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(72) Inventors:
• **JURKIEWICZ, Damian**
32 050 Skawina (PL)
• **BELZOWSKI, Michal**
32 050 Skawina (PL)
• **SZOSTEK, Dawid**
32 050 Skawina (PL)

(71) Applicant: **VALEO SYSTEMES THERMIQUES**
78320 Le Mesnil Saint-Denis (FR)

(74) Representative: **Valeo Systèmes Thermiques**
Service Propriété Intellectuelle
8, rue Louis Lormand
La Verrière
78320 Le Mesnil Saint Denis (FR)

(54) **A WATER CHILLER**

(57) A water chiller (100) includes a housing (10) and a plurality of micro-channel tubes (20). The housing (10) is formed by assembling at least one first panel (10a), at least one, second panel (10b) and a pair of oppositely disposed and spaced apart header plates (10c) formed with multiple openings (12c). The micro-channels (20) are received in the openings (12c) formed on the header plates (10c) and are disposed between the header plates (10c) to define fluid communication between the end manifolds (30) corresponding to the pair of header plates (10c). At least one of the first panel (10a), the second panel (10b) and the header plate (10c) formed with at least one of gripping crimp (14c) and positioning tab (16c) to pre-assemble at least one of the first panel (10a), the second panel (10b) and the header plates (10c) to define a pre-assembled configuration thereof, before subjecting to joining.

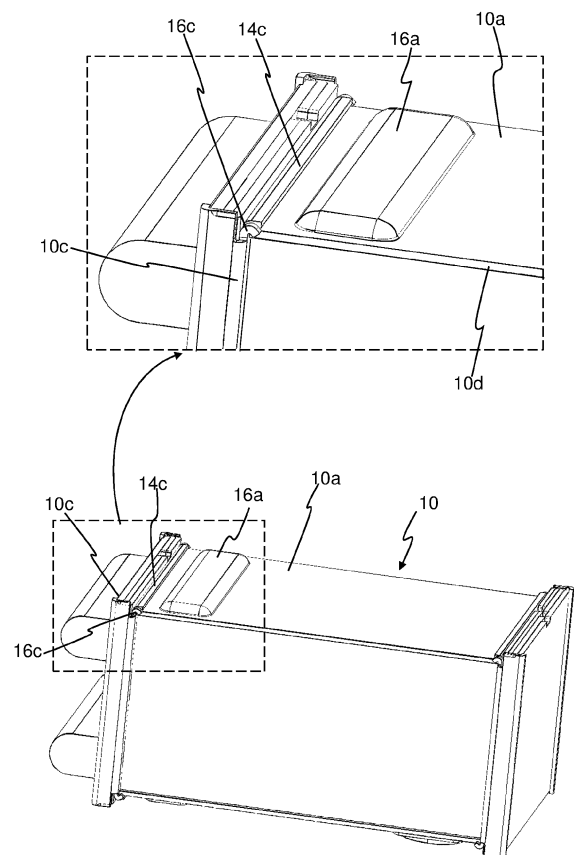


FIG. 6

Description

TECHNICAL FIELD

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

BACKGROUND

[0002] Generally, a conventional water chiller 1 includes a housing 2 as illustrated in FIG. 1 - FIG. 3 and a plurality of micro-channel tubes 4 disposed within the housing 2 as illustrated in FIG. 2. The micro-channel tubes 4 are for flow of a first fluid, particularly refrigerant there through and the housing 2 defines an enclosure for receiving a second fluid, particularly, water therein and around the micro-channel tubes 4. The housing 2 is formed of a plurality of panels that are assembled together and connected to each other by a joining process, such as for example, but not limited to brazing to define an enclosure. Particularly, the housing 2 is formed by assembling one pair of opposite first panels, one pair of opposite second panels and a pair of spaced apart header plates 2c formed with openings. More specifically, one set of the first panel 2a, the second panel 2b and the header plate 2c are disposed orthogonal to each other to form a portion of the housing 2. Another set of the first panel 2a, the second panel 2b and the header plate 2c disposed orthogonal to each other forms the remaining second portion of the housing 2 that is substantially symmetrical to the first portion of the housing 2. The first panel 2a is formed with water boxes 2d for defining u-flow of the refrigerant within the housing 2. The housing 2 includes an inlet 2e and an outlet 2f for ingress and egress of the second fluid to be cooled, for example, water with respect to the housing 2. The spaced apart headers 2c support the micro-channel tubes 4 there-between, the refrigerant distributed to the micro-channel tubes 4 by a manifold flows through the micro-channel tubes, such configuration enables heat exchange between the water flowing around the micro-channel tubes 4 and the refrigerant flowing through the micro-channel tubes 4, thereby causing cooling of the water.

[0003] The first panel 2a and the second panels 2b are generally in the form of plates and are required to be maintained in aligned position and abutting with respect to each other and with respect to the header plates 2c before being joined by a joining process, such as for example, but not limited to brazing. The first panel 2a is required to be urged against and held in position with respect to the header plate 2c. Also, the first panel 2a is required to be urged against edges of the second panels 2b and maintained in that position for configuring proper joining there between. However, the first panel 2a and the second panels 2b are prone to get dislocated with respect to each other. Particularly, the first panel 2a is free to laterally move along the lateral side of the header

plate 2c, depicted by arrows a-a', when pre-assembled thereto for brazing. The dislocation of the first panels 2a and the second panels 2b before the joining adversely affects the joint between the first panel 2a, the second panel 2b and the header plates 2c, particularly, causes defective joint between these elements that in turn can cause leakage. None of the prior art addresses the problems due to the dislocation of the first panel 2a and second panel 2b with respect to each other and the header plates 2c.

[0004] Accordingly, there is a need for a water chiller with provision for proper and accurate positioning of the panels and the header plates with respect to each other before the joining to form a secure connection / joint between the various panels and header plates configuring the housing.

OBJECTS

[0005] An object of the present invention is to provide a water chiller that address the challenges faced in maintaining the various elements of conventional water chillers in pre-assembled configuration, particularly, in desired position before subjecting the pre-assembly to a joining process such as for example, brazing in brazing furnace.

[0006] A primary object of the present invention is to provide a water chiller with provision for proper and accurate positioning of the panels and the header plates with respect to each other before the joining to form a secure connection / joint between the various panels and header plates configuring the housing.

[0007] 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

[0008] A water chiller is disclosed in accordance with an embodiment of the present invention. The water chiller includes a housing and a plurality of micro-channel tubes. The housing is formed by assembling at least one first panel, at least one, second panel and a pair of oppositely disposed and spaced apart header plates formed with multiple openings. The micro-channel tubes are received in the openings formed on the header plates and are disposed between the header plates to define fluid communication between end manifolds corresponding to the pair of header plates. At least one of the first panel, the second panel and the header plate formed with at least one of gripping crimp and positioning tab to pre-assemble at least one of the first panel, the second panel and the

header plates to define a pre-assembled configuration thereof, before subjecting to joining.

[0009] The micro-channel tubes are disposed between the header plates.

[0010] The header plates are disposed between the end manifolds.

[0011] Generally, the first panels, the second panel and the header plate are disposed orthogonal with respect to each other.

[0012] Particularly, at least one of the header plates includes at least one gripping crimp extending therefrom and crimped over the corresponding first panel to grip and urge the first panel against the second panel.

[0013] Alternatively, at least one of the first panels includes at least one gripping crimp extending therefrom and crimped over the corresponding header plate to grip and urge the first panel against the second panel.

[0014] More specifically, the gripping crimp grips and urges the first panel against a longitudinal edge of the second panel.

[0015] Further, at least one of the header plates includes at least one positioning tab disposed proximal to at least one end of the gripping crimp to arrest lateral movement of the corresponding first panel along lateral side thereof.

[0016] Preferably, the positioning tabs are disposed on both sides of the gripping crimp.

[0017] Particularly, in the pre-assembled configuration the positioning tab is so positioned with respect to at least one of the opposite second panels that the positioning tab either aligns at least one of the sides of the first panel to the corresponding second panels or permits the first panel to overhang with respect to at least one of the opposite second panels.

[0018] More specifically, the positioning tab is either crimped or deformed to extend beyond thickness of the first panel.

[0019] In accordance with another embodiment, at least one of the first panels and the second panels includes at least one positioning tab extending therefrom to be deformed or crimped to arrest lateral movement of the first panel.

[0020] A method of assembling a water chiller is disclosed in accordance with an embodiment of the present invention. The method involves 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, wherein the first panel, the second panel and header plates are orthogonal with respect to each other. The pre-assembling step involves the step of gripping and urging the first panel against longitudinal edge of the second panel by crimping at least one gripping crimp formed on at least one of the header plate, the first panel and the second panel. Thereafter, either crimping or deforming at least one positioning tab for arresting lateral movement of the first panel along lateral side thereof. Thereafter the method includes the step of receiving a plurality of micro-channel tubes in

openings formed on the header plates to define fluid communication between end manifolds corresponding to the pair of header plates. Finally, the method involves step of joining the pre-assembled elements of the water chiller by a joining process to define an enclosure.

BRIEF DESCRIPTION

[0021] 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 water chiller;

FIG. 2 illustrates a side view of the conventional water chiller of FIG.1;

FIG. 3 illustrates an enlarged view of a portion of the conventional water chiller of FIG. 1 depicting unrestricted movement of the first panel along lateral side thereof;

FIG. 4 illustrates an isometric view of a water chiller in accordance with an embodiment of the present invention;

FIG. 5 illustrates a side view of water chiller of the FIG. 4;

FIG. 6 illustrates another isometric view of the water chiller of FIG. 4, also is depicted an enlarged view depicting a gripping crimp and a positioning tab formed on header plate interacting with a first panel;

FIG. 7 illustrates a top view of the water chiller of FIG. 4, wherein one of the header plates with positioning crimps and gripping tabs formed thereon are depicted interacting with the first panel; and

FIG. 8 illustrates an isometric view of one of the header plates of the pair of header plates formed with a central gripping crimp and a pair of positioning tabs disposed on both sides of the gripping crimp;

FIG. 9 illustrates a block diagram depicting the various steps involved in assembling the water chiller of FIG. 4.

DETAILED DESCRIPTION

[0022] The present invention is explained with example of a water chiller. The water chiller includes a housing

and a plurality of micro-channel tubes received inside the housing. The housing is formed by pre-assembling and joining panels and spaced apart header plates. The micro-channel tubes are received in the openings formed on the header plates. The micro-channel tubes are for flow of a first fluid there-through and are disposed between the header plates to define fluid communication between end manifolds corresponding to the pair of spaced apart header plates. The housing defines the enclosure for receiving a second fluid, particularly, water therein and around the micro-channel tubes. At least one of the first panel, the second panel and the header plates are formed with at least one gripping crimp and at least one positioning tab. The gripping crimp extends from at least one of the header plates and is crimped over the corresponding first panel to grip and urge the first panel against the second panel. Further, the positioning tab extends from the at least one header plates and arrests lateral movement of the corresponding first panel. Although, the present invention is explained with example of water chiller used in automobile environment. However, the present invention is also applicable in other applications, wherein an enclosure is formed by pre-assembling a plurality of panels and it is required to maintain the panels in desired position and in abutting relation with respect to each other before subjecting the pre-assembly to a joining process to avoid joining defects.

[0023] Referring to the FIG. 4 - FIG. 5 of the accompanying drawings, a water chiller 100 in accordance with an embodiment of the present invention is illustrated. Particularly, FIG. 4 illustrates an isometric view of water chiller 100. FIG. 5 illustrates a side view of the water chiller 100. Referring to the FIG. 5, the water chiller 100 includes a housing 10 and a plurality of micro-channel tubes 20 disposed within the housing 10. The housing 10 includes at least one first panel 10a, at least one second panel 10b and a pair of oppositely disposed and spaced apart header plates 10c formed with multiple openings 12c. The openings 12c are formed along lateral sides of the header plates 10c and are generally disposed parallel to each other. The first panels 10a, the second panels 10b and the header plates 10c are disposed orthogonal to each other and abutting each other. Although, in the preferred embodiment, the first panel 10a and the second panels 10b are disposed orthogonal to header plates 10c, however, the first panel 10a and the second panels 10b can be disposed at an angle with respect to the header plates 10c. 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.

[0024] 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. Particularly, the present invention is not limited to the arrangement and orientation of the first panel 10a and the second panel

10b with respect to the header plates 10c as far as the first panel 10a and the second panels 10b configure an enclosure in conjunction with the header plates 10c for receiving and holding the second fluid to be cooled.

[0025] The openings 12c formed on the header plates 10c receive and hold micro-channel tubes 20 for flow of a first fluid there-through. Particularly, the micro-channel tubes 20 are disposed between the header plates 10c to define fluid communication between end manifolds 30 corresponding to the pair of header plates 10c,

[0026] The plurality of micro-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 micro-channel tubes 20 can be arranged inside the housing to configure either I-flow or U-flow. In accordance with an embodiment of the present invention, the micro-channel tubes 20 define fluid communication between a first manifold 30a corresponding to a first header plate 10c and an intermediate manifold 30b corresponding to a second header plate 10c opposite to the first header plate 10c. With such configuration the extruded micro-channel tubes 20 with first fluid flowing there-through are arranged in a spaced apart configuration with respect to each other with second fluid around the micro-channel tubes 20 for heat exchange between first fluid, particularly, the refrigerant flowing through the micro-channel tubes 20 and second fluid around the micro-channel tubes 20. In case the micro-channel tubes 20 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 32a distributes refrigerant to either a first set of extruded micro-channel tubes 20 or a portion of the same extruded micro-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 micro-channel tubes 20 or remaining portion of the same extruded micro-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 micro-channel tubes to the second set of extruded micro-channel tubes, the first and the second set of micro-channel tubes are disposed along the same plane. The refrigerant after flowing through the return pass is collected in the second portion 32b. Such arrangement defines the refrigerant flow path within the water chiller 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 micro-channel tubes 20 of the water chiller 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 micro-channel tubes 20 of the water chiller 100 after heat exchange with the water in the housing 10.

[0027] The housing 10 further includes an inlet port 10e and an outlet port 10f for ingress of water around the

micro-channel tubes 20 received inside the housing 100. The water received in the housing 10 and flowing around the extruded micro-channel tubes 20 rejects thermal energy to the refrigerant flowing through the extruded micro-channel tubes 20 and is cooled in the process. Particularly, the hot water enters through the inlet port 10e, the water flows around the micro-channel tubes 20, cools down and cooled water egresses through the outlet port 10f.

[0028] The first and second panels 10a and 10b are joined to the header plates 10c and the micro-channel tubes 20 are joined to the header plates 10c. Such configuration enables heat exchange between the first fluid, particularly refrigerant flowing through the micro-channel tubes 20 and the second fluid, particularly, water received in the enclosure and around the micro-channel tubes 20.

[0029] More specifically, once pre-assembled along with other components to be joined, the first panels 10a and the second panels 10b are joined to the header plates 10c by a joining process such as for example, brazing. Generally, the micro-channel tubes 20 are simultaneously joined to the header plates 10c as the first and second panels 10a and 10b are being joined to the header plates 10c by subjecting the pre-assembly of first and second panels 10a and 10b, the micro-channel tubes 20 and the headers 10c to brazing in a brazing furnace. However, the present invention is not limited to any particular joining process and any other joining process can be used for securing the first panels 10a and the second 10b to each other and to the header plates 10c and the micro-channel tubes 20 to the header plates 10c. As the enclosure is required to hold the second fluid and leakage of the fluids may cause in-efficient operation and lag in performance of the water chiller 100. Accordingly, the enclosure is required to be leak-proof and the first panels 10a, the second panels 10b and the header plates 10c are required to be properly positioned abutting to each other during the joining, in order to prevent any dislocation during the joining and prevent to any joining defects resulting in leakages.

[0030] In order to ensure proper positioning of the first panels 10a with respect to the corresponding second panels 10b and the header plates 10c, gripping crimps 14c and positioning tabs 16c are used. The gripping crimps 14c and the positioning tabs 16c are configured on at least one of the first panel 10a, the second panel 10b and the header plate 10c.

[0031] Preferably, at least one gripping crimp 14c is configured on at least one of the header plates 10c as illustrated in FIG. 7 and FIG. 8. The gripping crimp 14c extends from at least one of the header plates 10c and is crimped over the corresponding first panel 10a to grip and urge the first panel 10a against the second panel 10b. More specifically, the gripping crimp 14c grips and urges the first panel 10a against a longitudinal edge of the second panel 10b. Further, at least one of the header plates 10c includes at least one positioning tab 16c disposed proximal to at least one end of the gripping crimp

14c. Preferably, the positioning tabs 16c are disposed on both sides of the gripping crimp 14c. The positioning tab 16c is either crimped or deformed and extends beyond thickness of the first panel 10a. The positioning tabs 16c arrests movement of the corresponding first panel 10a along lateral side thereof in both directions. The positioning tab 16c is so positioned with respect to at least one of the opposite second panels 10b that the positioning tab 16c permits the first panel 10a to overhang with respect to at least one of the opposite second panels 10b. FIG. 6 illustrates an overhang portion of the first panel 10a overhanging from the second panel 10b. Alternatively, the positioning tab 16c is so positioned with respect to at least one of the opposite second panels 10b that the positioning tab 16c aligns at least one of the opposite sides of the first panel 10a with respect to the corresponding second panel 10b. The positioning tab 16c can either be crimped or deformed to extend beyond thickness of the first panel 10a held by the gripping crimp 14c to obstruct lateral movement of the first panel 10a. More specifically, the positioning tab 16c is crimped or deformed beyond the gripping crimp 14c to obstruct lateral movement of the first panel 10a, while the gripping crimp 14c grips and urges the first panel 10a against longitudinal edge of the second panel 10b.

[0032] Instead of the gripping crimp 14c and the positioning tab 16c being configured on the header plate 10c, the gripping crimp and the positioning tab can also be configured on either one of the first panel 10a and the second panel 10b for arresting the movement of the first panel 10a and the second panel 10b with respect to the header plate 10c. At least one of the first panels 10a and the second panels 10b includes at least one gripping crimp 14a and 14b respectively extending therefrom and crimped over the corresponding header plate 10c to prevent movement of the first and second panels 10a and 10b with respect to the header plate 10c. In one embodiment, the first panels 10a includes at least one gripping crimp 14a extending therefrom and crimped over the corresponding header plate 10c to grip and urge the first panel 10a against the second panel 10b. For example, the gripping crimp 14a is configured on the first panel 10a and is crimped to an edge of an aperture formed on the header plate 10c to arrest relative movement between the first panel 10a and the header plate 10c. With such configuration, the first panel 10a is securely positioned with respect to the header plate 10c without requiring the positioning tab. Similarly, in another example, the gripping crimp is configured on the second panel 10b and is crimped to an edge of an aperture formed on the header plate 10c to arrest relative movement between the second panel 10b and the header plate 10c. With such configuration, the second panel 10b is securely positioned with respect to the header plate 10c without requiring the positioning tab. The at least one of the first panels 10a and the second panels 10b includes at least one positioning tab 16a, 16b extending therefrom to be crimped or deformed to arrest lateral movement of the

first panel 10a.

[0033] However, the present invention is not limited to any particular configuration, number and placement of the gripping crimps and whether the gripping crimps are formed on the first panel 10a and the header plate 10c as far as the gripping crimps are capable of gripping and urging the first panel 10a against the second panel 10b.

[0034] Also, is disclosed a method 200 of assembling a water chiller 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 water chiller 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 first panels 10a are urged against the corresponding second panels 10b and held in position by the gripping crimp 14c and positioning tabs 16c formed on the header plates 10c. The gripping crimps 14c and the positioning tabs 16c ensure maintaining the panels 10a and 10b in position with respect to each other and the header plates 10c to configure secure connection there between during the joining. 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

[0035] Particularly, the method 200 involves the 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, wherein the first panel 10a, the second panel 10b and header plates 10c are arranged orthogonal with respect to each other. The pre-assembling step 102 involves the step 102a of gripping and urging the first panel 10a against the second panel 10b by crimping at least one gripping crimp 14c formed on at least one of the header plate 10c, the first panel 10a and the second panel 10b. Thereafter, step 102b, either crimping or deforming at least one positioning tab 16c for arresting lateral movement of the first panel 10a along lateral side thereof. Thereafter the method 200 involves the step 104 of receiving a plurality of micro-channel tubes in openings 12c formed on the header plates 10c to define fluid communication between end manifolds 30 corresponding to the pair of header plates 10c. Finally, the method 200 involves step 106 of joining the pre-assembled elements of the water chiller 100 by a joining process to define an enclosure.

[0036] 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 water chiller (100) comprising:

- a housing (10), the housing (10) comprising:
 - at least one first panel (10a);
 - at least one second panel (10b); and
 - a pair of oppositely disposed spaced apart header plates (10c) formed with multiple openings (12c),
- a plurality of micro-channel tubes (20) received in the openings (12c) formed on the header plates (10c) 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 of a gripping crimp (14c) and a positioning tab (16c) to pre-assemble at least one of the first panel (10a), the second panel (10b) and the header plates (10c) to define a pre-assembled configuration thereof, before subjecting to joining.

2. The water chiller (100) as claimed in the previous claims, wherein the first panels (10a), the second panel (10b) and the header plate (10c) are disposed orthogonal with respect to each other.

3. The water chiller (100) as claimed in any of the preceding claims, wherein the at least one of the header plates (10c) comprises at least one gripping crimp (14c) extending therefrom and adapted to be crimped over the corresponding first panel (10a) to grip and urge the first panel (10a) against the second panel (10b).

4. The water chiller (100) as claimed in any of the preceding claims, wherein the gripping crimp (14c) is adapted to grip and urge the first panel (10a) against a longitudinal edge of the second panel (10b).

5. The water chiller (100) as claimed in any of the preceding claims, wherein the at least one of the header plates (10c) comprises at least one positioning tab (16c) disposed proximal to at least one end of the gripping crimp (14c) and adapted to arrest lateral movement of the corresponding first panel (10a) along lateral side thereof.

6. The water chiller (100) as claimed in any of the preceding claims, wherein the positioning tabs (16c) are disposed on both sides of the gripping crimp (14c).

7. The water chiller (100) as claimed in any of the preceding claims, wherein in the pre-assembled configuration, the positioning tab (16c) is so positioned with respect to at least one of the opposite second panels (10b) that the positioning tab (16c) is either adapted to align at least one of the opposite sides of the first panel (10a) with respect to the corresponding second panel (10b) or permit the first panel (10a) to overhang with respect to at least one of the opposite second panels (10b). 5 10
8. The water chiller (100) as claimed in any of the preceding claims, wherein the positioning tab (16c) is adapted to be crimped or deformed and extend beyond thickness of the first panel (10a). 15
9. The water chiller (100) as claimed in any of the preceding claims, wherein the heat exchanger comprises a plurality of micro-channel tubes (20) and a plurality of turbulators configured between two adjacent tubes of the plurality of micro-channel tubes (20). 20
10. A method (200) of assembling a water chiller (100), the method (200) comprising: 25
- 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, wherein the first panel (10a), the second panel (10b) and the header plates (10c) are orthogonal with respect to each other, the pre-assembling step (102) comprising; 30
 - a step (102a) of gripping and urging a first panel (10a) against longitudinal edge of the second panel (10b) by crimping at least one gripping crimp (14c) formed on at least one of the header plate (10c), the first panel (10a) and the second panel (10b); 35 40
 - a step (102b) of crimping or deforming at least one positioning tab (16c) for arresting lateral movement of the first panel (10a) along lateral side thereof; 45
 - a step (104) of receiving a plurality of micro-channel tubes (20) in openings (12c) formed on the header plates (10c) to define fluid communication between end manifolds (30) corresponding to the pair of header plates (10c), 50
 - a step (106) of joining the pre-assembled elements of the water chiller (100) by a joining process to define an enclosure. 55

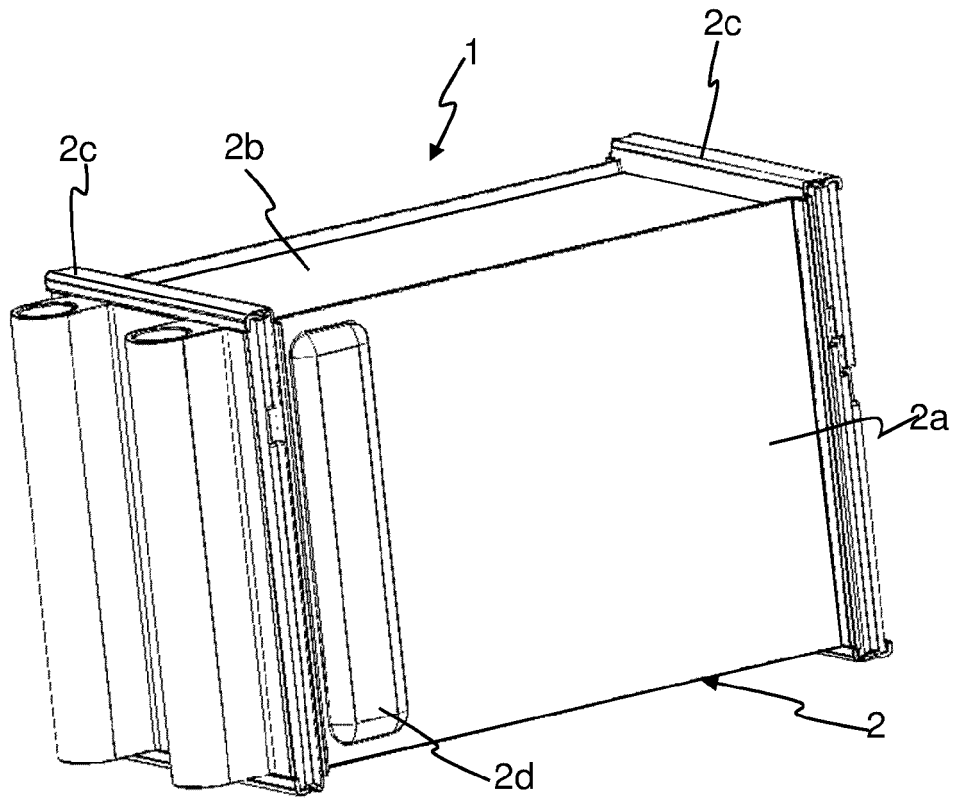


FIG. 1
(PRIOR ART)

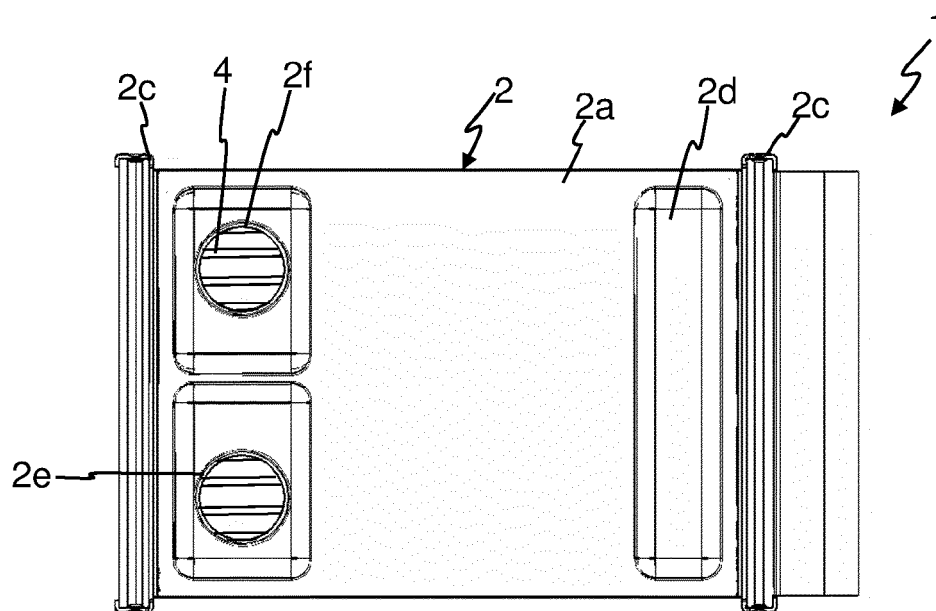


FIG. 2
(PRIOR ART)

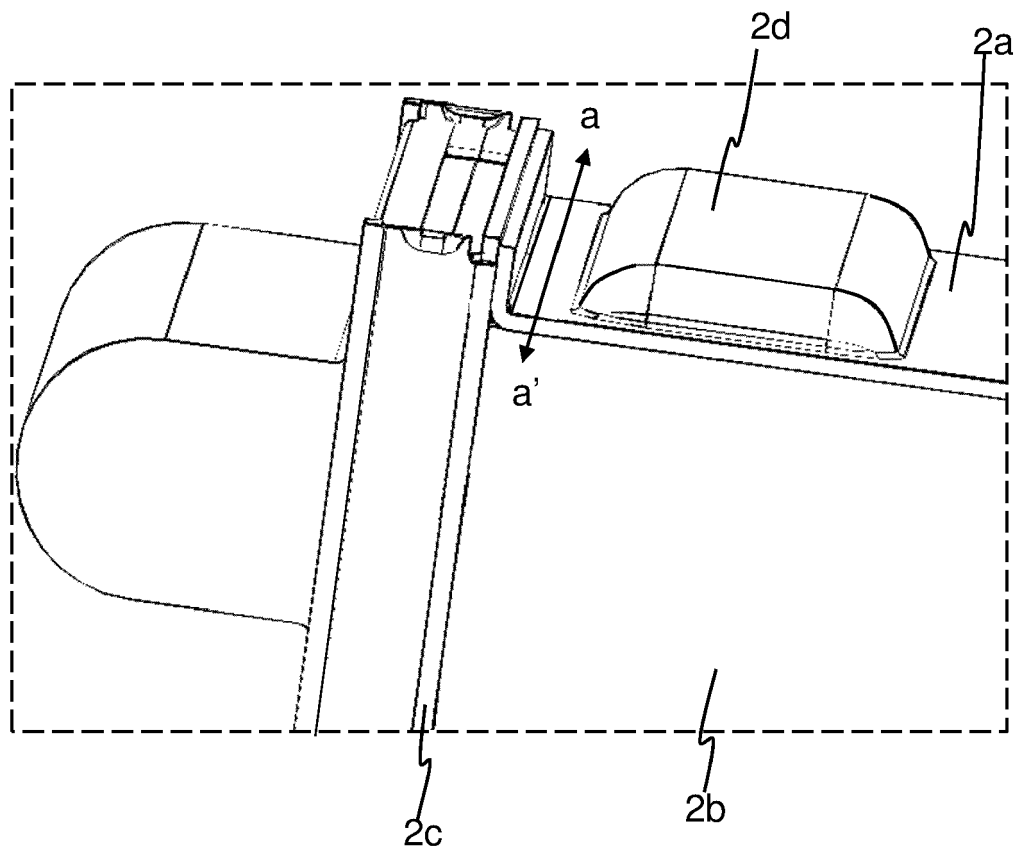


FIG. 3
(PRIOR ART)

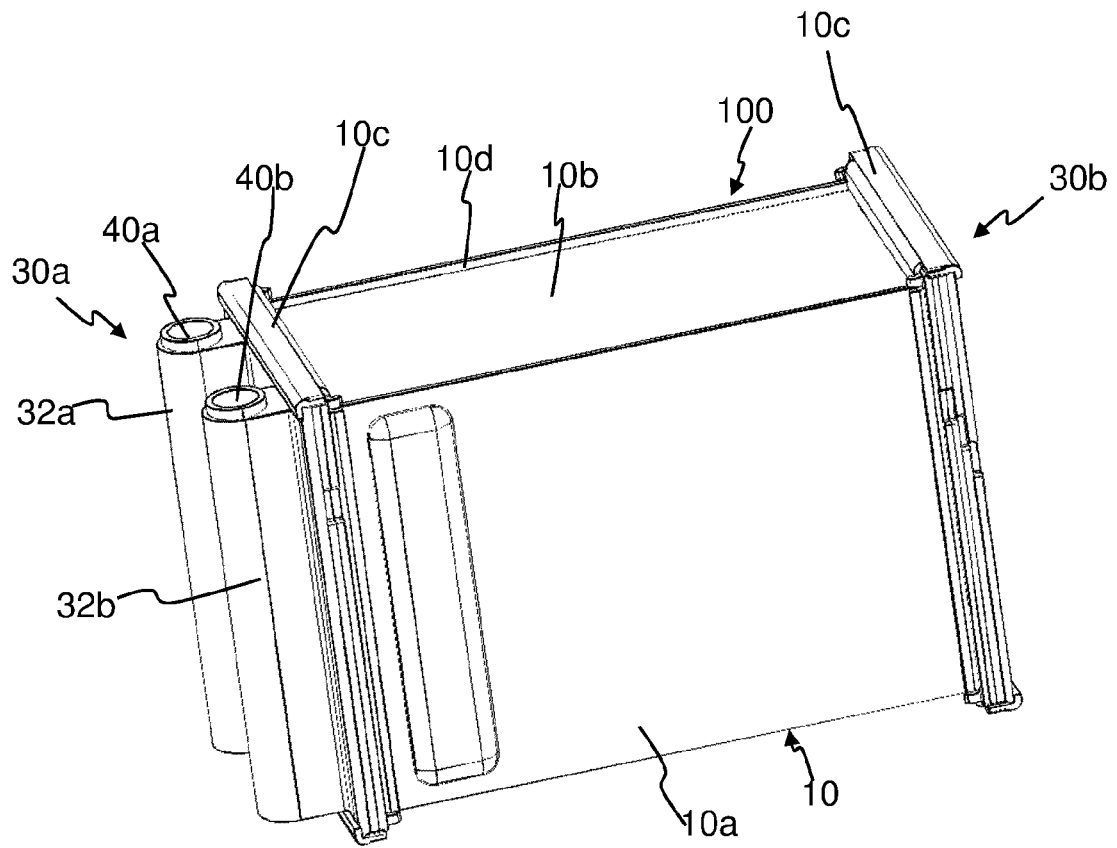


FIG. 4

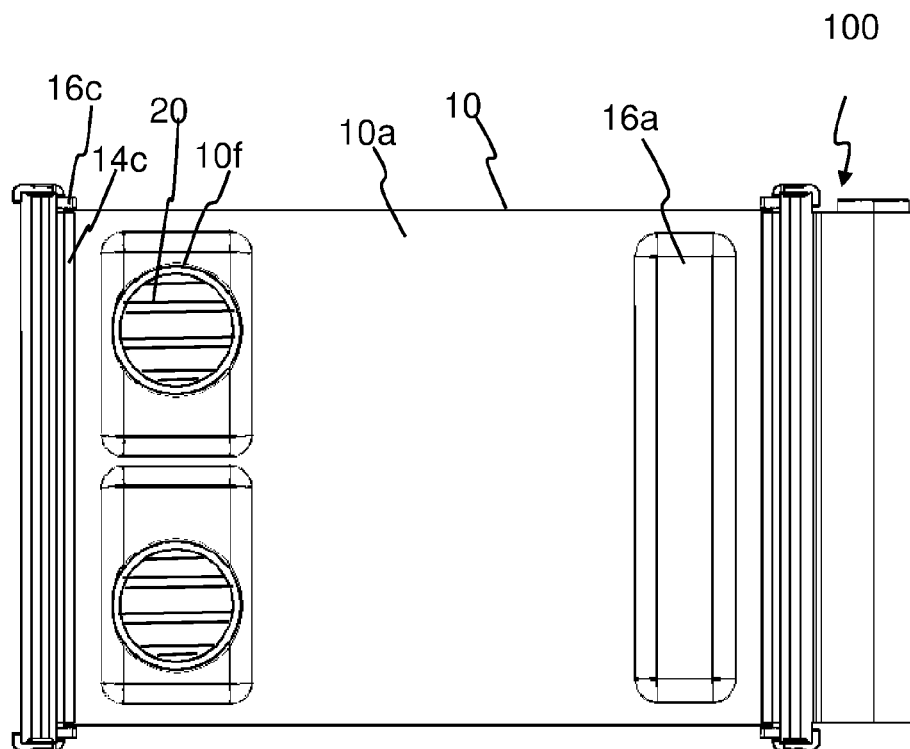


FIG. 5

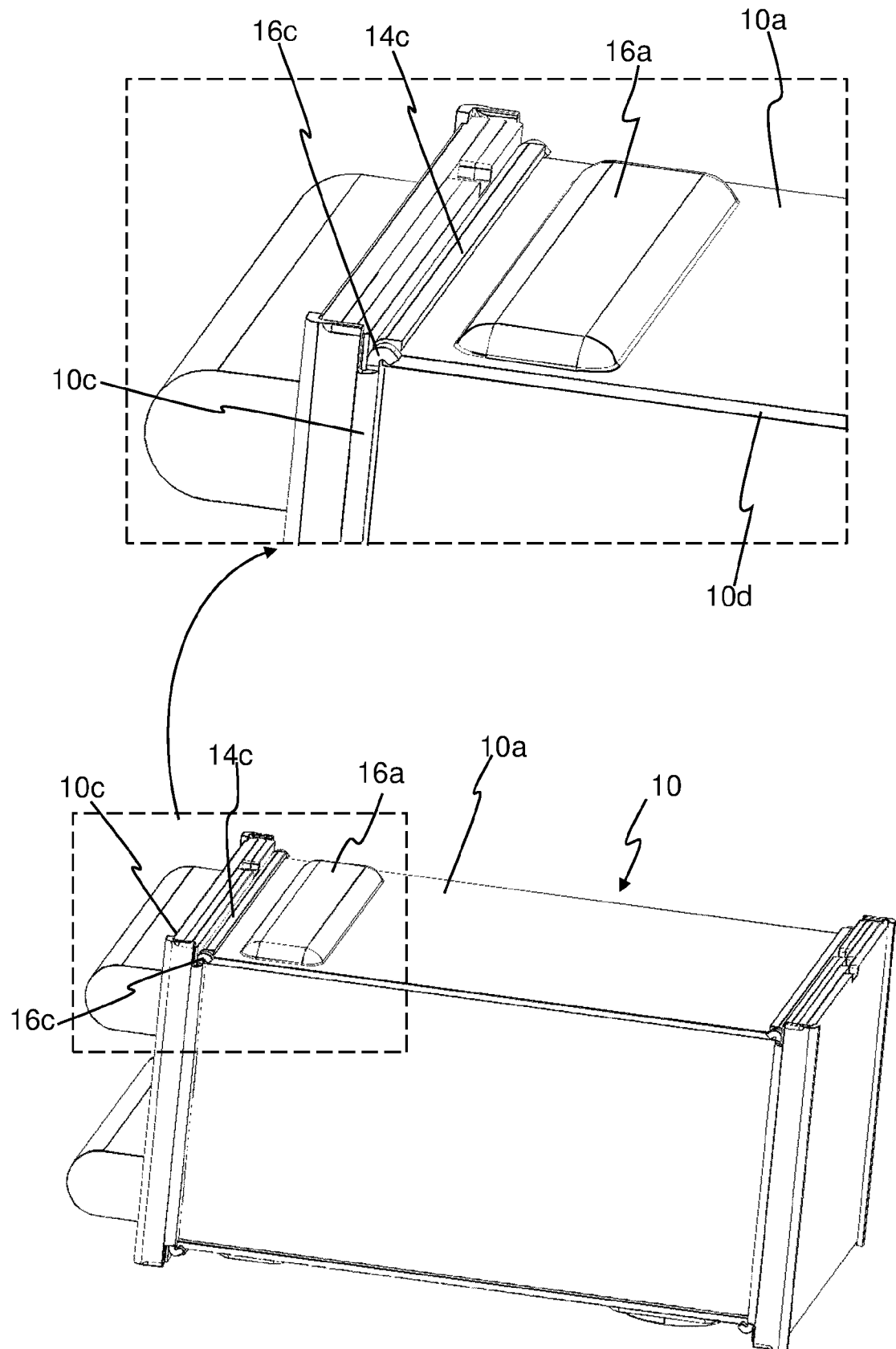


FIG. 6

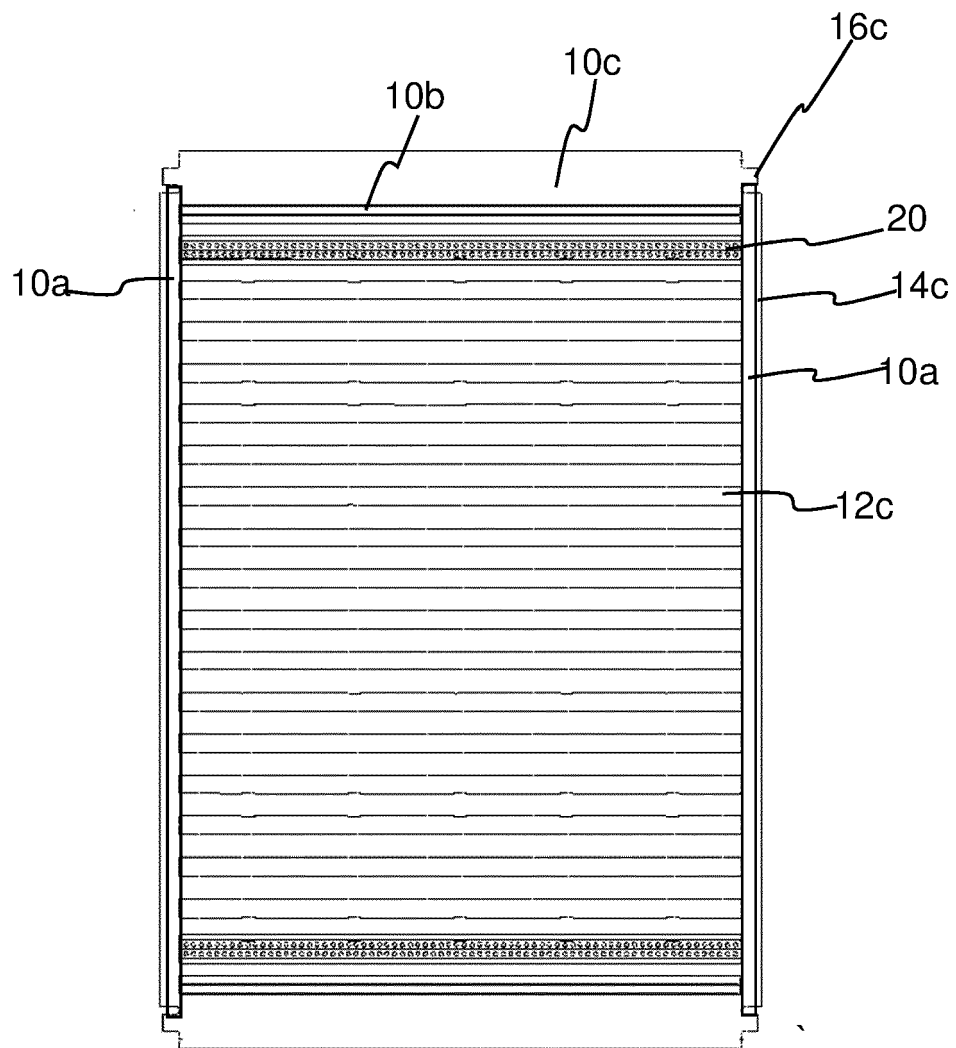


FIG. 7

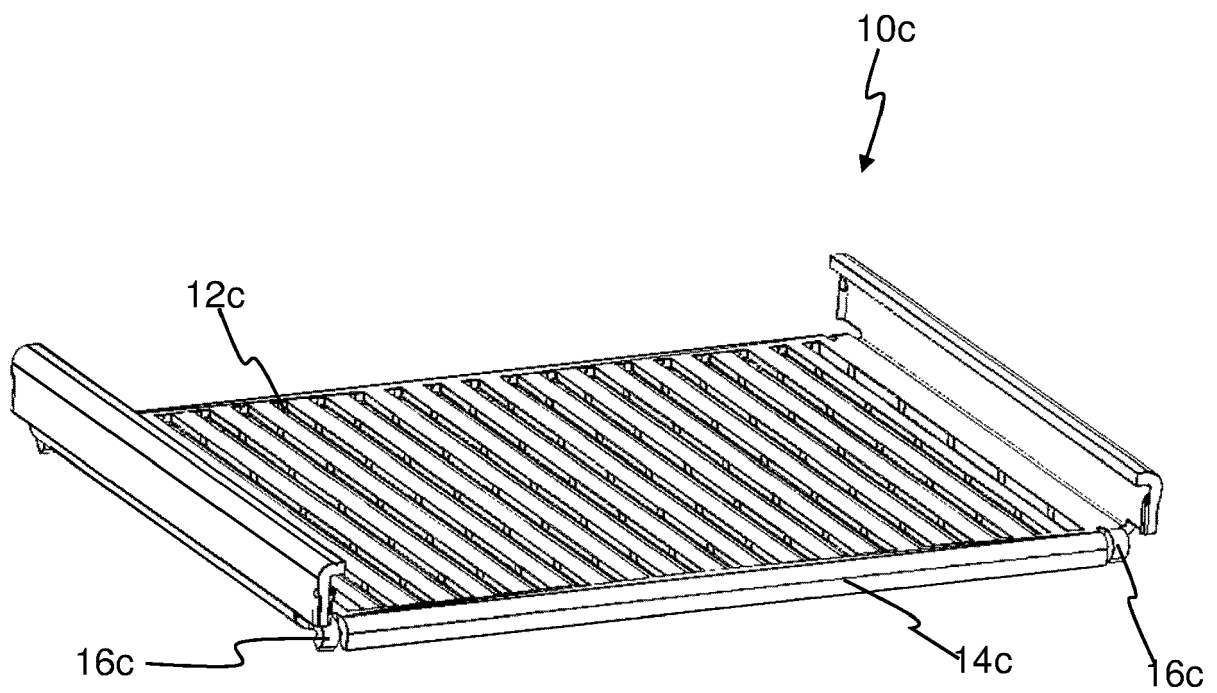


FIG. 8

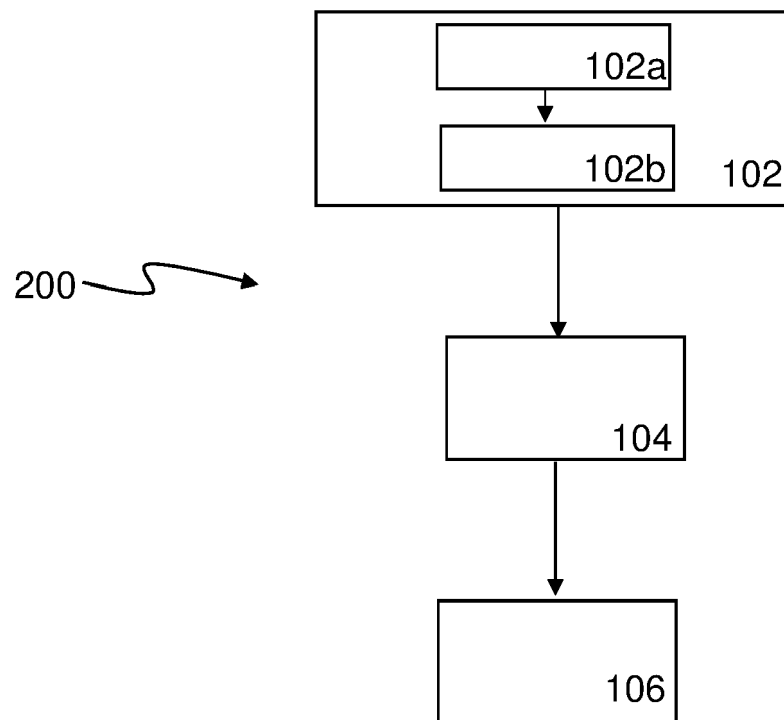


FIG. 9



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