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(54) **AN EXHAUST GAS RE-CIRCULATION (EGR) COOLER**

(57) A heat exchanger is disclosed in accordance with an embodiment of the present invention. The heat exchanger includes a housing formed of a first portion and a second portion that are separate from each other and that are joined to configure an enclosure to encapsulate a heat exchange core. The heat exchanger core includes a plurality of heat exchange tubes. At least one of the first portion and the second portion of the housing includes slots to receive respective ends of the heat exchange tubes.

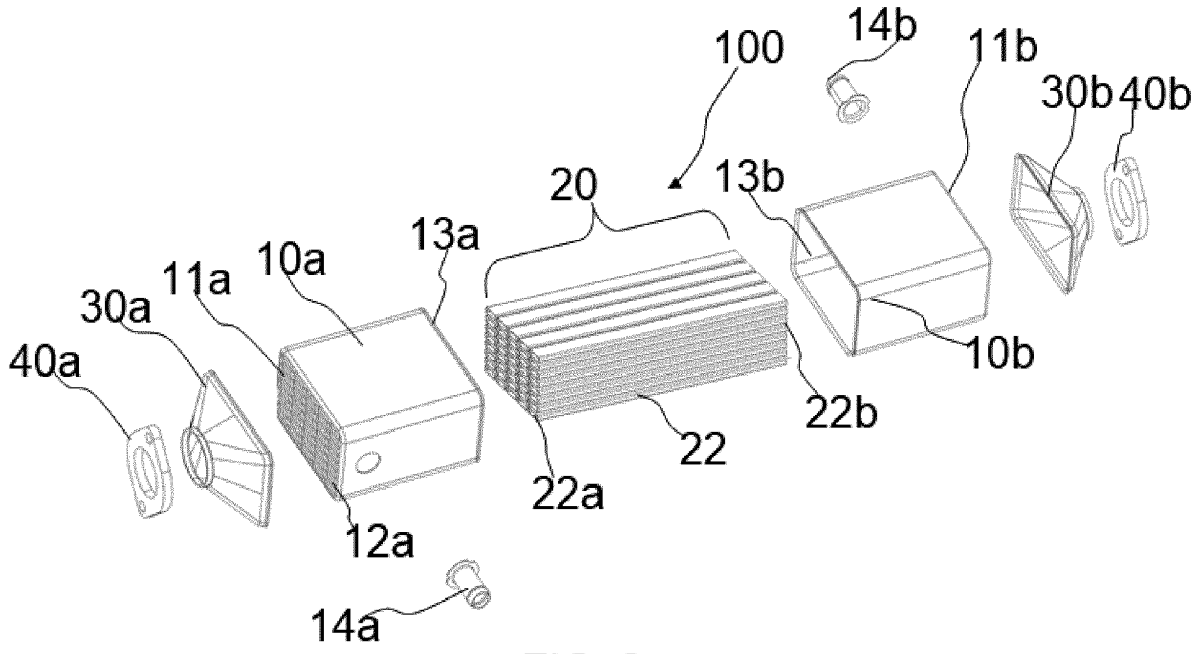

FIG. 2

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Description

[0001] The present invention relates to a heat exchanger, particularly, to an Exhaust Gas Re-circulation (EGR) cooler for a vehicle.

Background of the invention:

[0002] An Exhaust Gas Re-circulation (EGR) system re-circulates a portion of an engine's exhaust gas back to the engine's cylinders. By re-circulating the engine's exhaust gas back to the engine's cylinder, peak in-cylinder temperatures are regulated, specifically, lowered to reduce formation of NOx gases. The exhaust gas re-circulation (EGR) system may further include a heat exchanger such as for example an Exhaust Gas Re-circulation (EGR) cooler that cools the exhaust gas before the exhaust gas is re-circulated into an intake manifold of the engine. The EGR cooler further reduces the combustion chamber temperature, thereby preventing valve clatter, detonation and further reduces NO_x formation. As a result, the Exhaust Gas Re-circulation (EGR) system substantially reduces vehicle emissions to enable meeting stringent vehicular exhaust emission norms prevalent in most parts of the world.

[0003] Referring to **FIG. 1a** and **FIG. 1b** of the accompanying drawings, a conventional heat exchanger, such as for example, an Exhaust Gas Re-circulation (EGR) cooler **01** includes a pair of spaced apart headers **02a** and **02b** connected to two distant and opposite end portions of a heat exchanger core **03.** The heat exchanger core **03** is configured of a plurality of heat exchange elements, particularly, heat exchange tubes **03a** and a plurality of fin elements **03b** (not illustrated in **FIGS.**) lodged between the adjacent heat exchange tubes **03a.** The headers **02a** and **02b** are configured with slots for receiving end portions of the heat exchange tubes **03a.** The end portions of the heat exchange tubes **03a** are joined to inside walls defining the slots configured on the headers **02a** and **02b** for connecting the headers **02a** and **02b** to the heat exchanger core **03.** Such configuration facilitates distribution of first heat exchange fluid, particularly, exhaust gases to be cooled, to and collection of first heat exchange fluid from the heat exchange core **03** respectively. A Housing **04** receives second heat exchange media, particularly coolant therein and around the heat exchange tubes **03a** through at least one inlet **4a.** The second heat exchange media or coolant is delivered out of the housing **04** through at least one outlet **04b** after the coolant has extracted heat from the first heat exchange fluid, particularly, the exhaust gases flowing through the heat exchange tubes **03a.** The heat exchanger core **03** is received inside the housing **04** such that the heat exchange elements **3a** in conjunction with the housing **04** configure adjacent yet separated spaces between the headers **02a** and **02b** for facilitating heat exchange between first heat exchanging fluid flowing inside the heat exchange tubes **03a** and second heat exchange fluid flowing outside the heat exchange tubes **03a.** The exhaust gas re-circulation (EGR) cooler **01** further includes a pair of heat exchanger tanks **06a** and **06b,** hereinafter referred to as tanks, wherein each tank **06a, 06b** is joined to the corresponding header **02a** and **02b** for configuring a sealed connection between the headers **02a, 02b** and the corresponding tanks **06a, 06b.** The tanks **06a, 06b** are capable of receiving first heat exchanging fluid, often pressurized heat exchanging fluid such as exhaust gases and the tanks **06a** and **06b** in conjunction with the corresponding headers **02a** and **02b** facilitate distribution of first heat exchange fluid to and collection of first heat exchange fluid from the heat exchange core **03** respectively. The tanks **06a** and **06b** are further connected to respective flanges **08a** and **08b.**

[0004] However, there are several drawbacks associated with the conventional EGR coolers. Specifically, in case of the conventional EGR coolers, the single housing **04** is connected to the separate headers **02a** and **02b,** such configuration involves more number of components and more number of process or assembly steps, and accordingly, higher overall cost due to higher product and process costs. As along with functional parameters such as thermal efficiency and pressure drop across the heat exchanger, for example, the EGR cooler, cost of the EGR coolers is also a crucial selection parameter considered while selecting the EGR coolers, hence, there is need for reducing the overall cost of the EGR cooler. The overall cost of the EGR cooler has two parts, i.e. product cost and process cost. The product cost is determined based on number of components required for configuring the EGR cooler, whereas the process cost is determined based on the processes and steps involved in manufacturing the EGR cooler, for example, steps involved in joining or assembling the various components configuring EGR cooler. The conventional heat exchanger, particularly, EGR cooler involves large number of components, joining and assembly steps for configuring the EGR cooler and as such the product and process costs associated with the EGR cooler are high. Accordingly, the overall cost of the EGR cooler is high. The product cost and the process cost can be reduced by reducing the number of the components or assembly steps required for configuring the EGR cooler. Accordingly, there is a need for a heat exchanger configured of comparatively fewer components than conventional heat exchangers, thereby reducing the product costs. Also, there is a need for a heat exchanger that involves comparatively fewer assembly or manufacturing steps for manufacturing thereof than conventional heat exchanger, thereby reducing the process costs.

[0005] The overall costs can further be reduced by using more standard components of predetermined size. However, in case of the conventional EGR cooler with single housing configuration, there are fewer number of standard parts used for manufacturing different configurations of EGR cooler. Each time the configuration of the EGR cooler changes, a different housing is required to

be manufactured.

Description of the invention:

[0006] An object of the present invention is to provide a heat exchanger that is comparatively inexpensive than conventional heat exchangers.

[0007] Another object of the present invention is to provide a heat exchanger that is configured of comparatively fewer components than conventional heat exchangers, thereby reducing the product costs.

[0008] Still another object of the present invention is to provide a heat exchanger that eliminates certain joining and assembly processes involved in configuring the EGR cooler, thereby involves comparatively fewer manufacturing steps and lesser process costs than conventional heat exchangers.

[0009] Another object of the present invention is to use more number of standard components for configuring different EGR coolers.

[0010] Yet another object of the present invention is to provide a heat exchanger that is simple in construction, convenient to assembly and manufacture.

[0011] 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.

[0012] A heat exchanger is disclosed in accordance with an embodiment of the present invention. The heat exchanger includes a housing formed of a first portion and a second portion that are separate from each other and that are joined to configure an enclosure to encapsulate a heat exchange core. The heat exchanger core includes a plurality of heat exchange tubes. At least one of the first portion and the second portion of the housing includes slots to receive respective ends of the heat exchange tubes.

[0013] Specifically, the first portion is a tubular structure that includes a closed end with slots formed thereon, an open end and side walls joining the closed end to the open end, the second portion is a tubular structure complimentary to the first portion and includes a closed end with slots formed thereon, an open end and side walls joining the closed end to the open end.

[0014] Generally, the open ends of the respective first portion and the second portion are joined by at least one of laser welding and brazing to configure the enclosure with an interface at the joint between the first portion and the second portion.

[0015] Specifically, the open ends of the respective first portion and the second portion are joined by either one of butt welding and overlap welding to configure the enclosure with the interface at the joint between the first portion and the second portion.

[0016] In a preferred embodiment of the present invention, the first portion and the second portion are identical and symmetric with respect to the interface.

[0017] Alternatively, the first portion and the second portion are different and non-symmetric with respect to the interface.

[0018] Specifically, the first portion and the second portion are formed by either one of deep drawing and stamping.

[0019] Further, at least one of the first portion and the second portion is joined to the respective tanks, the slots configured on the first portion and the second portion in conjunction with the respective tanks facilitate distribution of first heat exchange fluid to and collection of first heat exchange fluid from the heat exchange tubes respectively.

[0020] Generally, the tanks are connected to corresponding flanges.

[0021] Further, the heat exchanger includes at least one inlet and at least one outlet, the at least one inlet receives second heat exchange fluid inside the housing and around the heat exchange tubes, whereas the at least one outlet delivers second heat exchange fluid out of the housing.

[0022] In accordance with an embodiment of the present invention, the housing further includes at least one intermediate portion disposed between the first portion and the second portion and adapted to configure joint there between.

[0023] A method of assembling a heat exchanger is disclosed in accordance with an embodiment of the present invention. The method includes the steps of selecting a first portion and a separate second portion of the housing based on desired overall length of the housing. The first portion is a tubular structure that includes a closed end with slots formed thereon, an open end and side walls joining the closed end to the open end. The second portion is also a tubular structure complimentary to the first portion and includes a closed end with slots formed thereon, an open end and side walls joining the closed end to the open end. Thereafter, the first portion receives at least a portion of a plurality of heat exchange tubes of a heat exchange core and slots formed on the first portion receives first end of the heat exchange tubes. Similarly, the second portion receives remaining portion of the heat exchange tubes and slots formed on the second portion receives second end of the heat exchange tubes opposite to the first end. Thereafter, joining by at least one of brazing and laser welding, the open ends of the respective first portion and the second portion to each other, the ends of the heat exchange tubes to inside walls defining the slots respectively, tanks to the first portion and the second portion respectively, and flanges to the first tank and the second tank respectively.

[0024] Specifically, the first portion and the second portion are formed by either one of deep drawing and stamping.

[0025] Generally, the step of joining the open ends of the respective first portion and the second portion involves directly joining the open ends to each other.

[0026] Alternatively, the step of joining the open ends of the respective first portion and the second portion to each other involves disposing at least one intermediate tubular element between the first portion and the second portion and joining the ends of the intermediate portion to the first portion and the second portion respectively.

[0027] Further, the step of joining the open ends of the respective first portion and the second portion to each other, the ends of the heat exchange tubes to inside walls defining the slots respectively, the tanks to the first portion and the second portion respectively and flanges to the first tank and the second tank respectively involves arranging all components to be joined in pre-braze assembled configuration and subjecting to brazing in a brazing furnace.

Brief description of the drawings:

[0028] 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. 1a illustrates a conventional heat exchanger, wherein housing is a single piece component, and the housing and collector plates are separate components;

FIG. 1b illustrates an exploded view of the conventional heat exchanger of **FIG. 1a;**

FIG. 2 illustrates an exploded view of a heat exchanger in accordance with an embodiment of the present invention;

FIG. 3a illustrates an assembled view of the heat exchanger of **FIG. 2;**

FIG. 3b illustrates a first housing portion of the heat exchanger of **FIG. 3a** with slots formed on a closed end thereof;

FIG. 3c illustrates a second housing portion of the heat exchanger of **FIG. 3a** with slots formed on a closed end thereof;

FIG. 4a illustrates a front view of the heat exchanger of **FIG. 2;**

FIG. 4b illustrates a sectional view of the heat exchanger along section line A-A' of **FIG. 4a;**

FIG. 5a illustrates a left side view of the heat exchanger of **FIG. 2;**

FIG. 5b illustrates a sectional view of the heat exchanger along section line B-B' of **FIG. 5a;** and

FIG. 6 illustrates an assembled view of the heat exchanger in accordance with yet another embodiment of the present invention; and

FIG. 7 illustrates a flow chart depicting various steps involved in assembling a heat exchanger in accordance with an embodiment of the present invention.

[0029] 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.

Detailed description of the preferred embodiments:

[0030] An Exhaust Gas Re-circulation cooler, hereinafter referred to as an EGR cooler is disclosed in accordance with an embodiment of the present invention. The EGR cooler of the present invention involves fewer components and fewer manufacturing and assembly steps as compared to a conventional EGR cooler and as such EGR cooler of the present invention is comparatively inexpensive as compared to the conventional EGR coolers. The EGR cooler includes a housing formed of a first portion and a second portion joined to configure an enclosure to encapsulate a heat exchange core. The heat exchanger core includes a plurality of heat exchange tubes and fins lodged between the heat exchange tubes. At least one portion of the housing itself includes slots that receive respective ends of the heat exchange tubes, thereby performing function of the headers and eliminating the headers. By eliminating the header, the process steps involved in configuring joint between the header and the tanks are also eliminated. Accordingly, the overall cost of the EGR cooler is reduced. The at least one of the first portion and the second portion is further connected to respective tanks. Although, the heat exchanger of the present invention is explained in the forthcoming description with example of an EGR cooler, however, present invention is not limited to EGR coolers only and is applicable to any heat exchanger used in vehicular as well as non vehicular environment.

[0031] **FIG.1a** illustrates an assembled view of a conventional heat exchanger, particularly an EGR cooler **01. FIG. 1b** illustrates an exploded view of the conventional heat exchanger, particularly the EGR cooler **01.** The conventional EGR cooler **01** includes a pair of headers or collector plates **02a** and **02b,** one housing **04** with an inlet **04a** and an out let **04b,** a pair of tanks **06a** and **06b,** a pair of flanges **08a** and **08b** and a heat exchanger core **03** formed by assembling a plurality of heat exchange

tubes **03a** and fins **03b** lodged between the adjacent heat exchange tubes **03a.** The housing **04** of the conventional EGR cooler **01** is a single piece, non-standard component and as such different size of housing **04** is used based on different configuration of the EGR cooler **01** to be formed thereby. Further, the collector plates or headers **02a** and **02b** are separate components that are joined to the housing **04** by any of the joining processes. Specifically, the headers **02a** and **02b** are joined to opposite ends of the housing 04 by any of the joining processes such as brazing or laser welding. In case the headers **02a** and **02b** are joined to the opposite ends of the housing **04** by laser welding, more process steps are involved. Even in case the joint between headers **02a** and **02b** and the opposite ends of the housing **04** is configured by brazing along with other joints by arranging all components to be joined in a pre-brazing assembled configuration and subjecting all the components to brazing inside a brazing furnace, still the headers **02a** and **02b** and the opposite ends of the housing **04** are required to be arranged in pre-brazing assembled configuration for configuring the brazing joint there-between. As such irrespective of the process by which the headers **02a** and **02b** are joined to opposite ends of the housing **04,** the conventional EGR cooler requires additional process steps for configuring joint between the headers **02a** and **02b** and the opposite ends of the housing **04.**

[0032] **FIG. 2** illustrates an exploded view of a heat exchanger, particularly an EGR cooler **100** in accordance with an embodiment of the present invention. The EGR cooler **100** includes housing **10** formed of at least two separate portions **10a** and **10b,** a heat exchange core **20** configured of a plurality of heat exchange tubes **22** and fins **24** lodged between the adjacent heat exchange tubes **22,** a pair of heat exchanger tanks **30a** and **30b** and a pair of flanges **40a** and **40b.**

[0033] The first portion **10a** is a tubular structure that includes a closed end **11a** with slots **12a** formed thereon, an open end **13a** and side walls **15a** joining the closed end **11a** to the open end **13a.** Similarly, the second portion **10b** is also a tubular structure complimentary to the first portion **10a** and includes a closed end **11b** with slots **12b** formed thereon, an open end **13b** and side walls **15b** joining the closed end **11b** to the open end **13b.** The first portion **10a** and the second portion **10b** of the housing **10** are joined to configure an enclosure as illustrated in **FIG. 3a.** The enclosure so configured is capable of encapsulating the heat exchange core **20,** particularly, the plurality of heat exchange tubes **22** and the fins **24.** Specifically, the **FIG. 3a** illustrates an assembled view of the EGR cooler **100.** More specifically, the open ends **13a** and **13b** of the first portion **10a** and the second portion **10b** respectively abut against each other and are joined together to configure the enclosure with an interface **10c** at the joint between the first portion **10a** and the second portion **10b.** At least one of the first portion **10a** and the second portion **10b** of the housing **10** includes the slots **12a, 12b** formed thereon. In a preferred embodiment, the portions **10a** and **10b** of the housing **10** include the slots **12a** and **12b** to receive the respective ends **22a** and **22b** of the heat exchange tubes **22.** More specifically, the closed ends **11a** and **11b** of the first portion **10a** and the second portion **10b** configured with the slots **12a** and **12b** function as the collector plates. **FIG 3b** illustrates the first portion **10a** with the slots **12a** formed on the closed end **11a** thereof. **FIG. 3c** illustrates the second housing portion **10b** with the slots **12b** formed on the closed end **11b** thereof.

[0034] The slots **12a** configured on the closed end **11a** of the first portion **10a** and the slots **12b** configured on the closed end **11b** of the second portion **10b** receive the respective ends **22a** and **22b** of the heat exchange tubes **22.** More specifically, the slots **12a** and **12b** configured on the closed ends **11a** and **11b** of the first portion **10a** and the second portion **10b** receive the respective ends **22a** and **22b** of the heat exchange tubes **22** in a spaced configuration to facilitate distribution of first heat exchange fluid to and collection of first heat exchange fluid from the heat exchange core **20** respectively. In accordance with an embodiment of the present invention, joint between the ends **22a** and **22b** of the heat exchange tubes **22** and inside walls defining the slots **12a** and **12b** is achieved by brazing. More specifically, the ends **22a** and **22b** of the heat exchange tubes **22** are arranged inside the slots **12a** and **12b** along with other components to be joined to define a pre-braze assembled configuration and subjected to brazing inside the brazing furnace for configuring brazing joint between the heat exchange tubes **22** and the walls defining the slots **12a** and **12b** along with brazing joint between the respective other components.

[0035] In one embodiment, the open ends **13a** and **13b** of the first portion **10a** and the second portion **10b** respectively are joined by either one of laser welding and brazing to configure the interface **10c.** In accordance with another embodiment, the first portion **10a** and the second portion **10b** of the housing are arranged in configuration to be joined along with the other components to be joined to define pre-braze assembled configuration and subjected to brazing inside the brazing furnace for configuring brazing joint between the first portion **10a** and the second portion **10b** along with brazing joints between the respective other components. As such most of the components to be joined for configuring the EGR cooler **100** are joined by the single step brazing process. However, the present invention is not limited to any particular method of joining the first portion **10a** to the second portion **10b.**

[0036] With such configuration, the housing **10** is performing functions of two components thereby eliminating one component. More specifically, which such configuration, the housing **10** not only performs its primary function of encapsulating the heat exchange core **20** but also performs the function of the collector plates and the collector plates that are essential components of the conventional heat exchanger are no longer required. Com-

paring exploded views of the conventional EGR cooler **01** and the EGR cooler **100** of the present invention, it is evident that the EGR cooler **100** of the present invention requires comparatively fewer components as compared to the conventional EGR cooler **01.** By elimination of the components, particularly, elimination of the collector plates, the product costs of the EGR cooler **100** is reduced. Also, with such configuration of the EGR cooler **100,** the process steps required for configuring the joint between the opposite ends of the housing and the collector plates are eliminated. With such configuration, process cost savings are achieved. The housing **10** configured by joining the first portion **10a** and the second portion **10b** further includes at least one inlet **14a** and at least one outlet **14b.** The at least one inlet **14a** receives second heat exchange fluid inside the housing **10** and around the heat exchange tubes **22.** The at least one outlet **14b** delivers second heat exchange fluid out of the housing **10.** With such configuration, the first heat exchange fluid, particularly, the exhaust gases to be cooled flows inside the heat exchange tubes **22,** whereas second heat exchange fluid, particularly coolant received in the housing **10** through the at least one inlet **14a** flows outside the heat exchange tubes **22** to facilitate heat exchange between the first heat exchange fluid and the second heat exchange fluid. The coolant is delivered out of the housing **10** through the at least one outlet **14b** after the coolant had extracted heat from the first heat exchange fluid, particularly, the exhaust gases flowing through the heat exchange tubes **22.**

[0037] Generally, the open ends **13a** and **13b** of the first portion **10a** and the second portion **10b** are joined to configure the enclosure with the interface **10c** by either one of butt welding and overlap welding.

[0038] In accordance with an embodiment, the first portion **10a** and the second portion **10b** are identical standard components. With such configuration, we can achieve standardization of the components and one single standard component can be used either as the first portion **10a** or the second portion **10b,** also, the hassle of manufacturing the first portion **10a** and the second portion **10b** in pairs of complimentary components is eliminated.

[0039] In accordance with an embodiment of the present invention, the first portion **10a** and the second portion **10b** are different and non-symmetric about the interface **10c.** More specifically, in accordance with an embodiment of the present invention the housing **10** can be configured by joining the first portion **10a** that is a standard component of a pre-determined length and a second portion **10b** that is of any different dimension. The housing **10** so formed can be of different overall lengths based on different configurations of the EGR coolers as per customer requirements. In accordance with still another embodiment, the first portion **10a** and the second portion **10b** are identical standard components that are joined by at least one intermediate portion **10d** as illustrated in **FIG. 6.** The at least one intermediate portion **10d** is disposed between the first portion **10a** and the second portion **10b** and configures joint there between. Particularly, one end of the at least one intermediate portion **10d** is joined to the first portion **10a** to form interface **10c** between the first portion and the at least one intermediate portion **10d,** whereas opposite end of the at least one intermediate portion **10d** is joined to the second portion **10b** to configure another interface **10c** between the second portion **10b** and the at least one intermediate portion **10d.** The at least one intermediate portion **10d** can be of different lengths based on the different overall lengths of the housing **10** required based on different configurations of the EGR coolers as per customer requirements. With such configuration of the EGR cooler **100,** comparatively more number of standard parts can be used for manufacturing different configurations of EGR cooler as compared to conventional EGR cooler, thereby reducing the overall costs.

[0040] The first portion **10a** and the second portion **10b** are having simple profile with straight external surfaces and accordingly, the first portion **10a** and the second portion **10b** are formed by deep drawing. In accordance with another embodiment of the present invention, the first portion **10a** and the second portion **10b** are formed by stamping. The first portion **10a** and the second portion **10b** are formed of stainless steel or aluminum or alloy thereof.

[0041] The first portion **10a** and the second portion **10b** can be of any length based on the size of the EGR core to be received and encapsulated, for example, in case the thickness of the sheet from which the first portion and the second portion are configured of is 1 mm, then the length of first portion and second portion that can be configured from such sheet by stamping can be 90 mm. Considering, the first portion **10a** and the second portion **10b** are of same length, the total length of the housing formed by joining the first portion **10a** and the second portion **10b** can be 180mm that is sufficient for receiving and encapsulating the core of the EGR cooler. The first portion **10a** and the second housing portion **10b** can be rectangular in shape or circular in shape. However, the present invention is not limited to any particular shape or configuration of the first portion **10a** and the second portion **10b** of the housing **10.** The present invention is not limited to whether the first portion **10a** and the second portion **10b** are identical in length or not or any particular method of joining the first portion **10a** and the second portion **10b.** The present invention is still not limited to any material of the first portion **10a** and the second portion **10b.** The housing **10** of the present invention formed of two separate portions **10a** and **10b** will still be within scope and ambit of the present invention as far as the closed ends **11a** and **11b** of the respective first portion **10a** and the second portion **10b** are configurable with the slots **12a** and **12b** and function as collector plates to facilitate distribution of heat exchange fluid to and collection of heat exchange fluid from the heat exchange core **20** respectively and as far as the first portion **10a** and the

second portion **10b** are capable of being joined together to configure the enclosure for enclosing the heat exchange core **20.**

[0042] **FIG. 4a** illustrates a front view of the heat exchanger **100. FIG. 4b** illustrates a sectional view of the heat exchanger along section line A-A'. **FIG. 5a** illustrates a left side view of the EGR cooler 100. **FIG. 5b** illustrates a sectional view of the heat exchanger along section line B-B'. The closed ends **11a** and **11b** of the respective first portion **10a** and the second portion **10b** are configured with the slots **12a** and **12b** and function as collector plates integrally formed with the respective portions **10a** and **10b** of the housing **10.** The slots **12a** and **12b** configured on at least one of the closed ends **11a** and **11b** receives the respective ends **22a** and **22b** of the heat exchange tubes **22.** Preferably, the slots **12a** and **12b** configured on the closed ends **11a** and **11b** of the respective first portion **10a** and the second portion **10b** receive the respective ends **22a** and **22b** of the heat exchange tubes **22** as illustrated in **FIG. 5b.** The ends **22a** and **22b** of the heat exchange tubes **22** are joined to inside walls defining the slots **12a** and **12b** configured on the closed ends **11a** and **11b** of the corresponding first portion **10a** and the second portion **10b.** In accordance with an embodiment of the present invention, the ends **22a** and **22b** of the heat exchange tubes **22** are joined to inside walls defining the slots **12a** and **12b** by laser welding or brazing. However, the present invention is not limited to any particular method for configuring the joint between the ends **22a** and **22b** of the heat exchange tubes **22** and the inside walls of the respective slots **12a** and **12b.** The at least one of the first portion **10a** and the second portion **10b** is further connected to the respective tanks **30a** and **30b.** Preferably, the first portion **10a** and the second portion **10b** are connected to the respective tanks **30a** and **30b** by crimping. The slots **12a** and **12b** configured on the first portion **10a** and the second portion **10b** respectively in conjunction with the respective tanks **30a** and **30b** facilitate distribution of first heat exchange fluid to and collection of first heat exchange fluid from the heat exchange core **20** respectively. However, the present invention is not limited to any particular connection method for configuring joint between the first portion **10a** and the second portion **10b** and the respective tanks **30a** and **30b** as long as the connection method configures secure joint between the first and second portions **10a** and **10b** and the respective tanks **30a** and **30b.**

[0043] A method of assembling an EGR cooler **100** is disclosed in accordance with an embodiment of the present invention. **FIG. 6** is a flow chart depicting various steps involved in assembling the heat exchanger **100.** The method includes the steps of selecting a first portion **10a** and a separate second portion **10b** for configuring the housing **10** based on desired overall length of the housing **10** that in turn is based on the configuration of the heat exchanger **100.** The first portion **10a** is a tubular structure that includes a closed end **11a** with slots **12a** formed thereon, an open end **13a** and side walls **15a** joining the closed end **11a** to the open end **13a.** Similarly, the second portion **10b** is a tubular structure complimentary to the first portion **10a** and includes a closed end **11b** with the slots **12b** formed thereon, an open end **13b** and side walls **15b** joining the closed end **11b** to the open end **13b.** Thereafter, the first portion **10a** receives at least a portion of a plurality of heat exchange tubes **22** of a heat exchange core **20** and the slots **12a** formed on the first portion **10a** receives the first end **22a** of the heat exchange tubes **22.** Similarly, the second portion **10b** receives the remaining portion of the heat exchange tubes **22** and the slots **12b** formed on the second portion **10b** receives the second end **22b** of the heat exchange tubes **22** opposite to the first end **22a.** Thereafter, joining by either one of brazing and laser welding, the open ends **13a** and **13b** of the respective first portion **10a** and the second portion **10b** to each other, the ends **22a** and **22b** of the heat exchange tubes **22** to inside walls of slots **12a** and **12b** configured on the respective first portion **10a** and the second portion **10b,** tanks **30a** and **30b** to the first portion **10a** and the second portion **10b** respectively, and the flanges **40a** and **40b** to the first tank **30a** and the second tank **30b** respectively. The flange **40a** facilitate connection of the EGR cooler **100** with an inlet pipe delivering exhaust gases into the EGR cooler **100.** The flange **40b** facilitate connection of the EGR cooler **100** with an outlet pipe receiving exhaust gases out of the EGR cooler **100** after the exhaust gases are cooled in the EGR cooler **100.**

[0044] Generally, the step of joining the open ends **13a** and **13b** of the respective first portion **10a** and the second portion **10b** involves directly joining the open ends **13a** and **13b** to each other. Alternatively, the step of joining the open ends **13a** and **13b** of the respective first portion **10a** and the second portion **10b** to each other involves disposing at least one intermediate tubular element **10d** between the first portion **10a** and the second portion **10b** and joining the ends of the intermediate portion **10d** to the first portion **10a** and the second portion **10b** respectively. The intermediate tubular element **10d** is complimentary to the first portion **10a** and the second portion **10b** and is having simple profile with straight external surfaces, accordingly, the intermediate tubular element **10d** is also formed by deep drawing. In accordance with another embodiment of the present invention, the intermediate tubular element **10d** is formed by stamping. The step of joining the open ends **13a** and **13b** of the respective first portion **10a** and the second portion **10b** to each other, the ends **22a** and **22b** of the heat exchange tubes **22** to inside walls defining the slots **12a** and **12b** respectively, tanks **30a** and **30b** to the first portion **10a** and the second portion **10b** respectively, and flanges **40a** and **40b** to the first tank **30a** and the second tank **30b** respectively involves arranging all components to be joined in pre-braze assembled configuration and subjecting to brazing in a brazing furnace. With such method all the components to be joined are joined in a single step brazing, thereby reducing the assembly time and effort.

[0045] Several modifications and improvement might be applied by the person skilled in the art to the EGR cooler 100 as defined above, and such modifications and improvements will still be considered within the scope and ambit of the present invention, as long as the heat exchanger includes a housing formed of a first portion and a second portion that are separate from each other and that are joined to configure an enclosure to encapsulate a heat exchange core. The heat exchanger core includes a plurality of heat exchange tubes. At least one of the first portion and the second portion of the housing includes slots formed thereon to receive respective ends of the heat exchange tubes.

[0046] 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) formed of a first portion (10a) and a second portion (10b) that are separate from each other and that are joined to configure an enclosure adapted to encapsulate a heat exchange core (20) comprising a plurality of heat exchange tubes (22), at least one of the first portion (10a) and the second portion (10b) of the housing (10) comprising slots (12a, 12b) adapted to receive respective ends (22a, 22b) of the heat exchange tubes (22).

2. The heat exchanger (100) in accordance with the previous claim, wherein the first portion (10a) is a tubular structure comprising a closed end (11a) with the slots (12a) formed thereon, an open end (13a) and side walls (15a) joining the closed end (11a) to the open end (13a), the second portion (10b) is a tubular structure complimentary to the first portion (10a) and comprising a closed end (11b) with the slots (12b) formed thereon, an open end (13b) and side walls (15b) joining the closed end (11b) to the open end (13b).

3. The heat exchanger (100) in accordance with claim 2, wherein the open ends (13a) and (13b) of the respective first portion (10a) and the second portion (10b) are joined by at least one of laser welding and brazing to configure the enclosure with an interface (10c) at the joint between the first portion (10a) and the second portion (10b).

4. The heat exchanger (100) in accordance with any of the preceding claims, wherein the open ends (13a, 13b) of the respective first portion (10a) and the second portion (10b) are joined by either one of butt welding and overlap welding to configure the enclosure with the interface (10c) at the joint between the first portion (10a) and the second portion (10b).

5. The heat exchanger (100) in accordance with claim 3, wherein the first portion (10a) and the second portion (10b) are identical and symmetric with respect to the interface (10c).

6. The heat exchanger (100) in accordance with the claim 3, wherein the first portion (10a) and the second portion (10b) are different and non-symmetric with respect to the interface (10c).

7. The heat exchanger (100) in accordance with any of the preceding claims, wherein the first portion (10a) and the second portion (10b) are formed by either one of deep drawing and stamping.

8. The heat exchanger (100) in accordance with any of the preceding claims, wherein at least one of the first portion (10a) and the second portion (10b) is adapted to be joined to the respective tanks (30a) and (30b), the slots (12a) and (12b) configured on the first portion (10a) and the second portion (10b) in conjunction with the respective tanks (30a,30b) are adapted to facilitate distribution of first heat exchange fluid to and collection of first heat exchange fluid from the heat exchange tubes (22) respectively.

9. The heat exchanger (100) in accordance with any of the preceding claims, wherein the tanks (30a, 30b) are connected to corresponding flanges (40a, 40b).

10. The heat exchanger (100) in accordance with any of the preceding claims, further comprising at least one inlet (14a) and at least one outlet (14b), the at least one inlet (14a) is adapted to receive second heat exchange fluid inside the housing (10) and around the heat exchange tubes (22) whereas the at least one outlet (14b) is adapted to deliver second heat exchange fluid out of the housing (10).

11. The heat exchanger (100) in accordance with any of the preceding claims, wherein the housing further comprises at least one intermediate portion (10d) disposed between the first portion (10a) and the second portion (10b) and adapted to configure joint there between.

12. A method for assembling a heat exchanger (100) comprising the steps of:

    • selecting a first portion (10a) and a separate second portion (10b) for configuring the housing (10) based on desired overall length of the housing (10), wherein the first portion (10a) is a tubular structure comprising a closed end (11a) with slots (12a) formed thereon, an open end

(13a) and side walls (15a) joining the closed end (11a) to the open end (13a), the second portion (10b) is also a tubular structure complimentary to the first portion (10a) and comprising a closed end (11b) with slots (12b) formed thereon, an open end (13b) and side walls (15b) joining the closed end (11b) to the open end (13b);

• receiving at least a portion of a plurality of heat exchange tubes (22) of a heat exchange core (20) within the first portion (10a) and receiving the first end (22a) of the heat exchange tubes (22) in the slots (12a) formed on the first portion (10a);

• receiving the remaining portion of the heat exchange tubes (22) in the second portion (10b) and receiving the second end (22b) of the heat exchange tubes (22) opposite to the first end (22a) in the slots (12b) formed on the second portion (10b);

• joining by at least one of brazing and laser welding, the open ends (13a) and (13b) of the respective first portion (10a) and the second portion (10b) to each other, the ends (22a) and (22b) of the heat exchange tubes (22) to inside walls defining the slots (12a) and (12b) respectively, tanks (30a) and (30b) to the first portion (10a) and the second portion (10b) respectively, and flanges (40a) and (40b) to the first tank (30a) and the second tank (30b) respectively.

13. The method of assembling as claimed in the previous claim, wherein the first portion (10a) and the second portion (10b) are formed by either one of deep drawing and stamping.

14. The method of assembling as claimed in the previous claim, wherein the step of joining the open ends (13a) and (13b) of the respective first portion (10a) and the second portion (10b) involves directly joining the open ends (13a) and (13b) to each other.

15. The method of assembling as claimed in the previous claim, wherein the step of joining the open ends (13a) and (13b) of the respective first portion (10a) and the second portion (10b) to each other involves disposing at least one intermediate tubular element (10d) between the first portion (10a) and the second portion (10b) and joining the ends of the intermediate portion (10d) to the first portion (10a) and the second portion (10b) respectively.

16. The method of assembling as claimed in the previous claim, wherein the step of joining the open ends (13a) and (13b) of the respective first portion (10a) and the second portion (10b) to each other, the ends (22a) and (22b) of the heat exchange tubes (22) to inside walls defining the slots (12a) and (12b) respectively, tanks (30a) and (30b) to the first portion (10a) and the second portion (10b) respectively, and flanges (40a) and (40b) to the first tank (30a) and the second tank (30b) respectively involves arranging all components to be joined in pre-braze assembled configuration and subjecting to brazing in a brazing furnace.

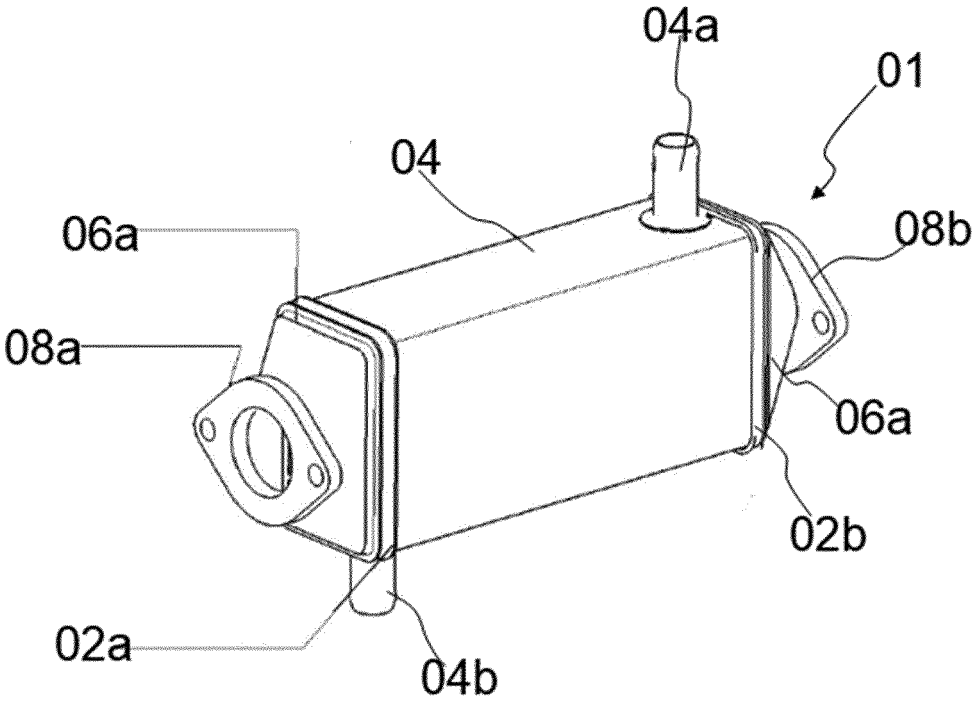

FIG. 1a

(PRIOR ART)

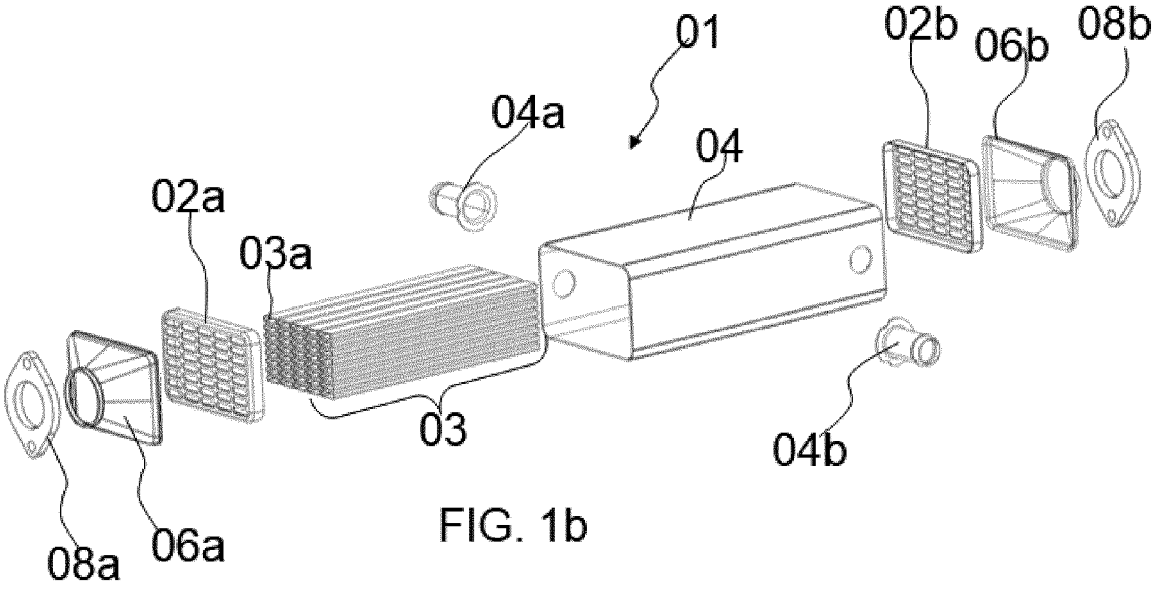

FIG. 1b

(PRIOR ART)

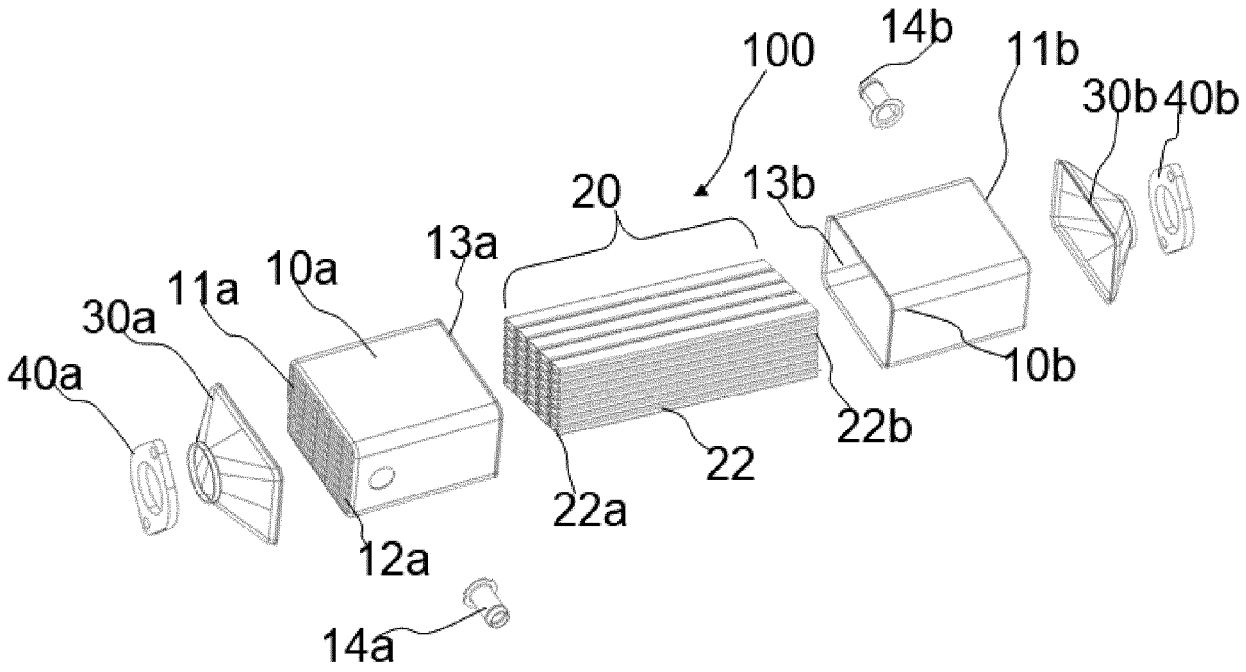
100
14b
11b
30b
40b
20
13b
13a
10a
11a
30a
40a
10b
22b
22
22a
12a
14a

FIG. 2

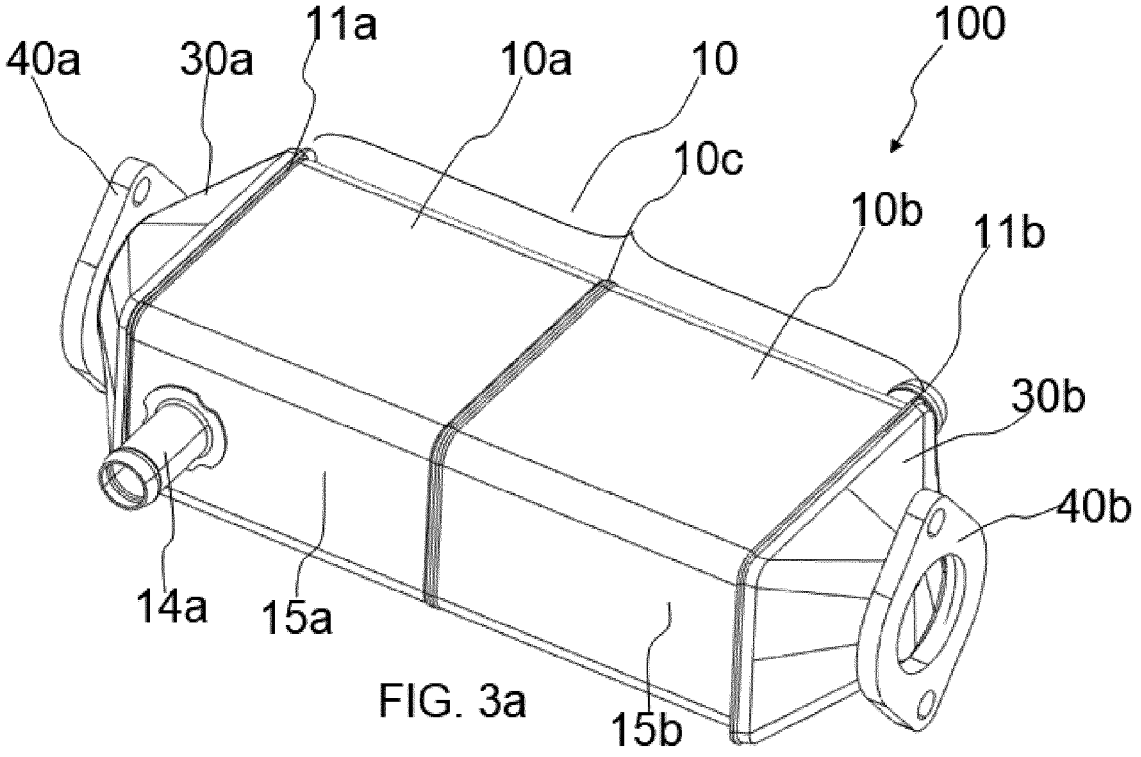
40a
30a
11a
10a
10
100
10c
10b
11b
30b
40b
14a
15a
15b

FIG. 3a

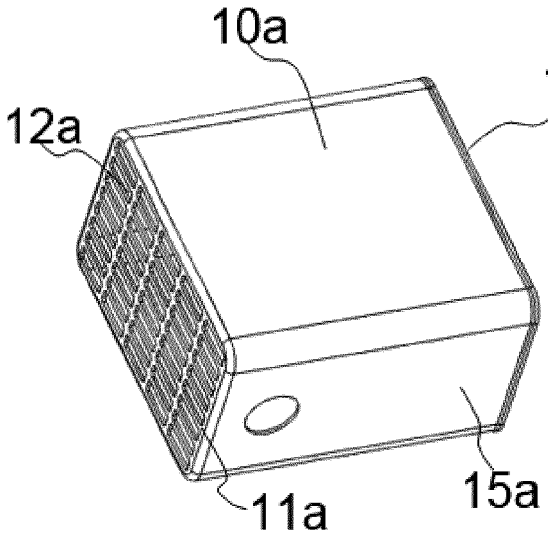

FIG. 3b

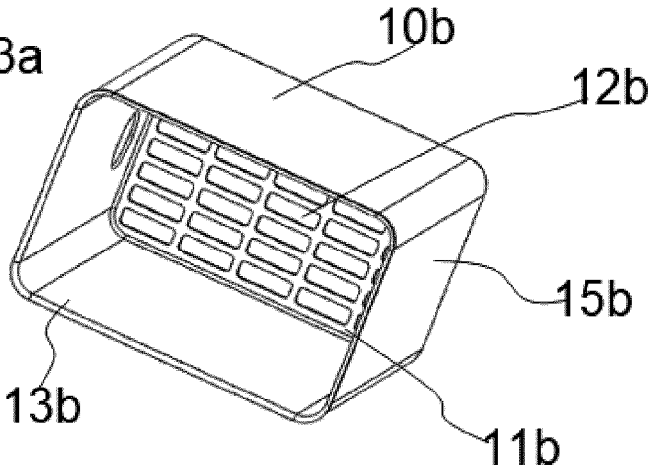

FIG. 3c

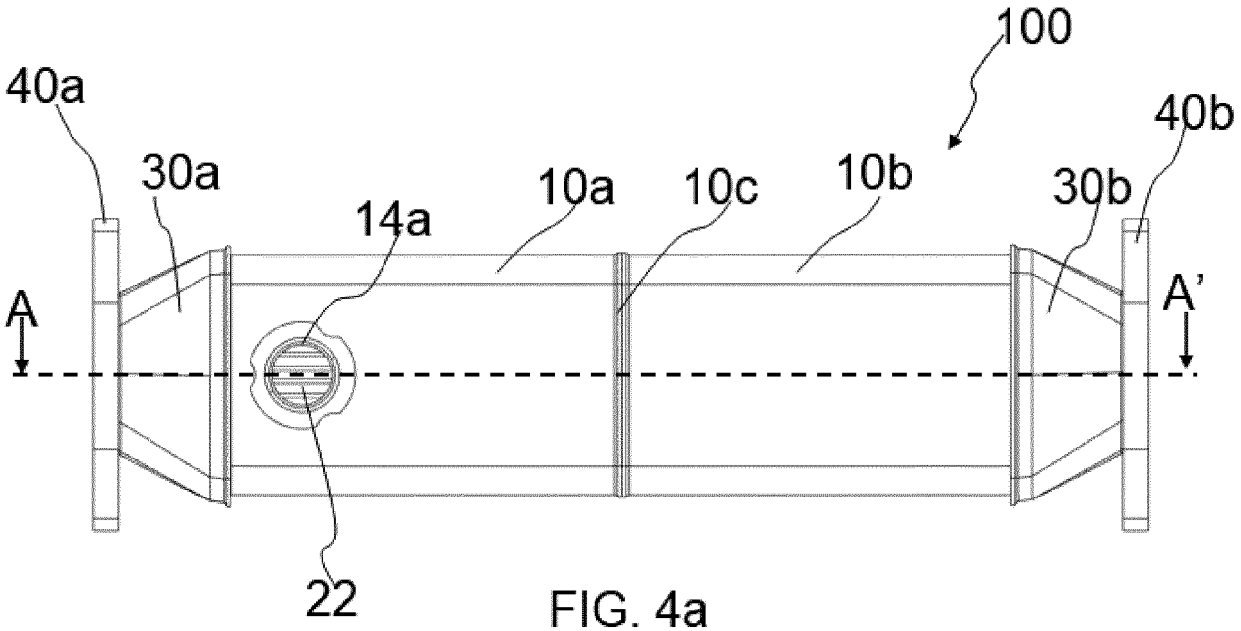

FIG. 4a

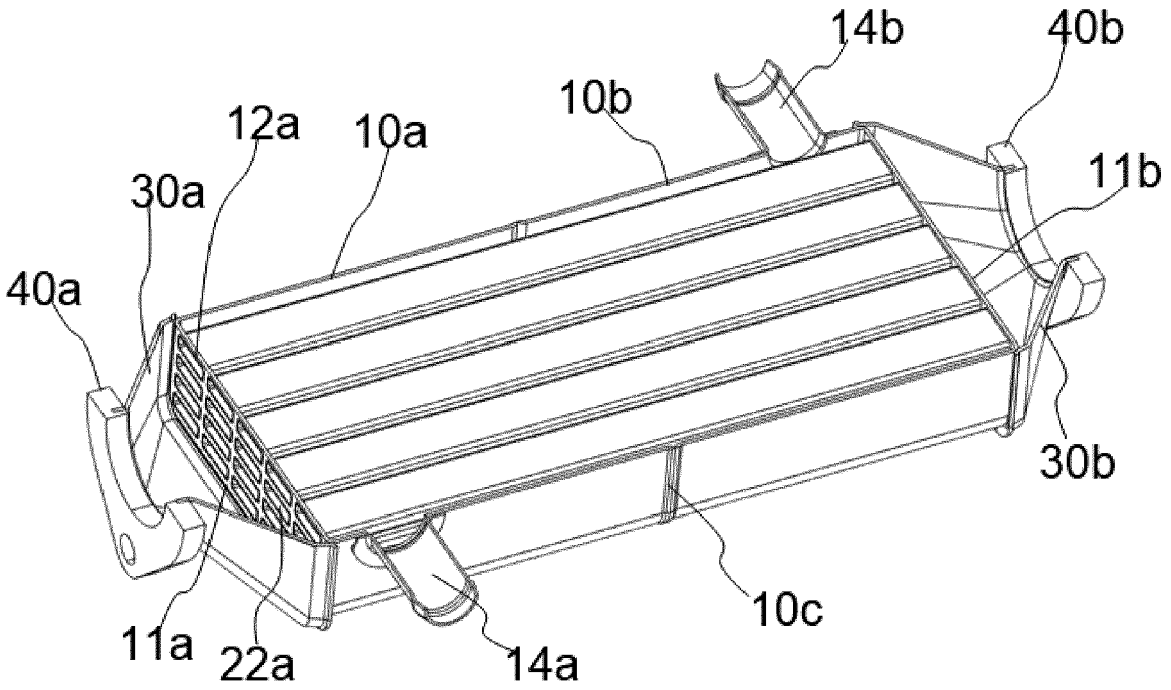
14b
40b
10b
12a
10a
11b
30a
40a
30b
10c
11a
22a
14a

FIG. 4b

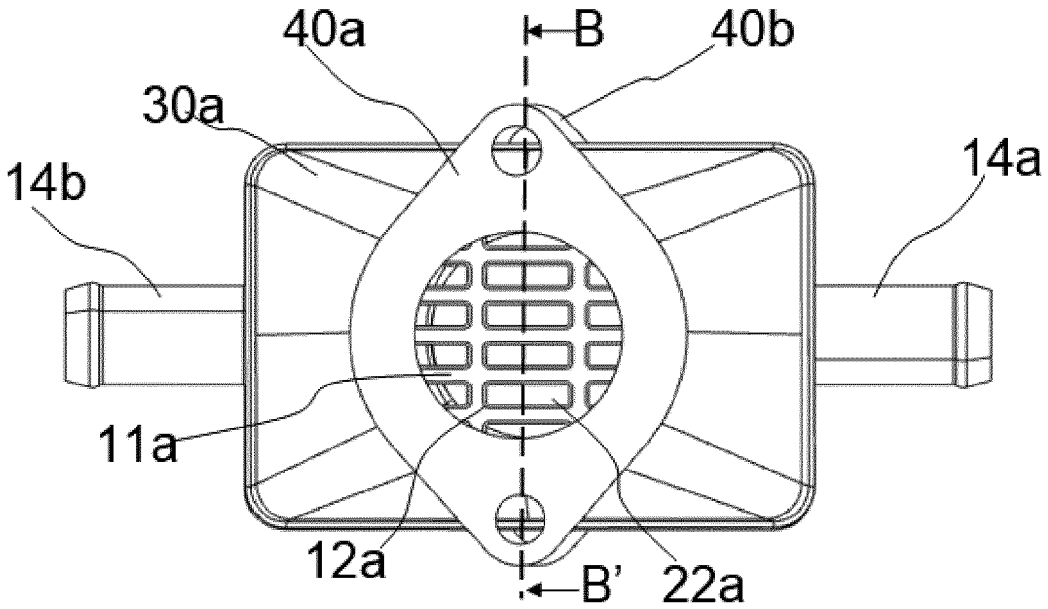
40a
B
40b
30a
14a
14b
11a
12a
B'
22a

FIG. 5a

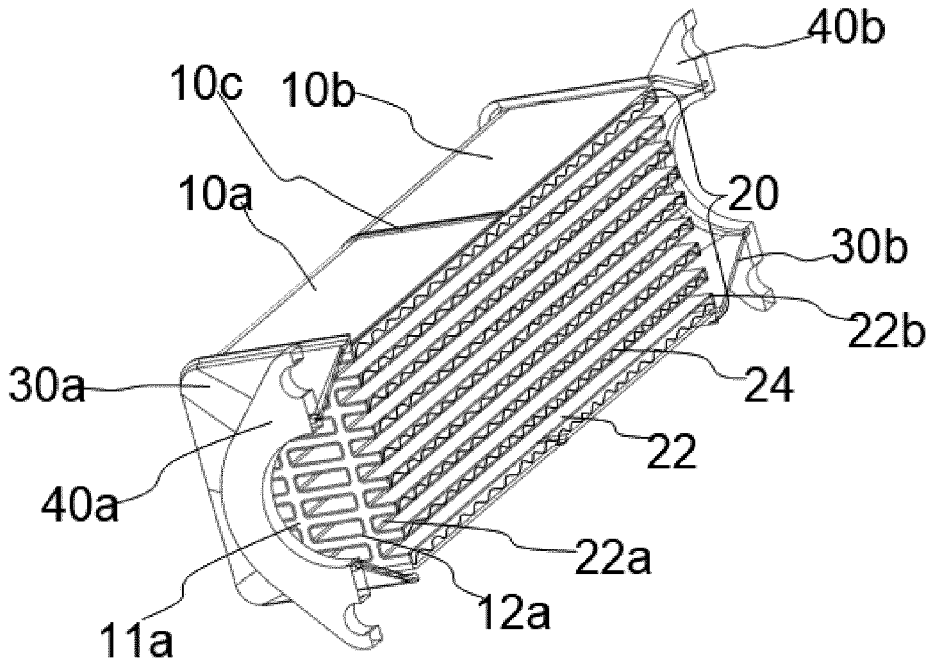
40b
10c
10b
10a
20
30b
22b
30a
24
22
40a
22a
12a
11a

FIG. 5b

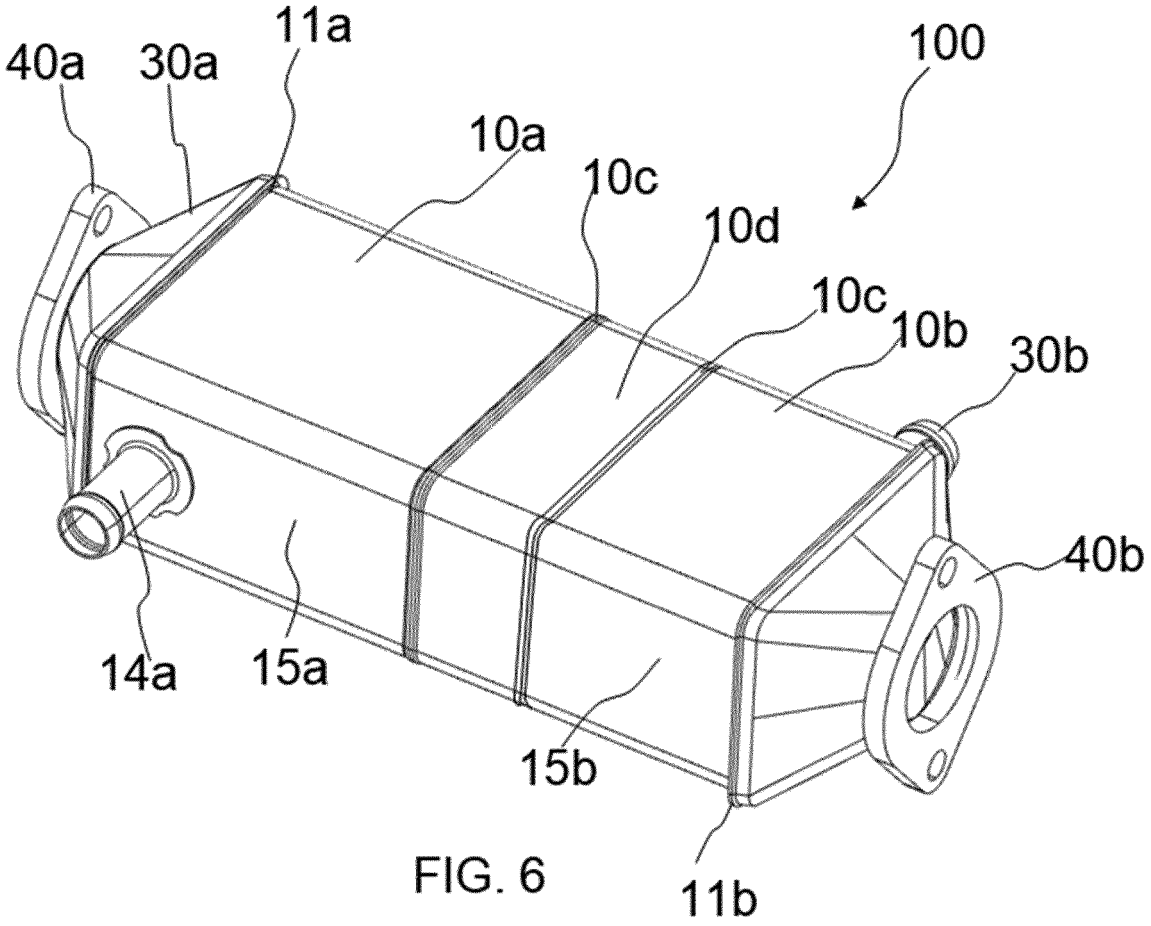
11a
40a
30a
100
10a
10c
10d
10c
10b
30b
40b
14a
15a
15b
11b

FIG. 6

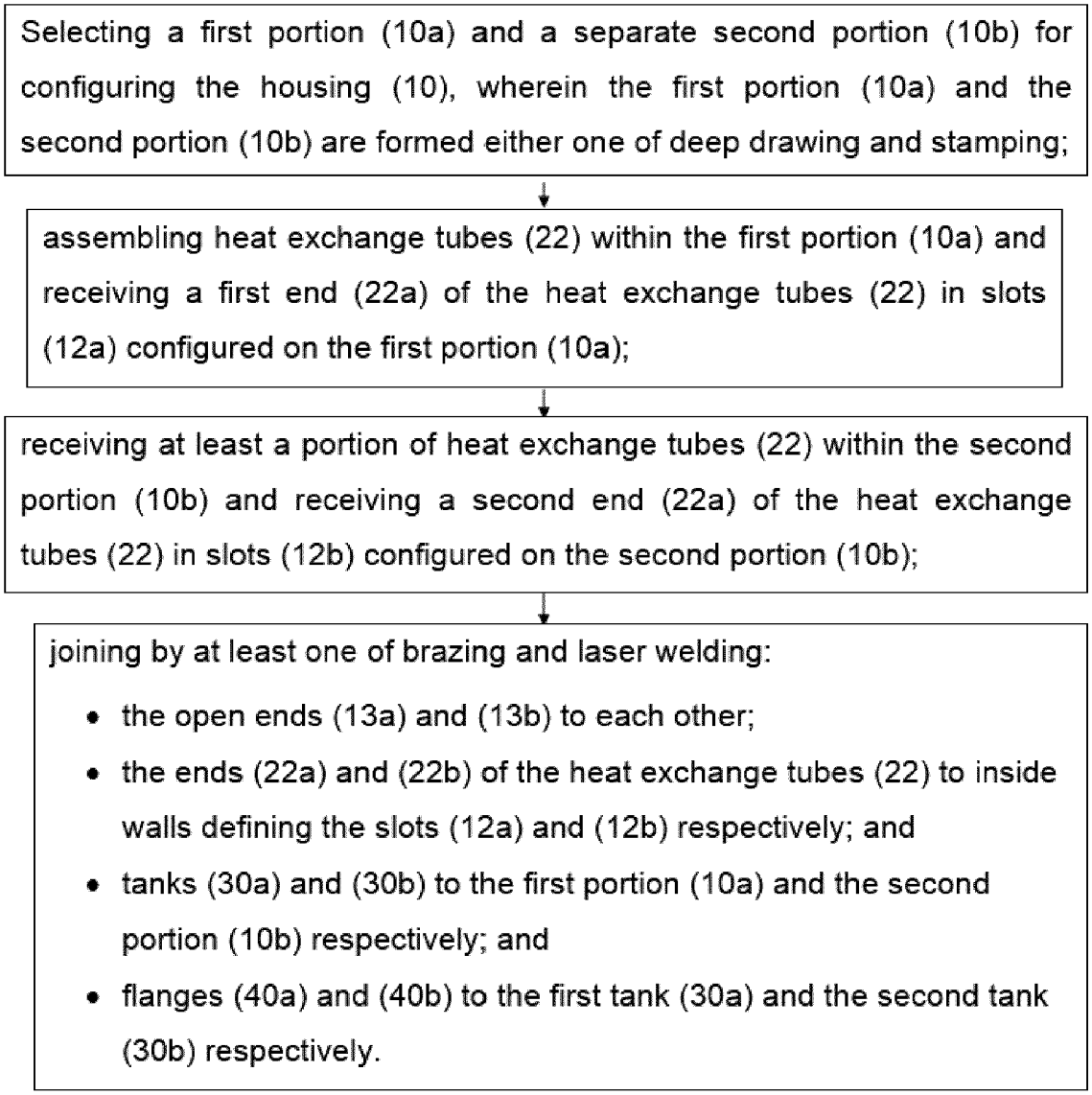
Selecting a first portion (10a) and a separate second portion (10b) for configuring the housing (10), wherein the first portion (10a) and the second portion (10b) are formed either one of deep drawing and stamping;
assembling heat exchange tubes (22) within the first portion (10a) and receiving a first end (22a) of the heat exchange tubes (22) in slots (12a) configured on the first portion (10a);
receiving at least a portion of heat exchange tubes (22) within the second portion (10b) and receiving a second end (22a) of the heat exchange tubes (22) in slots (12b) configured on the second portion (10b);
joining by at least one of brazing and laser welding:
• the open ends (13a) and (13b) to each other;
• the ends (22a) and (22b) of the heat exchange tubes (22) to inside walls defining the slots (12a) and (12b) respectively; and
• tanks (30a) and (30b) to the first portion (10a) and the second portion (10b) respectively; and
• flanges (40a) and (40b) to the first tank (30a) and the second tank (30b) respectively.

FIG. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 19 38 2416

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	US 8 393 382 B2 (AGEE KEITH [US]; HONEYWELL INT INC [US]) 12 March 2013 (2013-03-12) * figure 5 *	6	
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A	WO 2008/049648 A1 (VALEO TERMICO SA) 2 May 2008 (2008-05-02) * page 7, paragraph 3; figure 1 *	1,12	

TECHNICAL FIELDS SEARCHED (IPC)

F02M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	4 November 2019	Kolodziejczyk, Piotr

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 38 2416

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04-11-2019

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		EP 1985953 A1	29-10-2008
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