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(54) HEAT EXCHANGER WITH RESTRICTOR

(57) A heat exchanger (100) includes a first and a second tank (10a) and (10b) disposed opposite to each other and heat exchange tubes (14). The first tank (10a) includes an inlet (12a) and an outlet (12b). The heat exchange tubes (14) connect and configure fluid communication between the first tank (10a) and the second tank (10b). The heat exchange tubes include a first set of heat exchange tubes (14a), a second set of heat exchange tubes (14b) and at least one intermediate tube (14c) disposed between them. At least one of the first tank (10a), the second tank (10b) and the at least one intermediate tube (14c) includes a restrictor (16) that prevents fluid communication between the at least one intermediate tube (14c) and the inlet (12a) and the at least one intermediate tube (14c) and the outlet (12b) through the first tank (10a).

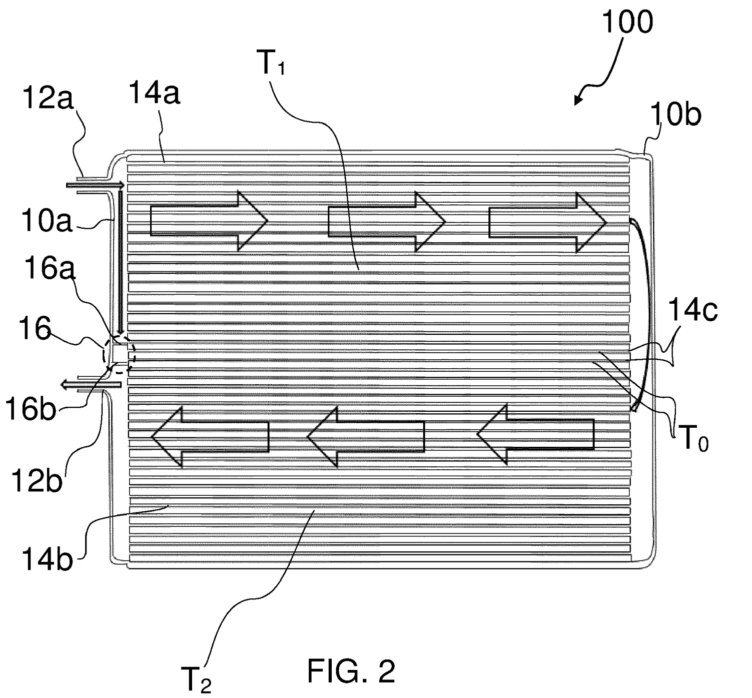

FIG. 2

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Description

[0001] The present invention relates to a heat exchanger, particularly, a heat exchanger for use in a vehicle.

[0002] A heat exchanger, particularly, a radiator as illustrated in **FIG. 1** is subjected to thermal stress. The thermal stress is stress created by any change in temperature to a material. More specifically, the thermal stress is caused by temperature gradient, thermal expansion or contraction and thermal shock. The thermal shock is a combination of a large temperature gradient in addition to rapid change in temperature. In case of a heat exchanger, the thermal shock is caused due to high temperature gradient between heat exchange tubes through which heat exchange fluid, particularly a coolant, at different temperatures flows. Also, the heat exchange tubes are subjected to rapid, repetitive change in temperature when flow of the heat exchange fluid through the heat exchange tubes is commenced and stopped as the vehicle is turned ON and OFF respectively. The high temperature gradient along with the rapid, repetitive temperature change cause thermal shock. In a conventional heat exchanger, a single baffle is disposed inside a tank to separate entering heat exchange fluid from an egressing heat exchange fluid to define a U-flow through a heat exchanger core. In case of the U-flow, a first set of heat exchange tubes defines a first flow pass and a second set of heat exchange tubes defines a second flow pass for a heat exchange fluid. The heat exchange fluid flowing through the first flow pass is at a different temperature, particularly, is at a higher temperature than the heat exchange fluid flowing through the second flow pass. As the first set of heat exchange tubes and the second set of heat exchange tubes are adjacent to each other at the interface, a high thermal gradient exists at the interface of the first set of heat exchange tubes and the second set of heat exchange tubes. Due to high thermal gradient, the heat exchange tubes at the interface of the first set of heat exchange tubes and the second set of heat exchange tubes is subjected to thermal stresses, thereby causing cracks and mechanical failures. Such cracks and mechanical failure detrimentally affect the service life of the heat exchanger. In addition, the cracks and mechanical failure of the heat exchange tubes may cause leakage of the heat exchange fluid from the tubes, thereby reducing the thermal efficiency and performance of the heat exchanger.

[0003] Accordingly, there is a need for a heat exchanger that addresses problems such as cracks and mechanical failures due to thermal stresses resulting from the high temperature gradient to which elements of conventional heat exchangers are often subjected. Further, there is a need for a heat exchanger that exhibits comparatively longer service life, is comparatively less prone to failures and requires comparatively less maintenance as compared to conventional heat exchangers. Furthermore, there is a need for a heat exchanger that exhibits high thermal efficiency and improved performance as compared to the conventional heat exchangers.

[0004] An object of the present invention is to provide a heat exchanger that obviates drawbacks associated with conventional heat exchanger by addressing problems such as cracks and mechanical failures due to thermal stresses resulting from the high temperature gradient to which elements of the conventional heat exchanger are often subjected.

[0005] Yet another object of the present invention is to provide a heat exchanger that exhibits comparatively longer service life.

[0006] Still another object of the present invention is to provide a heat exchanger that is comparatively less prone to failures and requires comparatively less maintenance as compared to conventional heat exchangers.

[0007] Another object of the present invention is to provide a heat exchanger that exhibits high thermal efficiency and improved performance as compared to the conventional heat exchangers

[0008] 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.

[0009] A heat exchanger is disclosed in accordance with an embodiment of the present invention. The heat exchanger includes a first tank, a second tank and a plurality of heat exchange tubes. The first tank includes an inlet and an outlet. The second tank is disposed opposite to the first tank. The plurality of heat exchange tubes connect and configure fluid communication between the first tank and the second tank. The plurality of heat exchange tubes includes a first set of heat exchange tubes, a second set of heat exchange tubes and at least one intermediate tube disposed between them. At least one of the first tank, the second tank and the at least one intermediate tube include a restrictor that prevents fluid communication between the at least one intermediate tube and the inlet and between the at least one intermediate tube and the outlet.

[0010] Specifically, the restrictor is placed in the first tank and prevents fluid flow from the at least one intermediate tube to the inlet and to the outlet within the first tank.

[0011] Generally, the restrictor includes a pair of baffles disposed inside the first tank between the inlet and the outlet, the pair of baffles prevent fluid communication between the inlet and the corresponding at least one intermediate tube disposed between the pair of baffles and between the outlet and the corresponding at least one intermediate tube.

[0012] Preferably, the baffles are integrally formed with the first tank by a single step moulding process.

[0013] Alternatively, at least one of the baffles are movable with respect to each other to adjust the spacing there between and adjust the number of the corresponding intermediate tubes disposed between the baffles.

[0014] In accordance with an embodiment of the present invention, at least one of the baffles is a first blocking element that blocks entry of the heat exchange fluid into the at least one intermediate tube from the first tank, thereby preventing fluid communication between the at least one intermediate tube and the inlet.

[0015] Specifically, the first blocking element is a planar plate disposed orthogonally to the at least one intermediate tube and secured to first end of the at least one intermediate tube.

[0016] In another example, the restrictor includes a second blocking element to block entry of fluid into the at least one intermediate tube from the second tank, thereby preventing fluid communication between the at least one intermediate tube and the second tank.

[0017] Specifically, the second blocking element is a planar plate disposed orthogonally to the at least one intermediate tube and secured to second end of the at least one intermediate tube opposite to first end thereof.

[0018] Still further, the at least one intermediate tube is filled with insulation material to provide insulation between the first set of heat exchange tubes and a second set of heat exchange tubes and prevent fluid flow through the at least one intermediate tube.

[0019] Particularly, the number of the intermediate tubes are in the range of 2%-4% of the heat exchange tubes.

[0020] Other characteristics, details and advantages of the invention can be inferred from the description of the invention hereunder. A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying figures, wherein:

FIG. 1 illustrates a schematic representation of a conventional heat exchanger with a single baffle configuring U-flow through a heat exchanger core;

FIG. 2 illustrates a schematic representation of a heat exchanger in accordance with an embodiment of the present invention, wherein a first tank of the heat exchanger includes two baffles disposed there inside to prevent temperature gradient;

FIG. 3 illustrates a schematic representation of a heat exchanger in accordance with another embodiment of the present invention, wherein a first blocking element disposed in a first tank blocks entry of heat exchange fluid in intermediate tubes;

FIG. 4 illustrates a schematic representation of a heat exchanger in accordance with another embodiment of the present invention, wherein a second blocking element disposed in a second tank blocks entry of heat exchange fluid in the intermediate tubes; and

FIG. 5 illustrates a schematic representation of a heat exchanger in accordance with yet another embodiment of the present invention, wherein intermediate tubes are filled with insulation material.

[0021] 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.

[0022] The present invention envisages a heat exchanger, particularly, a radiator. The radiator includes a first tank a second tank and a plurality of heat exchange tubes disposed between the first tank and the second tank and configuring fluid communication between the first tank and the second tank. The first tank includes an inlet and an outlet for ingress and egress of a heat exchange fluid into and out of the first tank respectively. The first tank further includes a pair of baffles disposed therein to separate entering heat exchange fluid from egressing heat exchange fluid. A pair of baffles is disposed in the first tank between the inlet and the outlet and near the outlet to prevent fluid flow through intermediate tubes disposed between the pair of baffles and at the interface between the heat exchange tubes defining the first pass and the second pass respectively. Once the heat exchange fluid fills the tubes, further flow through the intermediate tubes is prevented, and the intermediate tubes do not participate in heat exchanger and hence are referred to as "*intermediate tubes*" instead of *"intermediate heat exchange tubes".* The heat exchanger may alternatively or additionally include other arrangements for preventing the fluid flow through the intermediate tubes. For example, at least one of the intermediate tubes is filled insulation material. In another example, heat exchange fluid is prevented from entering into the intermediate tubes by blocking a first entrance to the intermediate tubes from the first tank by a first blocking plate. In another example, the heat exchange fluid is prevented from entering into the intermediate tubes by blocking a second entrance to the intermediate heat exchange tubes from the second tank by a second blocking plate. Such a configuration of the intermediate tubes without any fluid flow there through prevents high temperature gradient that would had existed if the first set of tubes and the second set of tubes are adjacent to each other. By preventing the high temperature gradient, the thermal stresses and problems such as occurrence of cracks and mechanical failure arising due to thermal stresses are prevented. Although, the present invention is explained in the forthcoming description and accompanying drawings with an example of a radiator. However, the present invention is not limited to radiators only and is applicable for any heat exchanger in which the thermal stresses arising due to high thermal gradient between heat exchange tubes due to different temperature fluid flowing there-through is to be prevented.

[0023] A conventional heat exchanger **1** as illustrated in **FIG. 1** includes a first tank **2a,** a second tank **2b** and a plurality of heat exchange tubes **4** defining a heat exchange core between the first tank **2a** and the second tank **2b.** The first tank **2a** includes an inlet **3a** for ingress of the heat exchange fluid into the first tank **2a** and an outlet **3b** for the egress of the heat exchange fluid from the first tank **2a.** The first tank **2a** further includes a single baffle **2** disposed therein to separate entering heat exchange fluid from an egressing heat exchange fluid and define a U-flow through the heat exchanger core defined by the heat exchange tubes **4.** More specifically, the heat exchange fluid enters the first tank **2a** from the inlet **3a,** the baffle **2** prevents the heat exchange fluid received in a first portion of the first tank **2a** at a first side of the baffle **2** from flowing to a second portion of the first tank **2a** at other side of the baffle **2.** The heat exchange fluid received in the first portion of the first tank **2a** is distributed to a first set of heat exchange tubes **4a** defining a first flow pass and is returned back to the second portion of the first tank **2a** at the other side of the baffle **2** through a second set of heat exchange tubes **4b.** The heat exchange fluid received in the second portion of the first tank **2a** on the other side of the baffle **2** egresses from the second portion of the first tank **2b** through the outlet **3b.** Specifically, the first set of heat exchange tubes **4a** on one side of the baffle **2** defines the first flow pass of the heat exchange fluid from the first tank **2a** to the second tank **2b.** The second set of heat exchange tubes **4b** on the other side of the baffle **2** defines a second flow pass for the heat exchange fluid from the second tank **2b** to the first tank **2a.** The heat exchange fluid flowing through the first flow pass is at a different temperature **t1,** particularly, it may be at a higher temperature than the temperature **t2** of the heat exchange fluid flowing through the second flow pass or the return flow pass. This is because the heat exchange fluid flowing through the second flow pass or the return pass had already rejected heat as the heat exchanger fluid passed through the first flow pass before entering into the second flow pass. As the first set of heat exchange tubes **4a** and the second set of heat exchange tubes **4b** through which different temperature heat exchange fluid flows respectively are adjacent to each other at an interface of the first set of heat exchange tubes **4a** and the second set of heat exchange tubes **4a.** Accordingly, a large thermal gradient Δt exist between the heat exchange tubes, particularly, at the interface. Also, the heat exchange tubes are subjected to rapid, repetitive change in temperature when flow of the heat exchange fluid through the heat exchange tubes is commenced and stopped as the vehicle is turned ON and OFF respectively. Due to thermal shock caused due to heat exchange tubes being subjected to thermal gradient Δt, between the heat exchange tubes at the interface, and rapid, repetitive change in temperature, the heat exchange tubes are subjected to thermal stresses, thereby causing cracks and mechanical failures in the heat exchange tubes, particularly, the heat exchange tubes at the interface. Specifically, the first and the second set of heat exchange tubes **4a** and **4b** that are close to the baffle **2** are subjected to mechanical failure. The reason for the mechanical failure is temperature difference between temperature of the first set of heat exchange tubes **4a** and the second set of heat exchange tubes **4b.** The first set of heat exchange tubes **4a** on one side of the baffle **2** through which hot heat exchange fluid flows becomes hot. The second set of heat exchange tubes **4b** on other side of the baffle **2** though which cooled heat exchange fluid flows is at comparatively lower temperature than the temperature of the first set of heat exchanger tubes **4a.** Accordingly, the heat exchange tubes of the first set of heat exchange tubes **4a** near the baffle **2** expand/ elongate while the heat exchange tubes of the second set of heat exchange tubes **4b** near the baffle **2** contract or are shortened, thereby causing thermal stress and failure. Sometimes portion of the headers around the apertures for receiving the heat exchange tubes at the interface are also subjected to thermal stresses due to thermal gradient. Such cracks and mechanical failure detrimentally affect the service life of the heat exchanger **1.** In addition, the cracks and mechanical failure of the heat exchange tubes at the interface may cause leakage of the heat exchange fluid from the tubes, thereby reducing the thermal efficiency and performance of the heat exchanger **1.**

[0024] In order to mitigate the adverse impact of thermal gradient **At** between the heat exchange tubes at the interface of the first set of heat exchange tubes defining a first pass and a second set of heat exchange tubes defining a second pass or the return pass, different arrangements are provided in accordance with different embodiments of the present invention.

[0025] **FIG. 2** illustrates a schematic representation of a heat exchanger **100** in accordance with an embodiment of the present invention. The heat exchanger **100** includes a first tank **10a,** a second tank **10b** and a plurality of heat exchange tubes **14** defining a heat exchanger core. The second tank **10b** is disposed opposite to the first tank **10a.** The plurality of heat exchange tubes **14** connect and configure fluid communication between the first tank **10a** and the second tank **10b.** The first tank **10a** includes an inlet **12a** and an outlet **12b.** The inlet **12a** is for ingress of the heat exchange fluid into the first tank **10a** and the outlet **12b** is for the egress of the heat exchange fluid from the first tank **10a.** The first tank **10a** further includes at least one baffle **16a, 16b** disposed therein to separate entering heat exchange fluid from egressing heat exchange fluid and define a U-flow through the heat exchanger core defined by the plurality of heat exchange tubes **14.** The heat exchange tubes **14** includes a first set of heat exchange tubes **14a,** a second set of heat exchange tubes **14b** and at least one intermediate tube **14c,** specifically one or more intermediate tubes **14c** (hereinafter referred to as intermediate tubes) disposed between the first set of heat exchange tubes **14a** and the second set of heat exchange tubes **14b.** In one example, there can be a single intermediate tube **14c** disposed between the first set of heat exchange tubes **14a** and the second set of heat exchange tubes **14b.** In another example, there can be multiple intermediate tube **14c** disposed between the first set of heat exchange tubes **14a** and the second set of heat exchange tubes **14b.** The heat exchange fluid enters the first tank **10a** from the inlet **12a,** the at least one baffle **16a, 16b** prevents the heat exchange fluid received in a first portion of the first tank **10a** at a first side of the at least one baffle **16a, 16b** from flowing to a second portion of the first tank **10a** at other side of the at least one baffle **16a, 16b.** The heat exchange fluid received in the first portion at one side of the at least one baffle **16a, 16b** is distributed to the first set of heat exchange tubes **14a** defining a first flow pass. The heat exchange fluid after passing through the first pass is collected in the second tank **10b** and is returned back to the second portion of the first tank **10a** at the other side of the at least one baffle **16a, 16b** through the second set of heat exchange tubes **14b** defining a second flow pass. The heat exchange fluid received in the second portion of the first tank **10a** at the other side of the at least one baffle **16a, 16b** egresses from the second portion of the first tank **10a** through the outlet **12b.** Specifically, the first set of heat exchange tubes **14a** at one side of the at least one baffle **16a, 16b** defines the first flow pass for the heat exchange fluid from the first tank **10a** to the second tank **10b.** Whereas, the second set of heat exchange tubes **14b** at the other side of the at least one baffle **16a, 16b** defines a second flow pass for the heat exchange fluid from the second tank **10b** to the first tank **10a.** At least one of the first tank **10a,** the second tank **10b** and the intermediate tubes **14c** includes a restrictor **16** that prevents fluid communication between the intermediate tubes **14c** and the inlet **12a** and between the intermediate tubes **14c** and the outlet **12b** through the first tank **10a.** More specifically, the restrictor **16** is placed in the first tank **10a** and prevents fluid flow from the intermediate tubes **14c** to the inlet **12a** and to the outlet **12b** within the first tank **10a.**

[0026] In accordance with an embodiment of the present invention, the restrictor **16** includes two baffles **16a** and **16b** disposed inside the first tank **10a** of the heat exchanger **100.** The baffles **16a** and **16b** are disposed between the inlet **12a** and the outlet **12b** and proximal to the outlet **12b.** In accordance with one embodiment, the baffles **16a** and **16b** are spaced apart from each other. Particularly, the baffles **16a** and **16b** prevent fluid communication between the inlet **12a** and the corresponding intermediate tubes **14c** disposed between the pair of baffles **16a** and **16b** through the first tank **10a.** In addition, the baffles **16a** and **16b** prevent fluid communication between the outlet **12b** and the corresponding intermediate tubes **14c** through the first tank **10a.** In accordance with an embodiment of the present invention, the baffles **16a** and **16b** are integrally formed with the first tank **10a** by a single step moulding process. In accordance with another embodiment, the at least one of the baffles **16a** and **16b** can be moved with respect to each other to adjust the spacing there between and adjust the number of corresponding intermediate tubes **14c** disposed between the baffles **16a** and **16b.** The baffles **16a** and **16b** prevent high temperature gradient between the heat exchange tubes on different sides of the baffles **16a** and **16b.** More specifically, the baffles **16a** and **16b** prevent the heat exchange fluid from entering inside the intermediate tubes **14c** disposed between the baffles **16a** and **16b** and between the first set of heat exchange tubes **14a** and the second set of heat exchange tubes **14b.** As the flow through the intermediate tubes **14c** is prevented, the intermediate tubes **14c** do not participate in heat exchanger and hence are referred to as *"intermediate tubes"* instead of *"intermediate heat exchange tubes".* The intermediate tubes **14c** without fluid flow there through act as thermal barrier between the first set of heat exchange tubes **14a** and the second set of heat exchange tubes **14b.** The temperature of the intermediate tubes **14c** is $\mathbf{T_0}$. The temperature of the first set of heat exchange tubes **14a** at the interface between the first set of heat exchange tubes **14a** and the intermediate tubes **14c** is $\mathbf{T_1}$ due to the heat exchange fluid at temperature $\mathbf{T_1}$ flowing there through. Similarly, the temperature of the second set of heat exchange tubes **14b** at the interface between the second set of heat exchange tubes **14b** and the intermediate tubes **14c** is $\mathbf{T_2}$ due to the heat exchange fluid at temperature $\mathbf{T_2}$ flowing there through. The difference in temperature of the heat exchange fluid passing through the first set of heat exchange tubes **14a** and the second set of heat exchange tubes **14b** is due to the heat exchange fluid rejecting heat to the air surrounding the first set of heat exchange tubes **14a** as the heat exchange fluid passes through the first set of heat exchange tubes **14a.** Since, the first set of heat exchange tubes **14a** receive hot heat exchange fluid to be cooled and the second set of heat exchange tubes **14b** receive heat exchange fluid cooled in the first heat exchange tube **14a,** the intermediate tubes **14c** are at an intermediate temperature $\mathbf{T_0}$ such that $\mathbf{T_1} > \mathbf{T_0} > \mathbf{T_2}$. In another scenario, if the second set of heat exchange tubes **14b** received the hot heat exchange fluid to be cooled and the first set of heat exchange tubes **14a** received the heat exchange fluid cooled in the second heat exchange tube **14b,** then the intermediate tubes **14c** are at an intermediate temperature $\mathbf{T_0}$ such that $\mathbf{T_2} > \mathbf{T_0} > \mathbf{T_1}$. In any case, the temperature gradient between the temperature $\mathbf{T_0}$ of the intermediate tubes **14c** and the temperature $\mathbf{T_1}$ of the heat exchange tubes at the interface between the first set of heat exchanger tubes **14a** and the intermediate tubes **14c** is $\Delta\mathbf{T_1}$. Similarly, the temperature gradient between the temperature $\mathbf{T_0}$ of the intermediate tubes **14c** and the temperature $\mathbf{T_2}$ of the second set of heat exchange tubes **14b** at the interface between the second set of heat exchanger tubes **14b** and the intermediate tubes **14c** is ΔT_2. The temperature gradient ΔT_1 and ΔT_2 are smaller than the temperature gradient Δt. In accordance with another embodiment, at least one of the baffles **16a** and **16b** is a first blocking element **16c** as illustrated in **FIG. 3** that blocks entry of the heat exchange fluid into the intermediate tubes **14c** from the first tank **10a,** thereby preventing fluid flow through the intermediate tubes **14c.** The first blocking element **16c** is a planar plate disposed orthogonally to the intermediate tubes **14c** and secured to first end of the intermediate tubes **14c.** More specifically, the first blocking element **16c** closes the first end of the intermediate tubes **14c.** However, the present invention is not limited to any particular configuration, placement and number of the baffles, the first blocking element as far as the baffles, the first blocking element are capable of preventing fluid flow through the intermediate tubes **14c** to prevent high temperature gradient between the heat exchange tubes on different sides of each of the baffles **16a** and **16b.**

[0027] By restricting the fluid flow through the intermediate tubes **14c,** the temperature gradient between the heat exchange tubes on opposite sides of each baffle **16a** and **16b** is reduced. Accordingly, the problem of thermal stresses cracks and mechanical failure due to high thermal gradients is considerable reduced. Other arrangements can also be used to restrict the flow of the heat exchange fluid through the intermediate tubes **14c. FIG. 4** illustrates a schematic representation of the heat exchanger **100,** wherein a second blocking element **16d** prevents the heat exchange fluid collected in the second tank **10b** after passing through the first set of heat exchange tube **14a** from entering into the intermediate tubes **14c** from the second tank **10b.** More specifically, the second blocking element **16d** blocks entrance to the intermediate tubes **14c** from the second tank **10b.** The second blocking element **16d** is a planar plate disposed orthogonally to the intermediate tubes **14c** and secured to second end of the intermediate tubes **14c** opposite to first end thereof. More specifically, the second blocking element **16d** closes the second end of the intermediate tubes **14c.** However, the present invention is not limited to any particular configuration of the second blocking element **16d** as far as the second blocking element is capable of blocking entrance to the intermediate tubes **14c** from the second tank **10b.**

[0028] Such a configuration of the intermediate tubes **14c** without any fluid flow there through prevents high temperature gradient that would had existed if the first set of tubes and the second set of tubes are adjacent to each other. By preventing the high temperature gradient, the thermal stresses and problems such as occurrence of cracks and mechanical failure arising due to thermal stresses are prevented.

[0029] **FIG. 5** illustrates a schematic representation of the heat exchanger **100,** wherein the intermediate tubes **14c** are filled with insulation material to provide insulation between the first set of heat exchange tubes **14a** and the second set of heat exchange tubes **14b** and also prevent fluid flow through the intermediate tubes **14c.** In one example, the insulating material is rubber. In another example, the insulating material is plastic. However, the present invention is not limited to any particular material filled inside the intermediate tubes as far as the intermediate tubes are capable of providing insulation between the first set of heat exchange tubes **14a** and the second set of heat exchange tubes **14b** and prevent fluid flow through the intermediate tubes **14c.** With such configuration, in spite of the high temperature gradient between the first set of heat exchanger tubes **14a** and the second set of heat exchanger tube **14b,** the thermal stresses are prevented and the problems of cracks and mechanical failure in the heat exchange tubes is also prevented.

[0030] Generally, the number of intermediate tubes are in the range of 2%-4% of the heat exchange tubes. In one example, if the total number of heat exchange tubes are 100, then the number of intermediate tubes is 2. However, the present invention is not limited to any particular proportion of the intermediate tubes with respect to the heat exchange tubes as far as the intermediate tubes are capable of preventing high thermal gradient and problems such as thermal stresses, cracks and mechanical failures arising due to the thermal stresses.

[0031] Several modifications and improvement might be applied by the person skilled in the art to the heat exchanger **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 first tank, a second tank and a plurality of heat exchange tubes. The first tank includes an inlet and an outlet. The second tank is disposed opposite to the first tank. The plurality of heat exchange tubes connect and configure fluid communication between the first tank and the second tank. The heat exchange tubes include a first set of heat exchange tubes, a second set of heat exchange tubes and at least one intermediate tube disposed between them. At least one of the first tank, the second tank and the at least one intermediate tube includes a restrictor that prevents fluid communication between the at least one intermediate tube and the inlet and the at least one intermediate tube and the outlet.

Claims

1. A heat exchanger (100) comprising:

- a first tank (10a) comprising an inlet (12a) and an outlet (12b);
- a second tank (10b) opposite to the first tank (10a); and
- a plurality of heat exchange tubes (14) connecting and configuring fluid communication between the first tank (10a) and the second tank (10b), the plurality of heat exchange tubes (14)

comprising a first set of heat exchange tubes (14a), a second set of heat exchange tubes (14b) and at least one intermediate tube (14c) disposed between them,

characterized in that at least one of the first tank (10a), the second tank (10b) and the at least one intermediate tube (14c) comprises a restrictor (16) adapted to prevent fluid communication between the at least one intermediate tube (14c) and the inlet (12a) and between the at least one intermediate tube (14c) and the outlet (12b).

2. The heat exchanger according to claim 1, wherein the restrictor (16) is placed in the first tank (10a) and prevents fluid flow from the at least one intermediate tube (14c) to the inlet (12a) and to the outlet (12b) within the first tank (10a).

3. The heat exchanger (100) as claimed in any of the preceding claims, wherein the restrictor (16) comprises a pair of baffles (16a) and (16b) disposed inside the first tank (10a) between the inlet (12a) and the outlet (12b), the pair of baffles (16a) and (16b) being adapted to prevent fluid communication between the inlet (12a) and the corresponding at least one intermediate tube (14c) disposed between the pair of baffles (16a) and (16b) and between the outlet (12b) and the corresponding at least one intermediate tube (14c).

4. The heat exchanger (100) as claimed in claim 3, wherein the baffles (16a) and (16b) are integrally formed with the first tank (10a) by a single step moulding process.

5. The heat exchanger (100) as claimed in claim 3, wherein at least one of the baffles (16a) and (16b) is adapted to be moved with respect to each other to adjust the spacing there between and adjust the number of the corresponding intermediate tubes (14c) disposed between the baffles (16a) and (16b).

6. The heat exchanger (100) as claimed in claim 3, wherein at least one of the baffles (16a) and (16b) is a first blocking element (16c) adapted to block entry of the heat exchange fluid into the at least one intermediate tube (14c) from the first tank (10a), thereby preventing fluid communication between the at least one intermediate tube (14c) and the inlet (12a).

7. The heat exchanger (100) as claimed in claim 6, wherein the first blocking element (16c) is a planar plate disposed orthogonally to the at least one intermediate tube (14c) and secured to first end of the at least one intermediate tube (14c).

8. The heat exchanger (100) as claimed in any one of the preceding claims, wherein the restrictor (16) comprises a second blocking element (16d) adapted to block entry of the heat exchange fluid into the at least one intermediate tube (14c) from the second tank (10b), thereby preventing fluid communication between the at least one intermediate tube (14c) and the second tank (10b).

9. The heat exchanger (100) as claimed in claim 8, wherein the second blocking element (16d) is a planar plate disposed orthogonally to the at least one intermediate tube (14c) and secured to second end of the at least one intermediate tube (14c) opposite to first end thereof.

10. The heat exchanger (100) as claimed in any one of the preceding claims, wherein the at least one intermediate tube (14c) is filled with insulation material to provide insulation between the first set of heat exchange tubes (14a) and the second set of heat exchange tubes (14b) and prevent fluid flow through the at least one intermediate tube (14c).

11. The heat exchanger (100) as claimed in any one of the preceding claims, wherein the number of intermediate tubes (14c) are in the range of 2%-4% of the heat exchange tubes (14).

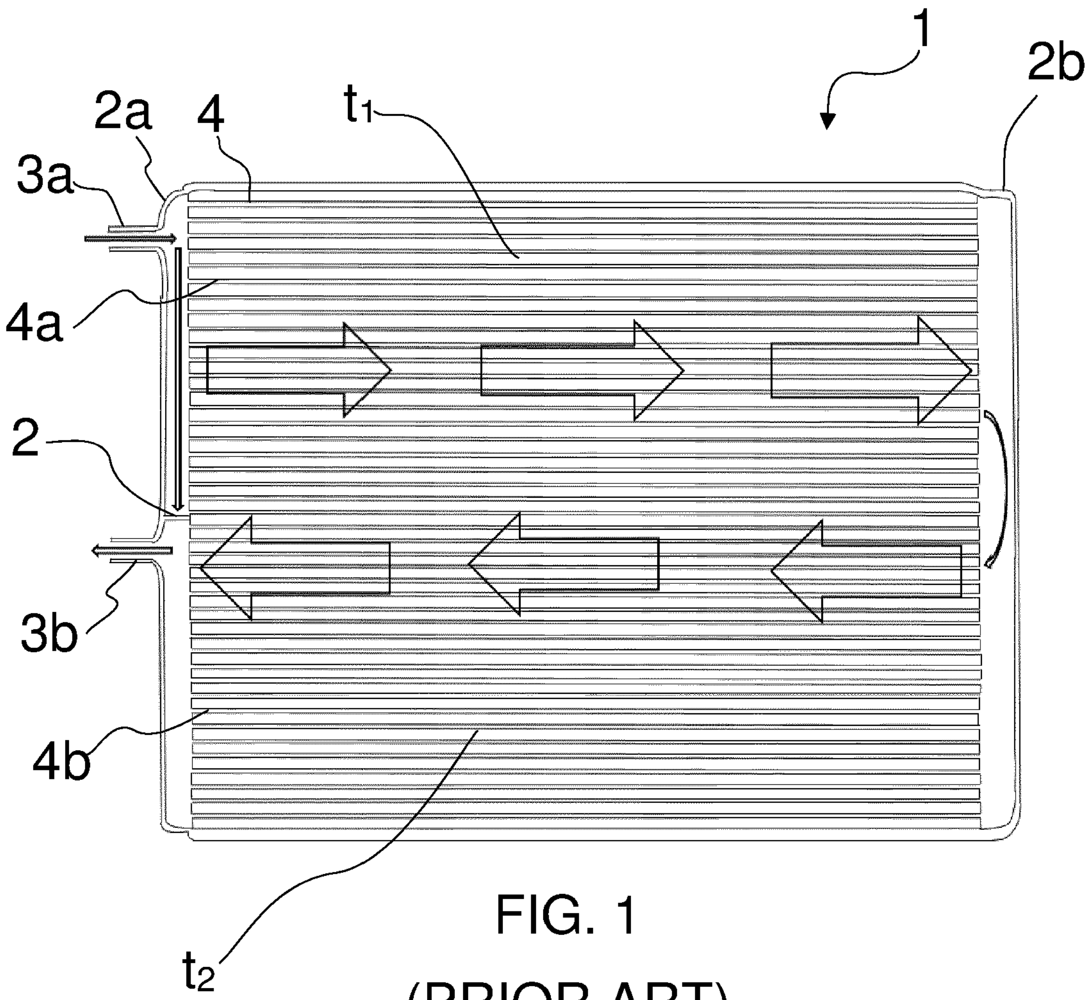

FIG. 1
(PRIOR ART)

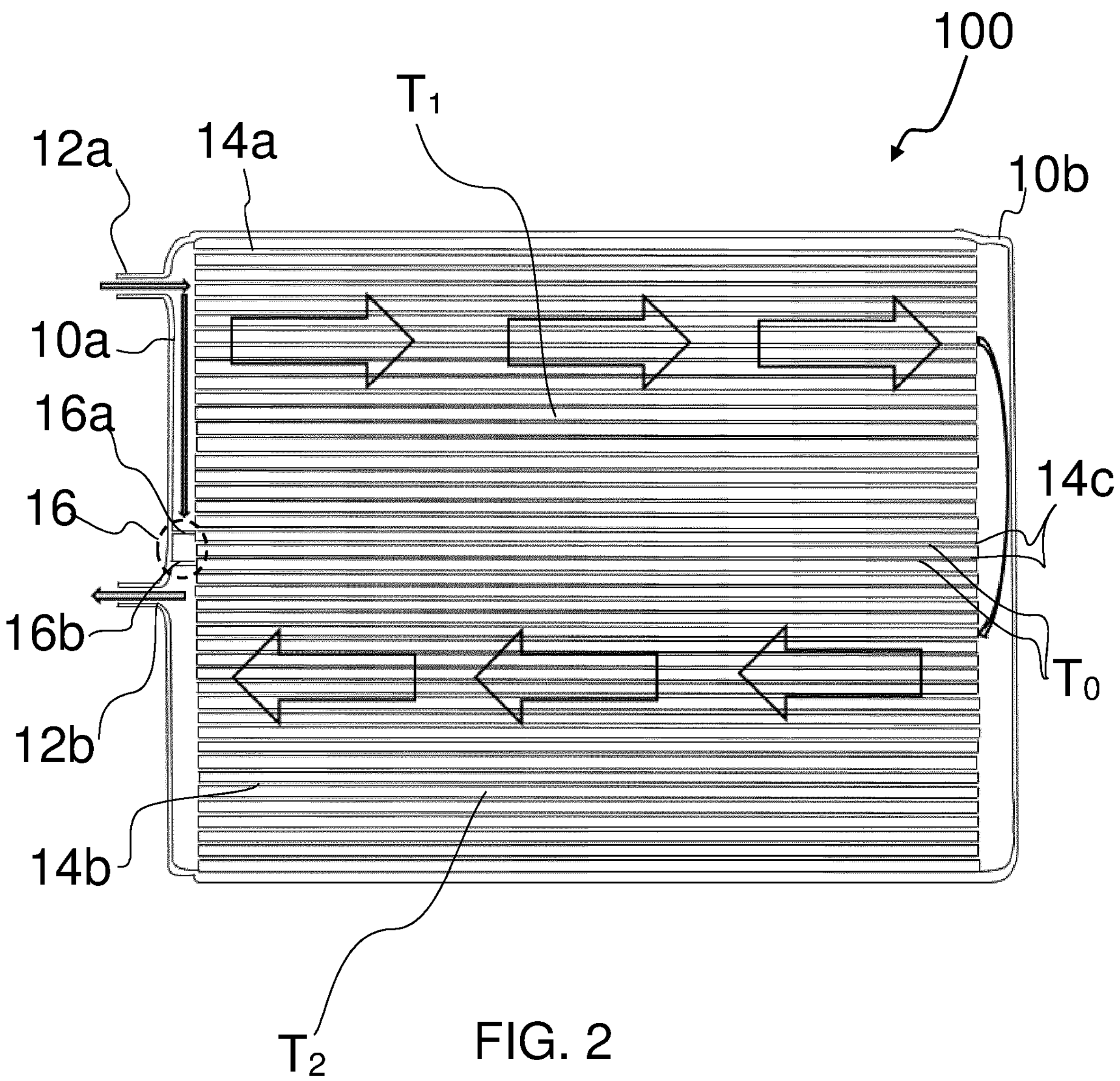

FIG. 2

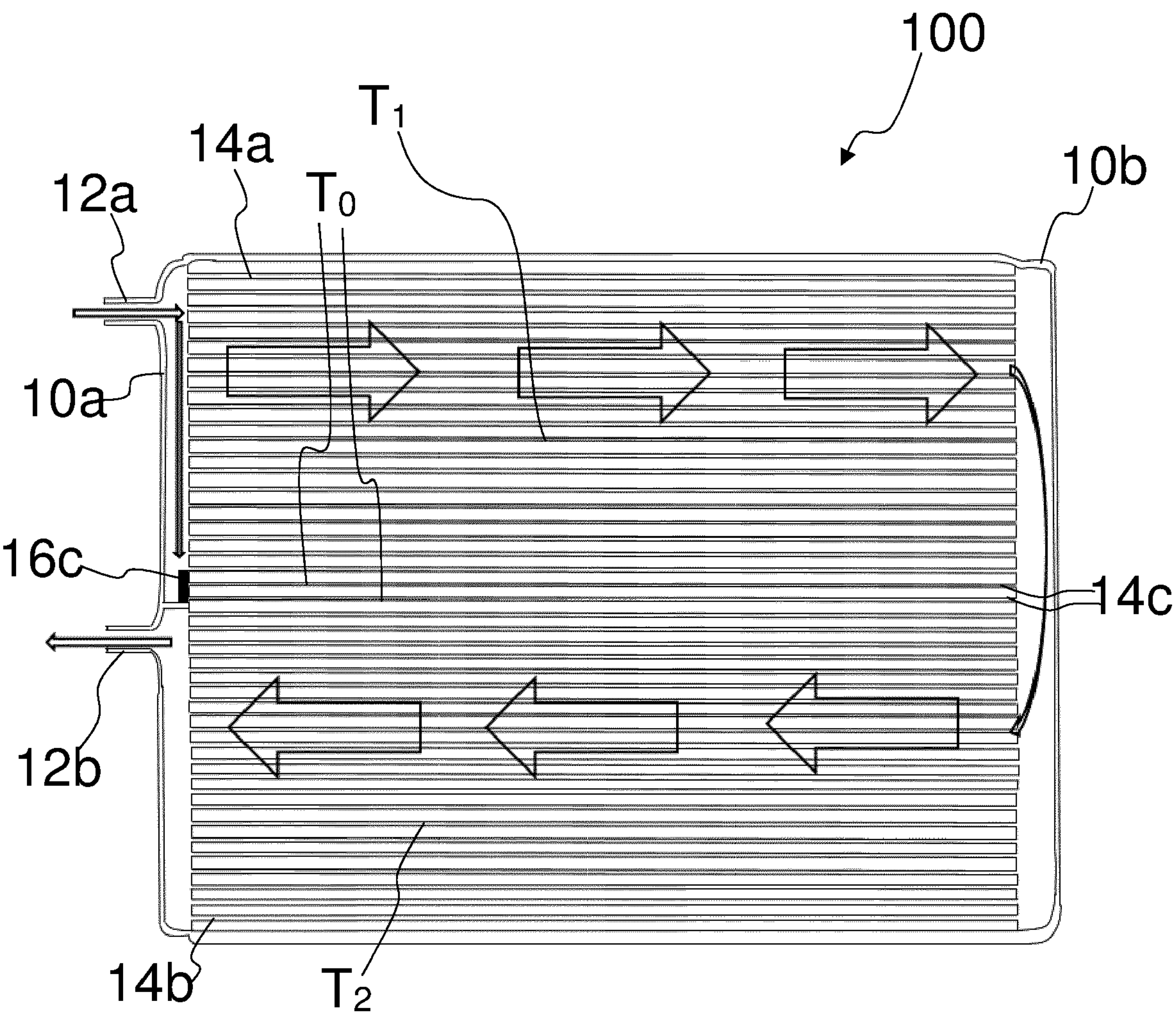

FIG. 3

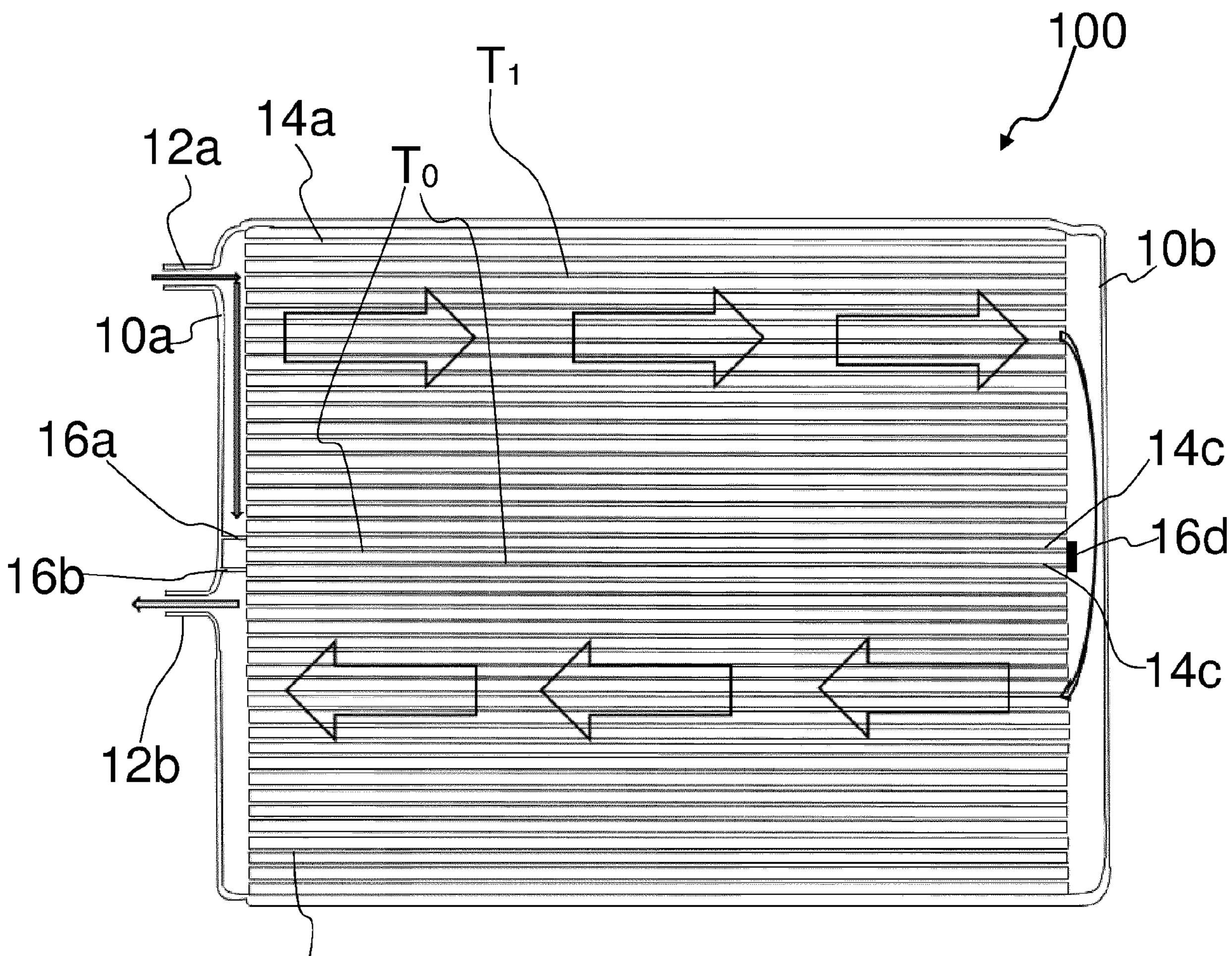

FIG. 4

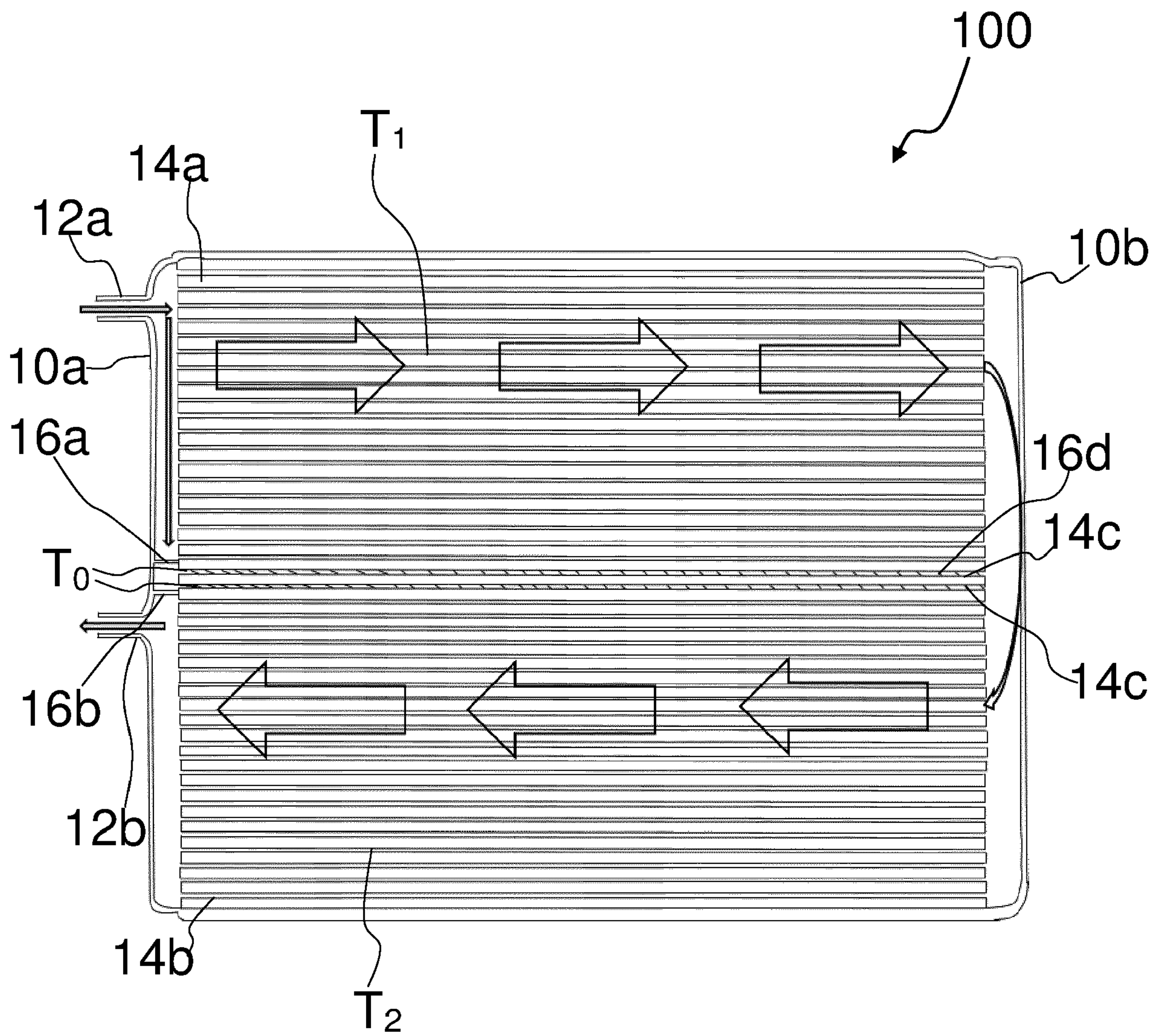

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 20 46 1536

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1

Place of search	Date of completion of the search	Examiner
Munich	20 October 2020	Schindler, Martin

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