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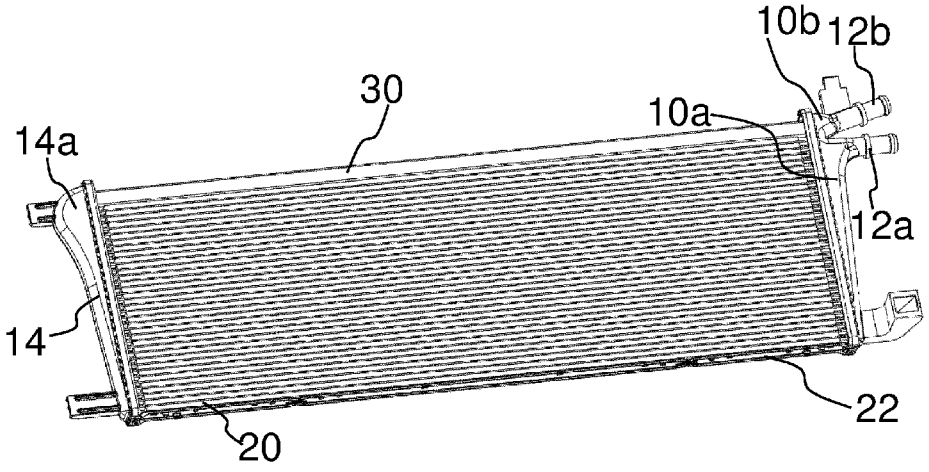

FIG. 3a

(57) Abstract: A heat exchanger includes an inlet tank (10a) connected to and in fluid communication with an inlet pipe (12a) for ingress of a coolant therein, an outlet tank (10b) connected to and in fluid communication with an outlet pipe (12b) for egress of coolant there from. The heat exchanger further includes heat exchange tubes (20) and a tubular element (30) to configure fluid communication between the inlet tank (10a) and the outlet tank (10b). A first side of the outlet tank (10b) is complimentary to and connected to the outlet pipe (12b) and an opposite second side of the outlet tank (10b) is complimentary to and aligned with the tubular element (30). The tubular element (30) and the outlet pipe (12b) are of different cross sections, wherein shape of the outlet tank (10b) transforms smoothly between those cross sections along fluid path.

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A HEAT EXCHANGER

The present invention relates to a heat exchanger, particularly, the present invention relates to a compact heat exchanger for use in a vehicle.

A vehicle generally includes a number of heat exchangers, such as for example a radiator, evaporator and a condenser. The heat exchanger for use in the vehicle is to be packaged in a limited space due to space constraints and accordingly, is required to be compact. Generally, compactness of the heat exchanger is achieved by limiting the size of a core of the heat exchanger, particularly, by reducing the number of heat exchange tubes. However, by reducing the number of heat exchange tubes, the pressure drop across the heat exchange tubes, particularly, pressure drop across the heat exchanger core is increased. In spite of fewer heat exchange tubes for imparting compactness to the heat exchanger, the flow rate of the coolant flowing through the heat exchange tubes is required to be maintained by increasing the flow velocity, particularly, by increasing the pressure drop across the heat exchanger tubes. With increase in flow velocity of coolant flowing through first heat exchange tubes, problems such as inefficient heat exchange arises. The inefficient heat exchange due to increase in flow velocity of coolant flowing through first heat exchange tubes adversely affects the performance of the heat exchanger. Further, the increase in pressure drop across the heat exchange tubes give rise to need of a higher capacity pump to cause the coolant to flow across the heat exchanger core. The need of higher capacity pump increases the overall cost of the coolant loop.

In order to address the above mentioned problems such as need of higher capacity pump due to increase in pressure drop across the heat exchange tubes and inefficient operation of the heat exchanger due to increase in flow velocity, an additional tube is used. The additional tube connects and configures fluid communication between an inlet tank and an outlet tank of the heat exchanger. In case of an I-flow or Z-flow, the inlet tank and the outlet tank are disposed on opposite sides of the heat exchanger core. Whereas in case of the U-flow the inlet tank and the outlet tank are disposed along same side of the heat exchanger core and an intermediate tank is disposed on a side opposite to the side on which the inlet tank and outlet tank are

disposed. Accordingly, the additional tube configures fluid communication between intermediate tank and outlet tank in case of U-flow and inlet and outlet tank in case of I flow or Z flow. The additional tube is having larger cross sectional dimension compared to the remaining individual heat exchanger tubes, consequently the flow rate through the additional tube is greater than through the heat exchange tube of the core. The main function of the additional tube is to enhance fluid flow there through as the additional tube configures fluid communication between the inlet tank and the outlet tank. The additional tube further provides a robust reinforcement of the structure of the heat exchanger due to its shape. Although there is some extent of heat exchange between the first heat exchange fluid flowing through the additional tube and air flowing outside the additional tube, such heat exchange is limited or minimal. In one example, the additional tube forms a return flow passage from the intermediate tank to the outlet tank, in case the heat exchange tubes along with the additional tube are configuring U-flow. Similarly, in other example, the additional tube forms flow passage from the inlet tank to the outlet tank, in case the heat exchange tubes along with the additional tube are configuring I flow or Z flow. The additional tube is of rectangular cross section and comparatively larger internal dimension than the heat exchange tubes, such configuration of the additional tube provides limited pressure drop there across. The slowing of the flow through the additional tube defeats the purpose of using the additional tube. Further, the transition of flow from the additional tube to an outlet pipe through the outlet tank is not smooth and causes flow/ energy losses. Further, the outlet tank and the outlet pipe faces packing issues. More specifically, the rectangular cross-section of the additional tube provides a robust reinforcement to the structure at low cost. However, such shape and sizing complicates effective optimization of the heat exchanger in view of restrictive space constraints, especially concerning fluid inlet and outlet of the heat exchanger.

Accordingly, there is a need for a heat exchanger with features incorporated in an inlet tank, an outlet tank, and an intermediate tank to decrease internal pressure drop across whole heat exchanger to improve fluid flow through the whole heat exchanger, thereby limiting dependency on external power source such as pump. Further, there is a need for a heat exchanger that permits use of lower capacity pump for fluid flow between the inlet tank and the outlet tank. Still further, there is a need for

a heat exchanger that addresses the issues such as flow/energy losses due to transition of flow cross section not being smooth as coolant flows from the additional tube to the outlet pipe through the outlet tank. In addition, there is a need for a heat exchanger that is compact and addresses packaging issues. Furthermore, there is a need for a heat exchanger that is compact but still is energy efficient and comparatively inexpensive. Further, there is need for a heat exchanger that exhibits improved efficiency due to decreased internal pressure drop across the whole heat exchanger.

An object of the present invention is provide a heat exchanger that obviates the drawbacks with conventional heat exchangers, particularly, that obviates problems with flow across the heat exchanger core and inefficient operation of the heat exchanger by reducing internal pressure drop across the whole heat exchanger.

Yet another object of the present invention is to provide a heat exchanger that ensures smooth transition of flow cross section from the additional tube to the outlet pipe through the outlet tank, thereby preventing flow / energy losses.

Still another object of the present invention is to provide a heat exchanger that is compact and addresses the packaging issues associated with conventional heat exchangers.

Another object of the present invention is to provide a heat exchanger with features incorporated in at least one of an inlet tank, an outlet tank and an intermediate tank to decrease internal pressure drop across the whole heat exchanger.

Still another object of the present invention is to provide a heat exchanger that permits use of lower capacity pump for fluid flow between the inlet tank and the outlet tank.

Yet another object of the present invention is to provide a heat exchanger that eliminates at least one side plate by commonization of parts.

Still another object of the present invention is to provide a heat exchanger that permits use of shorter core with use of lower capacity pump, thereby is compact, inexpensive and energy efficient.

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.

A heat exchanger is disclosed in accordance with an embodiment of the present invention. The heat exchanger includes an inlet tank, an outlet tank, a plurality of heat exchange tubes and a tubular element. The inlet tank is connected to and in fluid communication with an inlet pipe for ingress of a first heat exchange fluid into the inlet tank. The outlet tank is connected to and in fluid communication with an outlet pipe for egress of the first heat exchange fluid from the outlet tank. The plurality of heat exchange tubes and the tubular element configures fluid communication between the inlet tank and the outlet tank. A first side of the outlet tank is complimentary to and connected to the outlet pipe. A second side of the outlet tank opposite to the first side is complimentary to and aligned with the tubular element. The tubular element and the outlet pipe are of different cross-sections. The shape of the outlet tank transforms smoothly between those cross-sections along the fluid path.

Generally, the inlet tank is in fluid communication with and supplies the first heat exchange fluid to the heat exchange tubes and the outlet tank is in fluid communication with and collects the first heat exchange fluid only from the tubular element.

Specifically, the inlet tank is of variable cross section and the cross section thereof is decreasing in a direction away from the inlet pipe.

In accordance with an embodiment, the tubular element and the outlet pipe are of same cross sectional area and different shapes.

Further, the tubular element and the outlet pipe are co-axial.

Alternatively, the tubular element and the outlet pipe at an angle with respect to each other.

Furthermore, the inlet pipe and the outlet pipe are parallel with respect to each other.

Alternatively, the inlet pipe and the outlet pipe are at an angle with respect to each other.

Generally, the inlet pipe is disposed proximal to an interface between the inlet tank and the outlet tank and fluid flows away from the inlet pipe.

Generally, the inlet tank and the outlet tank are crimped to a first header configured with a first set of slots to receive one end of the plurality of heat exchange tubes and a first aperture to receive one end of the tubular element.

Specifically, the outlet pipe is of circular cross section and the tubular element is of rectangular cross section, cross section of the outlet tank changes from circular at the first side thereof to rectangular at the second side thereof.

More specifically, the outlet pipe is of circular cross section and the tubular element is of square cross section, the cross section of the outlet tank changes from circular at the first side thereof to square at the second side thereof.

More specifically, the outlet tank is of larger dimension at the second side as compared to the first side, thereby is converging towards the first side thereof.

Generally, the heat exchange tubes and the tubular element configure either one of U-flow and Z-flow

Further, the heat exchanger includes an intermediate tank that is in fluid communication with the heat exchange tubes and the tubular element, the intermediate tank collects the first heat exchange fluid from the heat exchange tubes and delivers the collected first heat exchange fluid to the tubular element. The intermediate tank is of variable cross section and the cross section thereof is increasing towards an entrance of the tubular element with maximum cross section at the entrance of the tubular element.

Still further, the intermediate tank is crimped to a second header configured with a second set of slots to receive opposite end of the plurality of heat exchange tubes and a second aperture to receive the opposite end of the tubular element.

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 an isometric view of a conventional heat exchanger, wherein a baffle disposed inside a tank configures an inlet tank and an outlet tank on same side of a heat exchanger core of the conventional heat exchanger;

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

FIG. 2a illustrates an isometric view of the tank with the baffle disposed inside the tank to configure the inlet tank and the outlet tank of the conventional heat exchanger of **FIG. 1a**;

FIG. 2b illustrates an isometric view of an intermediate tank of the conventional heat exchanger of **FIG. 1a**;

FIG. 3a illustrates an isometric view of a heat exchanger in accordance with an embodiment of the present invention, wherein an inlet tank and an outlet tank are separate tanks disposed on same side of the heat exchanger core;

FIG. 3b illustrates an exploded view of the heat exchanger of **FIG. 3a**;

FIG. 4a illustrates an isometric view of the separate inlet tank and the outlet tank of the heat exchanger of **FIG. 3a;**

FIG. 4b illustrates an isometric view of the intermediate tank of the heat exchanger of **FIG. 3a**;

FIG. 5a illustrates a cut sectional isometric view of the heat exchanger of **FIG. 3a**, depicting a plurality of heat exchange tubes and a tubular element;

FIG. 5b illustrates another cut sectional isometric view of the heat exchanger of **FIG. 3a**;

FIG. 6a illustrates an isometric view of the heat exchanger of **FIG. 3a**, without the intermediate tank; and

FIG. 6b illustrates another isometric view of the heat exchanger of **FIG. 3a**, without the inlet tank and the outlet tank.

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.

The heat exchanger includes the inlet tank, the outlet tank, an intermediate tank and a plurality of heat exchange tubes. The plurality of heat exchange tubes receive a first heat exchange fluid from the inlet tank and delivers the first heat exchange fluid to the intermediate tank. More specifically, the first heat exchange fluid flows through the heat exchange tubes, in the process the first heat exchange fluid undergoes heat exchange with a second heat exchange fluid flowing across and around the heat exchange tubes. The tubular element enables fluid communication between the outlet tank and the intermediate tank. The outlet tank and the intermediate tank is configured with features to promote fluid flow through the tubular element. For example, a first side of the outlet tank is complimentary to and connected to an outlet pipe and a second side of the outlet tank opposite to the first side is complimentary to and aligned with the tubular element. The shape of the outlet tank transforms smoothly between the cross-sections of the tubular element and the outlet pipe along the fluid path. Such configuration ensures smooth transition of flow from the tubular element to the outlet pipe through the outlet tank, thereby preventing flow / energy losses. The tubular element and the outlet pipe are of different cross-section and dimension and the outlet tank is converging towards the first side thereof. At least one section of the

intermediate tank at an entrance of the tubular element is larger than the remaining section of the intermediate tank to promote fluid flow through the tubular element. Although, the present invention is explained with an example of radiator, however, the present invention is also applicable for other heat exchangers, wherein the pressure drop across the tubular element is inherently decreased due to larger internal dimension thereof and the pressure drop across the whole heat exchanger is required to be decreased.

FIG. 1a illustrates a schematic representation of a conventional heat exchanger **1**. **FIG. 1b** illustrates an exploded view of the conventional heat exchanger **1**. The conventional heat exchanger includes a tank **2a**, an intermediate tank **2b** spaced apart from the tank **2a** and a plurality of heat exchange tubes **4a** disposed between the tank **2a** and the intermediate tank **2b** and forming a heat exchanger core **4**. The conventional heat exchanger **1** further includes a tubular element **6** and an additional side element **7**. The side element **7** is disposed between the tubular element **6** and one of the side plates **8a, 8b**. As illustrated in the **FIG. 1b**, the heat exchange tubes **4a** forming the core **4**, the tubular element **6** and the additional side element **7** are sandwiched between a pair of side plates **8a** and **8b**. The opposite ends of the heat exchange tubes **4a** and the tubular element **6** are received in respective slots formed on the corresponding headers **9a** and **9b.** The headers **9a** and **9b** are crimped to the tank **2a** and the intermediate tank **2b** respectively.

Referring to **FIG. 2a** and **FIG. 2b** of the accompanying drawings, the **FIG. 2a** illustrates an isometric view of the tank **2a** with a baffle **3a** disposed inside the tank **2a** to configure an inlet tank **3b** and an outlet tank **3d** of the conventional heat exchanger **1**. **FIG. 2b** illustrates an isometric view of the intermediate tank **2b**. More specifically, the baffle **3a** divides an interior of the tank **2a** into a first portion defining the inlet tank **3b** and a second portion defining the outlet tank **3d**. The inlet tank **3b** receives heat exchange fluid from an inlet pipe **3c**. The inlet tank **3b** is in fluid communication with and supplies the first heat exchange fluid received therein to the heat exchange tubes **4a**. The plurality of heat exchange tubes **4a** receive the first heat exchange fluid from the inlet tank **3b** and delivers the first heat exchange fluid to the intermediate tank **2b**. More specifically, the first heat exchange fluid flows through the heat exchange tubes

4a, in the process the first heat exchange fluid undergoes heat exchange with a second heat exchange fluid flowing across and around the heat exchange tubes **4a**. The intermediate tank **2b** collects the first heat exchange fluid that had passed through the heat exchange tubes **4a**. The outlet tank **3d** is in fluid communication with and receives the first heat exchange fluid collected in the intermediate tank **2b** through the tubular element **6**. The heat exchange fluid received in the outlet tank **3d** egresses the outlet tank **3d** through the outlet pipe **3e**.

The conventional heat exchanger **1** may not be provided with means to sufficiently decrease the internal pressure drop across the whole heat exchanger **1**. Accordingly, causing increase in internal pressure drop across the whole heat exchanger **1** that is detrimental for efficiency of the conventional heat exchanger **1**. Further, the conventional heat exchanger **1** do not include any provision for smooth transition of fluid flow cross section, as the fluid flows from the additional tube to the outlet pipe through the outlet tank causing flow/energy losses. Accordingly, a higher capacity pump is required to counter issues such energy losses arising due to abrupt change in flow cross section and decrease in pressure drop across the tubular element **6.** Accordingly, the overall costs of the heat exchanger **1** is increased. Further, the heat exchanger **1** with the additional tubular element **6** still requires the pair of side plates **8a** and **8b**. With more number of parts and requirement of higher power pump, the overall costs of the heat exchanger **1** is further increased.

FIG 3a illustrates a heat exchanger **100** in accordance with an embodiment of the present invention. The heat exchanger **100** includes an inlet tank **10a**, an outlet tank **10b**, a plurality of heat exchange tubes **20**, an intermediate tank **14** and a tubular element **30**. The tubular element **30** is of rectangular section and comparatively larger diameter than the heat exchange tubes **30** to improve the fluid flow through the tubular element **30**. The outlet tank **10b** is separate from the inlet tank **10a**. The inlet tank **10a** is connected to and in fluid communication with an inlet pipe **12a** for ingress of a first heat exchange fluid into the inlet tank **10a**. The outlet tank **10b** is connected to and is in fluid communication with an outlet pipe **12b** for egress of the first heat exchange fluid from the outlet tank **10b**. The inlet tank **10a** and the outlet tank **10b** are crimped to a first header **16a** that includes a first set of slots **18a** that receive one end of the

plurality of heat exchange tubes **20**. The first header also includes a first aperture **18b** to receive one end of the tubular element **30** defining an exit **30b** of the tubular element **30**. The intermediate tank **14** is crimped to a second header **16b** that includes a second set of slots **18c** to receive opposite end of the plurality of heat exchange tubes **20** and a second aperture **18d** to receive the opposite end **30a** of the tubular element **30**. With such configuration, the plurality of heat exchange tubes **20** and the tubular element **30** configure fluid communication between the inlet tank **10a** and the outlet tank **10b**.

In one example, the inlet tank **10a** is in fluid communication with and supplies the first heat exchange fluid received therein to the heat exchange tubes **20**. The plurality of heat exchange tubes **20** receive the first heat exchange fluid from the inlet tank **10a** and deliver the first heat exchange fluid to the intermediate tank **14**. Specifically, as the first heat exchange fluid flows through the heat exchange tubes **20**, the first heat exchange fluid undergoes heat exchange with a second heat exchange fluid flowing across and around the heat exchange tubes **20**. The intermediate tank **14** collects the first heat exchange fluid that had passed through the heat exchange tubes **20** and delivers the collected heat exchange fluid to the tubular element **30**. The outlet tank **10b** is in fluid communication with and receives the first heat exchange fluid collected in the intermediate tank **14** through the tubular element **30.** The heat exchange tubes **20** and the tubular element **30** connecting the inlet tank **10a** and the outlet tank **10b** configure either one of I-flow, U-flow and Z-flow of the first heat exchange fluid, particularly coolant between the inlet tank **10a** and the outlet tank **10b**. In one example, the tubular element **30** forms a return flow passage from the intermediate tank **14** to the outlet tank **10b**, in case the heat exchange tubes **20** along with the tubular element **30** are configuring U-flow. In another example, the tubular element **30** forms flow passage from the inlet tank **10a** to the outlet tank **10b**, in case the heat exchange tubes **20** along with the tubular element **30** are configuring I flow or Z flow. The main function of the tubular element **30** is fluid communication, particularly, enhance fluid flow between the inlet tank **10a** and the outlet tank **10b**, instead of heat exchange. Although there is heat exchange between the first heat exchange fluid flowing through the tubular element **30** and air flowing outside the tubular element **30**, however, such heat exchange is limited. The tubular element **30** is of rectangular cross section instead of circular section, thereby lowering internal pressure drop across the

tubular element **30**. Such configuration of the tubular element **30** limits energy loss connected to transfer of fluid through the heat exchanger **100**. Such configuration of the tubular element results in reduced flow through the tubular element **30**, thereby defeating the purpose of the tubular element **30**.

The inlet tank **10a**, the intermediate tank **14** and the outlet tank **10b** are configured with at least one feature to decrease pressure drop across the whole heat exchanger **100**.

Referring to **FIG. 3b** and **FIG. 4a** of the accompanying drawings, the outlet tank **10b** has a first side and a second side opposite to the first side. The first side of the outlet tank **10b** is complimentary to and connected to the outlet pipe **12b**. The second side of the outlet tank **10b** is complimentary to and aligned with the tubular element **30**. The tubular element **30** and the outlet pipe **12b** are co-axial. Alternatively, the tubular element **30** and the outlet pipe **12b** are at an angle with respect to each other. The inlet pipe **12a** and the outlet pipe **12b** are parallel with respect to each other. Alternatively, the inlet pipe **12a** and the outlet pipe **12b** are at an angle with respect to each other. As illustrated in the accompanying **FIGS. 3a -3b**, **4a**, **5b**, the inlet pipe **12a** and the outlet pipe **12b** are at an angle to each other. The angle between the inlet pipe **12a** and the outlet pipe **12b** is selected to address the packaging issues. The tubular element **30** and the outlet pipe **12b** are of different cross-section. Particularly, the outlet pipe **12b** is of circular cross section and the tubular element **30** is of rectangular cross section, the cross section of the outlet tank **10b** changes from circular at the first side thereof to rectangular at the second side thereof. In accordance with another embodiment, the outlet pipe **12b** is of circular cross section and the tubular element **30** is of square or rectangular cross section, the cross section of the outlet tank **10b** changes from circular at the first side thereof to square or rectangular at the second side thereof. In still another embodiment, the tubular element **30** and the outlet pipe **12b** are of same cross sectional area and different shapes. The outlet tank's **10b** shape transforms smoothly from the cross-section of the tubular element **30** to the cross section of the outlet tank **10b** along the fluid path. Such configuration of the outlet tank **10b** ensures smooth transition of flow cross section as the first heat exchange fluid

flows from the additional tube to the outlet pipe through the outlet tank, thereby preventing flow / energy losses. The outlet tank **10b** is of larger dimension at the second side thereof aligned with the tubular element **30** as compared to the first side thereof connected to the outlet pipe **12b**, thereby the outlet tank **10b** is converging towards the first side thereof. Such converging configuration of the outlet tank **10b** promotes fluid flow through the tubular element **30**. Such configuration of the outlet tank **10b**, promotes smooth and undisrupted fluid flow from the tubular element **30** to the outlet pipe **12b.**

Further referring to **FIG. 3a**, **FIG. 3b**, **FIG. 4a** and **FIG. 5a** the inlet tank **10a** is of variable cross section and the cross section thereof is decreasing in a direction away from the inlet pipe **12a**. The inlet pipe **12a** is disposed proximal to an interface between the inlet tank **10a** and the outlet tank **10b** and fluid flows away from the inlet pipe **12a**. With such configuration of the inlet tank **10a**, the first heat exchange fluid is uniformly distributed across the inlet tank **10a**. More specifically, with such configuration of the inlet tank **10a**, the first heat exchange fluid entering inside the inlet tank **10a** through the inlet pipe **12a** reaches even that portion of the inlet tank **10a** that is farthest from the inlet pipe **12a**. With such configuration of the inlet tank **10a**, the first heat exchange fluid is uniformly distributed in the heat exchange tubes **20**.

Further referring to **FIG. 3a**, **FIG. 3b** and **FIG 4b**, the intermediate tank **14** is of variable cross section and the cross section thereof is increasing towards the entrance **30a** of the tubular element **30** with maximum cross section at the entrance **30a** of the tubular element **30**. With such configuration the first heat exchange fluid collected in the intermediate tank **14** is accumulated in a section **14a** of the intermediate tank **14** that is at the entrance **30a** of the tubular element **30**, thereby improving the fluid flow through the tubular element **30**. More specifically, variable cross sectional configuration of the intermediate tank **14** with the cross section thereof increasing towards the entrance **30a** of the tubular element **30** and converging configuration of the outlet tank **10b** in combination increases the pressure drop across the tubular element **30.**

Such modifications in the inlet tank **10a**, the outlet tank **10b** and the intermediate tank decreases the internal pressure drop across the whole heat exchanger **100**, thereby enhancing the efficiency of the heat exchanger **100**. Further, such configuration of the heat exchanger **100** with improved fluid flow through the tubular element **30**, requires small capacity / power pump and as such the heat exchanger **100** is inexpensive compared to conventional heat exchangers.

The tubular element **30** also acts as a side plate, thereby eliminating the need for a dedicated component acting as a side plate. Comparing the exploded view of the heat exchanger **100** of the present invention as illustrated in **FIG. 3b** with the conventional heat exchanger **1** illustrated in **FIG. 1b**, two side plates **8a** and **8b** are used in the conventional heat exchanger **1,** whereas the tubular element **30** used in the heat exchanger **100** of the present invention functions as side plate on one side of the heat exchanger core and only a single side plate **22** is required on the other side of the heat exchanger core.

Several modifications and improvement might be applied by the person skilled in the art to a heat exchanger as defined above, and such modifications and improvements will still be considered within the scope and ambit of the present invention, as long as it is comprising an inlet tank connected to and in fluid communication with an inlet pipe for ingress of a coolant therein, an outlet tank connected to and in fluid communication with an outlet pipe for egress of coolant there from. The heat exchanger further includes heat exchange tubes and a tubular element to configure fluid communication between the inlet tank and the outlet tank. A first side of the outlet tank is complimentary to and connected to the outlet pipe and an opposite second side of the outlet tank is complimentary to and aligned with the tubular element. The tubular element and the outlet pipe are of different cross sections, wherein shape of the outlet tank transforms smoothly between those cross sections along fluid path.

CLAIMS:

1. A heat exchanger (100) comprising:

- an inlet tank (10a) connected to and in fluid communication with an inlet pipe (12a) for ingress of a first heat exchange fluid into the inlet tank (10a);
- an outlet tank (10b) connected to and in fluid communication with an outlet pipe (12b) for egress of the first heat exchange fluid from the outlet tank (10b);
- a plurality of heat exchange tubes (20) and a tubular element (30) adapted to configure fluid communication between the inlet tank (10a) and the outlet tank (10b),

characterized in that a first side of the outlet tank (10b) is complimentary to and connected to the outlet pipe (12b) and a second side of the outlet tank (10b) opposite to the first side is complimentary to and aligned with the tubular element (30), the tubular element (30) and the outlet pipe (12b) being of different cross-sections, wherein shape of the outlet tank (10b) transforms smoothly between those cross-sections along the fluid path.

2. The heat exchanger (100) as claimed in the previous claim, wherein the inlet tank (10a) is in fluid communication with and adapted to supply the first heat exchange fluid to the heat exchange tubes (20) and the outlet tank (10b) is in fluid communication with and adapted to collect the first heat exchange fluid only from the tubular element (30).

3. The heat exchanger (100) as claimed in any of the preceding claims, wherein the inlet tank (10a) is of variable cross section and the cross section thereof is decreasing in a direction away from the inlet pipe (12a).

4. The heat exchanger (100) as claimed in any of the preceding claims, wherein the tubular element (30) and the outlet pipe (12b) are of same cross sectional area and different shapes.

5. The heat exchanger (100) as claimed in any of the preceding claims, wherein the tubular element (30) and the outlet pipe (12b) are co-axial.

6. The heat exchanger (100) as claimed in any of the preceding claims, wherein the tubular element (30) and the outlet pipe (12b) at an angle with respect to each other.

7. The heat exchanger (100) as claimed in any of the preceding claims, wherein the inlet pipe (12a) and the outlet pipe (12b) are parallel with respect to each other.

8. The heat exchanger (100) as claimed in any of the preceding claims, wherein the inlet pipe (12a) and the outlet pipe (12b) are at an angle with respect to each other.

9. The heat exchanger (100) as claimed in any of the preceding claims, wherein the inlet pipe (12a) is disposed proximal to an interface between the inlet tank (10a) and the outlet tank (10b) and fluid flows away from the inlet pipe (12a).

10. The heat exchanger (100) as claimed in any of the preceding claims, wherein the inlet tank (10a) and the outlet tank (10b) are crimped to a first header (16a) that comprises a first set of slots (18a) adapted to receive one end of the plurality of heat exchange tubes (20) and a first aperture (18b) adapted to receive one end of the tubular element (30).

11. The heat exchanger (100) as claimed in any of the preceding claims, wherein the outlet pipe (12b) is of circular cross section and the tubular element (30) is of rectangular cross section, cross section of the outlet tank (10b) changes from circular at the first side thereof to rectangular at the second side thereof.

12. The heat exchanger (100) according to the previous claim, wherein the outlet pipe (12b) is of circular cross section and the tubular element (30) is of square cross section, the cross section of the outlet tank (10b) changes from circular at the first side thereof to square at the second side thereof.

13. The heat exchanger (100) as claimed in any of the preceding claims, wherein the outlet tank (10b) is of larger dimension at the second side as compared to the first side, thereby is converging towards the first side thereof.

14. The heat exchanger (100) as claimed in any of the preceding claims, wherein the plurality of heat exchange tubes (20) and the tubular element (30) are adapted to configure either one of U-flow and Z-flow.

15. The heat exchanger (100) as claimed in any of the preceding claims further comprising an intermediate tank (14) that is in fluid communication with the heat exchange tubes (20) and the tubular element (30), the intermediate tank (14) is adapted to collect the first heat exchange fluid from the heat exchange tubes (20) and delivers the collected first heat exchange fluid to the tubular element (30), the intermediate tank (14) is of variable cross section and the cross section thereof is increasing towards an entrance (30a) of the tubular element (30) with maximum cross section at the entrance (30a) of the tubular element (30).

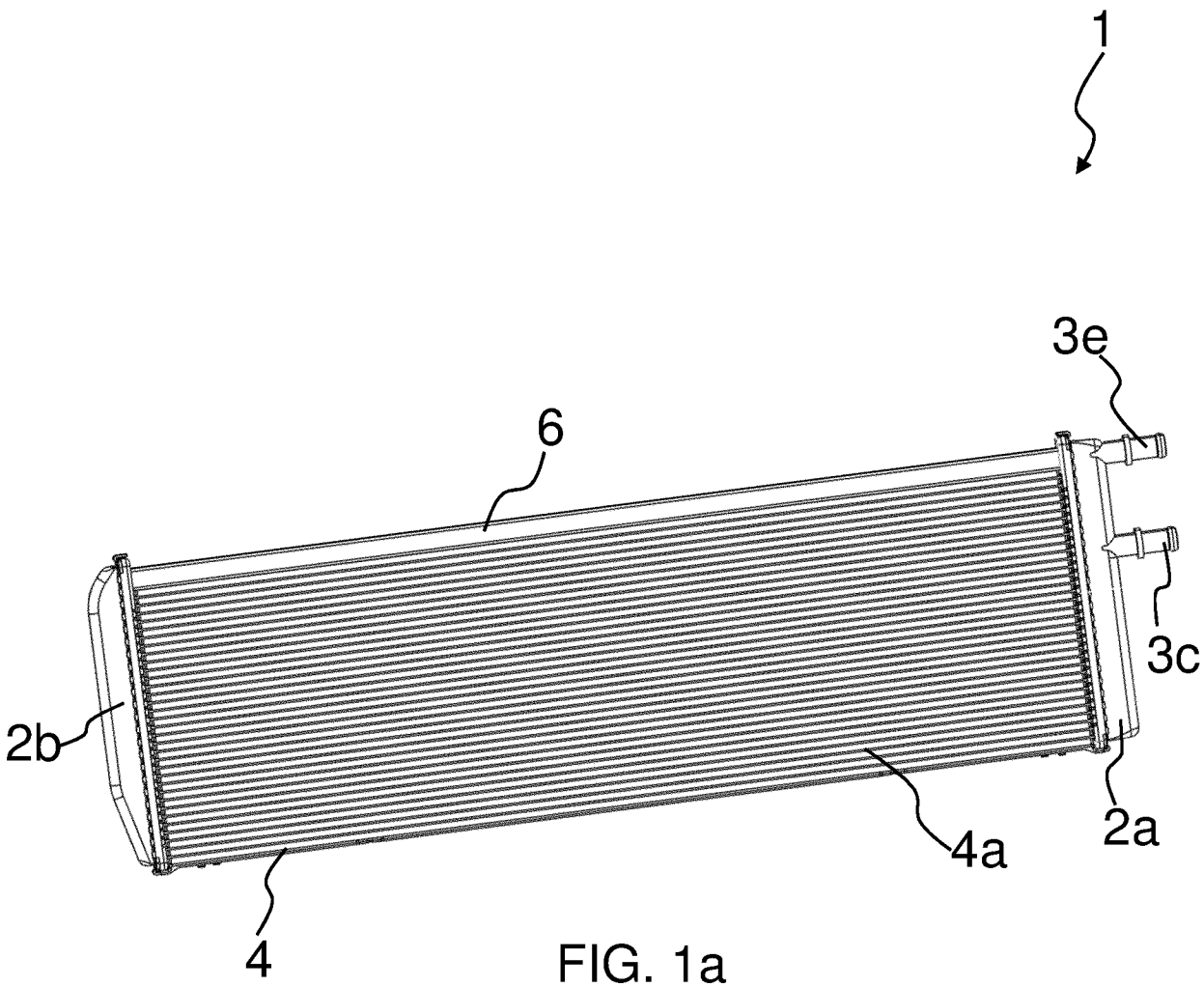

FIG. 1a
(PRIOR ART)

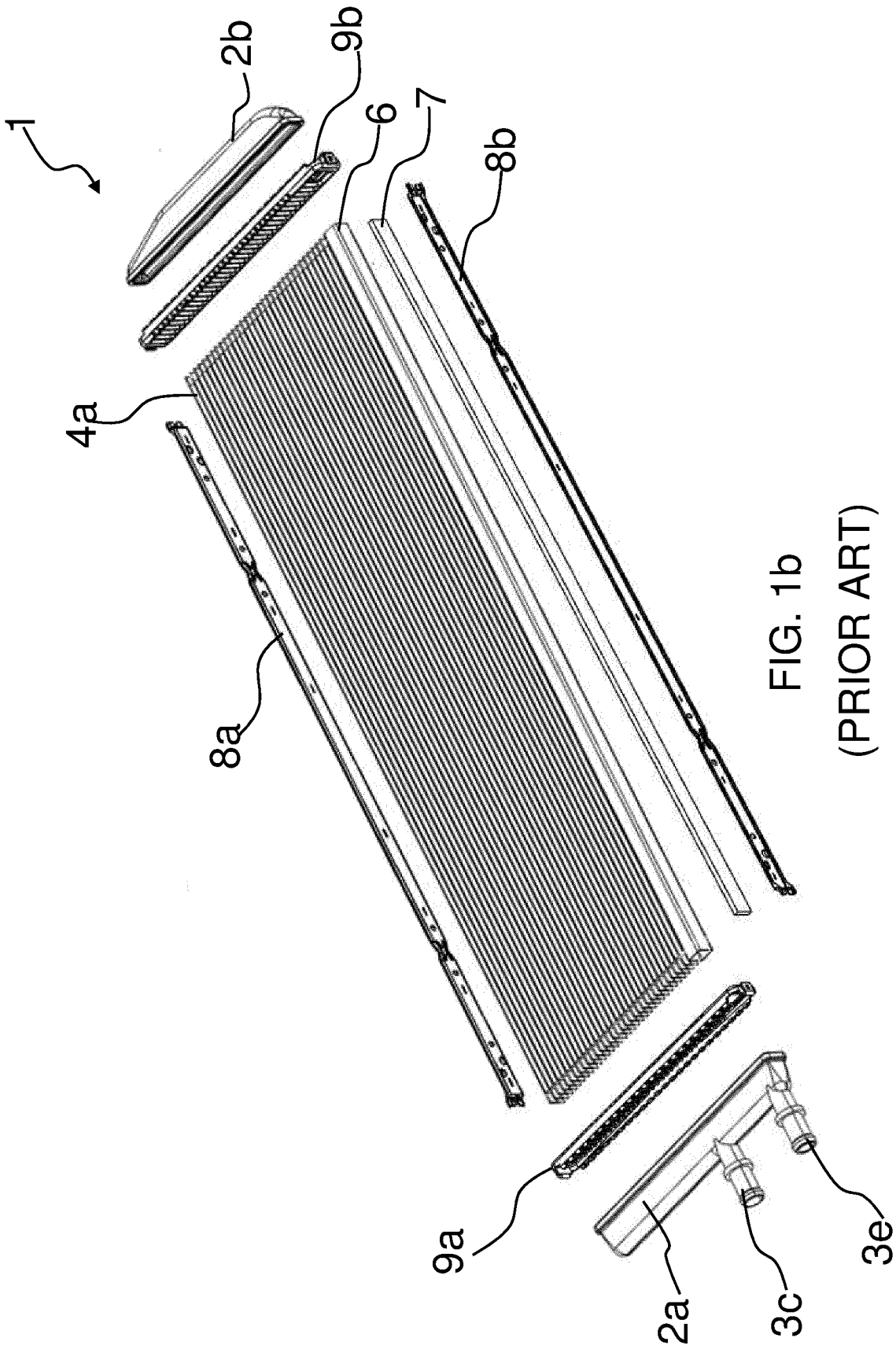

FIG. 1b
(PRIOR ART)

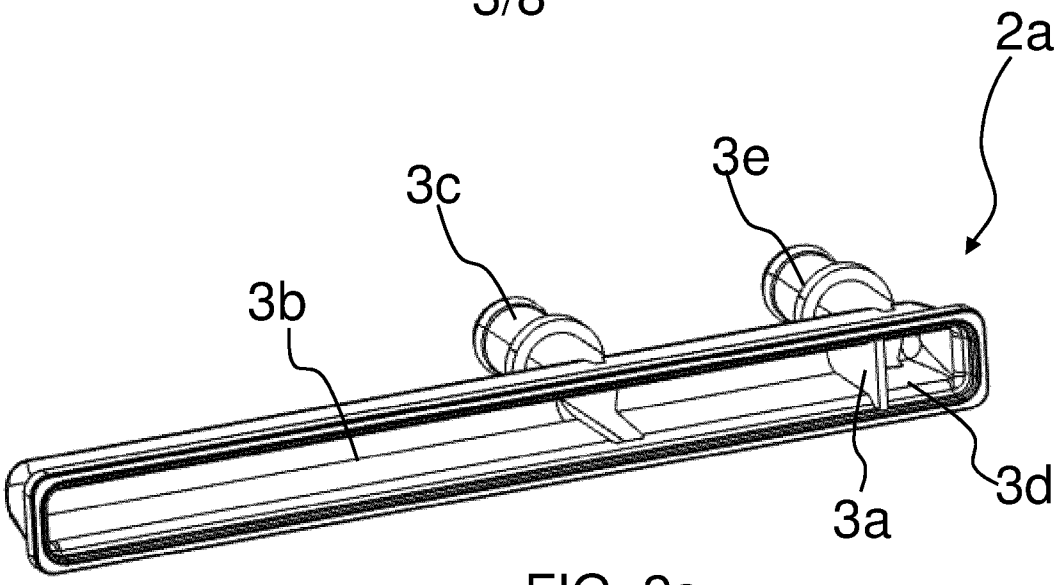

FIG. 2a
(PRIOR ART)

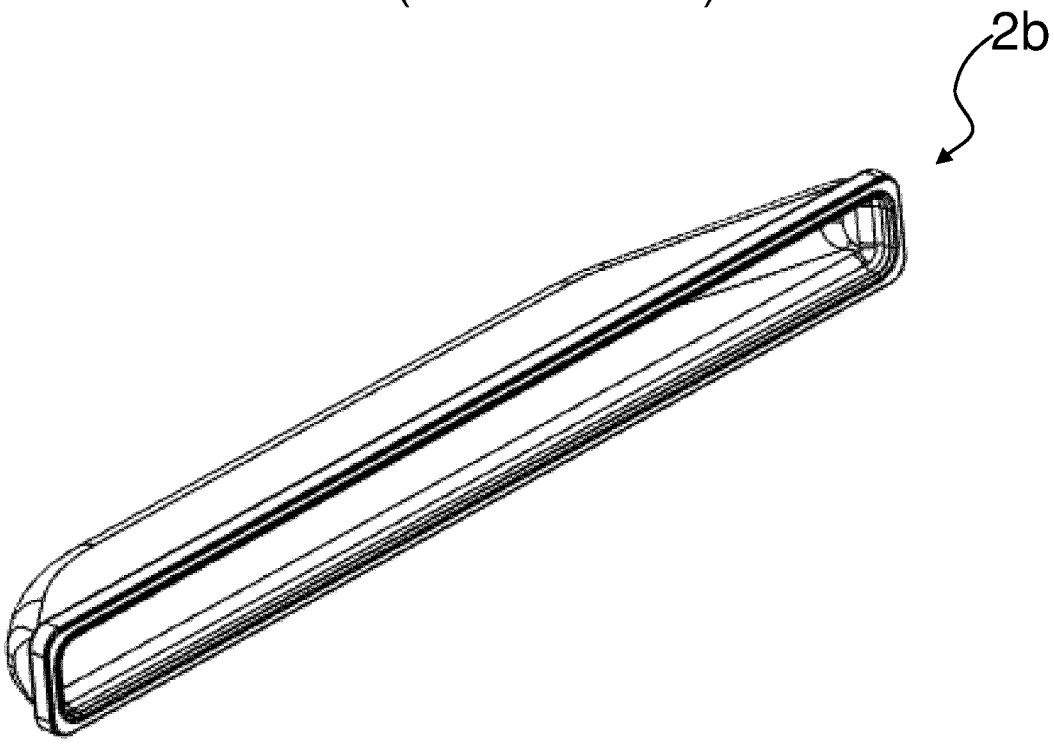

FIG. 2b
(PRIOR ART)

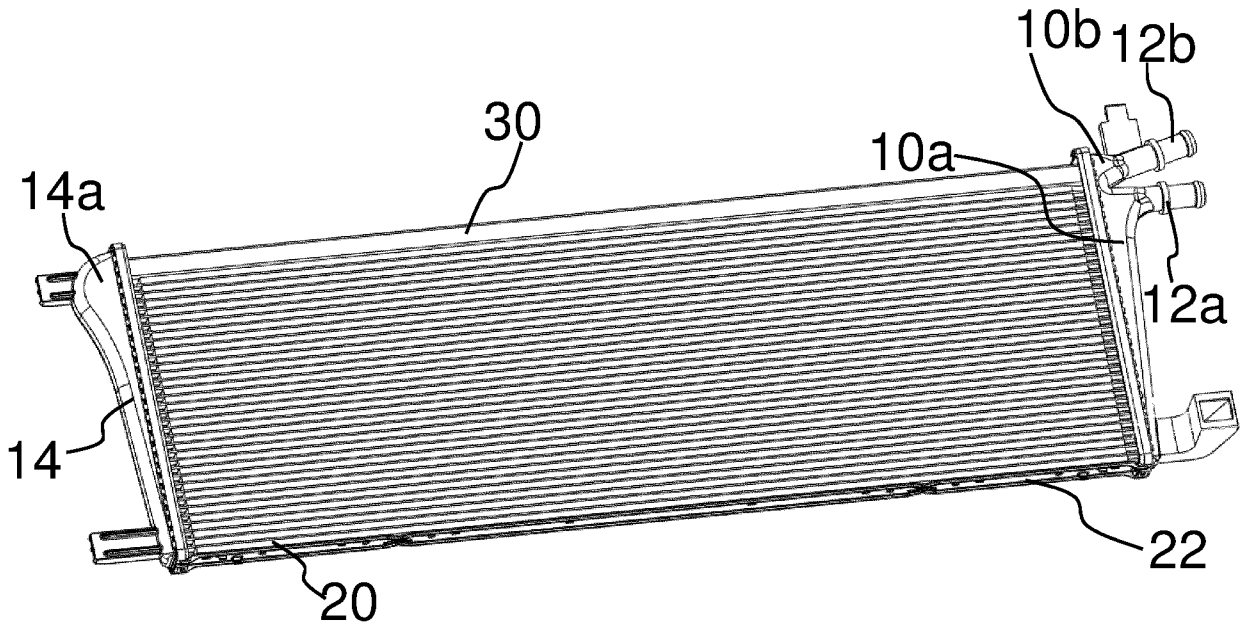

FIG. 3a

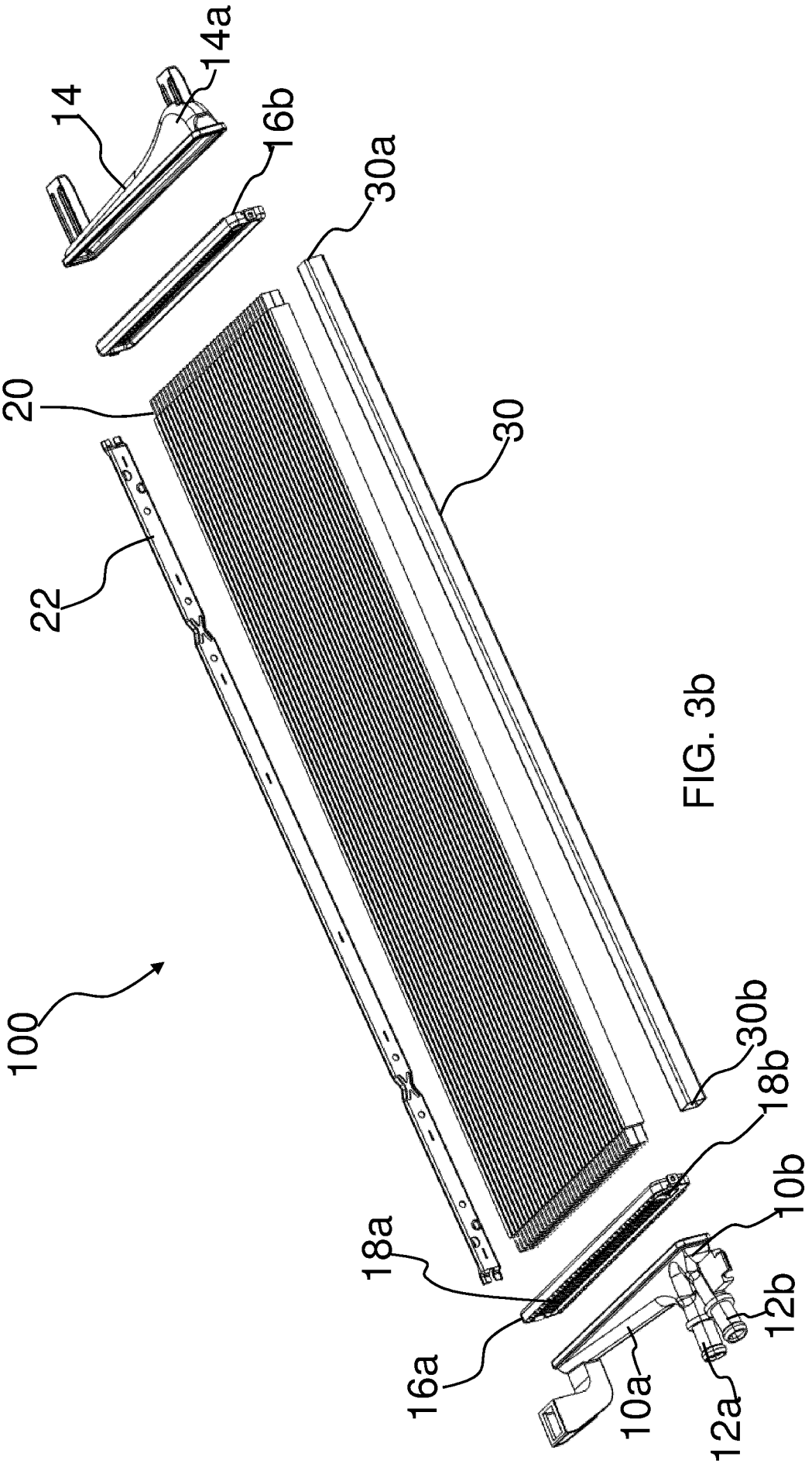

FIG. 3b

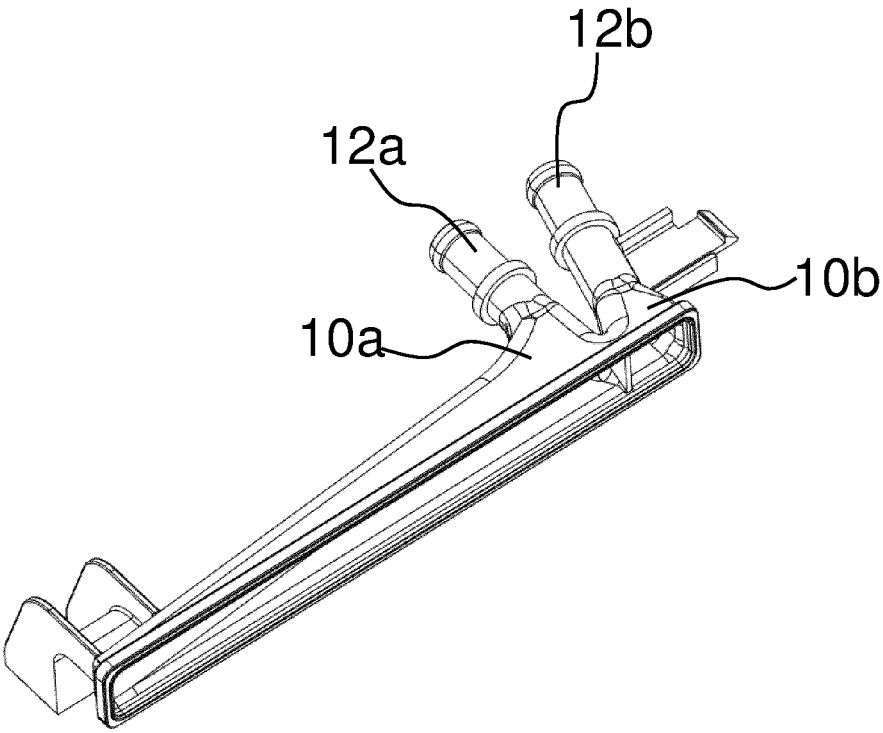

FIG. 4a

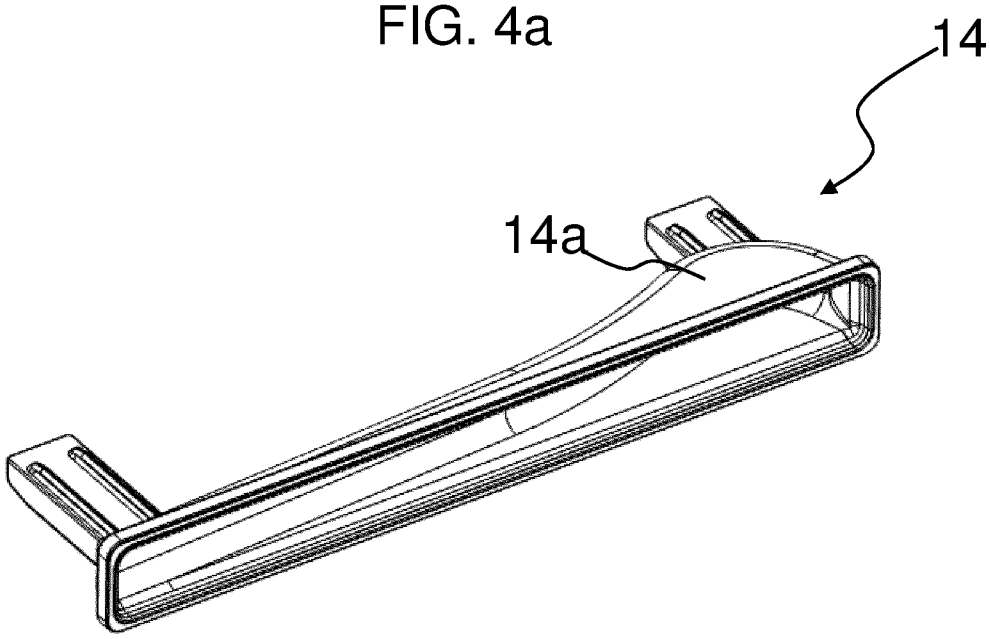

FIG. 4b

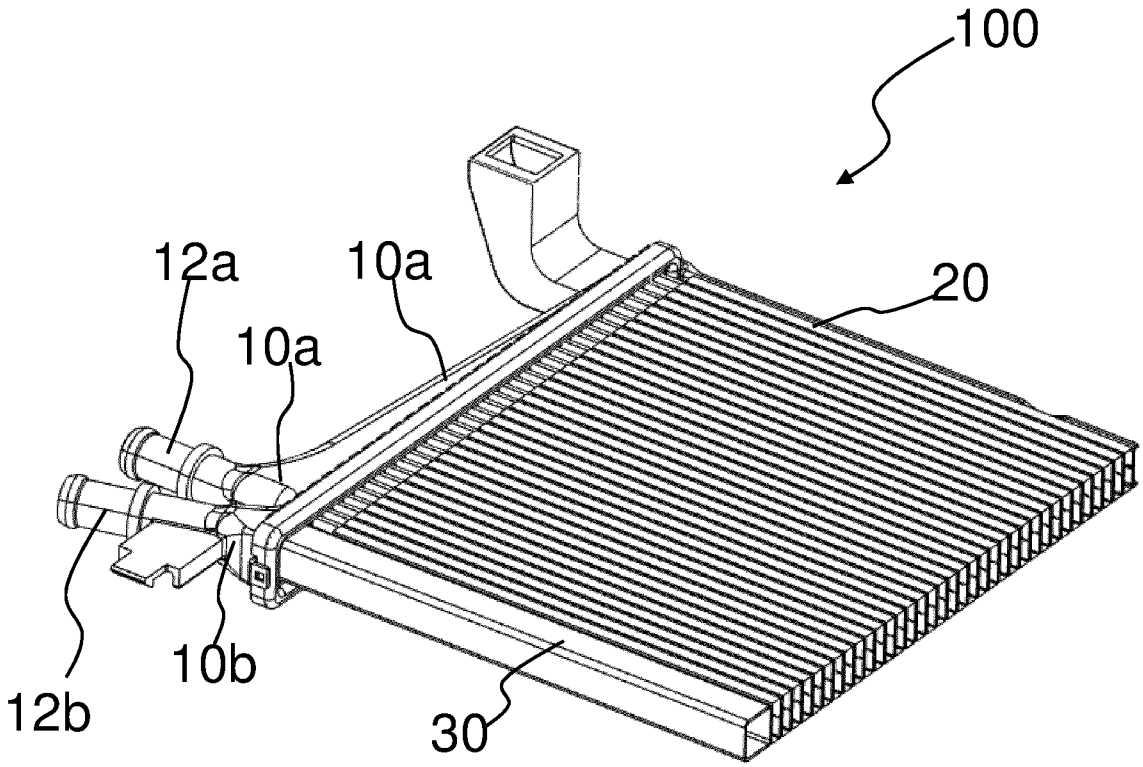

FIG. 5a

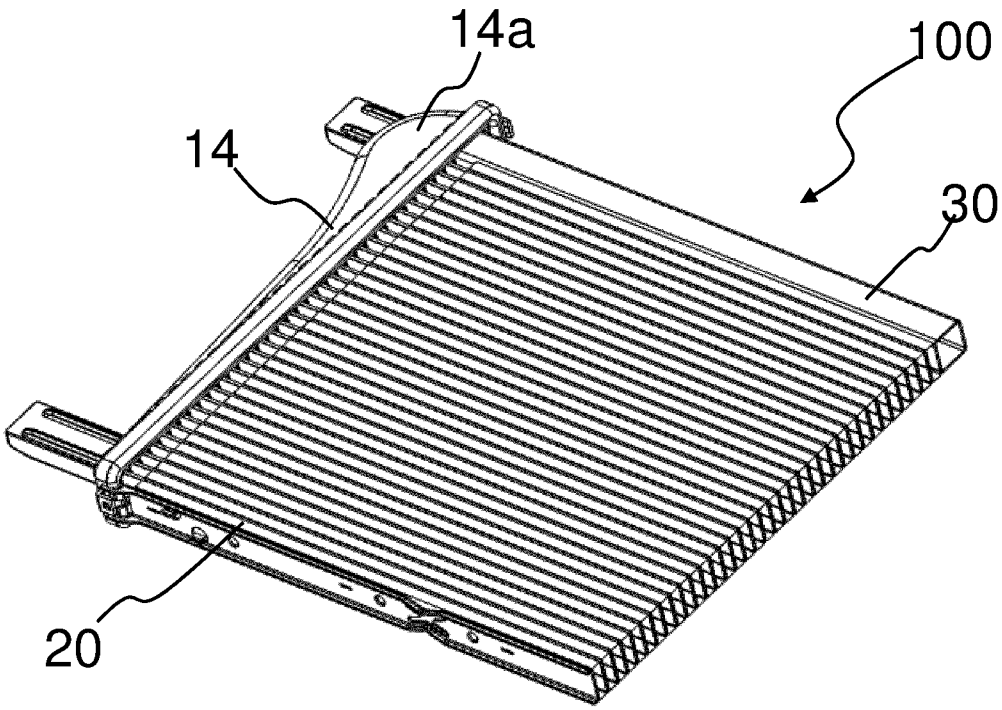

FIG. 5b

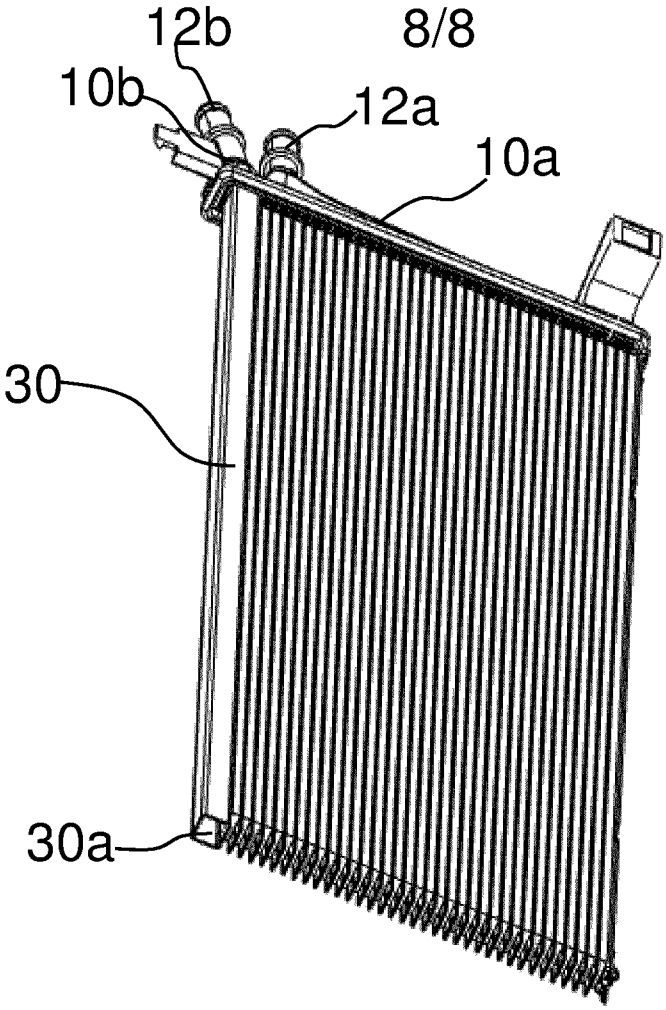

FIG. 6a

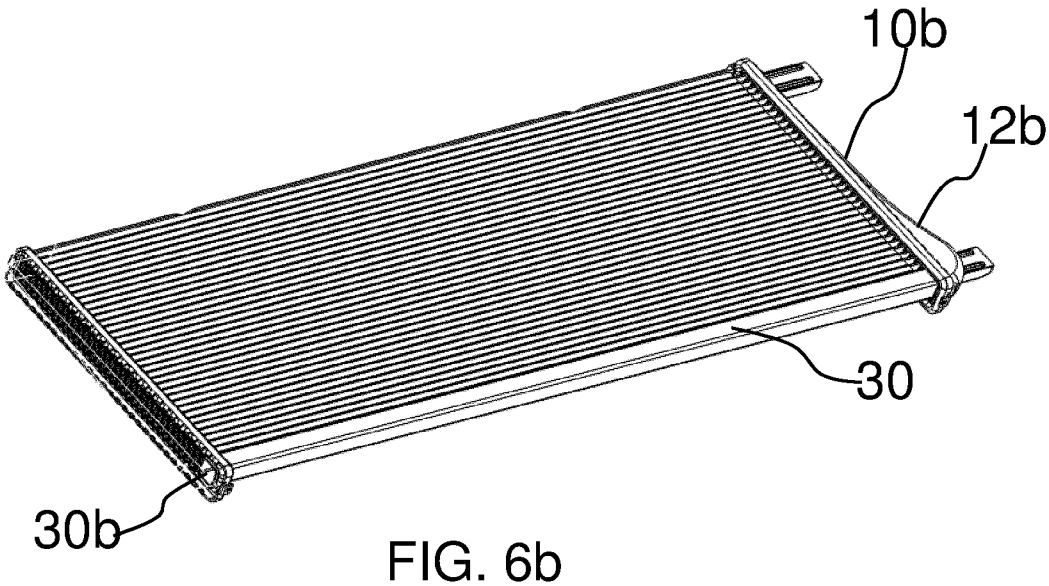

FIG. 6b

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2021/068052

A. CLASSIFICATION OF SUBJECT MATTER
INV. F28D1/053 F28D21/00 F28F9/00 F28F9/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F28D F28F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 3 361 204 A1 (RADIADORES ORDONEZ S A [ES]) 15 August 2018 (2018-08-15) paragraph [0028]; figures 6b, 7b, 8b	1-15
Y	GB 1 479 093 A (BARRY WEHMILLER CO) 6 July 1977 (1977-07-06) page 2, line 25 - page 3, line 33; figures 1,2	1-15
Y	WO 2014/056151 A1 (TRANE INT INC [US]; HARTFIELD JON PHILLIP [US] ET AL.) 17 April 2014 (2014-04-17) page 2, lines 10-21; figures 1A, 2A, 2B page 4, line 1 - page 8, line 18	1-15
Y	EP 3 540 357 A1 (HAMILTON SUNDSTRAND CORP [US]) 18 September 2019 (2019-09-18) paragraphs [0012] - [0023]; figures 2A-2E	1-15

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 August 2021	19/08/2021

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Axters, Michael

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2021/068052

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	EP 1 746 377 A1 (DELPHI TECH INC [US]) 24 January 2007 (2007-01-24) paragraphs [0001], [0006], [0007], [0014] - [0019]; figures 1-4	1-15

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INTERNATIONAL SEARCH REPORT

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International application No
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