(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 751 128 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
**16.12.2020 Bulletin 2020/51**

(21) Application number: **19179512.9**

(22) Date of filing: **11.06.2019**

(51) Int Cl.:
***F02M 26/29*** *(2016.01)* ***F02M 26/32*** *(2016.01)*
***F28F 9/00*** *(2006.01)* ***F28D 21/00*** *(2006.01)*
***F28D 7/16*** *(2006.01)*

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
**BA ME**
Designated Validation States:
**KH MA MD TN**

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# (54) EXHAUST GAS RE-CIRCULATION COOLER

(57) An exhaust gas re-circulation (EGR) cooler for a vehicle is provided. The EGR cooler may include a housing and at least one corner bead. The housing having lateral walls and sidewalls connected to the lateral walls to form the housing, in which a first fluid circuit is formed in the housing to receive pulsating pressure of exhaust gas from an engine of a vehicle. The at least one corner bead formed at corners in which the lateral walls are connected with the side walls of the housing to reduce stress acting on the housing.

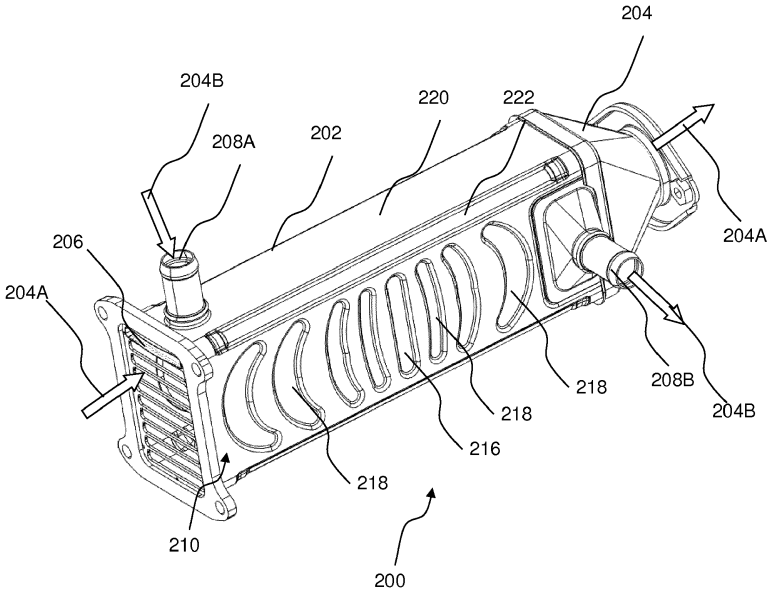


**FIG. 2A**

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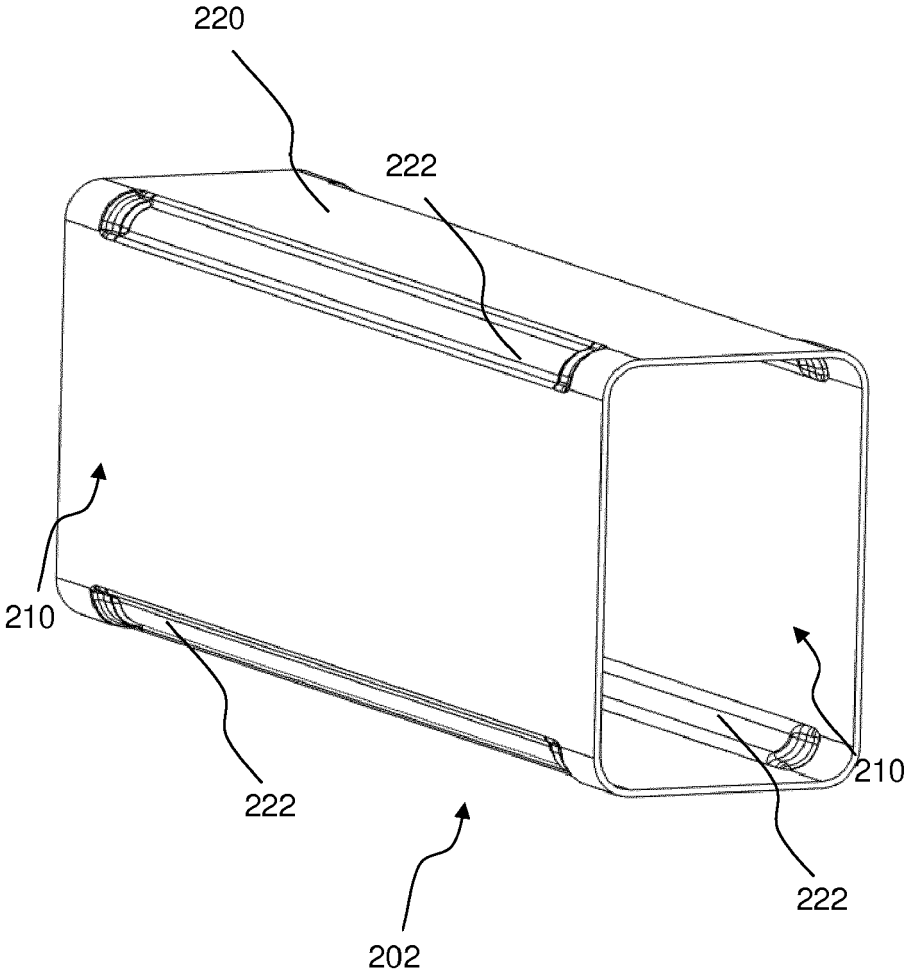



FIG. 5

## Description

**[0001]** The present invention generally relates to an Exhaust Gas Re-circulation (EGR) cooler, and in more particularly, to an Exhaust Gas Re-circulation cooler having beads to withstand pulsating pressure of exhaust gas from an engine of a vehicle.

**[0002]** Generally, an Exhaust Gas Re-circulation cooler, hereinafter referred to as EGR cooler, is provided in a vehicle to cool exhaust gas before being re-circulated to an engine of the vehicle. The EGR cooler receives a part of exhaust gas from the engine of the vehicle and the exhaust gas rejects heat to the coolant flowing in the EGR cooler. After rejecting heat, the exhaust gas can be reused in the vehicle. The exhaust gas received from the engine may be subjected to different pressure levels or pulsating pressure over a time-period based on the speed of the engine. In one example, pressure of the exhaust gas may be "P1" at time "T1", and "P2" at time "T2". As the pressure of the exhaust gas entering the EGR cooler is differential or pulsating nature, a housing of the EGR cooler may experience some stress, which leads to damages of the housing. Further, the higher stress acting on the housing may cause swelling of the housing, which may crack the housing of the EGR cooler.

**[0003]** To mitigate such problems, beads 104 are provided in housing 102 of a conventional EGR cooler 100 as shown in Fig. 1. The beads 104 are formed in lateral walls of the housing 102, with an aim of enabling the housing 102 to withstand the pulsating pressure of exhaust gas. Although the beads 104 provided in the housing 102 withstand the pulsating pressure of exhaust gas to some extent, corners and the lateral walls of the housing 102 still experience some stress Therefore, the stress acting on the housing 102 of the EGR cooler 100 needs to eliminated to improve service life of the EGR cooler 100 and to avoid cracking of the housing 102 of the EGR cooler 100.

**[0004]** Accordingly, there is a need for an EGR cooler that withstands the exhaust gas received from an engine of a vehicle and having differential pressure over the time. Further, there is a need for a housing of an EGR cooler that avoids cracking even when the housing is subjected to the exhaust gas having pulsating pressure over the time.

**[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.

**[0006]** In view of the foregoing, an embodiment of the invention herein provides an exhaust gas re-circulation (EGR) cooler for a vehicle. The EGR cooler may include a housing and at least one corner bead. The housing having lateral walls and sidewalls connected to the lateral walls to form the housing. Futher, a first fluid circuit is formed in the housing to receive pulsating pressure of exhaust gas from an engine of a vehicle. The at least one corner bead formed at corners in which the lateral walls are connected with the side walls of the housing to reduce stress acting on the housing.

**[0007]** In one embodiment, the first fluid circuit is formed by a plurality of heat exchange elements to receive pulsating pressure of exhaust gas from the engine of the vehicle.

**[0008]** In another embodiment, the housing comprises a second fluid circuit formed around the plurality of heat exchange elements to enable heat exchange between the pulsating pressure of exhaust gas and a coolant flowing in the second fluid circuit.

**[0009]** In yet another embodiment, the housing further includes a first inlet and a first outlet to ingress and egress the pulsating pressure of exhaust gas to the housing.

**[0010]** Further, the at least one corner bead provided in the housing is adapted to reduce stress acting on the housing, due to the pulsating pressure of exhaust gas, by 4%. The at least one corner bead is engraved in the housing.

**[0011]** In one embodiment, the housing further includes a second inlet and a second outlet to ingress and egress the coolant to the housing.

**[0012]** 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 a schematic representation of a conventional EGR cooler, in accordance with an embodiment of prior art;

Figs. 2A and 2B illustrate perspective views of the EGR cooler, in accordance with an embodiment of the present invention;

Fig. 2C illustrates a front view of a housing of the EGR cooler of the Fig. 2A;

Fig. 3A illustrates a perspective view of the housing of Fig. 2A having first beads, second beads and corner beads;

Fig. 3B illustrates a perspective view of a heat exchange element provided in the housing of the EGR cooler of Fig. 2A;

Fig. 4 illustrates another perspective view of the housing having the first and second beads, in accordance with another embodiment of the invention;

and

Fig. 5 illustrates another perspective view of the housing having the corner beads, in accordance with another embodiment of the invention.

**[0013]** It must be noted that the figures disclose the invention in a detailed enough way to be implemented, the figures helping to better define the invention if needs be. The invention should however not be limited to the embodiment disclosed in the description.

**[0014]** The present invention relates to an Exhaust Gas Re-circulation cooler, hereinafter referred to as EGR cooler, for a vehicle. Generally, the EGR cooler is provided at exhaust channel of an engine. The EGR cooler cools down exhaust gas before being re-circulated into the engine in-order to reduce emission of pollutant from the vehicle. The EGR cooler may receive exhaust gas from the engine with differential or pulsating pressure based on the speed of the engine. To withstand the differential pressure of exhaust gas, one or more curved beads are provided in a housing the EGR cooler. The one or more curved beads are progressively continuous curved beads to eliminate the stress acting on lateral walls of the housing. Further, corner beads are provided in the corners of the housing to eliminate stress acting on the housing due to the differential pressure of exhaust gas. As the one or more curved beads and the corner beads withstand the differential pressure of exhaust gas entering the housing and reduce stress acting on the housing, damages and cracking of the housing are mitigated which enhances service life of the EGR cooler.

**[0015]** While aspects relating to one or more curved and corner beads provided the EGR cooler as described above and henceforth can be implemented in symmetrical and non-symmetrical shapes on the lateral walls of the EGR cooler, the embodiments are described in the context of the following system(s).

**[0016]** Figs. 2A, 2B and 2C illustrate different views of an EGR cooler 200, according to an embodiment of the present invention. In one example, Figs. 2A and 2B are perspective views of the EGR cooler 200, and Fig. 2C is a front view of a housing 202 of the EGR cooler 200. The EGR cooler 200 is provided at an exhaust channel of a vehicle to receive a part of the exhaust gas from an engine of the vehicle. The EGR cooler 200 may reduce the temperature of the exhaust gas received from the engine and recirculate back to the engine. The EGR cooler 200 may include the housing 202 connected with respective tanks 204 to facilitate distribution of the exhaust gas to the housing 202 of the EGR cooler 200. For sake of brevity and clarity, single heat exchange element 206 is shown in the figure and is explained in the forthcoming sections. The housing 202 further may include a first fluid circuit 204A and a second fluid circuit 204B formed in such a way to enable heat exchange between exhaust gas flowing through the first fluid circuit 204A and coolant flowing through the second fluid circuit 204B. The first fluid circuit 204A is formed by the heat exchange element 206 to receive the exhaust gas from the engine. In one embodiment, the exhaust gas may flow through the heat exchange element 206 in the first fluid circuit 204A. The respective tanks 204 may include a first inlet and a first outlet to facilitate ingress and egress the exhaust gas to/from the tanks 204. The second fluid circuit 204B may be formed around the heat exchange element 206 and adapted to receive a coolant to enable heat exchange between the exhaust gas flowing through the heat exchanger element 206 and the coolant flowing around the heat exchanger element 206. The housing may further include a second inlet 208A and a second outlet 208B to provide the coolant and to receive the coolant from the housing 202 respectively. The EGR cooler 200 may include other elements which are necessary to function and known to the person skilled in the art.

**[0017]** The housing 202 further includes lateral walls 210 provided with a middle portion 212, a first side portion 214A, and a second side portion 214B. The middle portion 212 may be defined in center of the lateral walls 210 of the housing 202. The first side portion 214A and the second side portion 214B are formed on adjacent side of the middle portion 212 defined on the housing 202. In one example, the first side portion 214A is defined at right side with respect to the middle portion 212 and the second side portion 214B is defined at left side with respect to the middle portion 212. The housing may include one or more first beads 216 and one or more second beads 218. In one embodiment, the one or more first beads 216 are straight beads, and the one or more second beads are curved beads. In one aspect, the one or more first beads 216 are formed at the middle portion 212 of the housing 202. For the sake of brevity and clarity, the invention is explained with single first bead formed in the middle portion 212, however, it does not limit to define any number of first beads in the middle portion 212. The one or more second beads 218 are formed on the first side portion 214A and the second side portion 214B of the lateral walls 210 of the housing 202. The one or more second beads 218 are formed along a longitudinal axis on the lateral walls 210 of the housing 202 and each of the beads extend along at least a portion of the width of the housing 202. In one embodiment, the first bead 216 and the one or more second beads 218 may be in form of grooves or protruded outwards. As the exhaust gas entering into the first fluid circuit 204A is pulsating in nature, stress is formed in the housing 202. As the first bead 216 and the one or more second beads 218 are formed in the housing 202, the stress acting on the housing 202 is reduced, which mitigate cracking in the housing 202 and enhance the fatigue life span of the EGR cooler 200.

**[0018]** The housing 202 is formed by connecting the lateral walls 210 with sidewalls 220, thereby forming corners in the housing 202. In other words, corners of the housing 202 are formed by connecting the lateral walls 210 with the sidewall 220. In one embodiment, the lateral walls 210 are perpendicular to the sidewalls 220, so that

the corners are formed in the housing 202. The housing 202 further includes one or more corner beads 222, hereinafter referred to as corner bead, formed in the corner of the housing 202 to reduce stress acting at the corners of the housing 202, due to the pulsating pressure of exhaust gas entering into the housing 202. In one embodiment, the first bead 216, the second beads 218 and the corner bead 222 are engraved in the housing 202. However, present invention is not limited to any particular method of configuring the beads on the housing.

**[0019]** Fig. 3A illustrates a perspective view of the housing 202 of the EGR cooler 200. The one or more second beads 218, hereinafter referred as to second beads, being curved in such a way that the second beads 218 are progressively curved. In other words, the second beads 218 are curved in such a way that a second bead at a distal end with respect to the middle portion 212 is more curved as compared to the second bead at a proximal end with respect to the middle portion 212 of the housing 202. In one embodiment, the second beads 218 formed in the first side portion 214A and the second side portion 214B are concaved with respect to the first bead 216 provided in the middle portion 212 of the housing 202. In another embodiment, the second beads 218 formed in the first side portion 214A and the second side portion 214B may be convex with respect to the first bead 216 provided in the middle portion 212 of the housing 202. In yet another embodiment, the second beads 218 formed in the first side portion 214A of the housing 202 is convex with respect to the first bead 214 provided in the housing 202, and the second beads 218 formed in the second side portion 218B of the housing 202 is concave with respect to the first bead 214 provided in the housing 202.

**[0020]** In one aspect of the invention, a height of the first bead 216 and the second beads 218 is 53.8mm. In one embodiment, a distance between adjacent second beads 218 are in ascending with respect to the first bead 216. In other words, a distance between adjacent second beads 218 that are formed proximal with respect to the first bead 216 is less as compared to a distance between adjacent second beads 218 formed distal with respect to the first bead 216. In another aspect of the invention, the second beads 218 may include eight curved beads equally distributed in the first side portion 214A and the second side portion 214B of the lateral walls 210 of the housing 202. Further, a distance between an inner curve 302 and an outer curve 304 of the second beads 218 is 6.5mm, 8.8mm, 12.7mm and 13.5mm respectively from the second bead at the proximal end to the second bead at the distal end. According to this aspect of the invention, an inner radius of the inner curve 302 of the second beads 218 is 96mm, 37mm, 29mm and 24 mm respectively from the second bead at the proximal end to the second bead at the distal end of the housing 202. Further, an outer radius of the outer curve 304 of the second beads 218 is 110mm, 36.5mm, 29mm, and 26.5mm respectively from the second bead at the proximal end to the second bead at the distal end of the housing 202. In one embodiment, the first bead 216 being a straight bead having a width of 8.6mm. Further, the first bead 216, the second beads 218, and the corner bead 222 provided in the EGR cooler 200 may reduce the stress by 10% as compared to the conventional EGR cooler 100 having only straight beads as shown in Fig. 1A. Further, life of the EGR cooler 200 is increased by 22 times as compared to the conventional EGR cooler 100, due to reduced stress level in the housing 202. In another embodiment, the conventional EGR cooler 100 may experience stress of 139 Mpa when it is connected to the exhaust of the vehicle, whereas the proposed EGR cooler 200 may experience 126 Mpa when it is connected to the exhaust of the vehicle.

**[0021]** Fig. 3B illustrates a perspective view of a heat exchanger element amongst the plurality of heat exchange elements 206 disposed inside the EGR cooler 200 of Fig. 2A. The plurality of heat exchanger elements 206 can be heat exchange tubes or plates stacked together. The first fluid circuit 204A is formed in such a way that the exhaust gas passes through the plurality of heat exchange elements 206 to enable heat exchange between the exhaust gases flowing through the heat exchange elements 206 and coolant flowing around the plurality of heat exchange elements 206.

**[0022]** Fig. 4 illustrates a perspective view of the housing 202 of Fig. 2A, in accordance with another aspect of the invention. In this aspect of the invention, the housing 202 may include the first bead 216 and the second bead 218 provided in the lateral walls 210 of the housing 202. The EGR cooler 200, according to this aspect, having the first bead 216 and the second beads 218 may reduce stress by 6% from the conventional EGR cooler 100 as shown in Fig. 1A. The EGR cooler 200, according to this aspect of the invention, may include the first bead 216 and the second beads 218. In one embodiment, the EGR cooler 200 having the first and second beads 216, 218 may experience stress of 131 MPa when it is connected to the exhaust of the vehicle, which is less than the stress acting on the conventional EGR cooler 100. As the stress experiencing in the EGR cooler 200 is reduced as compared to the conventional EGR cooler 100, cracking in the housing 202 is mitigated and the fatigue life span of the EGR cooler 200 is enhanced.

**[0023]** Fig. 5 illustrates another perspective view of the housing 202 of the EGR cooler 200 of Fig. 2A, in accordance with another aspect of the invention. In this aspect, the housing 202 may include the corner bead 222 alone, provided on the corner of the housing 202. The corner bead 222 is adapted to reduce stress acting on the housing 202 of the EGR cooler 200 by 4% from the conventional EGR cooler 100. In one embodiment, the EGR cooler 200 having the corner beads 222 may experience stress of 135 MPa when it is connected to the exhaust of the vehicle, which is less than of the stress acting on the conventional EGR cooler 100. As the stress experiencing in the EGR cooler 200 is reduced as compared to the conventional EGR cooler 100, cracking in the hous-

ing 202 is mitigated and the fatigue life span of the EGR cooler 200 is enhanced.

**[0024]** Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that the invention may be practiced otherwise than as specifically described herein.

**[0025]** 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. An Exhaust Gas Re-circulation (EGR) cooler (200), comprising:

   a housing (202) having lateral walls (210) and sidewalls (220), wherein the lateral walls (210) and the sidewalls (220) connected together to form the housing (202), wherein a first fluid circuit (204A) is formed in the housing (202) to receive pulsating pressure of exhaust gas from an engine of a vehicle; and
   at least one corner bead (222) formed at corners in which the lateral walls (210) are connected with the sidewalls (220) of the housing (202) to reduce stress acting on the housing, due to pulsating pressure of exhaust gas entering into the housing (202).

2. The Exhaust Gas Re-circulation cooler (200) as claimed in claim 1, wherein the first fluid circuit (204A) is formed by a plurality of heat exchange elements (206) to receive pulsating pressure of exhaust gas from the engine of the vehicle.

3. The Exhaust Gas Re-circulation cooler (200) as claimed in claim 1, wherein the housing (202) comprises a second fluid circuit (204B) formed around the plurality of heat exchange elements (206) to enable heat exchange between the pulsating pressure of exhaust gas and a coolant flowing in the second fluid circuit (204B).

4. The Exhaust Gas Re-circulation cooler (200) as claimed in claim 3, wherein the at least one corner bead (218) provided in the housing (202) is adapted to reduce stress acting on the housing (202), due to the pulsating pressure of exhaust gas, by 4%.

5. The Exhaust Gas Re-circulation cooler (200) as claimed in claim 1, wherein the at least one corner bead (222) is engraved in the housing (202).

6. The Exhaust Gas Re-circulation cooler (200) as claimed in any of preceding claims, the housing (202) further includes a first inlet and a first outlet to ingress and egress the pulsating pressure of exhaust gas to the housing (202).

7. The Exhaust Gas Re-circulation cooler (200) as claimed in any of preceding claims, the housing (202) further includes a second inlet (208A) and a second outlet (208B) to ingress and egress the coolant to the housing (202).

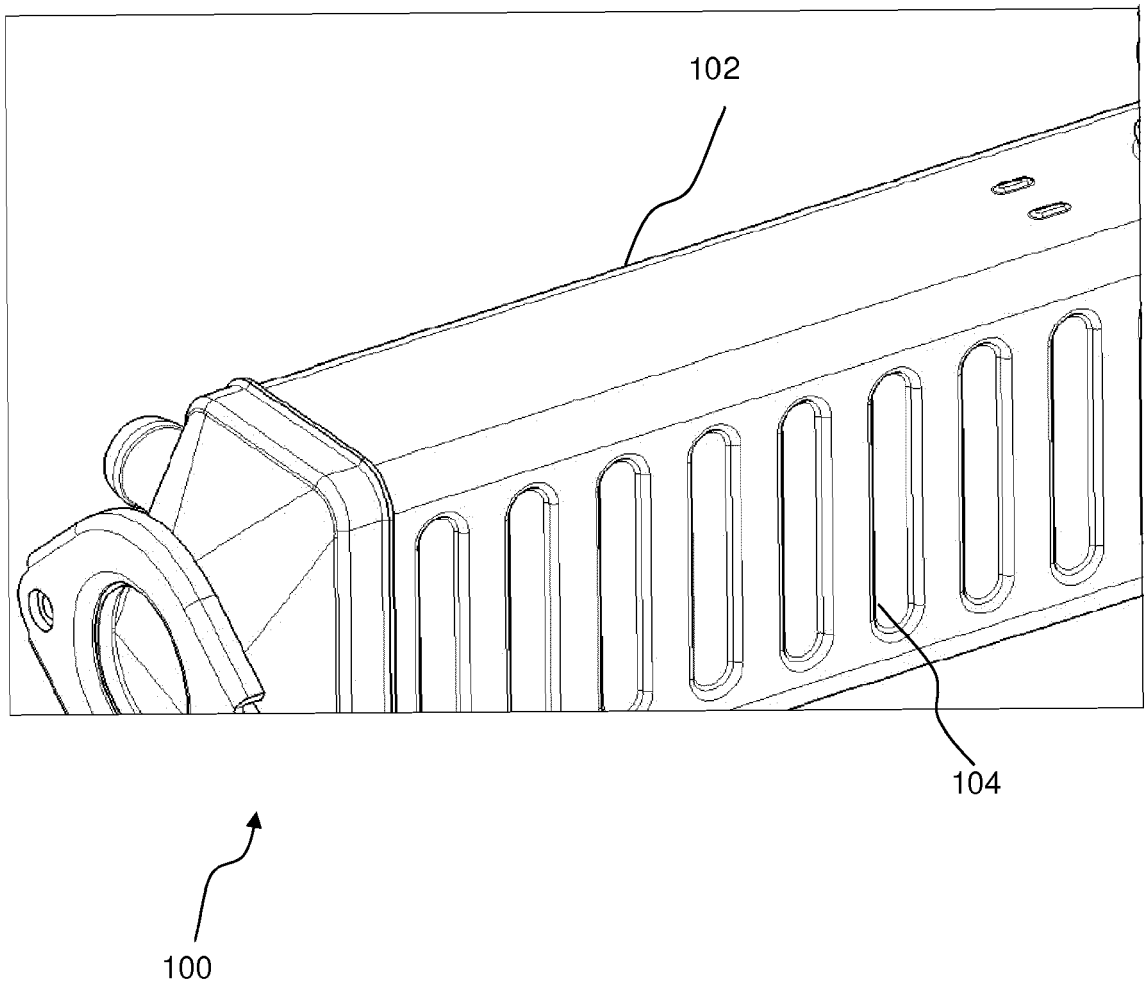
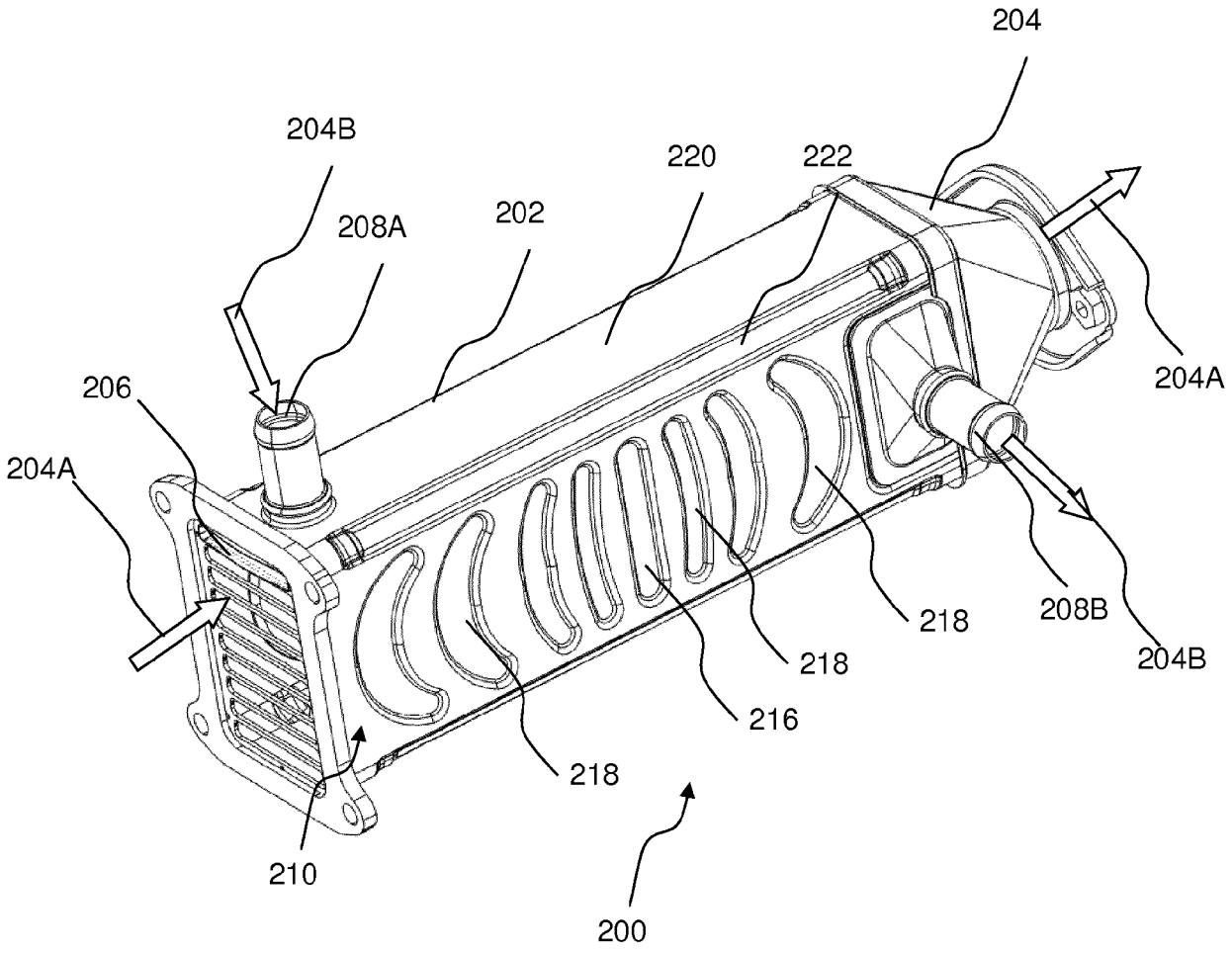



FIG. 1 (Prior Art)


204
204B
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200

FIG. 2A

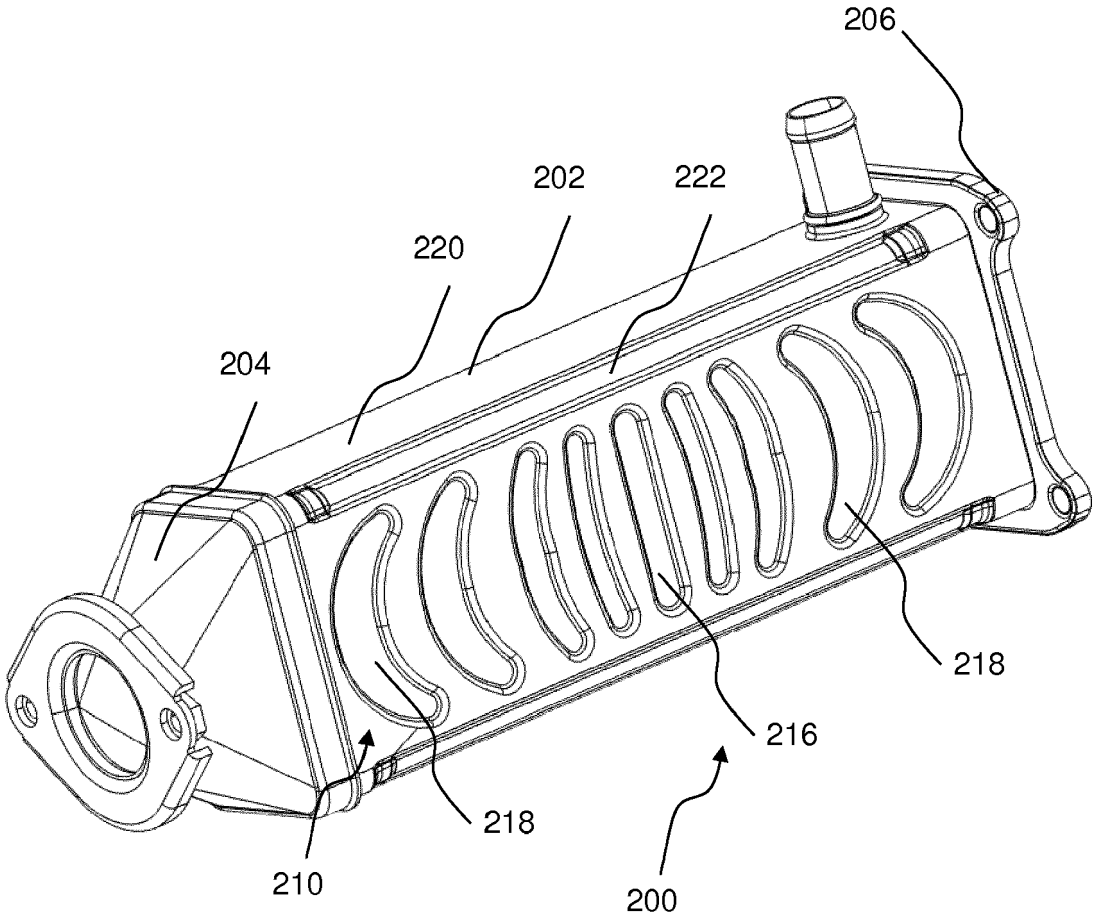


FIG. 2B

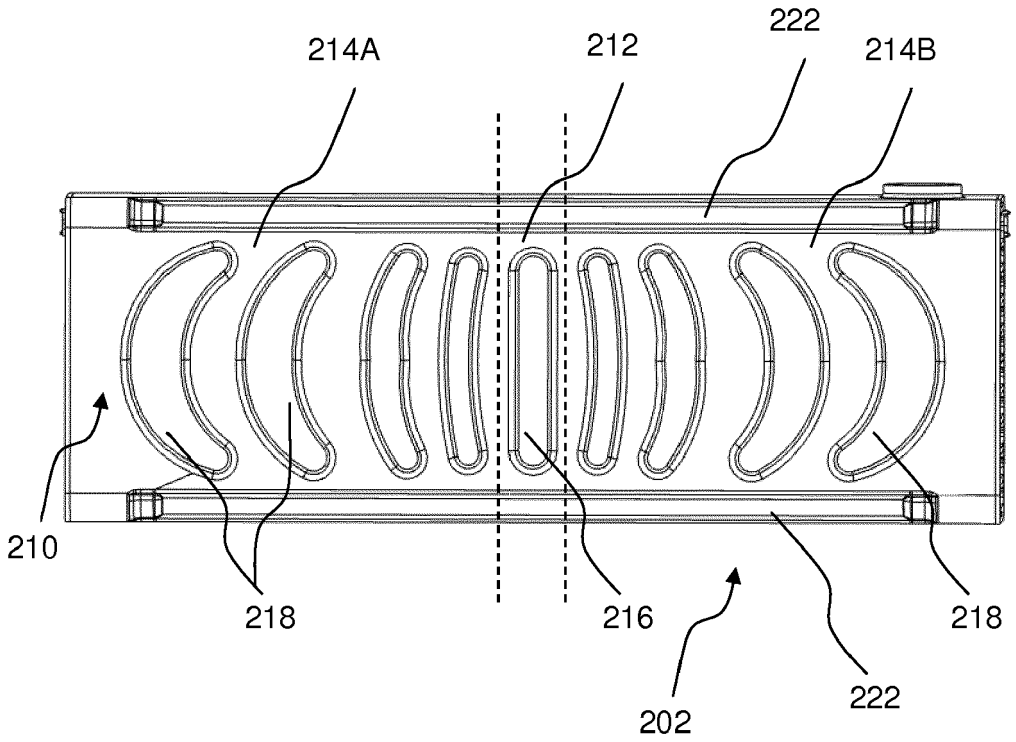


FIG. 2C

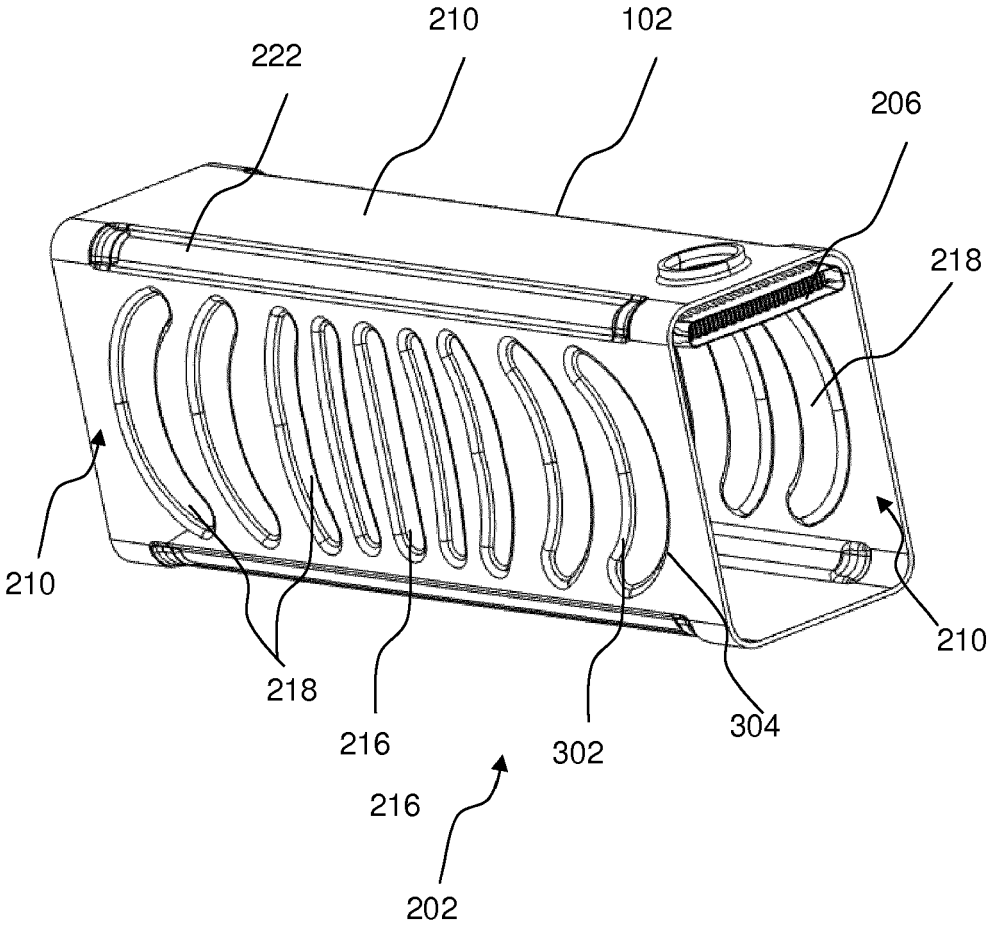


FIG. 3A

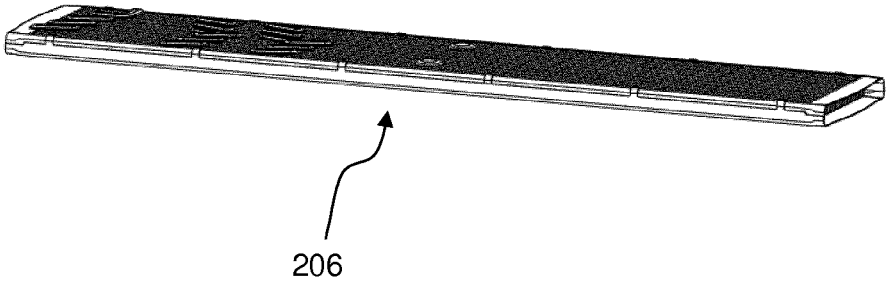


FIG. 3B

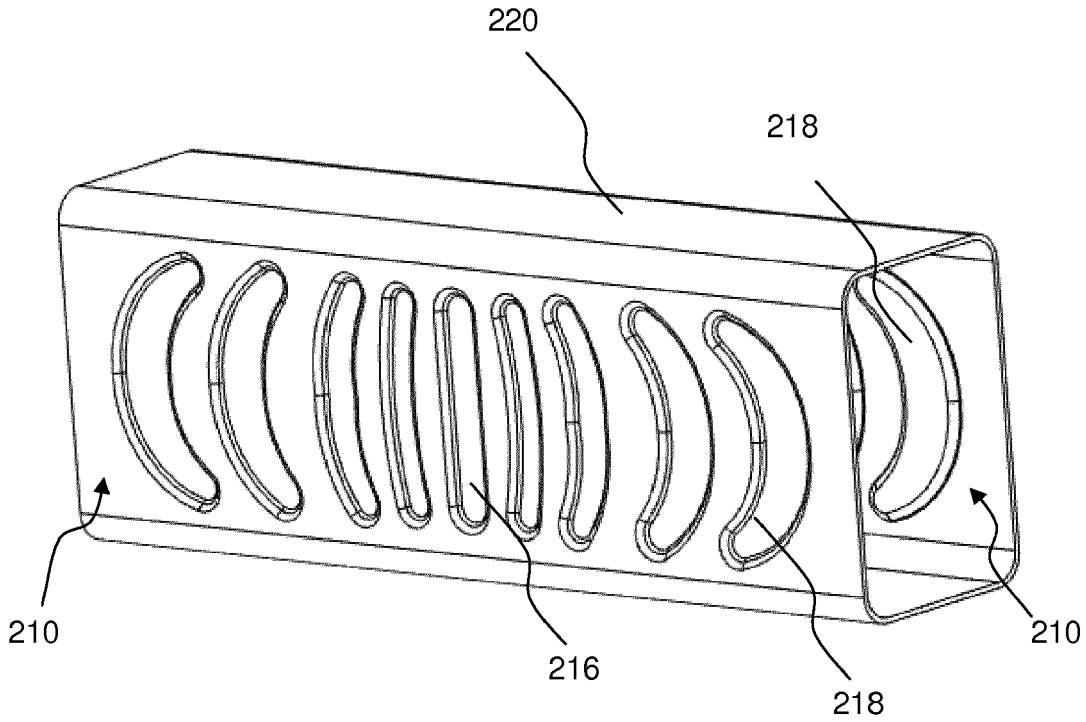


FIG. 4

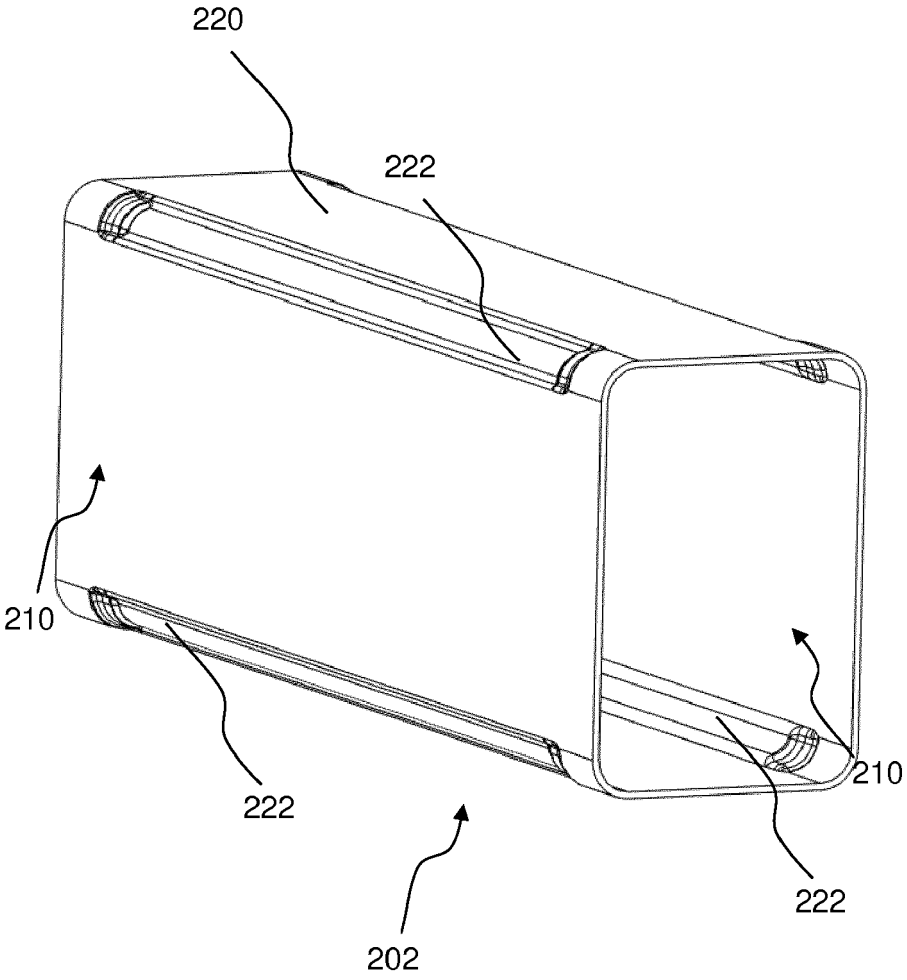


FIG. 5

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# EUROPEAN SEARCH REPORT

Application Number
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| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
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TECHNICAL FIELDS SEARCHED (IPC)

F02M
F28F
F28D

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 12 November 2019 | Karstens, Thede |

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