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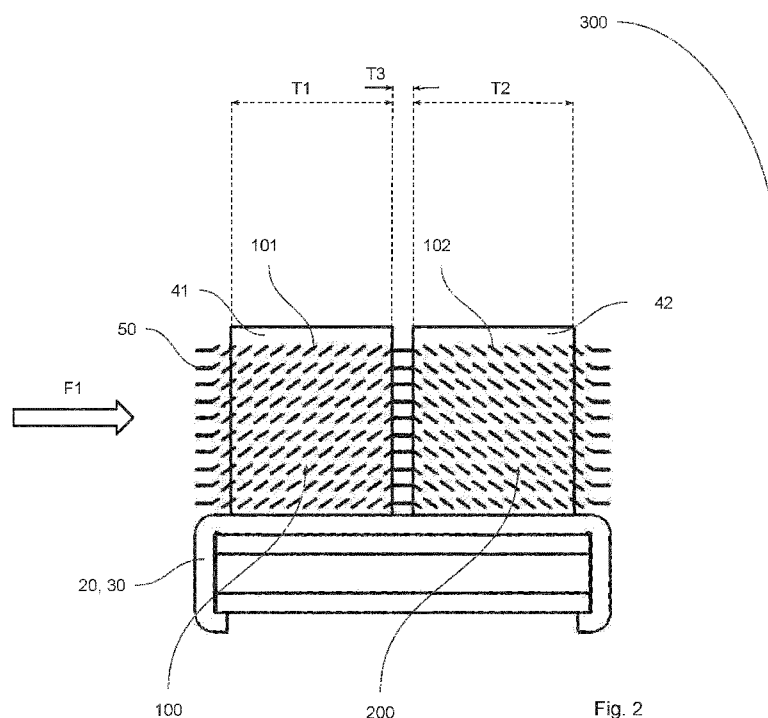


Fig. 2

(57) Abstract: The object of the invention is, among others, a heat exchanger (1) for heat exchange between a first fluid and a second fluid comprising: a first header- tank assembly (20); a second header- tank assembly (30) wherein the heat exchanger (1) is intended for operation in orientation in which the first header- tank assembly (20) is substantially higher with respect to a ground level than the second header- tank assembly (30); plurality of tubes (3) arranged in a first stack (41) and in a second stack (42), wherein the stacks (41, 42) are arranged between the first header- tank assembly (20) and the second header- tank assembly (30), wherein the second stack (42) is arranged downstream to the first stack (41) with respect to the intended first fluid flow path; at least one fin (50) interlaced between two adjacent tubes (40) of each stack (41, 42), wherein the fin (50) further comprises a first section (100) configured to deflect the first fluid substantially obliquely-upwardly, and a second section (200) configured to deflect the first fluid towards the second header-

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assembly (30), wherein the second section (200) is arranged downstream to the first section (100) with respect to the intended first fluid flow path, characterised in that the fin (50) further comprises a third section (300) arranged downstream to the first section (100) and the second section (200) so that the second section (200) is located substantially between the first stack (41) and the second stack (42).

A HEAT EXCHANGER

5 FIELD OF THE INVENTION

The invention relates to a heat exchanger. In particular, the invention relates to the heat exchanger for a motor vehicle.

BACKGROUND OF THE INVENTION

10 Evaporators look like, and in fact are, similar to radiators, only thicker and smaller in overall size. Like radiators, evaporators consist of a series of internal tubes or flow paths with fins attached to them. Air can pass freely through the fins, just like a radiator. But unlike a radiator, where the internal tubes carry moving engine coolant, the passages in the evaporator carry moving refrigerant.

15 In an automotive air conditioning system (further referred to as A/C system), cold, low-pressure liquid refrigerant enters the evaporator. Warm air from the interior of the vehicle passes through the evaporator by action of the blower fan. Since it's a fact of nature that heat always travels from a warmer area to a cooler area, the cooler refrigerant flowing inside the evaporator's absorbs heat from the warm air. At the same
20 time, humidity in the air condenses on the cool evaporator's surface, then eventually drips out of a drain tube to the outside. After the initially warmed refrigerant has completed its path through the evaporator, it moves on to the compressor.

In order to improve the heat exchange between the media, so-called fins are implemented in-between the tubes of the evaporator. The fins are interlaced to form a
25 sandwich with adjacent tubes. The fins allow to increase the heat exchange area while still allowing the air to flow in-between the tubes. However, during the heat exchange the ambient air may condensate. The water condensed during evaporation is hot and may contain a small amount of the debris. This 'carry over' in the vapour is due to air impurities creating a mist of tiny particles which can be carried over into the condensate

along with the water. For this reason the evaporator condensate, although relatively pure can contain enough organic material to support bacterial growth when cool. This makes the condensate unacceptable for re-use in any environment. The condensate accumulated on the surface of the evaporator may create the environment which may be harmful for the passengers. It may also lead to decreased service life of the whole heat exchanger due to deterioration or corrosion of different sub- components.

Thus, it is desirable to provide an efficient way to evacuate condensate form the surface of the heat exchanger.

SUMMARY OF THE INVENTION

The object of the invention is, among others, a heat exchanger for heat exchange between a first fluid and a second fluid comprising: a first header- tank assembly; a second header- tank assembly wherein the heat exchanger is intended for operation in orientation in which the first header- tank assembly is substantially higher with respect to a ground level than the second header- tank assembly; plurality of tubes arranged in a first stack and in a second stack, wherein the stacks are arranged between the first header- tank assembly and the second header- tank assembly, wherein the second stack is arranged downstream to the first stack with respect to the intended first fluid flow path; at least one fin interlaced between two adjacent tubes of each stack, wherein the fin further comprises a first section configured to deflect the first fluid substantially obliquely-upwardly, and a second section configured to deflect the first fluid towards the second header- assembly, wherein the second section is arranged downstream to the first section with respect to the intended first fluid flow path, characterised in that the fin further comprises a third section arranged downstream to the first section and the second section so that the second section is located substantially between the first stack and the second stack.

Preferably, the third section deflects the first fluid substantially in the same direction as the first section.

Preferably, the third section deflects the first fluid in different direction than the first section.

Preferably, the first stack comprises a first thickness measured perpendicularly to a stacking direction and a second stack comprises a second thickness also measured perpendicularly to a stacking direction, wherein the stacks are arranged between the first header- tank assembly, so that the gap is formed between the stacks.

- 5 Preferably, the third section at least partially overlaps the second thickness and the first section at least partially overlaps the first thickness.

Preferably, the heat exchanger comprises a gap between the first stack and the second stack, wherein the gap is smaller than any of the thickness.

Preferably, the second section at least partially overlaps the gap.

- 10 Preferably, the first header-tank assembly comprises two fluidly isolated channels for the first fluid, and wherein the first header-tank assembly further comprises an inlet and an outlet for connecting the heat exchanger into first fluid loop.

- Preferably, the second header-tank assembly comprises two fluidly isolated channels for the first fluid, and wherein the second header-tank assembly further comprises an
15 inlet and an outlet for connecting the heat exchanger into first fluid loop.

Preferably, the first section comprises at least one first louver aligned at a first louver angle measured with respect to the intended first fluid flow direction.

Preferably, the second section comprises at least one second louver aligned at a second louver angle measured with respect to the intended first fluid flow direction.

- 20 Preferably, the second louver angle is equal to $(\alpha_1)+90$ degrees.

Preferably, the third section comprises at least one third louver aligned at a third louver angle measured with respect to the intended first fluid flow direction.

Preferably, the third louver angle is substantially equal to the first louver angle.

- Preferably, the third louver angle is different than the first louver angle and the
25 second louver angle.

Preferably, at least one of the louver angles in the range from 30 to 40 degrees.

Preferably, at least one of the louver angles is in particular 35 degrees.

Preferably, the first thickness is substantially equal to the second thickness.

Preferably, the first thickness is different than the second thickness.

Preferably, the heat exchanger is evaporator.

Another object of the invention is a motor vehicle comprising such heat exchanger.

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BRIEF DESCRIPTION OF DRAWINGS

Examples of the invention will be apparent from and described in detail with reference to the accompanying drawings, in which:

10 Fig. 1 shows a perspective view of the heat exchanger.

Fig. 2 shows detailed, cross- sectional view of the fin according to prior art.

Fig. 3 shows detailed, cross- sectional view of the fin according to embodiment of an invention.

DETAILED DESCRIPTION OF EMBODIMENTS

The invention refers to a heat exchanger for a motor vehicle such as evaporator. The main sub-components of the evaporator are depicted by Fig. 1 and briefly described by further paragraphs.

A heat exchanger 1 enables the heat exchange between two fluids, wherein one fluid (e.g. refrigerant) is encapsulated and circulates within the heat exchanger 1 and the other (e.g. air) flows across the sub-components of the heat exchanger 1.

Fig. 1 shows the perspective view of the heat exchanger 1 comprising main sub-components, i.e. plurality of tubes 40 comprising open ends. The tubes 40 may be in form of elongated, flattened channels stacked between two header- tank assemblies 20, 30, wherein all tubes 40 are oriented in the same direction, so that the fluid (e.g. air) may flow through the stack. The tubes 40 may provide a fluidal communication between the header- tank assemblies 20, 30. The tubes 40 actively participate in the heat transfer process, so the flattened shape of the tubes 40 not only enables the fluid to flow through the stack, but also increases the heat transfer surface. However, the specific dimensions of the tubes 40 should be calculated respecting the characteristics of other sub-components. The tubes 40 may be arranged in a first stack 41 comprising a first thickness T1 measured perpendicularly to a stacking direction S1 and in a second stack 42 comprising a second thickness T2 also measured perpendicularly to a stacking direction S1. In order to show how the thickness T1, T2 and stacking direction S1 are supposed to be measured, they have been indicated in the figures. The header- tank assemblies 20, 30 may comprise minor differences, depending on what role may each one of them play for the heat exchanger 1.

The tubes 40 may be formed, for example, in the process of extrusion. This process enables to create the tubes 40 comprising one, or many channels within the single tube. Alternatively, the tubes 40 may be made of out of single, folded sheet of metal.

Fig. 1 further shows the architecture of the heat exchanger, in which the first header-tank assembly 20 comprises both inlet and outlet, so it is configured to deliver and collect the fluid from the heat exchanger 1. The first header and the first cover may form continuous channels for the fluid. In other words, there may be no baffles located within the channels formed by the first header-tank assembly 20 so that the fluid is delivered along the main axis of elongation of the channels up to the end portion of the first header-tank assembly 20. Similarly, the second header and the first cover may form continuous channels for the fluid. This allows to form two passes for the fluid, wherein one channel of the first header-tank assembly 20 is fluidly connected with one channel of the second header-tank assembly 30 via one stack of tubes 40, and the other channel of the first header-tank assembly 20 is fluidly connected with the other channel of the second header-tank assembly 30 via the other stack of tubes 40. The U-turn of the fluid is formed between the adjacent channels of the second header-tank assembly 30.

Further, the header-tank assemblies 20, 30 may comprise at least one baffle configured to redirect flow of the fluid within the channel. This allows to arrange more than two passes within the heat exchanger 1.

The heat exchanger 1 is intended for operation in orientation in which the first header-tank assembly 20 is substantially higher with respect to a ground level than the second header-tank assembly 30.

Term “ground level” may be understood as the plane P1 being perpendicular with respect to gravitational force F_g . The heat exchanger 1 may however be inclined relatively to ground level, depending on the position of the vehicle. Preferably, the heat exchanger is oriented vertically, i.e. the tubes 40 are arranged in perpendicular to the plane P1 whereas the axes of elongation of header-tank assemblies 20, 30 may be parallel to the plane P1.

The alternative architecture of the heat exchanger 1 may include the second header-tank assembly 30 comprising both inlet and outlet, so that it is configured to deliver and collect the fluid from the heat exchanger 1. In other words, the alternative design may include the heat exchanger 1 which is oriented upside-down to one depicted in Fig.1.

However, this embodiment is not preferred in view of overall performance of the heat exchanger 1, due to e.g. greater pressure drop associated with the location of the inlet and the outlet on the second header-tank assembly 30.

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Fig. 2 shows a detailed view of the heat exchanger with a header- tank assembly 20, 30 and the tubes 40 according to the preamble of claim 1. The tubes 40 may be arranged in a first stack 41 comprising a first thickness T1 measured perpendicularly to a stacking direction S1 (not shown) and in a second stack 42 comprising a second
10 thickness T2 also measured perpendicularly to a stacking direction S1. Again, the stacks 41, 42 may be arranged between the first header- tank assembly 20 and the second header- tank assembly 30, wherein the second stack 42 is arranged downstream to the first stack 41 with respect to the intended first fluid flow path depicted by arrows. The first thickness T1 may be substantially equal to the second
15 thickness T2. Alternatively, the first thickness T1 may be different than the second thickness T2.

In order to further facilitate the heat transfer process, the tubes 40 may be interlaced with so-called fins 50. The fins 50 may be in a form of corrugated sheet of material of relatively high thermal conductivity, e.g. aluminum. The corrugations form ridges
20 which may be in contact with the surface of two adjacent tubes 40. Usually, the fins 50 are initially squeezed to increase the number of possible corrugations and then brazed to the surface of the tubes 40, so that the fins 50 are immobilized with respect to the tubes 40.

The heat exchanger 1 may thus comprise at least one fin 50 interlaced between two
25 adjacent tubes 40, wherein said fin 50 may extend beyond the perimeter delimited by the stacks 41, 42 in a direction parallel to intended first fluid flow direction. Further, the fins 50 may also be delimited perpendicularly to the stacking direction S1 by inner faces of the header-tank assemblies 20, 30. The fin 50 may be configured to at least partially deflect the first fluid flow path. The term “deflect” should be understood as to
30 cause (the air) to change its direction with respect to its intended fluid flow path.

The fin 50 may further comprise a first section 100 extending by at least half of the first thickness T1, and the second section 200 arranged downstream to the first section 100 with respect to the intended first fluid flow path.

As further shown in Fig. 2, the first stack 41 may comprise the first thickness T1. The first thickness T1 may be measured perpendicularly to a stacking direction S1. The second stack 42 may comprise the second thickness T2 also measured perpendicularly to a stacking direction S1. The stacks 41, 42 may be arranged between the first header-tank assembly 20 and the second header-tank assembly 30, so that a gap T3 may be formed between said stacks 41, 42.

Fig. 3 shows the detailed view of the heat exchanger 1 according to the embodiment of the invention.

The first section 100 receives first fluid in a gaseous form, so the molecules are energetic, fast moving and far apart from each other. As the air encounters cooler surface of the heat exchanger 1, the molecules become slower, less energetic and closes together. Then they reach a threshold energy level, the gaseous air changes to liquid. Therefore, in terms of physical phenomena, the first section 100 may also be called a condensation section.

The second section 200 receives the first fluid both in gaseous and liquid form. The second section 200 is configured to separate two phases of the first fluid, so that the liquid is evacuated from the vicinity of the tubes as quickly, as possible. Therefore, the second section 200 may also be called evacuation section.

The heat exchanger 1 may further comprise a third section 300 arranged downstream to the first section 100 and the second section 200 so that the second section 200 is located substantially between the first stack 41 and the second stack 42. The term "arranged downstream" means that the third section 300 may be arranged subsequently to the first section 100 and the second section 200 in relation to the intended first fluid flow direction. The third section 300 may be configured to deflect the first fluid substantially in the same direction as the first section 100. Alternatively, the third section 300 may be configured to deflect the first fluid in different direction than

the first section 100, for example, in a direction parallel to intended first fluid flow direction.

As further shown in Fig. 3, the third section 300 may at least partially overlap the second thickness T2. Similarly, the first section 100 may at least partially overlap the first thickness T1. Preferably, at least 50% the second thickness T2 is overlapped by third section 300. Similarly, at least 50% the first thickness T1 is overlapped by the first section 100. This allows to provide sufficient condensation area for the first section 100.

Alternatively, the overlap between the first section 100 and the third section 30 may be asymmetric. In other words, one section may overlap a greater part of corresponding thickness than the other. This allows to optimize the flow of the first fluid through the sections 100, 200, 300.

As further shown in Fig.3, the heat exchanger 1 may comprise a gap T3 located between the first stack 41 and the second stack 42. It is evident from Fig.3 that the gap T3 is smaller than any of the thickness T1 or T2, however, an embodiment in which the gap T3 is greater than the first thickness, second thickness T2 or both first and second thickness T1, T2 is also envisaged.

The second section 200 may at least partially overlap the gap T3. In particular, the third section 300 may entirely overlap the gap T3, as shown in Fig. 3. This allows to facilitate extraction of the condensate from the heat exchanger 1.

In order to provide the proper functionality of the sections 100, 200, 300, the fins 50 may comprise additional features which enhance the heat exchange between the first fluid and the second fluid.

As shown in Figs 1 and 2, the first section 100 may comprise at least one first louver aligned at a first louver angle α_1 measured with respect to the intended first fluid flow direction. The second section 200 may comprise at least one second louver aligned at a second louver angle α_2 measured with respect to the intended first fluid flow direction. The second louver angle α_2 may be equal to $(\alpha_1) + 90$ degrees.

Referring to Fig. 3, the third section 300 may comprise at least one third louver aligned at a third louver angle α_3 measured with respect to the intended first fluid flow

direction. The third louver angle α_3 may be substantially equal to the first louver angle α_1 . However, an embodiment in which the third louver angle α_3 is different than the first louver angle α_1 and the second louver angle α_2 is also envisaged.

In order to maximize the efficiency of the heat exchanger, at least one of the louver angles α_1 , α_2 , α_3 may be the range from 30 to 40 degrees. For example, the first louver angle α_1 and the third louver angle α_3 may be the same, whereas the second louver angle α_2 may be $(\alpha_1) + 90$ degrees. In other words, the second louver angle α_2 is a mirror image of the first louver angle, relatively to the intended first fluid flow direction. As shown in Fig.3, the second louver of the second section 200 is pointing substantially obliquely- downwardly, whereas the first louver of the first section 100 is pointing substantially obliquely- upwardly.

In particular, at least one of the louver angles may be in particular 35 degrees.

The orientation and the location of the second section allow to facilitate evacuation of liquid first fluid from the heat exchanger, so that the efficiency of the second stack 42 is improved.

This also allows to reduce the bad odor which may be formed during non-operational mode of the heat exchanger 1.

Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of drawings, the disclosure, and the appended claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to the advantage.

Claims

1. A heat exchanger (1) for heat exchange between a first fluid and a second fluid comprising: a first header- tank assembly (20); a second header- tank assembly (30)
5 wherein the heat exchanger (1) is intended for operation in orientation in which the first header- tank assembly (20) is substantially higher with respect to a ground level than the second header- tank assembly (30); plurality of tubes (3) arranged in a first stack (41) and in a second stack (42), wherein the stacks (41, 42) are arranged between the first header- tank assembly (20) and the second header- tank assembly (30), wherein
10 the second stack (42) is arranged downstream to the first stack (41) with respect to the intended first fluid flow path;

at least one fin (50) interlaced between two adjacent tubes (40) of each stack (41, 42), wherein the fin (50) further comprises a first section (100) configured to deflect the first fluid substantially obliquely-upwardly, and a second section (200) configured to deflect
15 the first fluid towards the second header- assembly (30), wherein the second section (200) is arranged downstream to the first section (100) with respect to the intended first fluid flow path,

characterised in that the fin (50) further comprises a third section (300) arranged downstream to the first section (100) and the second section (200) so that the second
20 section (200) is located substantially between the first stack (41) and the second stack (42).

2. The heat exchanger (1) according to claim 1, wherein the third section (300) deflects the first fluid substantially in the same direction as the first section (100).

3. The heat exchanger (1) according to claim 1, wherein the third section (300) deflects
25 the first fluid in different direction than the first section (100).

4. The heat exchanger (1) according to any of the preceding claims, wherein the first stack (41) comprises a first thickness (T1) measured perpendicularly to a stacking direction (S1) and a second stack (42) comprises a second thickness (T2) also measured perpendicularly to a stacking direction (S1), wherein the stacks (41, 42) are

arranged between the first header- tank assembly (20), so that the gap (T3) is formed between the stacks (41, 42).

5 The heat exchanger (1) according to preceding claim, wherein the third section (300) at least partially overlaps the second thickness (T2) and the first section (100)

at least partially overlaps the first thickness (T1).

6. The heat exchanger (1) according to claims 4 or 5 comprising a gap (T3) between the first stack (41) and the second stack (42), wherein the gap (T3) is smaller than any of the thickness (T1) or (T2).

7. The heat exchanger (1) according to claim 6, wherein the second section (200) at
10 least partially overlaps the gap (T2).

8. The heat exchanger (1) according to any of the preceding claims, wherein the first header-tank assembly (20) comprises two fluidly isolated channels for the first fluid, and wherein the first header-tank assembly (20) further comprises an inlet and an outlet for connecting the heat exchanger (1) into first fluid loop.

15 9. The heat exchanger (1) according to claims 1-7, wherein the second header-tank assembly (30) comprises two fluidly isolated channels for the first fluid, and wherein the second header-tank assembly (30) further comprises an inlet and an outlet for connecting the heat exchanger (1) into first fluid loop.

10. The heat exchanger (1) according to any of the preceding claims, wherein the
20 first section (100) comprises at least one first louver aligned at a first louver angle (α_1) measured with respect to the intended first fluid flow direction.

11. The heat exchanger (1) according to any of the preceding claims, wherein the second section (200) comprises at least one second louver aligned at a second louver angle (α_2) measured with respect to the intended first fluid flow direction.

25 12. The heat exchanger (1) according to claims 10 and 11, wherein the second louver angle α_2 is equal to $(\alpha_1)+90$ degrees.

13. The heat exchanger (1) according to any of the preceding claims, wherein the third section (300) comprises at least one third louver aligned at a third louver angle (α_3) measured with respect to the intended first fluid flow direction.

14. The heat exchanger (1) according to claim 13, wherein the third louver angle (α_3) is substantially equal to the first louver angle (α_1).

15. A motor vehicle comprising a heat exchanger (1) according to any of the preceding claims.

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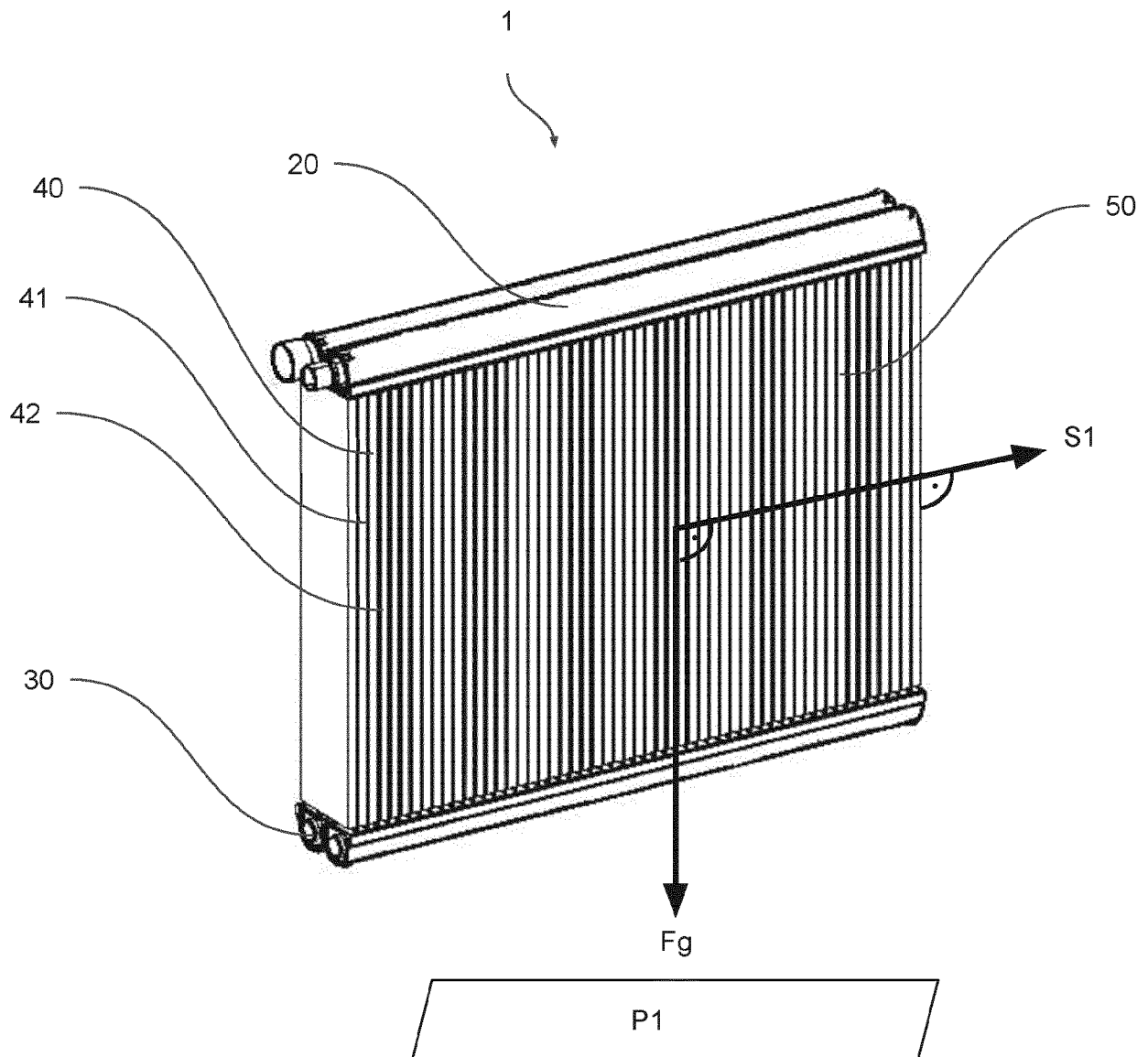


Fig. 1

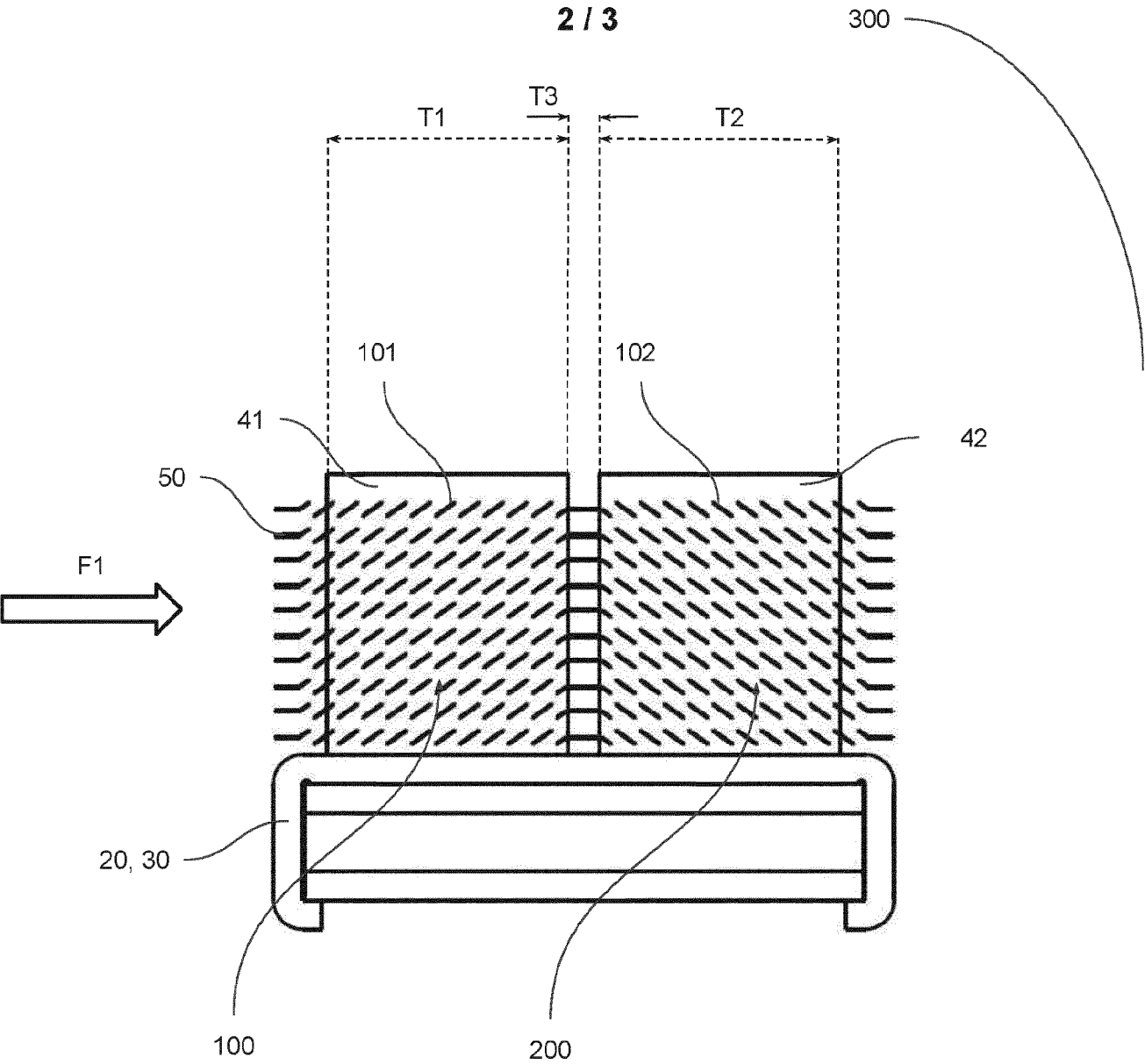


Fig. 2

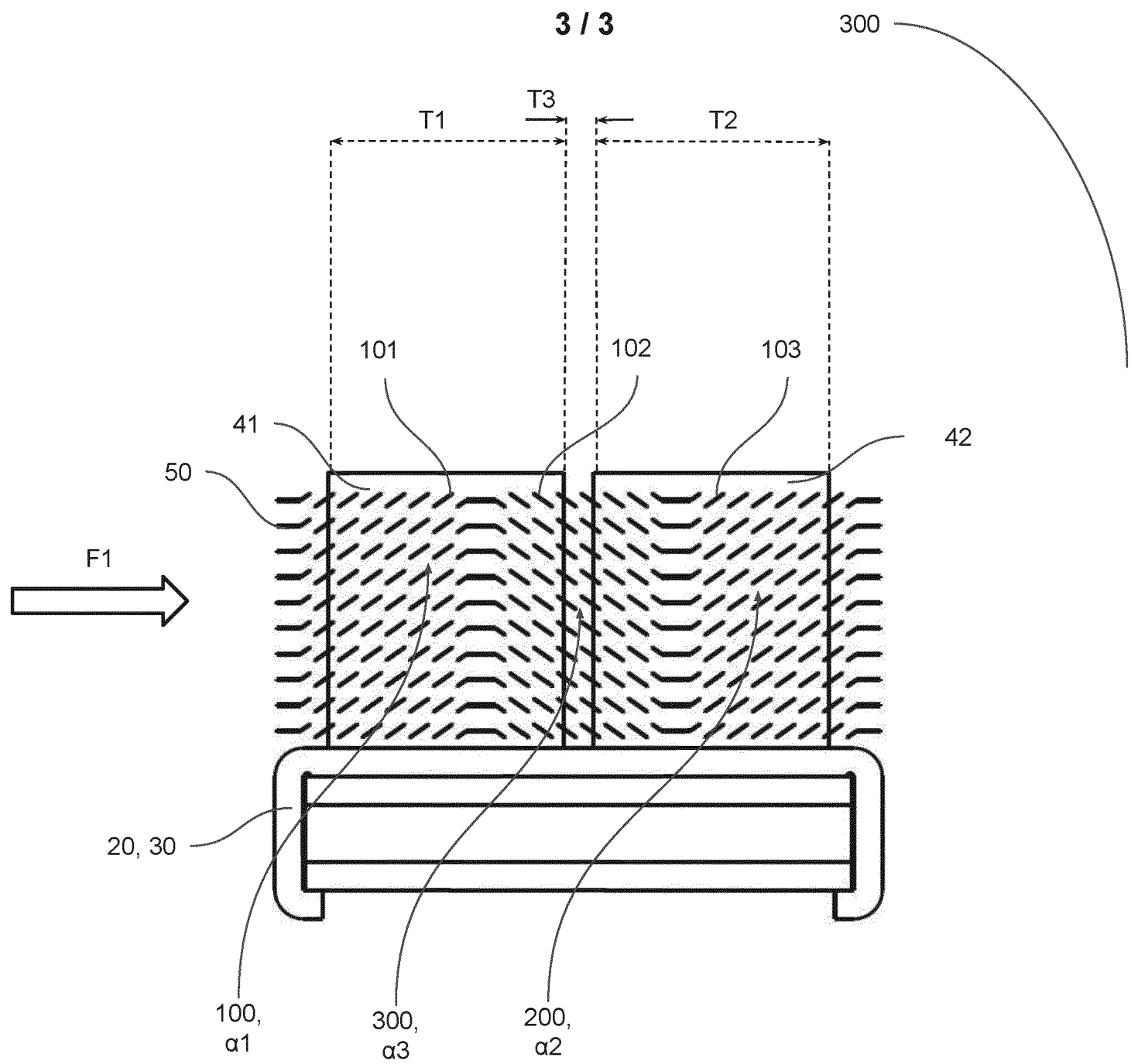


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2022/071408

A. CLASSIFICATION OF SUBJECT MATTER

INV. F28F1/12 F28F17/00
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)
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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2008/302131 A1 (HIGASHIYAMA NAOHISA [JP]) 11 December 2008 (2008-12-11) figure 3 -----	1-15
A	JP 2019 163921 A (DENSO CORP) 26 September 2019 (2019-09-26) figures 1,2 -----	1-15
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A	US 3 298 432 A (STANISLAUS PRZYBOROWSKI) 17 January 1967 (1967-01-17) figure 4 -----	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

25 August 2022

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Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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