 10a, the second panel 10b and the header plate 10c is formed with at least one depression 50 along the bend 12a. The depression 50 formed on the panel 10a, 10b or the corresponding header plate 10c pushes material of the panel 10a, 10b or the header plate 10c configured therewith towards the gap G to at least partially fill the gap G. In a preferred embodiment as illustrated in FIG. 7 and FIG. 8, wherein the depression 50 is formed on the first panel 10a. Referring to the FIG. 7, the depression 50 causes the material of the first panel 10a to be pushed towards the gap G to at least partially fill the gap G. With such configuration, the first panel 10a, the second panel 10b and the header plate 10c are at sufficient contact with respect to each other at the interface between the first panel 10a, the second panel 10b and the header plate 10c. Accordingly, robust connection is formed between the first panel 10a, the second panel 10b and the header plate 10c at the interface thereof and leak-proof joint is configured between the first panel 10a, the second panel 10b and the header plate 10c joined together to configure the housing 10. In one embodiment, the the at least one depression 50 extends along the length of the bend 12a. In accordance with yet another embodiment, the at least one depressions 50 are intermittently formed along the length of the bend 12a. Generally, the depression 50 is formed proximal to four corners of the first panel 10a. In accordance with another embodiment, the at least a portion of the at least one depression 50 extends to the lip portion 14a. The depression 50 is formed after the assembly of the at least one first panel 10a, the at least one second panel 10b and the pair of header plates 10c for configuring the housing 10 to improve surface contact between the elements to be joined. Further, the first panel 10a is formed with a water box 16a extending towards the lip portion 14a. The depression 50 is offset from the water box 16a so that the depression can be conveniently formed using a tool without being obstructed by the water box 16a during forming of the depression 50a on the first panel 10a or the lip portion 14a of the first panel 10a. However, the present invention is not limited to any particular configuration, shape, placement, number and whether the depressions 50 are formed on the first panel 10a or on the lip portion 14a of the first panel 10a as long as the depressions 50 are conveniently configurable and are capable of for filling the gap G created at the at least one triple point formed at the interface of the corresponding first panel and the header plate.

[0028] Also, is disclosed a method 200 of assembling a heat exchanger 100 in accordance with an embodiment of the present invention. FIG. 9 illustrates a block diagram depicting the various steps of the method 200 of assembling the heat exchanger 100. Particularly, the method 200 involves assembly a plurality of panels with header plates and joining these components by using any of the known joining processes, wherein the panels are held close to the corresponding header plate without any gap

between the two to ensure sufficient contact for forming robust connection there-between. Although, the various steps of the method 200 are depicted by blocks in the flow diagram and any number of steps described as method blocks can be combined in any order or can be performed in parallel to employ the method 200, or an alternative method. Additionally, individual blocks may be deleted from the flow chart depicting the method without departing from the scope and ambit of the present invention. The method 200 is to be understood with reference to the following description along with the Fig. 9

[0029] Particularly, the method 200 includes a step 102 of pre-assembling at least one first panel 10a, at least one second panel 10b and pair of spaced apart header plates 10c in an abutting manner with respect to each other to define an enclosure. At least one of the first panel 10a and the second panel 10b is formed with a bend 12a, 12b. Generally, the first panel 10a is formed with the bend 12a. The method 200 further includes a step 104 of receiving a plurality of channel tubes 20 in openings 12c formed on the oppositely disposed header plates 10c to define fluid communication between end manifolds 30 corresponding to the pair of header plates 10c. The method 200 further includes the step 106 of forming at least one depression 50 along the bend 12a, 12b for filling a gap G created at the at least one triple point formed at the interface of the corresponding first panel 10a, the second panel 10b and the header plate 10c. Finally, the method includes the step 108 of joining the different elements of the heat exchanger 100 by brazing.

[0030] In any case, the invention cannot and should not be limited to the embodiments specifically described in this document, as other embodiments might exist. The invention shall spread to any equivalent means and any technically operating combination of means.

Claims

1. A heat exchanger (100) comprising:

- a housing (10) comprising:
  - at least one first panel (10a);
  - at least one second panel (10b); and
  - a pair of spaced apart header plates (10c) formed with openings (12c),

wherein at least one of the first panel (10a) and the second panel (10b) is formed with a bend (12a, 12b), the at least one first panel (10a), the at least one second panel (10b) and the pair of header plates (10c) are disposed abutting each other to define an enclosure, thereby inherently creating gap G at the at least one triple point formed at the interface there-between along the bend (12a, 12b),

- a plurality of channel tubes (20) received in the openings (12c) and disposed between the header plates (10c) to define fluid communication between end manifolds (30) corresponding to the pair of header plates (10c),

characterized in that at least one of the first panel (10a), the second panel (10b) and the header plate (10c) is formed with at least one depression (50) along the bend (12a, 12b) and configured to at least partially fill the gap G.

2. The heat exchanger (100) as claimed in the previous claim, wherein the bend (12a) is formed on the first panel (10a) and a lip portion (14a) formed on the first panel (10a) due to the bending of the first panel (10a) abuts against the header plate (10c).

3. The heat exchanger (100) as claimed in the previous claim, wherein at least a portion of the at least one depression (50) extends to the lip portion (14a).

4. The heat exchanger (100) as claimed in any of the preceding claims, wherein the first panel (10a), the second panel (10b) and the header (10c) are all disposed orthogonal to each other.

5. The heat exchanger (100) as claimed in any of the preceding claims, wherein the first panel (10a), the second panel (10b) and the header (10c) are joined by brazing

6. The heat exchanger (100) as claimed in any of the preceding claims, wherein the first panel (10a) extends beyond the second panel (10b) with an overhang portion extending beyond the second panel (10b).

7. The heat exchanger (100) as claimed in any of the preceding claims, wherein the at least one depression (50) extends along the length of the bend (12a, 12b).

8. The heat exchanger (100) as claimed in any of the preceding claims, wherein the at least one depression (50) are intermittently formed along the length of the bend (12a, 12b).

9. The heat exchanger (100) as claimed in any of the preceding claims, wherein the depression (50) is formed proximal to four corners of the first panel (10a).

10. The heat exchanger (100) as claimed in claim 2, wherein the first panel (10a) is further formed with a water box (16a) extending along the lip portion (14a), the depression (50) being offset from the water box (16a).

11. A method (200) of assembling a heat exchanger

(100), the method (200) comprising:

- a step (102) of pre-assembling at least one first panel (10a), at least one second panel (10b) and pair of spaced apart header plates (10c) in an abutting manner with respect to each other to define an enclosure, wherein at least one of the first panel (10a) and the second panel (10b) is formed with a bend (12a, 12b);
- a step (104) of receiving a plurality of channel tubes (20) in openings (12c) formed on the oppositely disposed header plates (10c) to define fluid communication between end manifolds (30) corresponding to the pair of header plates (10c),
- a step (106) of forming at least one depression (50) along the bend (12a, 12b) for filling a gap G created at the at least one triple point formed at the interface of the corresponding first panel (10a), the second panel (10b) and the header plate (10c); and
- a step (108) of joining the different elements of the heat exchanger (100), such as the at least one first panel (10a), the at least one second panel (10b) and the pair of header plates (10c) by brazing for configuring the housing (10).

12. The heat exchanger (100) as claimed in any of the preceding claims, wherein the step (106) of forming at least one depression (50) is performed before the at least one first panel (10a), the at least one second panel (10b) and the pair of header plates (10c) are joined by brazing, to improve surface contact between these elements for improved brazing connection there between.

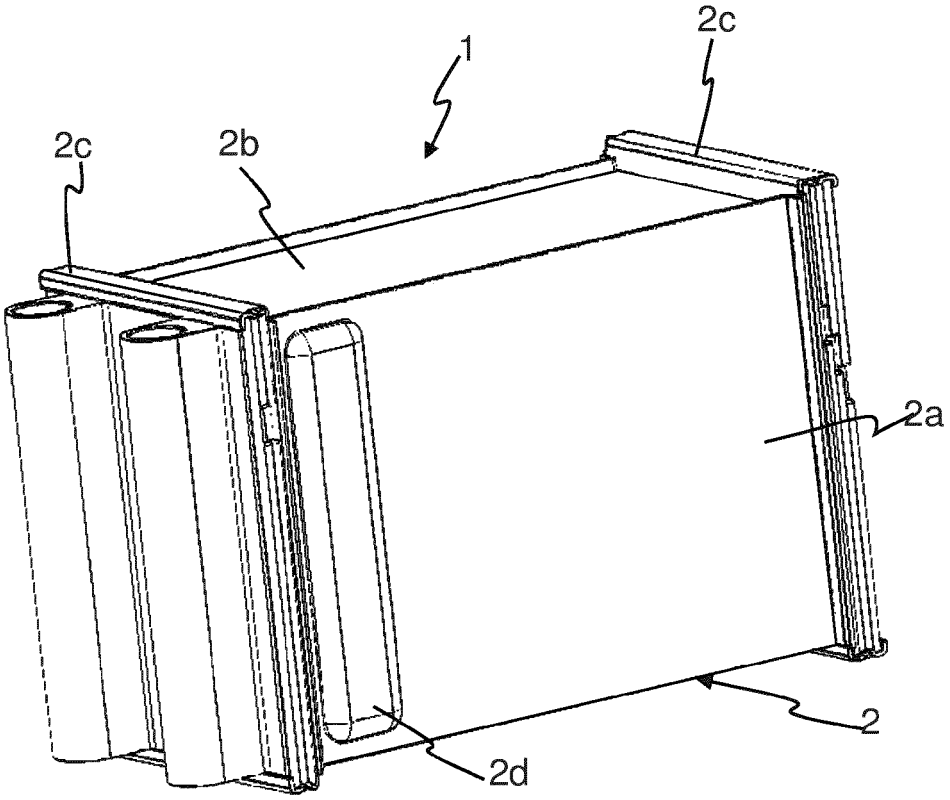


FIG. 1

(PRIOR ART)

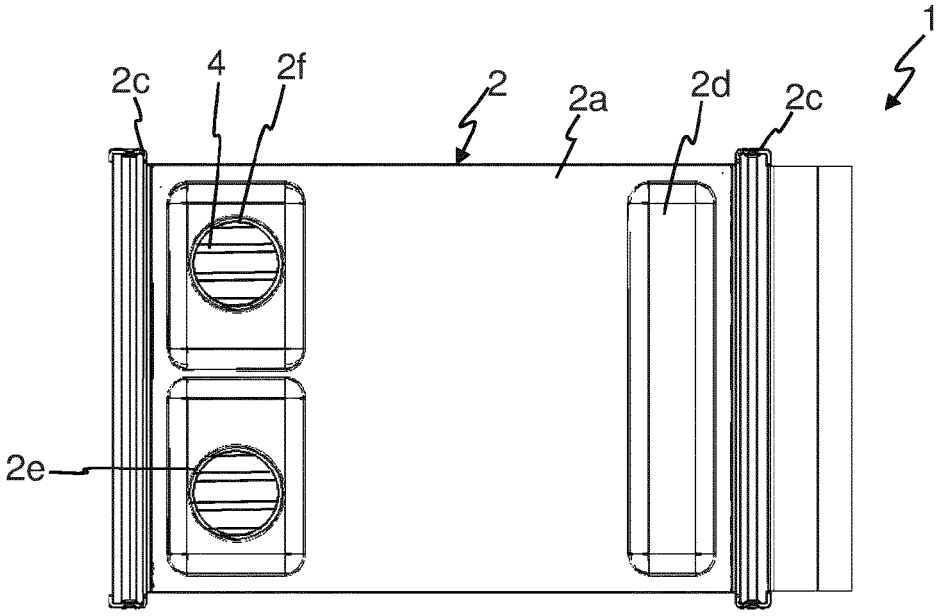


FIG. 2

(PRIOR ART)

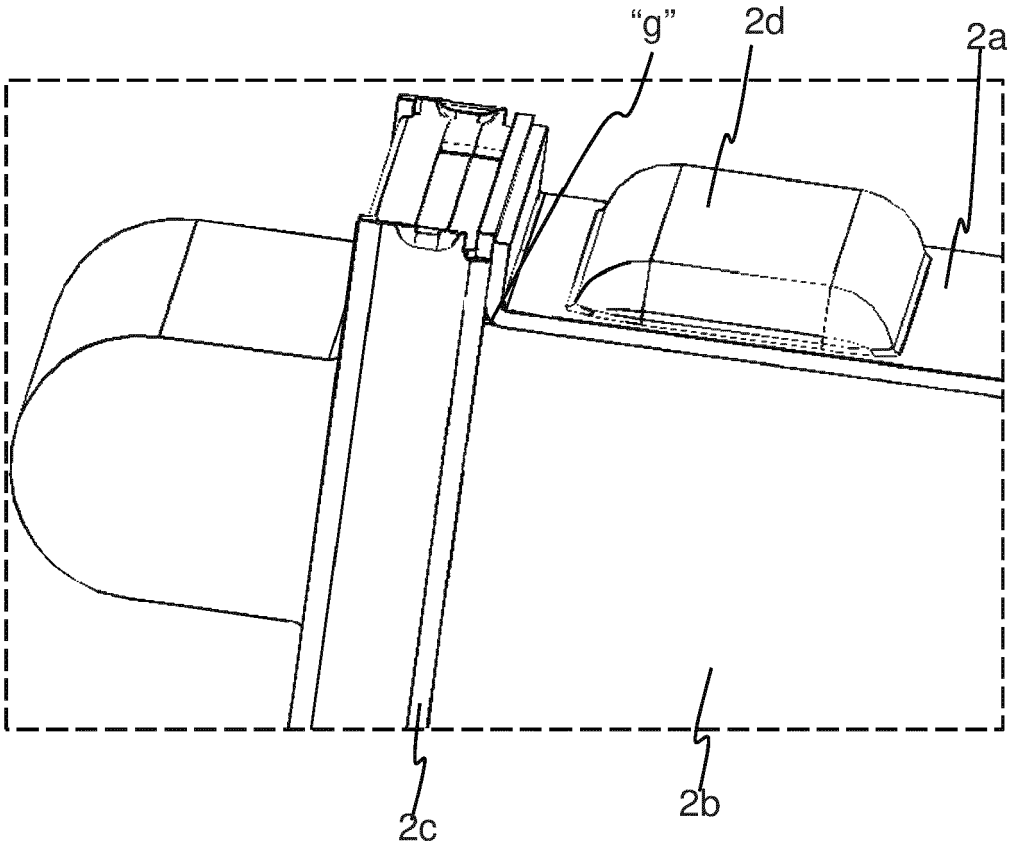
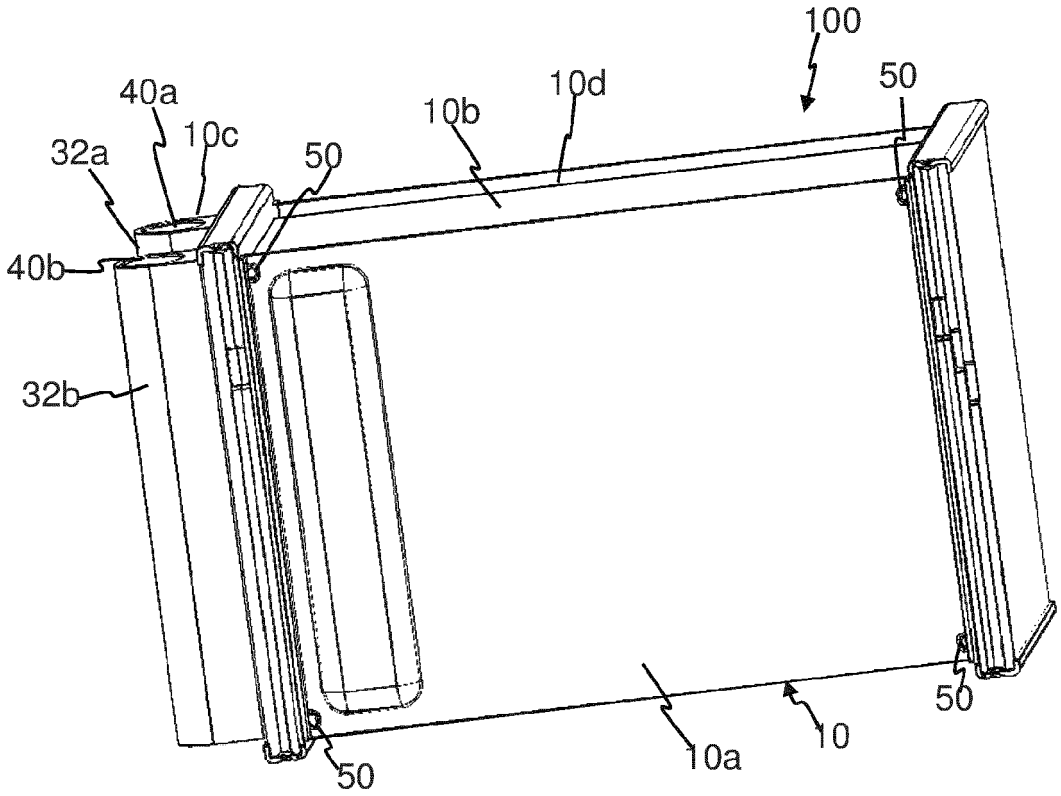


FIG. 3
(PRIOR ART)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10b
10d
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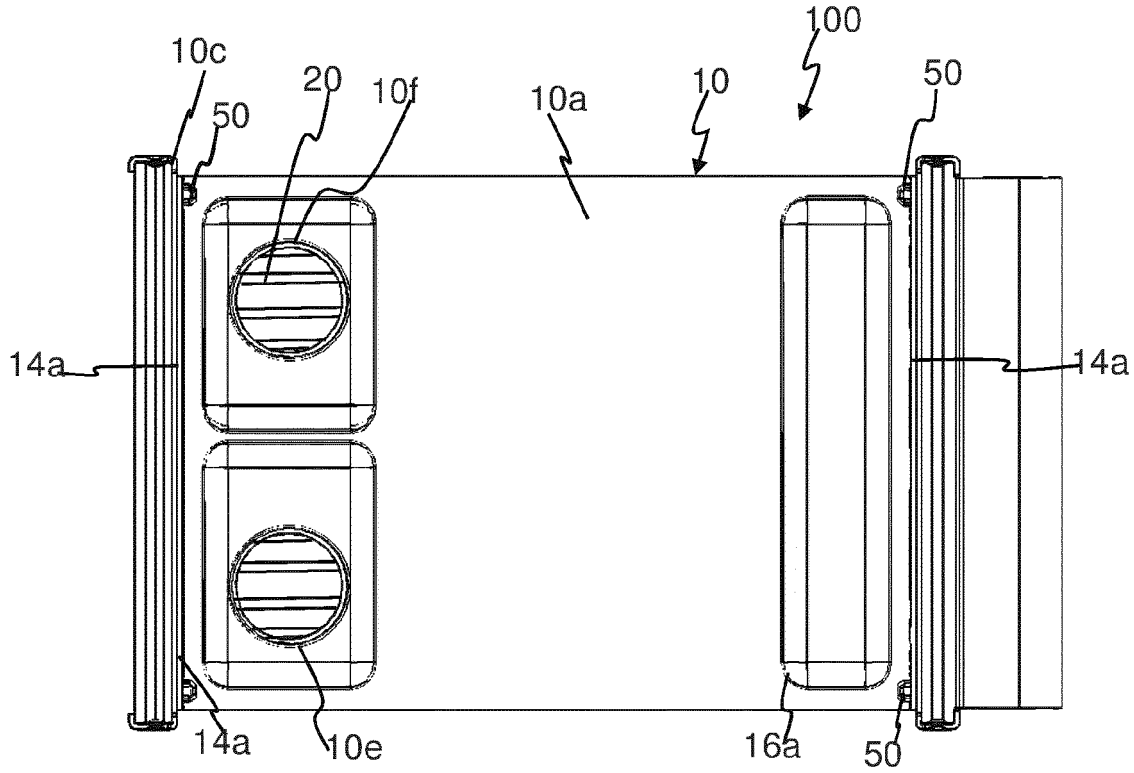
10a
10
50
50

FIG. 4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10f
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14a
10e
16a
50

FIG. 5

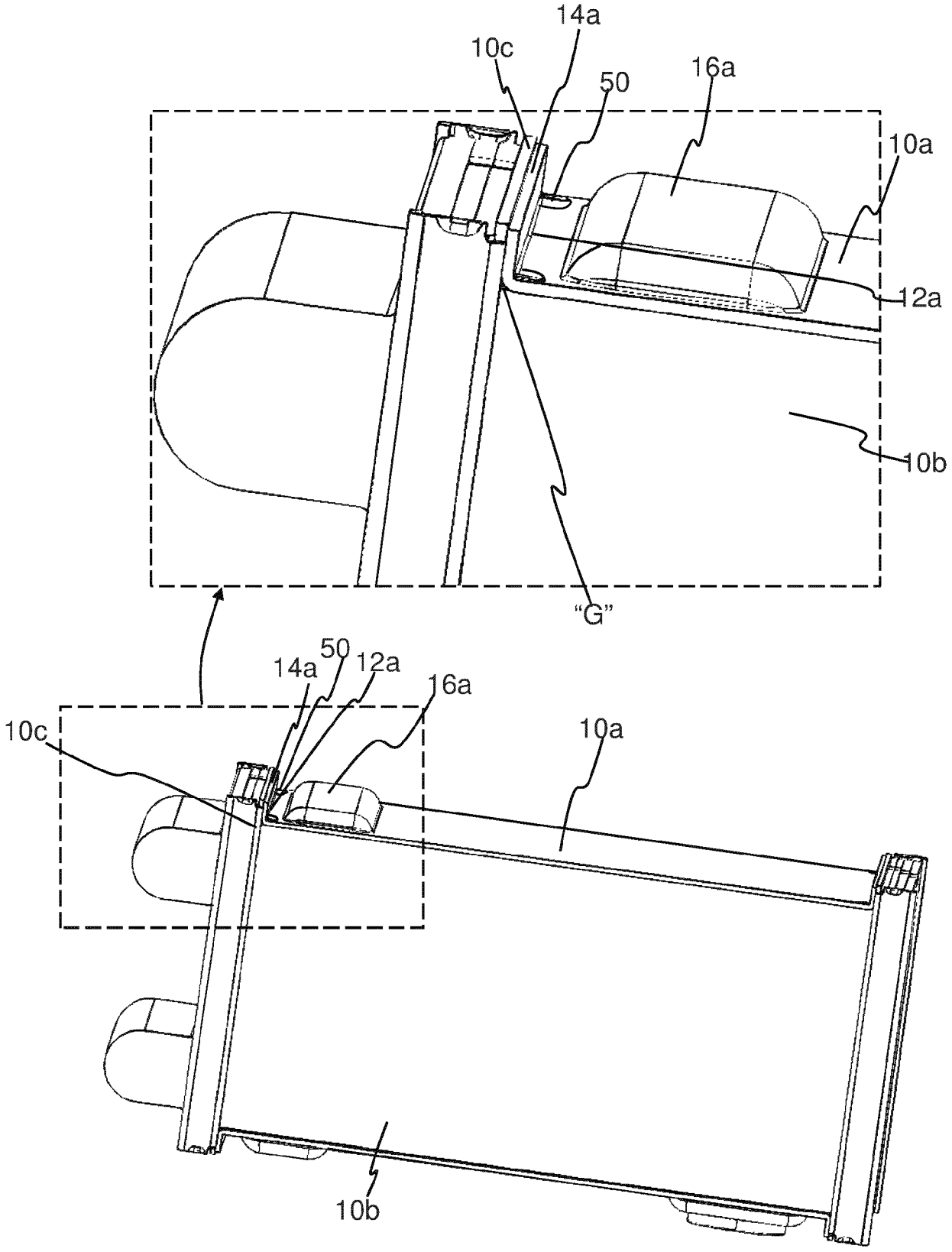

FIG. 6

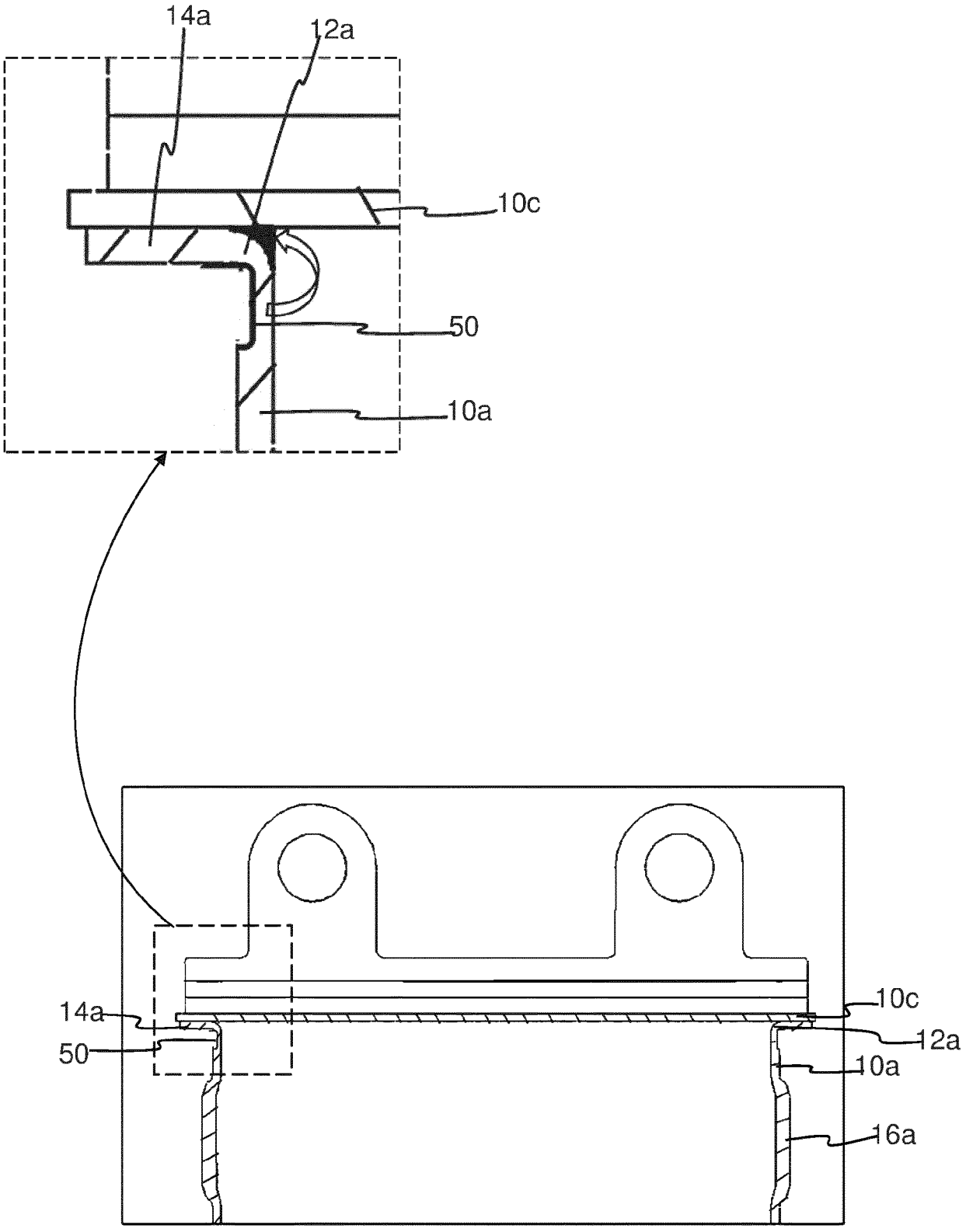

FIG. 7

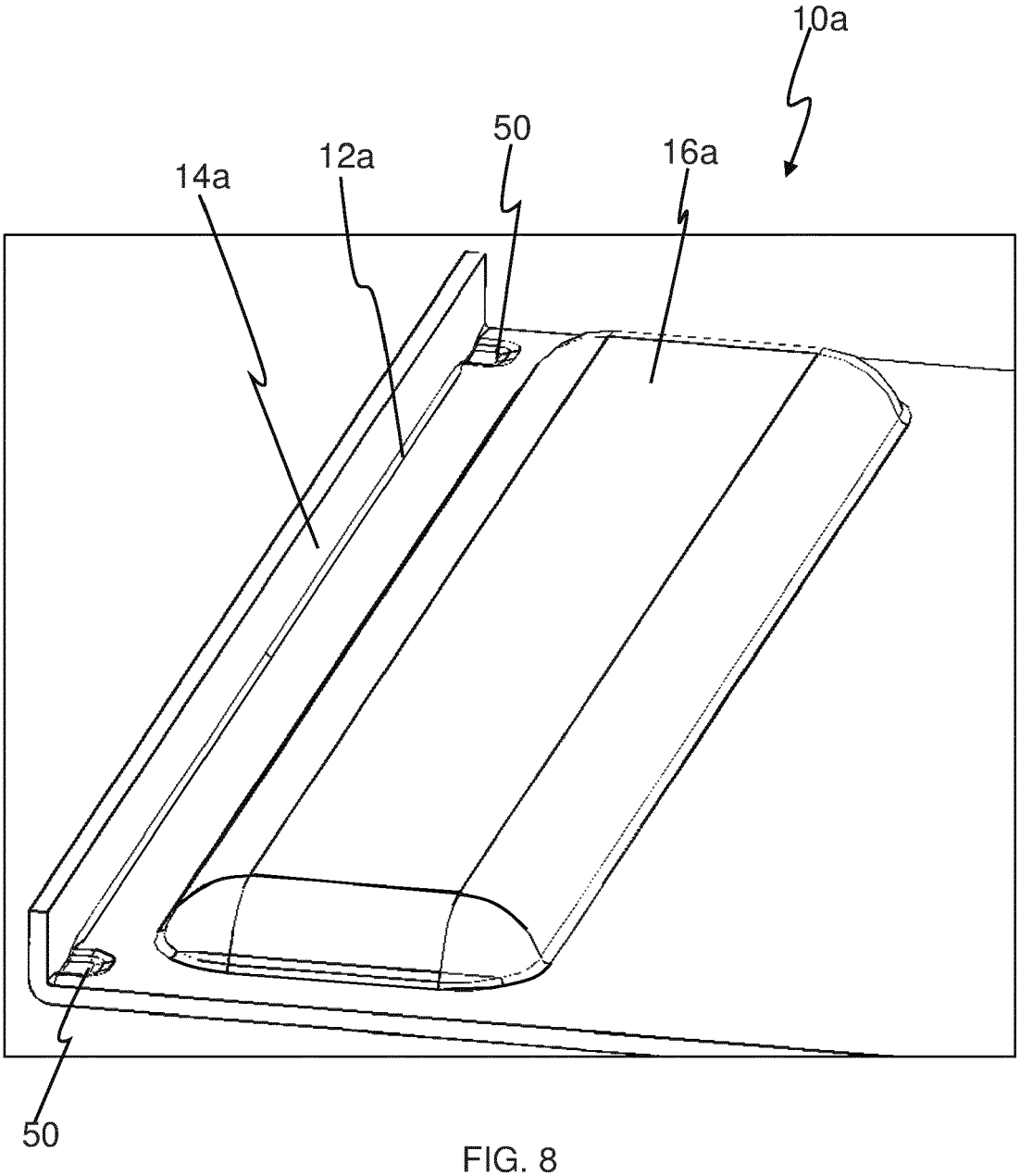

FIG. 8

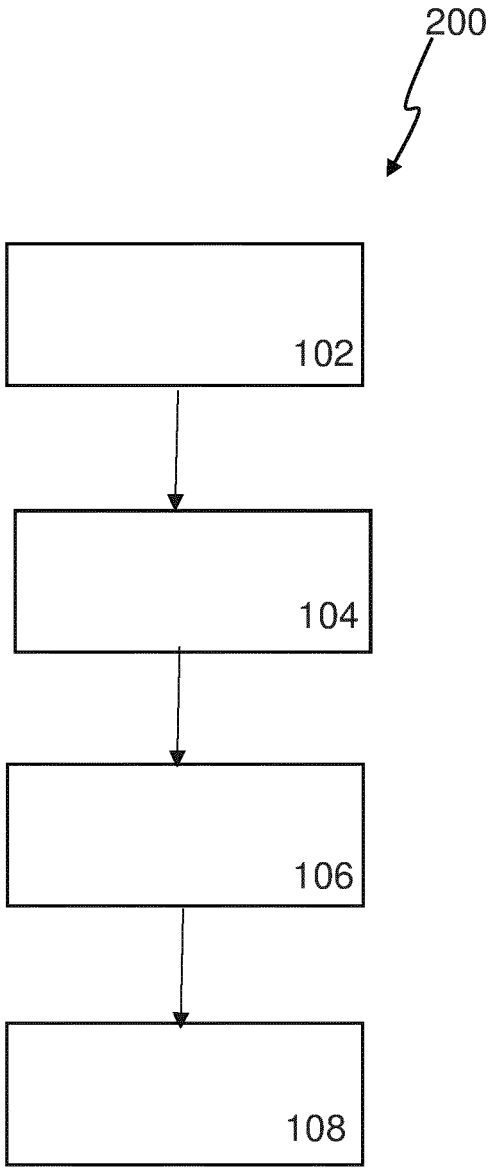

FIG. 9

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Place of search	Date of completion of the search	Examiner
Munich	31 July 2023	Mellado Ramirez, J

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