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(54) **A REINFORCING INSERT FOR A HEAT EXCHANGER TUBE**

(57) A reinforcing insert (100) for a heat exchanger tube (102) is disclosed. The reinforcing insert (100) includes at least two spaced legs (104) adapted to be received in the heat exchanger tube (102) through an open end (106a, 106b) of said tube (102), each of the at least two legs (104) being configured such that at least two side surfaces (108a, 108b) of each of the legs (104) are abutted with at least two inner side surfaces of the heat exchanger tube (102), and an outer connector (112) adapted for connecting outer ends of the at least two legs (104) and positioned outside of said tube (102). In addition, at least a portion (114a, 114b) of the outer connector (112) is bent at a predefined angle with respect to adjacent connecting portions (116) coupled to the at least two legs (104).

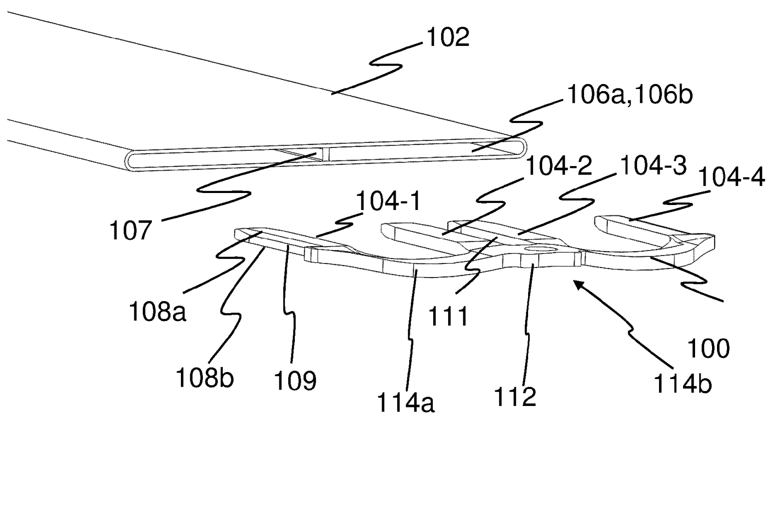

FIG. 2

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Description

FIELD OF INVENTION

[0001] The present invention relates to a heat exchanger, more specifically, the present invention relates to a reinforcing insert for a heat exchanger tube.

BACKGROUND

[0002] Heat exchangers, such as a radiator, is a part of a drive cooling system employed for cooling heat exchange fluid, such as a coolant, used for cooling a vehicle drive that can be at least one of an engine and a motor depending upon whether the vehicle is any one of internal combustion engine driven vehicle, hybrid vehicle and electric vehicle. The radiator typically includes a radiator core formed of a plurality of heat exchanger tubes (hereinafter, also referred to as tubes for simplicity) and fins arranged between outer surfaces of the adjacent tubes. Each tube has two opposite open ends including a first end and a second end. The opposite open ends of each tube are inserted into respective tube insertion slots of a first header and a second header. Further, the insertion portion of each tube is brazed and fixed integrally to the respective header.

[0003] Each of the first header and the second header in conjunction with a corresponding first tank and second tank define a first manifold and a second manifold for receiving and distributing the coolant to the tubes, wherein the coolant passes from the manifold on one end of the radiator through the tubes to the manifold on the other end of the heat exchanger. In addition, the coolant circulates through a drive-cooling loop to extract heat from the drive and in the process, the coolant is heated.

[0004] In use, these heat exchangers or radiators have intermittent duty cycles, i.e., the coolants at different temperature, such as high temperature and low temperature, pass through the tubes from one manifold to the other manifold. Because of the heating and/or cooling of the tubes and the headers, dimensional changes, i.e., thermal expansion or contraction, in the tubes and the headers occur. As the tubes are brazed to the headers, such thermal cycling/ thermal shock induces stresses in the tubes, particularly at the tube to header joints/ brazed portions. Therefore, in such a heat exchanger, cracks may occur in the tubes due to repeated thermal stress/shocks generated in the brazed portions of the tubes, which may leads to leakage, and thus failure of the heat exchanger.

[0005] Priors suggest different types of reinforcing inserts for the tubes, which prevents such a crack/fracture in the tubes. However, the existing reinforcing inserts are efficient in preventing cracks in the tubes as these existing reinforcing inserts are not properly brazed to the tubes due to small contact area/surfaces between the insert and the tube, therefore these existing inserts are failed to efficiently reinforce the tubes. In addition, the existing reinforcing inserts obstruct the coolant flow through the open ends of the tubes, thereby increasing a level of internal pressure drop on the inlet coolant side of the heat exchanger.

[0006] Therefore, there is a need for a simple, improved, and cost-effective tube reinforcement for all the heat exchangers, which can overcome the abovementioned problems associated with the existing reinforcing inserts.

SUMMARY

[0007] The present invention discloses a waved reinforcing insert for heat exchanger tube for efficient brazing between the tube and the insert, which insures efficient tube reinforcement, thereby preventing a crack from occurring in a portion where repeated thermal stress occurs, such as the brazed portion between the tube and a header plate of a heat exchanger, consequently eliminating abovementioned drawbacks of the existing reinforcing inserts. Besides, the disclosed waved tube reinforcement enhances the heat exchanger, such as a radiator, reliability for thermal shock by ensuring large contact area/surfaces between the insert and the tube through twisted insert leg's edges. In addition, due to reduced risk of failure of the heat exchanger by thermal shock effect, it also decreases potential of environment pollution by leak of coolant.

[0008] In accordance with an embodiment of the present invention, the disclosed reinforcing insert includes at least two spaced legs adapted to be received in the heat exchanger tube through an open end of the heat exchanger tube (hereinafter, alternatively referred to as tube for simplicity), each of the at least two legs can be configured such that at least two side surfaces of each leg are abutted with at least two inner side surfaces of the tube, and an outer connector adapted for connecting outer ends of the at least two legs and positioned outside of the tube.

[0009] In addition, at least a portion of the outer connector can be bent at a predefined angle with respect to adjacent connecting portions coupled to the at least two legs. Besides, at least the portion between the adjacent connecting portions of the outer connector can be configured in a plane offset to a longitudinal axis of the heat exchanger tube. For instance, the outer connector can be bent to form one or more waves between the reinforcement legs, these waved portions of the insert ensure better access to the tube openings for the coolant, thereby decreasing level of internal pressure drop on the inlet coolant side of the heat exchanger.

[0010] In an embedment, at least one of the at least two legs can include a tapered, chamfered or rounded inner end portion to aid insertion of the at least two legs through the open end of the heat exchanger tube.

[0011] In addition, at least two legs can be are coupled to the inner side surfaces of the heat exchanger tube through a joining process selected from a group comprising brazing and welding.

[0012] Further, the reinforcing insert can be formed from a single strip or a single sheet metal. Furthermore, the reinforcing insert can have variable thickens across a length of the reinforcing insert. Moreover, the reinforcing insert can include a hole on a portion of the outer connector.

[0013] In accordance with another embodiment, the present invention discloses a heat exchanger including at least one header having a plurality of slots configured spaced apart along length of the at least one header, a plurality of heat exchanger tubes, each heat exchanger tube comprising opposite open ends which are received in corresponding slots of the at least one header, and at least one reinforcing insert, such as the insert described above, configured with at least one of the plurality of heat exchanger tubes for reinforcing a region of at least one open end of the corresponding heat exchanger tube.

[0014] In addition, a plurality of fins are configured between outer surfaces of adjacent heat exchanger tubes of the plurality of heat exchanger tubes.

[0015] In accordance with another embodiment, the present invention discloses a method for reinforcing a heat exchanger tube, the disclosed method can include a step of inserting at least two spaced legs of a reinforcing insert inside the heat exchanger tube through an open end of the tube, and bending an outer connector, connected to outer ends of the at least two legs, of the reinforcing insert such that the at least two legs are twisted inside the tube and at least two side surfaces of each leg are abutted with at least two inner side surfaces of the heat exchanger tube, and at least a portion of the outer connector is bent at a predefined angle with respect to adjacent connecting portions coupled to the at least two legs.

[0016] In addition, the disclosed method can include a step of joining the at least two abutted surfaces of each leg with the corresponding inner side surfaces of the heat exchanger tube.

[0017] 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.

BRIEF DESCRIPTION OF DRAWINGS

[0018] Other characteristics, details and advantages of the invention may 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. 1A and FIG. 1B illustrate isometric views of reinforcing insert for a heat exchanger tube in accordance with an embodiment of the present invention;

FIG. 2 illustrates a disassembled view of the reinforcing insert and the heat exchanger tube;

FIG. 3 illustrates an assembled view of the reinforcing insert and the heat exchanger tube;

FIG. 4 illustrates enlarged view of ends of the heat exchanger tube fitted with reinforcing inserts;

FIG. 5 illustrates a sectional view of an end heat exchanger tube fitted with the reinforcing insert;

FIG. 6 illustrates an isometric view of a heat exchanger having tubes with reinforcing insert in accordance with an embodiment of the present invention;

FIG. 7 illustrates a side view of the heat exchanger of FIG. 6;

FIG. 8 illustrates a core of the heat exchanger of FIG. 6; and

FIG. 9 illustrates a block diagram depicting various steps of the method for reinforcing a heat exchanger tube in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

[0019] It must be noted that the figures disclose the invention in a detailed enough way to be implemented, said figures helping to better define the invention if needs be. The invention should however not be limited to the embodiment disclosed in the description.

[0020] Although, the present invention is explained in the forthcoming description and the accompanying drawings with an example of tube reinforcements for a heat exchanger, particularly with a reinforcing insert for a heat exchanger tube to prevent a crack from occurring in a portion where repeated thermal stress occurs, such as a brazed portion between the tube and a header plate of the heat exchanger, such as a radiator. The disclosed reinforcing insert locally reinforces the longitudinal tube end which is prone to fatigue failure on thermal shock cycling while use or testing by ensuring large contact area/surfaces between the insert and the tube through twisted insert leg's edges brazed to the tube.

[0021] Referring to FIG. 1A to FIG. 5, in accordance with an embodiment, the present invention discloses a reinforcing insert 100 for a heat exchanger tube 102. The reinforcing insert 100 includes a plurality of legs 104-1, 104-2, 104-3 and 104-4, (hereinafter, collectively referred to as legs 104), that are configured spaced apart and an outer connector 112 adapted for connecting outer ends of the legs 104. It is to be appreciated that although the present invention is explained with a reinforcing insert having four legs, the present invention is not limited to the same in any way whatsoever, and the reinforcing insert can include any numbers of legs and the space between the adjacent legs may vary based on requirements.

[0022] The legs 104 are adapted to be inserted in heat exchanger tube 102 through corresponding open ends 106a and 106b of the tube 102. For instance, as shown in FIG. 4, two reinforcing inserts 100 are fitted with both opposite ends of the tube 102 for reinforcing corresponding open end portions of the tube 102. Inner end portion/terminal 110 of each leg 104 can be pointy or can includes a tapered, chamfered or rounded shape to aid insertion of the legs 104 through the open end 106a and106b of the heat exchanger tube 102.

[0023] In addition, as shown in FIG. 5, the legs 104 of the reinforcing insert 100 can be in twisted form such that at least two side surfaces, such as opposite side surfaces 108a and 108b, of each leg 104 can be abutted with at least two inner side surfaces of the heat exchanger tube 102. For instance, when the legs 104 of the reinforcing insert 100 are inserted in the tube 102, the upper faces 108 of the legs 104 lie contiguous with the upper internal surface of the tube 102 and the lower faces 108b of the legs lie contiguous with the lower internal surface of the tube 102. The twisted legs 104 ensure good contact with the tube 102 during joining process, such as brazing. Besides, the legs 104 in the twisted from increase area of contact between the side surfaces 108a and 108b of the legs and the inner surfaces of the tube 102. This large contact area between the insert 100 and the tube 102 at the open end portions leads to efficient reinforcement of the tube 102.

[0024] In another embodiment, as shown in FIG. 2, when the legs 104 are inserted in the tube 102, the outer side edges 109 of the side legs 104-1 and 104-4 of the plurality of legs 104 can abut with respective opposite internal longitudinal edges of the tube 102. In another embodiment, the inner side edges 111 of the side legs 104-2 and 104-3 of the plurality of legs 104 can abut with respective opposite side surfaces of a dividing wall 107 of the tube 102.

[0025] As shown in FIGs 1A and 1B, portions 114a and 114b of the outer connector 112 can be bent at a predefined angle with respect to adjacent connecting portions 116 coupled to the corresponding legs 104. Besides, as shown in FIGs 3 and 4, the bent portion 114a and 114b between the adjacent connecting portions 116 of the outer connector 112 can be configured in a plane offset to a longitudinal axis of the heat exchanger tube 102. For instance, the outer connector 112 of the reinforcing insert 100 can have waved design with two wave portions 114a and 114b between the adjacent leg connecting portions 116.

[0026] In addition, the adjoining surfaces of the legs 104 of the reinforcement inset 100 are coupled to the heat exchanger tube 102 through a joining process that can be any or a combination of brazing, welding, and the like. The large contact area between legs 104 of the insert 100 and the inner surface of the tube 102 at the open end potions leads to efficient brazing between the legs 104 and the tube 102, resulting in efficient localized reinforcement at the outer end portions, which can prevent the crack from occurring in that portions due to repeated thermal stress/shocks.

[0027] In addition, the outer connector 112 can be provided with a hole 113. Such a characteristics creates a Poka Yoke for different thickness in different technologies, and also allows to use less material on radiator assembly and additional reduction for flow resistance.

[0028] Further, the reinforcing insert 100 can be formed from a single strip or a single sheet metal. In addition, the reinforcing insert 100 may have variable thickens across a length of the reinforcing insert 100, wherein the variable thickness may reduce required material, this can reduce weight of the reinforcing insert 100.

[0029] As shown in FIG. 6 to FIG. 8, in accordance with an embodiment, the present invention discloses a heat exchanger, such as a radiator, 150 including a heat exchanger core 175 that includes a plurality of heat exchanger tubes 102 and a plurality of fins 122 configured between two adjacent tubes of the plurality of tubes 102, and a pair of headers 118a and 118b configured on opposite side of the heat exchanger 150. The fins 122 are, for example, heat dissipating fins. In addition, each of the headers 118a and 118b includes a plurality of slots 120 configured spaced apart along length the respective header. In addition, opposite end portions of the tubes 102 are received in the corresponding slots 120 the headers 118a and 118b such that the opposite open ends 106a and 106b of the tubes 102 extended outside of the respective headers 118a and 118b. Besides, the plurality of tubes 102 are coupled to the headers 118a and 118b though the brazing process. In an exemplary embodiment, the heat exchanger 150 can be used for cooling the heat exchange fluid or coolant in vehicles as well as in non-vehicle applications.

[0030] Further, the plurality of tubes 102 are reinforcement reinforced through reinforcing inserts 100 at the opposite open end regions which are prone to fatigue failure on thermal shock cycling while use of the heat exchanger 150. In addition, waved design of the reinforcing inserts 100 with twisted legs ensures large area of contact with the tubes 102 leads to efficient brazing connection between the tubes 102 and the legs of the reinforcing inserts 100. Thus, reinforcement of the tubes 102 at the opposite open end regions provides resistance to severe thermal shock/stress with high level of cycles and increase heat exchanger reliability for thermal shock.

[0031] In addition, the bent/waved portions 114a and 114b of the reinforcing inserts 100 ensure better access to the tube openings 106a and 106b for the coolant. The heat exchange fluid/coolant guided into an inlet manifold on inlet side of the heat exchanger 150 can smoothly enters the opening of the tube 102 due to presence of the bent/waved portions 114a and 114b which are offset from the longitudinal axis of the respective tube 102, thereby decreasing level of internal pressure drop on the inlet coolant side of the heat exchanger 150 and reducing turbulent flow. At the same time, the heat exchange fluid/coolant can smoothly exit the tubes 102 into an exit manifold, located on opposite side with respect to the inlet manifold, due to presence of the bent/waved portions 114a and 114b.

[0032] Referring to FIG. 9, in accordance with an embodiment, the present invention discloses a method 200 for reinforcing a heat exchanger tube. Particularly, the method 200 includes the step of reinforcing a heat exchanger tube 102 of a heat exchanger 150. 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.

[0033] The disclosed method 200 for reinforcing the heat exchanger tube 102 can include a step 202 of inserting legs 104 of a reinforcing insert 100 inside the heat exchanger tube 102 through an open end 106a and/or106b of the tube 102. The method 200 further includes the step 204 of bending an outer connector 112, connected to outer ends of the legs 104, of the reinforcing insert 100 through any suitable means known in the art. When the outer connector 112 is bent, the legs 104 are twisted inside the tube 102 and at least two side surfaces 108a and108b of each of the legs 104 are abutted with at least two inner side surfaces of the heat exchanger tube 102. In addition, portions 114a and 114b of the outer connector 112 can be bent at a predefined angle with respect to adjacent connecting portions 116 coupled to the legs 104.

[0034] In addition, the method 200 further includes the step of joining the at least two abutted surfaces 108a and 108b of each of the legs 104 with the corresponding inner side surfaces of the heat exchanger tube 102 through a suitable joining process, for example, brazing.

[0035] 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 reinforcing insert (100) for a heat exchanger tube (102), the reinforcing insert (100) comprising:

   at least two spaced legs (104) adapted to be received in the heat exchanger tube (102) through an open end (106a, 106b) of said tube (102), each of the at least two legs (104) being configured such that at least two side surfaces (108a, 108b) of each of the legs (104) are abutted with at least two inner side surfaces of the heat exchanger tube (102); and

   an outer connector (112) adapted for connecting outer ends of the at least two legs (104) and positioned outside of said tube (102), wherein at least a portion (114a, 114b) of the outer connector (112) is bent at a predefined angle with respect to adjacent connecting portions (116) coupled to the at least two legs (104).

2. The reinforcing insert (100) as claimed in the preceding claim, wherein at least the portion (114a, 114b) between the adjacent connecting portions (116) of the outer connector (112) is configured in a plane offset to a longitudinal axis of the heat exchanger tube (102).

3. The reinforcing insert (100) as claimed in any of the preceding claims, wherein at least one of the at least two legs (104) includes a tapered, chamfered or rounded inner end portion (110) to aid insertion of the at least two legs (104) through the open end (106a, 106b) of the heat exchanger tube (102).

4. The reinforcing insert (100) as claimed in any of the preceding claims, wherein the at least two legs (104) are coupled to the inner side surfaces of the heat exchanger tube (102) through a joining process selected from a group comprising brazing and welding.

5. The reinforcing insert (100) as claimed in any of the preceding claims, wherein the outer connector (112) comprises a hole (113).

6. The reinforcing insert (100) as claimed in any of the preceding claims, wherein the reinforcing insert (100) is formed from a single strip or a single sheet metal, and wherein the reinforcing insert (100) comprises variable thickens across a length of the reinforcing insert (100).

7. A heat exchanger (150) comprising:

   at least one header (118a, 118b) comprising a plurality of slots (120) configured spaced apart along length of the at least one header (118a, 118b);

   a plurality of heat exchanger tubes (102), each heat exchanger tube (102) comprising opposite open ends (106a, 106b) received in correspond-

ing slots (120) of the at least one header (118a, 118b); and
at least one reinforcing insert (100) configured with at least one of the plurality of heat exchanger tubes (102) for reinforcing a region of at least one of the open ends (106a, 106b) of the corresponding heat exchanger tube (102);
characterized in that each reinforcing insert (100) comprises:

at least two spaced legs (104) adapted to be received in the corresponding heat exchanger tube (102) through the open end (106a, 106b) of said tube (102), each of the at least two legs (104) being configured such that at least two side surfaces (108a, 108b) of each leg (104) are abutted with at least two inner side surfaces of the corresponding heat exchanger tube (102); and
an outer connector (112) adapted for connecting outer ends of the at least two legs (104) and positioned outside of the corresponding heat exchanger tube (102), wherein at least a portion (114a, 114b) of the outer connector (112) is bent at a predefined angle with respect to adjacent connecting portions (116) coupled to the at least two legs (104).

8. The heat exchanger (150) as claimed in the preceding claim, wherein at least the portion (114a, 114b) between the adjacent connecting portions (116) of the outer connector (112) is configured in a plane offset to a longitudinal axis of the heat exchanger tube (102).

9. The heat exchanger (150) as claimed in any of the preceding claims, wherein the at least two legs (104) are coupled to the inner surface of the corresponding heat exchanger tube (102) through a joining process selected from a group comprising brazing and welding.

10. The heat exchanger (150) as claimed in any of the preceding claims, wherein at least one of the at least two legs (104) includes a tapered, chamfered or rounded inner end portion (110) to aid insertion of the at least two legs (104) through the open end (106a, 106b) of the heat exchanger tube (102), and wherein the reinforcing insert (100) is formed from a single strip or a single sheet metal.

11. The heat exchanger (150) as claimed in any of the preceding claims, wherein the reinforcing insert (100) comprises variable thickens across a length of the reinforcing insert (100).

12. The heat exchanger (150) as claimed in any of the preceding claims, wherein the outer connector (112) comprises a hole (113).

13. The heat exchanger (150) as claimed in any of the preceding claims, wherein a plurality of fins (122) are configured between adjacent heat exchanger tubes (102) of the plurality of heat exchanger tubes (102).

14. A method (200) for reinforcing a heat exchanger tube (102), the method (200) comprising steps of:

inserting at least two spaced legs (104) of a reinforcing insert (100) inside the heat exchanger tube (102) through an open end (106a, 106b) of said tube (102); and
bending an outer connector (112), connected to outer ends of the at least two legs (104), of the reinforcing insert (100) such that the at least two legs (104) are twisted inside said tube (102) and at least two side surfaces (108a, 108b) of each of the least two legs (104) are abutted with at least two inner side surfaces of the heat exchanger tube (102), and at least a portion (114a, 114b) of the outer connector (112) is bent at a predefined angle with respect to adjacent connecting portions (116) coupled to the at least two legs (104).

15. The method (200) as claimed in the preceding claim, wherein the method comprises joining the at least two abutted surfaces (108a, 108b) of each of the legs (104) with the corresponding inner side surfaces of the heat exchanger tube (102).

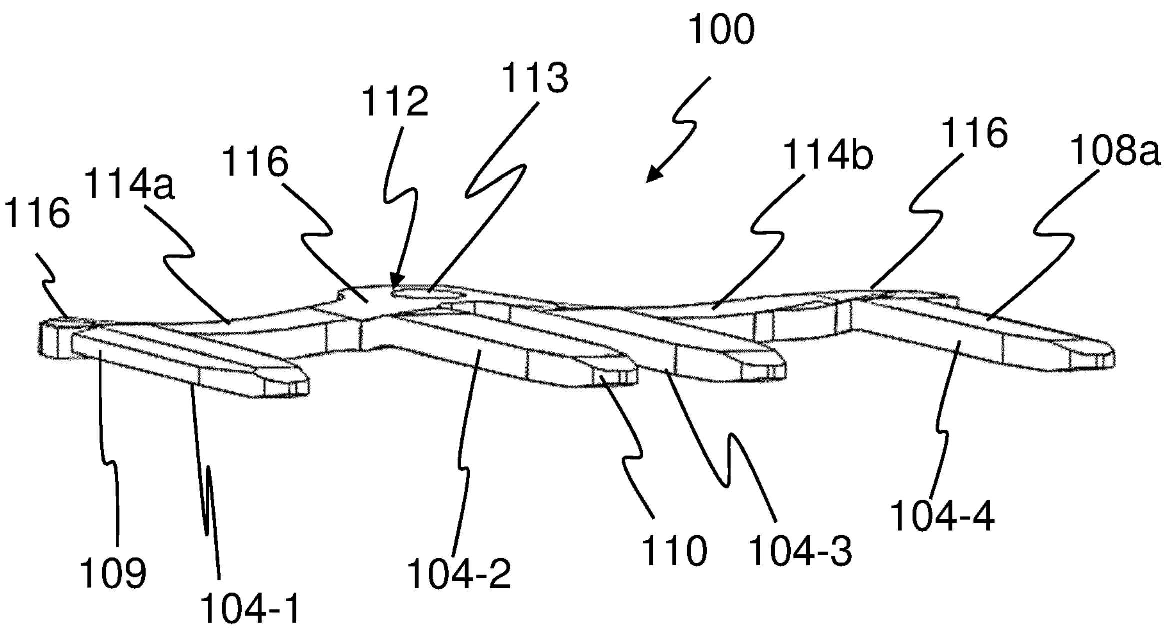

100
113
112
116
114a
116
114b
116
108a
109
104-1
104-2
110
104-3
104-4

FIG. 1A

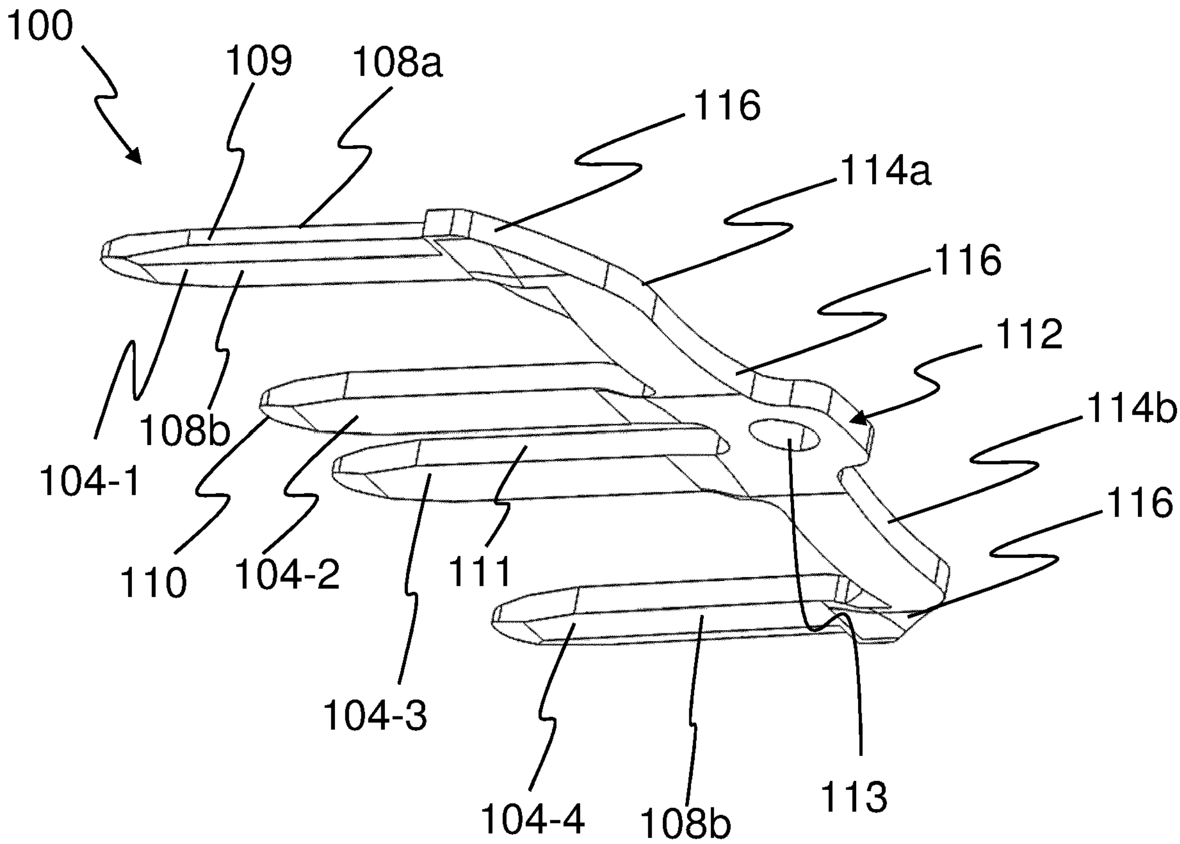

100
109
108a
116
114a
116
112
114b
116
104-1
108b
110
104-2
111
104-3
104-4
108b
113

FIG. 1B

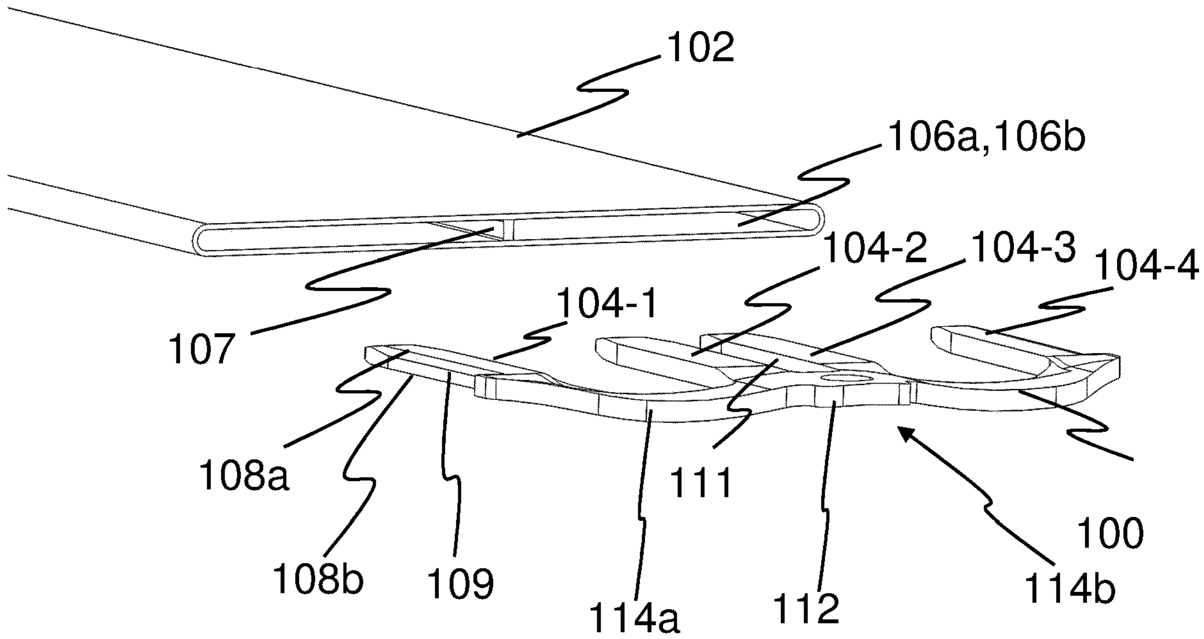

102
106a,106b
104-2
104-3
104-4
104-1
107
108a
111
100
108b
109
114a
112
114b

FIG. 2

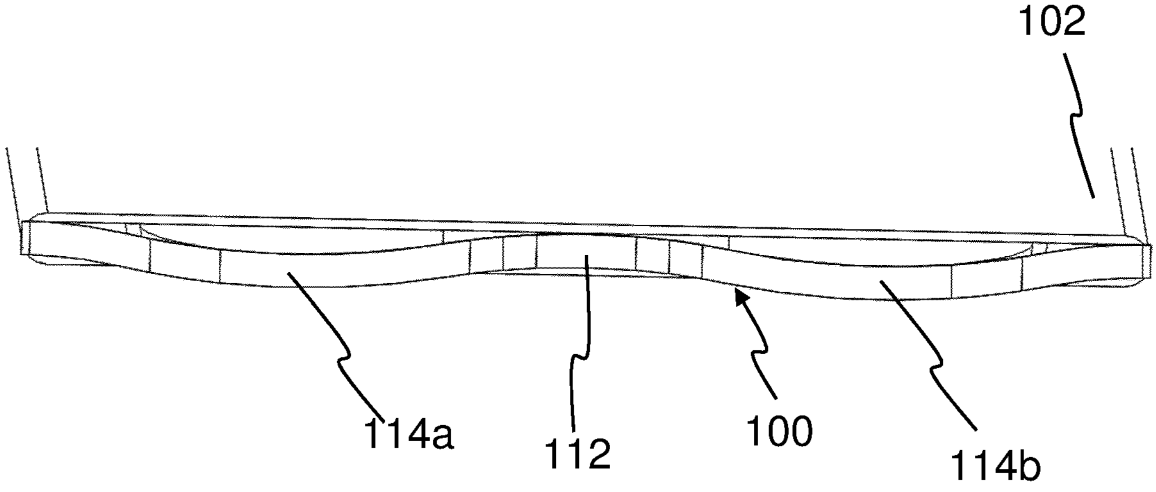

102
114a
112
100
114b

FIG. 3

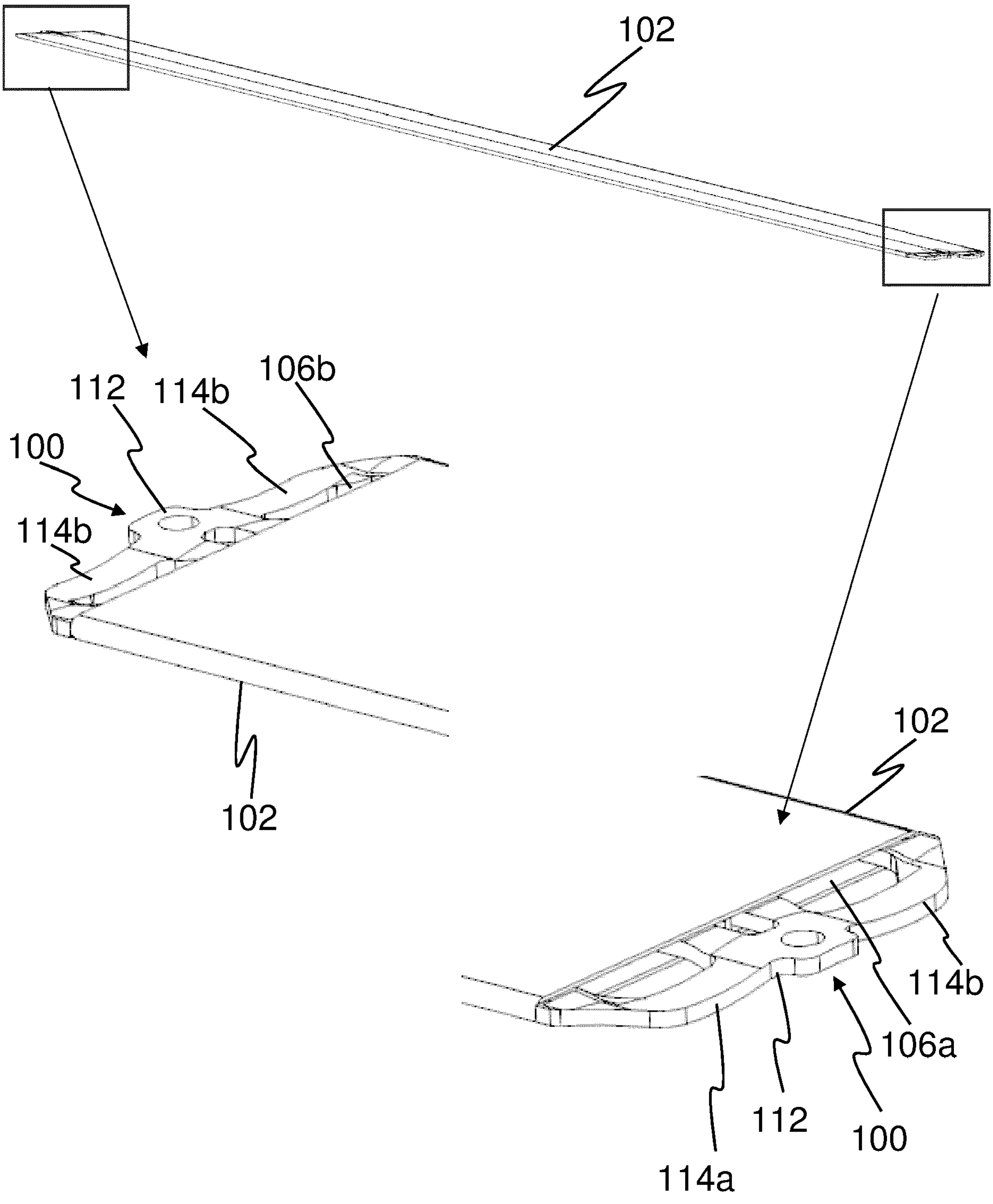
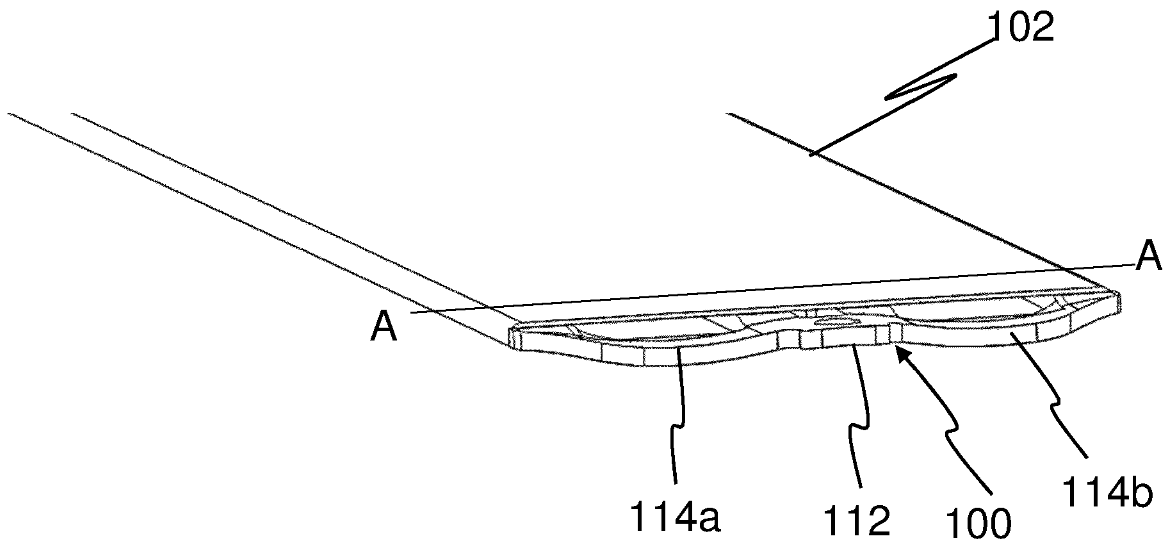
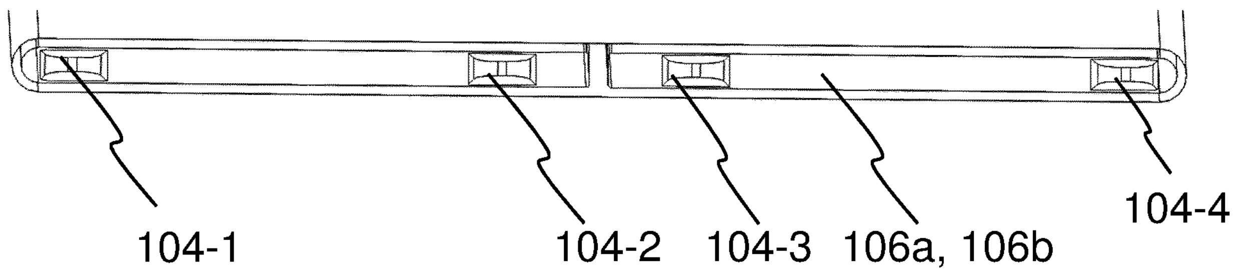


FIG. 4





SECTION A - A

FIG. 5

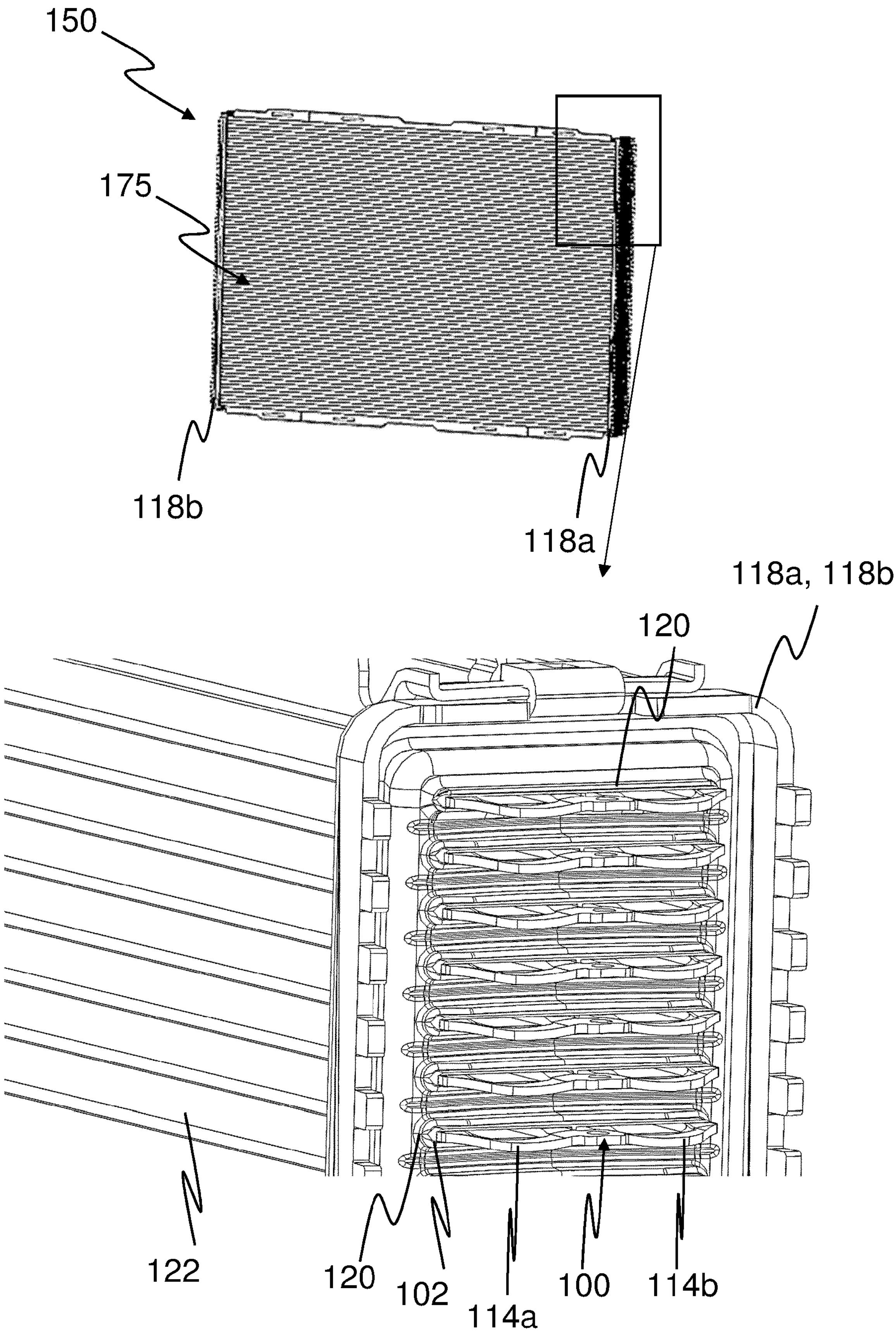


FIG. 6

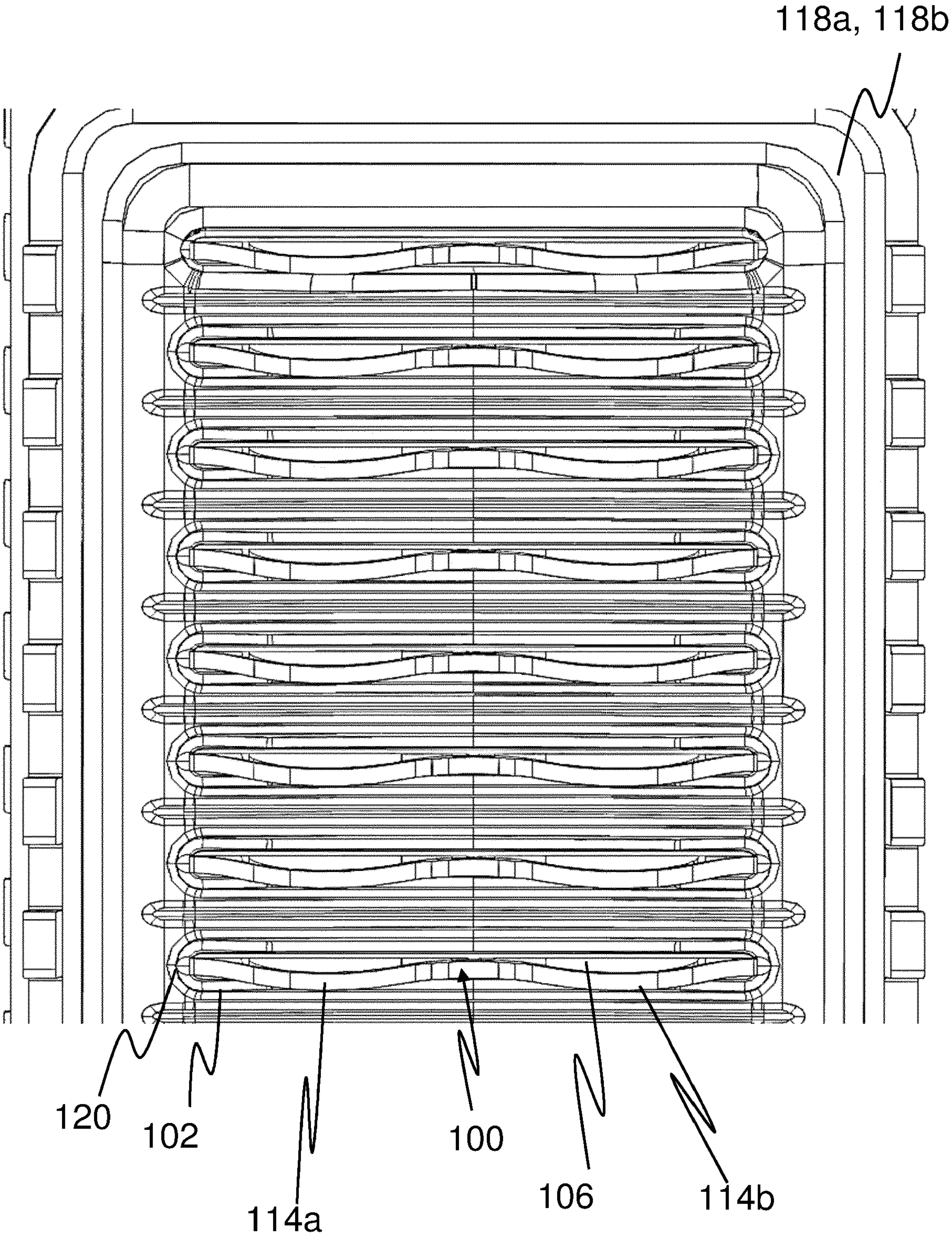


FIG. 7

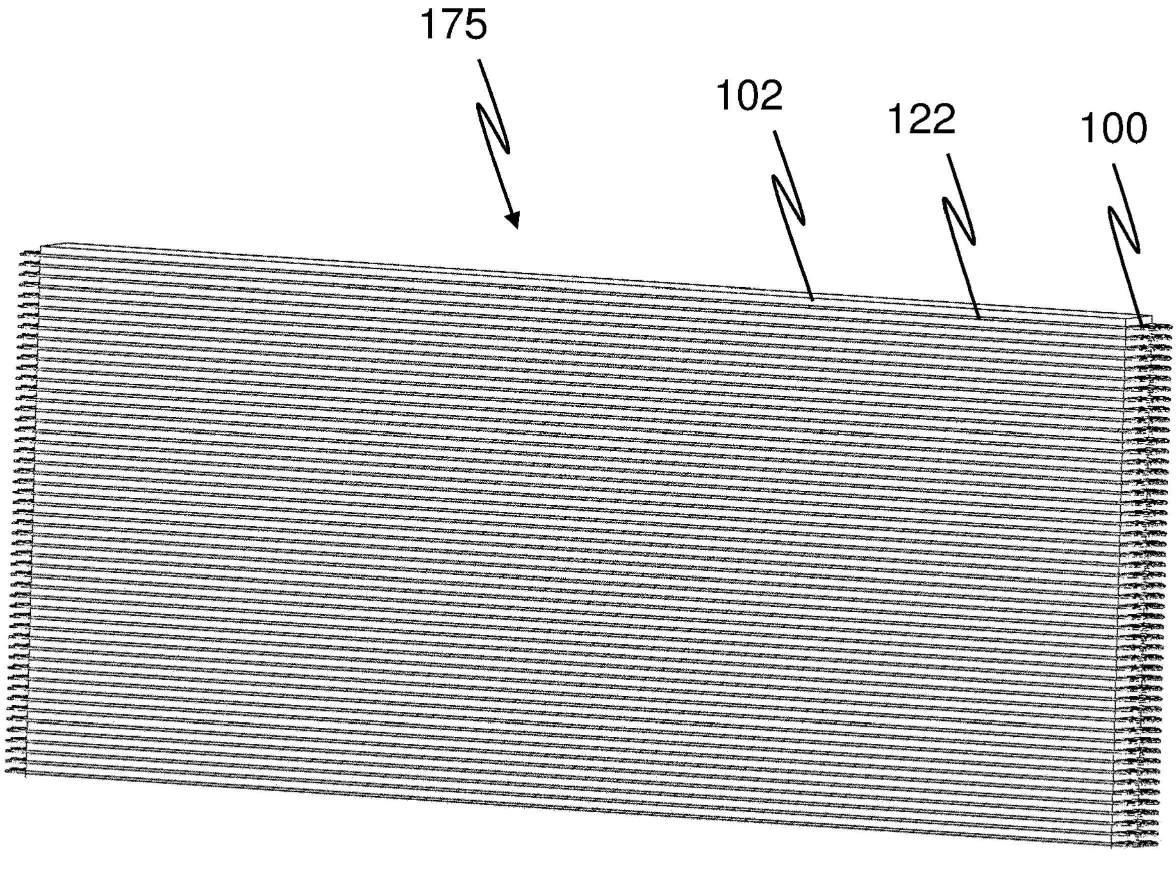


FIG. 8

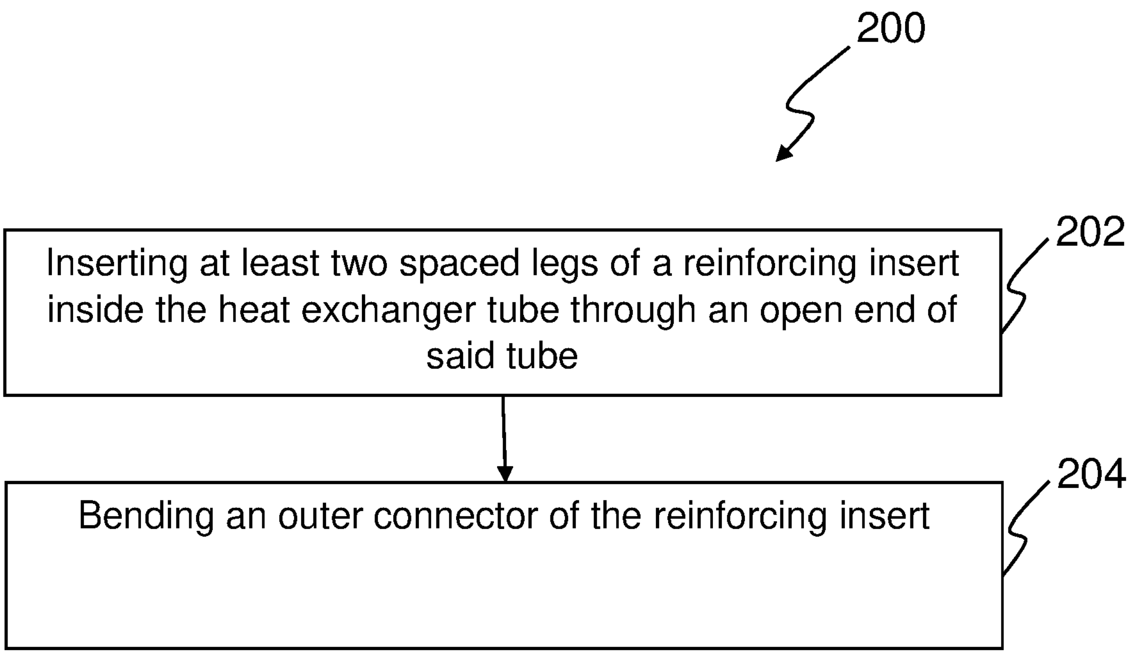

200
Inserting at least two spaced legs of a reinforcing insert inside the heat exchanger tube through an open end of said tube
202
Bending an outer connector of the reinforcing insert
204

FIG. 9

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 22 19 6352

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2005/199379 A1 (KIMURA SATOSHI [JP] ET AL) 15 September 2005 (2005-09-15) * figures 2,3 *	1-5,7-9, 12,13	INV. F28D1/053 F28F9/18 F28F9/16 ADD. F28F1/12 F28F1/02
X	WO 2019/098371 A1 (TOKYO RADIATOR SEIZO KK [JP]) 23 May 2019 (2019-05-23) * figures 2,4 *	1-4, 6-11,13	
X	US 11 143 463 B2 (DENSO INT AMERICA INC [US]; DENSO CORP [JP]) 12 October 2021 (2021-10-12) * figures 4, 6B *	1-4,6-11	
X	US 7 461 685 B2 (DENSO CORP [JP]) 9 December 2008 (2008-12-09) * figures 2,3 *	1,3,4,7, 9	
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Place of search	Date of completion of the search	Examiner
Munich	23 February 2023	Vassoille, Bruno

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