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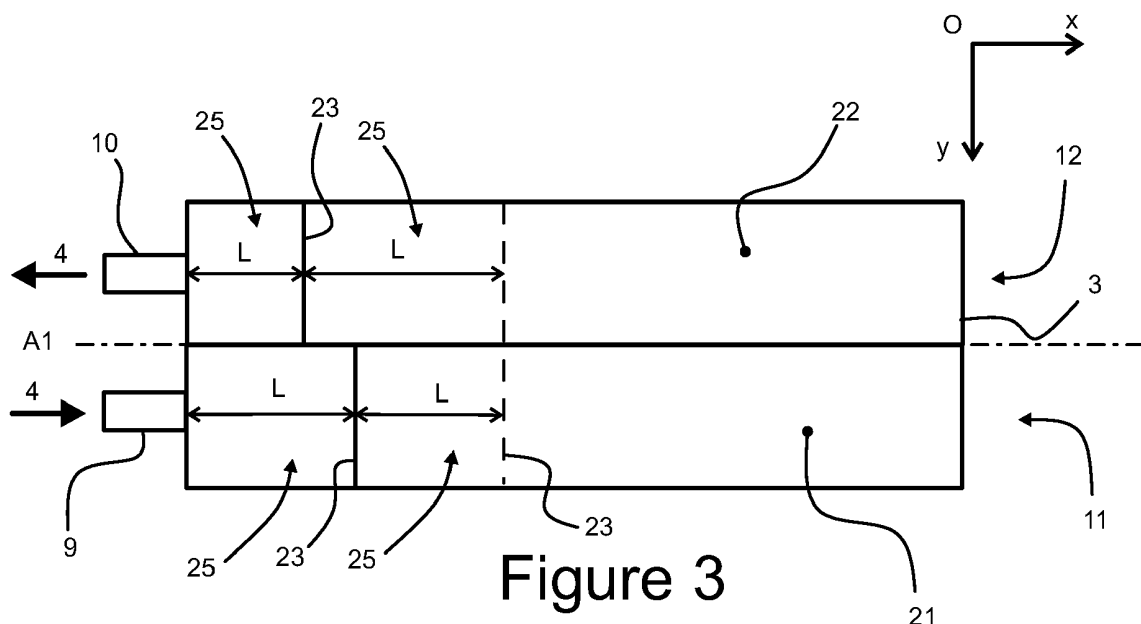
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(54) HEAT EXCHANGER FOR A REFRIGERANT FLUID CIRCULATION CIRCUIT

(57) The invention relates to a heat exchanger (1) comprising a core and at least one header box (3) that extends mainly in a longitudinal direction (A1), said core comprising at least four passes (25) distributed in two rows (11, 12), with two first inlet-passes (25) being part of a first row (11) of the heat exchanger (1) and two last outlet-passes (25) being part of a second row (12) of the

heat exchanger (1). Each pass (25) has a respective length (L) measured along the longitudinal direction (A1), wherein the sum of the length (L) of the two first inlet-passes (L) is equal $\pm 10\%$ to the sum of the length (L) of the two last outlet-passes (L), and the length (L) of the first inlet-pass (L) is bigger than the length (L) of the last outlet-pass (25).

**Figure 3****EP 3 587 980 A1**

Description

[0001] The present invention concerns a heat exchanger for a refrigerant circuit fitted for an automotive vehicle. The object of the present invention is such a heat exchanger.

[0002] An automotive vehicle is currently equipped with a heating, ventilating and air conditioning system, usually called the HVAC system, for thermally treating the air present or sent inside a passenger compartment of the automotive vehicle. The HVAC system is associated with a refrigerant circuit inside which a refrigerant fluid circulates. The refrigerant circuit comprises successively a compressor, a condenser or gas cooler, an expansion device and a heat exchanger. The heat exchanger is housed inside the HVAC system to allow a heat exchange between the refrigerant fluid and an air flow circulating inside the HVAC system, before being delivered inside the passenger compartment.

[0003] According to a mode of operation of the refrigerant circuit, the heat exchanger is used as an evaporator to cool down the air flow. In this case, the refrigerant fluid is compressed inside the compressor, then the refrigerant fluid is cooled inside the condenser or gas cooler, then the refrigerant fluid expands within the expansion device and finally the refrigerant fluid cools down the air flow passing through the heat exchanger.

[0004] The heat exchanger comprises a first header box and a second header box between which a bunch of tubes is interposed. The first header box and the second header box are both arranged parallel to a longitudinal direction. The tubes are arranged between the first header box and the second header box, each tube having a first extremity in connection with the first header box and a second extremity in connection with the second header box. The tubes are also arranged in a first row of first tubes and a second row of second tubes that are parallel to each other and perpendicular to the longitudinal direction. The first tubes of the first row are in fluid communication with a first chamber of the first header box and a first chamber of the second header box. The second tubes of the second row are in fluid communication with a second chamber of the first header box and a second chamber of the second header box. The second chambers of the second header box are coupled together by a connecting means so that the refrigerant fluid can circulate from one to the other. One of the first chambers of the first header box, the inlet chamber, is equipped with a refrigerant fluid inlet through which the refrigerant fluid is admitted in the heat exchanger and the other chamber of the first header box, the outlet chamber, is equipped with a refrigerant fluid outlet through which the refrigerant fluid exits from the heat exchanger.

[0005] The chambers are partitioned in several portions by at least a partition wall located in the first header box and the second header box. That divides each row in several passes of tubes, the tubes of a same pass having their first extremities in communication with the

same portion of the first chamber and having too their second extremities in communication with the same portion of the second chamber. In each pass, the refrigerant fluid is circulating in the same direction from one header box to the other header box as it is disclosed in the document US2005/0050915.

[0006] With such an arrangement of tubes, the temperature of the refrigerant fluid tends to be inhomogeneous from one pass to the other. Furthermore, within the same pass of tubes, the temperature of the refrigerant fluid from one tube to another tube tends to be different. Furthermore again, the temperature of the refrigerant fluid at the first extremity of the tubes of the same pass is different from one tube to another. Finally, within a same pass, the temperature of the refrigerant fluid in the same extremities of the tubes of the considered pass tends to be different from one tube to another tube. Especially, considering the tubes of the closest pass to the refrigerant fluid inlet, the temperature of the refrigerant fluid in the extremity of the tube close to the refrigerant fluid inlet is lower than the extremity opposite to the one close to the refrigerant fluid inlet. In other words, the refrigerant fluid tends not to reach the opposite extremity of the tubes of the extremity that is close to the refrigerant fluid inlet for those considered tubes. In this area, the temperature of the refrigerant fluid being higher, the air flow is badly cooled down there which decrease the global efficiency of the heat exchanger.

[0007] Therefore, there is a need of a heat exchanger that is arranged so that the temperature of the refrigerant fluid in the tubes of a same pass is as much homogeneous as possible.

[0008] The heat exchanger of the invention is a heat exchanger comprising a core and at least one header box that extends mainly in a longitudinal direction. The core comprises at least four passes distributed in two rows. Two first inlet-passes are part of a first row of the heat exchanger and two last outlet-passes are part of a second row of the heat exchanger. Each pass has a respective length measured along the longitudinal direction.

[0009] According to the invention, the sum of the length of the two first inlet-passes is equal $\pm 10\%$ to the sum of the length of the two last outlet-passes, and the length of the first inlet-pass is bigger than the length of the last outlet-pass.

[0010] The heat exchanger can be recognized thanks to any of the following technical characteristics:

- a row is a part of the core that comprises a plurality of passes,
- a pass is a section of a row that comprises a plurality of tubes, where the refrigerant fluid circulates in all the tubes along the same direction,
- two passes of a same row are separated by at least one partition wall,

- the partition wall separates a chamber arranged in the header box in several portions,
- each tube having a first extremity and a second extremity, the tubes of a same pass have all their first extremities in communication with the same portion of a chamber of the first header box and have all their second extremities in communication with the same portion of a chamber of the second header box,
- the inlet-passes are all located in an inlet plan which is parallel to an outlet plan comprising the outlet-passes,
- the first inlet-pass is the pass equipped with a refrigerant fluid inlet in the heat exchanger,
- the two first inlet-passes comprise the first inlet-pass and the immediate contiguous pass to the first inlet-pass,
- the last outlet-pass is the pass equipped with a refrigerant fluid outlet from the heat exchanger,
- the two last outlet-passes comprise the last outlet-pass and the immediate contiguous pass to the last outlet-pass,
- the inlet plan is the plan in which the tubes of the first row are arranged,
- the outlet plan is the plan in which the tubes of the second row are arranged,
- the length of the pass is measured from a first longitudinal side of a pass to a second longitudinal side of the pass in a parallel plan to either the inlet plan or the outlet plan,
- such a heat exchanger provides a homogeneous heat exchange between a refrigerant fluid circulating within the heat exchanger and an air flow passing through the heat exchanger, the less efficient pass as regard the heat transfer being reduced to a minimum length,
- such a heat exchanger is highly efficient because the before last outlet-pass is partially located in front of the first inlet-pass,
- the passes of the heat exchanger form a refrigerant fluid path along which a refrigerant fluid can circulate from the refrigerant fluid inlet to the refrigerant fluid outlet, by flowing first within the inlet-passes and then within the outlet-passes. Within the first row, the refrigerant fluid circulates from the first inlet-pass to the last inlet-pass; within the second row, the refrigerant fluid circulates from the first outlet-pass to the last outlet-pass. Within the first row, the refrigerant fluid circulates from the first inlet-passes and then in the other passes of the first row; within the second row, the refrigerant fluid exits from the heat exchanger from the last outlet-passes after having circulated inside the other outlet-passes,
- each pass comprises tubes regularly distributed along the longitudinal direction, a tube pitch of each pass being identical at $\pm 5\%$,
- the two first inlet-passes are immediately contiguous to each other and the first inlet-pass is equipped with the refrigerant fluid inlet,
- the two first outlet-passes are immediately contiguous to each other and the last outlet-pass is equipped with the refrigerant fluid outlet,
- the core comprises these identical tubes, two tubes of the same row being separated by corrugated fins,
- a tube can be made from a folded metallic sheet or can be extruded or can be made by the assembling of two plates that are delimitating together a canal for the refrigerant fluid circulation,
- the two first inlet-passes comprise a first inlet-pass which is equipped with a refrigerant fluid inlet into the heat exchanger core and a second inlet-pass which is contiguous to the first inlet-pass,
- the two last outlet-passes comprise a last outlet-pass which is equipped with a refrigerant fluid outlet out of the heat exchanger core and a second outlet-pass which is contiguous to the last outlet-pass,
- the inlet plan comprises the refrigerant fluid inlet,
- the outlet plan comprises the refrigerant fluid outlet,
- the refrigerant fluid inlet and the refrigerant fluid outlet are located on the same edge side of the heat exchanger,
- the refrigerant fluid inlet and the refrigerant fluid outlet are arranged on the same header box,
- the refrigerant fluid inlet and the refrigerant fluid outlet are located in the same transversal plan,
- the total number of passes of the heat exchanger is a pair number,
- the length of the last inlet-pass is equal to the length of the first outlet-pass,
- the heat exchanger is configured to be crossed by

an air flow firstly across the second row and lastly across the first row,

- the first row is a downwind-side row of the heat exchanger and the second row is an upwind-side row of the heat exchanger,
- the heat exchanger is configured to be crossed by an air flow firstly across the second row and lastly across the first row,
- the heat exchanger is provided with communication means which enable a communication between the first row and the second row, the first row and the second row delimiting together a volume of the heat exchanger,
- the communication means are accommodated within the volume of the heat exchanger,
- the communication means are located outside the volume of the heat exchanger,
- the heat exchanger comprises strictly four passes,
- the heat exchanger comprises strictly six passes,
- the heat exchanger comprises strictly eight passes.

[0011] The invention relates also to a heating, ventilating and air conditioning system comprising an air duct in which an air flow circulates and the said heat exchanger, the said heat exchanger being located in the air duct so that the air flow circulates firstly through the first row and secondly through the second row.

[0012] The invention relates also to a refrigerant fluid circulation circuit comprising at least the said heat exchanger.

[0013] The invention relates also to a utilization of the said heat exchanger as an evaporator in the said refrigerant fluid circuit.

[0014] Other specificities, details and characteristics of the present invention will be highlighted thanks to the following description, given for general guidance, in relation with the following figures:

- Figure 1 is a general view of a heat exchanger according to the present invention,
- Figure 2 is a side view of the heat exchanger illustrated in Figure 1,
- Figure 3 is a top view of the heat exchanger illustrated in Figure 1 and 2,
- Figure 4 is a schematic view of a refrigerant fluid circulation circuit comprising the heat exchanger illustrated in Figure 1 to 3.

[0015] In the Figures, a heat exchanger 1 according to the invention is shown in a coordinate system Oxyz in which Ox axis is a longitudinal axis, Oy axis is a lateral axis and Oz axis is a vertical axis.

[0016] In Figure 1, a heat exchanger 1 comprises a core 2 disposed between two header boxes 3. The core 2 is the part of the heat exchanger 1 that is dedicated to enable a heat exchange between a refrigerant fluid 4 circulating in the heat exchanger 1 and an air flow 5 passing through the heat exchanger 1. Both header boxes 3 extend mainly in a longitudinal direction A1 that is parallel to the Ox axis.

[0017] The core 2 comprises a plurality of tubes 6 that are interposed between the header boxes 3. The tubes 6 extend in a vertical direction A2 that is parallel to the vertical axis Oz. According to different embodiments of the invention, the tube 6 can be made from a folded metallic sheet or the tube 6 can be extruded or the tube 6 can be made by the assembling of two plates that are delimiting together a canal for the refrigerant fluid 4 circulation.

[0018] The tubes 6 are arranged in two rows 11, 12 comprising a first row 11 of tubes 6 and a second row 12 of tubes 6, both rows 11, 12 being respectively arranged parallel to a longitudinal plan Pi, the longitudinal plan P1 being parallel to the Oxz plan. Each tube 6 having a first extremity 7 and a second extremity 8, the tubes 6 have all their first extremities 7 in communication with a first header box 3 and have all their second extremities 8 in communication with a second header box 3.

[0019] Each header box 3 comprises a first chamber 21 and a second chamber 22 that are watertight one to the other. The first chambers 21 of the header boxes 3 are in fluid connection with the extremities 7, 8 of the tubes 6 of the first row 11 of tubes 6. The second chambers 22 of the header boxes 3 are in fluid connection with the extremities 7, 8 of the tubes 6 of the second row 12 of tubes 6.

[0020] The first extremities 7 of the tubes 6 in the first row 11 are in fluid communication with the first chamber 21 of the first header box 3 and the second extremities 8 of the tubes 6 in the first row 11 are in fluid communication with the first chamber 21 of the second header box 3. The second extremities 8 of the tubes 6 in the second row 12 are in fluid communication with the second chamber 22 of the first header box 3 and the second extremities 7 of the tubes 6 in the second row 12 are in fluid communication with the second chamber 22 of the second header box 3.

[0021] The heat exchanger 1 is equipped with a refrigerant fluid inlet 9 through which the refrigerant fluid 4 is admitted inside the heat exchanger 1. The refrigerant fluid inlet 9 equips the first chamber 21 of the first header box 3. The heat exchanger 1 is equipped with a refrigerant fluid outlet 10 through which the refrigerant fluid 4 is evacuated from the heat exchanger 1. The refrigerant fluid outlet 10 equips the second chamber 22 of the same first header box 3.

[0022] The refrigerant fluid inlet 9 and the refrigerant fluid outlet 10 are located on the same edge side of the heat exchanger 1. The refrigerant fluid inlet 9 and the refrigerant fluid outlet 10 are arranged on the same header box 3. Other localization of the refrigerant fluid inlet 9 and the refrigerant fluid outlet 10 are possible.

[0023] The heat exchanger 1 comprises communication means 13 that are interposed between the first chamber 21 of the second header box 3 and the second chamber 22 of the second header box 3, the communication means 13 enabling a fluid circulation between the tubes 6 of the first row 11 and the tubes 6 of the second row 12.

[0024] According to different embodiments, the communication means 13 are located inside a volume of the core 2 of the heat exchanger 1 or the communication means 13 are located outside the volume of the core 2 of the heat exchanger 1.

[0025] The core 2 comprises these tubes 6 and two contiguous tubes 6 of the same row 11, 12 are separated by corrugated fins 14 that are enhancing the heat exchange between the refrigerant fluid 4 and the air flow 5.

[0026] The first row 11 is a downwind-side row of the heat exchanger 1 and the second row 12 is an upwind-side row of the heat exchanger 1.

[0027] The chambers 21, 22 are equipped with partition walls 23 that are dividing the chambers 21, 22 in several portions 24. The partition walls 23 are arranged in respective lateral plans P2 that are parallel to the Oyz plan.

[0028] The core 2 comprises several passes 25 of tubes 6, the tubes 6 of a same pass 25 have all their first extremities 7 in communication with the same portion 24 of the first chamber 21 of the first header box 3 and have all their second extremities 8 in communication with the same portion 24 of the second chamber 22 of the second header box 3. In other words, a pass 25 is a section of a row 11, 12, either the first row 11 or the second row 12, that comprises a plurality of tubes 6, where the refrigerant fluid 4 circulates in all the tubes 6 along the same direction. Two passes 25 of a same row 11, 12 are separated by a partition wall 23.

[0029] Each pass 25 comprises a plurality of tubes 6 that are regularly distributed along the longitudinal direction A1 parallel to the Ox axis, a tube pitch of each pass 25 being identical at $\pm 5\%$.

[0030] The total number of passes 25 of the heat exchanger 1 is a pair number. According to different embodiments of the invention, the heat exchanger 1 comprises strictly four passes 25, or the heat exchanger 1 comprises strictly six passes 25, or the heat exchanger 1 comprises strictly eight passes 8.

[0031] The passes 25 are also distributed in the two rows 11, 12. The passes 25 comprise inlet-passes 25 that are located in the first row 11 and the outlet-passes 25 that are located in the second row 12. The inlet-passes 25 are arranged in an inlet plan that is parallel to the longitudinal plan P1 and the outlet-passes 25 are arranged in an outlet plan that is also parallel to the longitudinal plan P1.

The inlet plan comprises the refrigerant fluid inlet 9 and the outlet plan comprises the refrigerant fluid outlet 10.

[0032] At least two first inlet-passes 25 are part of the first row 11 of the heat exchanger 1 and at least two last outlet-passes 25 are part of the second row 12 of the heat exchanger 1. The two first inlet-passes 25 are immediately contiguous to each other.

[0033] A first inlet-pass 25 is the inlet-pass 25 that is equipped with the refrigerant fluid inlet 9 of the heat exchanger 1. This means that the first inlet-pass 25 is the inlet-pass 25 admitting the refrigerant fluid 4 inside the heat exchanger 1. The two first inlet-passes 25 comprise the first inlet-pass 25 and the immediate contiguous inlet-pass 25 to the first inlet-pass 25.

[0034] A last outlet-pass 25 is the outlet-pass 25 that is equipped with the refrigerant fluid outlet 10 from the heat exchanger 1. The two last outlet-passes 25 comprise the last outlet-pass 25 and the immediate contiguous outlet-pass 25 to the last outlet-pass 25. This means that the last outlet-pass 25 is the outlet-pass 25 from which the refrigerant fluid 4 exits from the heat exchanger 1. The two first outlet-passes 25 are immediately contiguous to each other.

[0035] The passes 25 of the heat exchanger 1 form a refrigerant fluid path along which the refrigerant fluid 4 can circulate from the refrigerant fluid inlet 9 to the refrigerant fluid outlet 10, by flowing first within the inlet-passes 25 and then within the outlet-passes 25. Within the first row 11, the refrigerant fluid 4 circulates from the first inlet-pass 25 to the last inlet-pass 25. Within the second row 12, the refrigerant fluid 4 circulates from the first outlet-pass 25 to the last outlet-pass 25. Within the first row 11, the refrigerant fluid 4 circulates from the first inlet-passes 25 and then in the other passes 25 of the first row 11. Within the second row 12, the refrigerant fluid 4 exits from the heat exchanger 1 from the last outlet-passes 25 after having circulated inside the other outlet-passes 25.

[0036] In Figures 2 and 3, each pass 25 has a respective length measured L along the longitudinal direction, wherein the sum of the length L of the two first inlet-passes 25 is equal $\pm 10\%$ to the sum of the length L of the two last outlet-passes 25. The length L of the first inlet-pass 25 is bigger than the length L of the last outlet-pass 25.

[0037] The length L of each pass 25 is measured from a first longitudinal side 27 of a pass 25 to a second longitudinal side 28 of the pass 25 in a parallel plan to the longitudinal plan P1.

[0038] The length L of the last inlet-pass 25 is equal to the length L of the first outlet-pass 25.

[0039] Figure 4 illustrates a refrigerant fluid circulation circuit 100 inside which circulates the refrigerant fluid 4. Following a direction Si of circulation of the refrigerant fluid 4 inside the refrigerant circulation circuit 100, the refrigerant fluid circulation circuit 100 successively comprises a compressor 101 for compressing the refrigerant fluid 4, a condenser or a gas cooler 102 for cooling the

refrigerant 4, an expansion device 103 inside which the refrigerant fluid 4 expands and the heat exchanger 1. The heat exchanger 1 is accommodated inside an air duct 104 of a heating, ventilating and air conditioning system 105 inside which circulates the air flow 5. The heat exchanger 1 allows a heat transfer between the refrigerant fluid 4 and the air flow 5 coming into contact with it and/or passing through it, as illustrated in Figure 1. According to the operating mode of the refrigerant circuit 1 described above, the heat exchanger 1 is used as an evaporator for cooling the air flow 5, during the passage of the air flow 5 in contact with and/or from one side of the heat exchanger 1.

[0040] Several modifications and improvements might be applied by the person skilled in the art to a heat exchanger 1 as defined above.

[0041] In any case, the invention cannot and should not be limited to the embodiments specifically described in this document, as other embodiments might exist. The invention shall spread to any equivalent mean and any technically operating combination of means.

[0042] The invention is not limited by the shape of organs or elements as described here, and covers any shape as long as described here, and covers any shape of heat exchanger as long as it comprises a first inlet pass wider the last outlet pass, the width of the two first inlet passes being globally equal to the two last outlet passes.

Claims

1. Heat exchanger (1) comprising a core (2) and at least one header box (3) that extends mainly in a longitudinal direction (A1), said core (2) comprising at least four passes (25) distributed in two rows (11, 12), with two first inlet-passes (25) being part of a first row (11) of the heat exchanger (1) and two last outlet-passes (25) being part of a second row (12) of the heat exchanger (1), each pass (25) having a respective length (L) measured along the longitudinal direction (A1), wherein the sum of the length (L) of the two first inlet-passes (L) is equal $\pm 10\%$ to the sum of the length (L) of the two last outlet-passes (L), and the length (L) of the first inlet-pass (L) is bigger than the length (L) of the last outlet-pass (25).
2. Heat exchanger (1) according to claim 1, wherein each pass (25) comprises tubes (6) regularly distributed along the longitudinal direction (A1), a tube pitch of each pass (25) being identical at $\pm 5\%$.
3. Heat exchanger (1) according to claim 1 or 2, wherein the two first inlet-passes (25) comprise a first inlet-pass (25) which is equipped with a refrigerant fluid inlet (9) into the heat exchanger core (2) and a second inlet-pass (25) which is contiguous to the first inlet-pass (25).

4. Heat exchanger (1) according to claims 1 to 3, wherein the two last outlet-passes (25) comprise a last outlet-pass (25) which is equipped with a refrigerant fluid outlet (10) out of the heat exchanger core (2) and a second outlet-pass (2) which is contiguous to the last outlet-pass (25).
5. Heat exchanger (1) according to any of claims 1 to 4, wherein the total number of passes (25) of the heat exchanger (1) is a pair number.
6. Heat exchanger (1) according to any of claims 1 to 4, wherein the length (L) of the last inlet-pass (25) is equal to the length (L) of the first outlet-pass (25).
7. Heat exchanger (1) according to any of claims 1 to 6, wherein the heat exchanger (1) is configured to be crossed by an air flow (5) firstly across the second row (12) and lastly across the first row (11).
8. Heat exchanger (1) according to any of claims 1 to 7, wherein the heat exchanger (1) is provided with communication means (13) which enable a communication between the first row (11) and the second row (12), the first row (11) and the second row (12) delimiting together a volume of the heat exchanger (1).
9. Heating, ventilating and air conditioning system (105) comprising an air duct (104) in which an air flow (5) circulates and a heat exchanger (1) according to any of claims 1 to 8, wherein the heat exchanger (1) is located in the air duct (104) so that the air flow (5) circulates firstly through the first row (11) and secondly through the second row (12).
10. Refrigerant fluid circulation circuit (100) comprising at least a heat exchanger (1) according to any of claims 1 to 8.
11. Utilization of the heat exchanger (1) according to any of claims 1 to 8 as an evaporator in a refrigerant fluid circuit (100) according to claim 10.

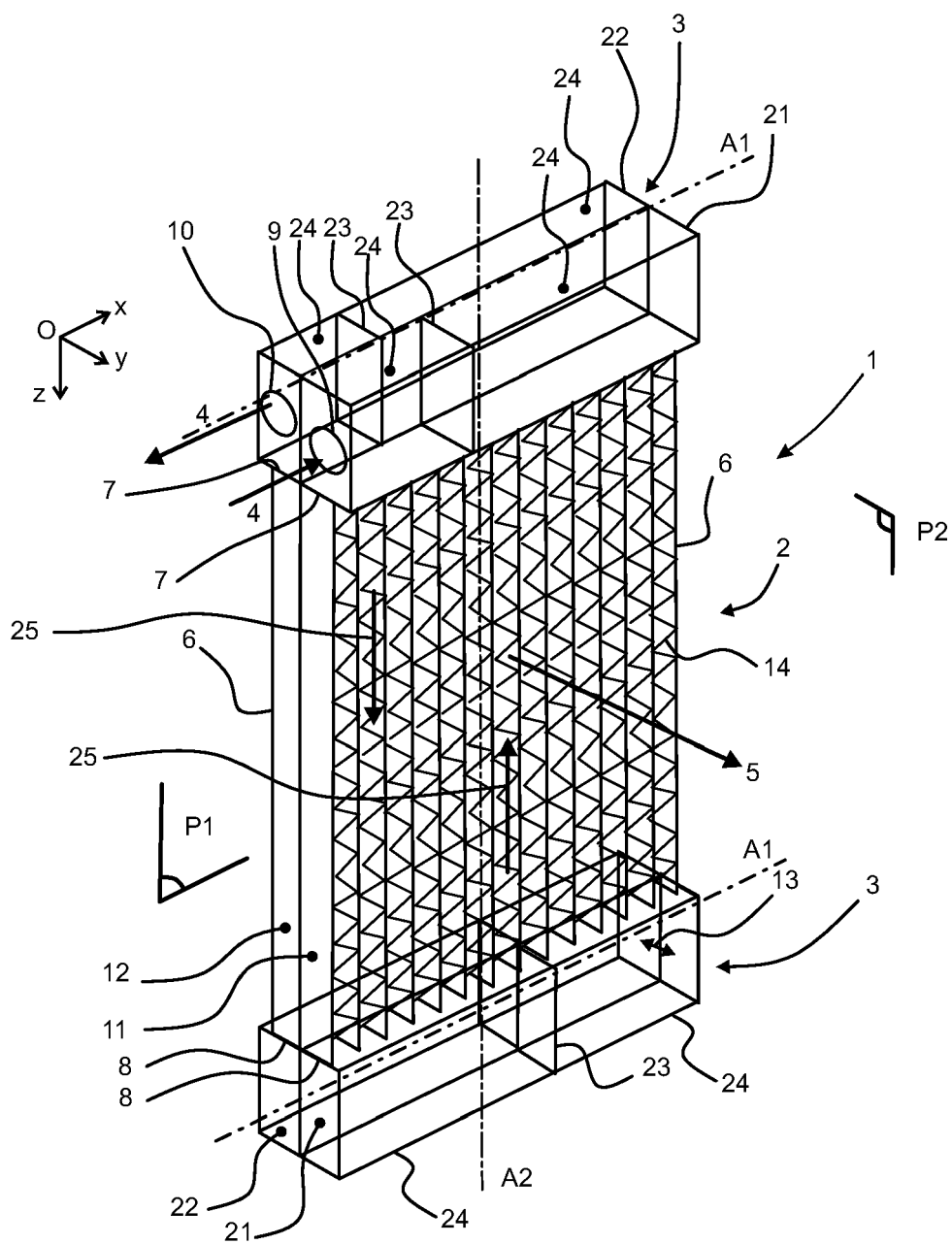


Figure 1

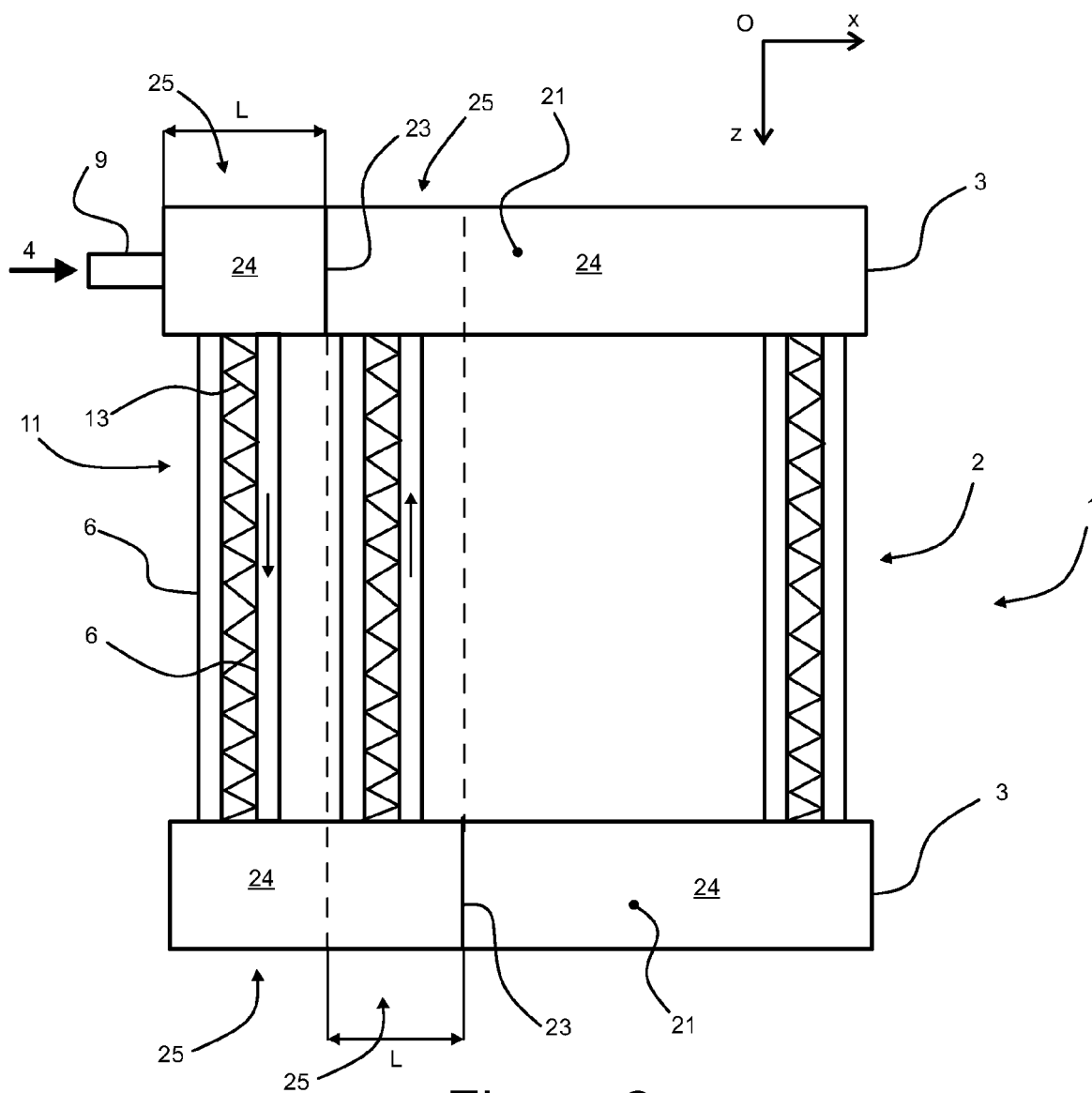


Figure 2

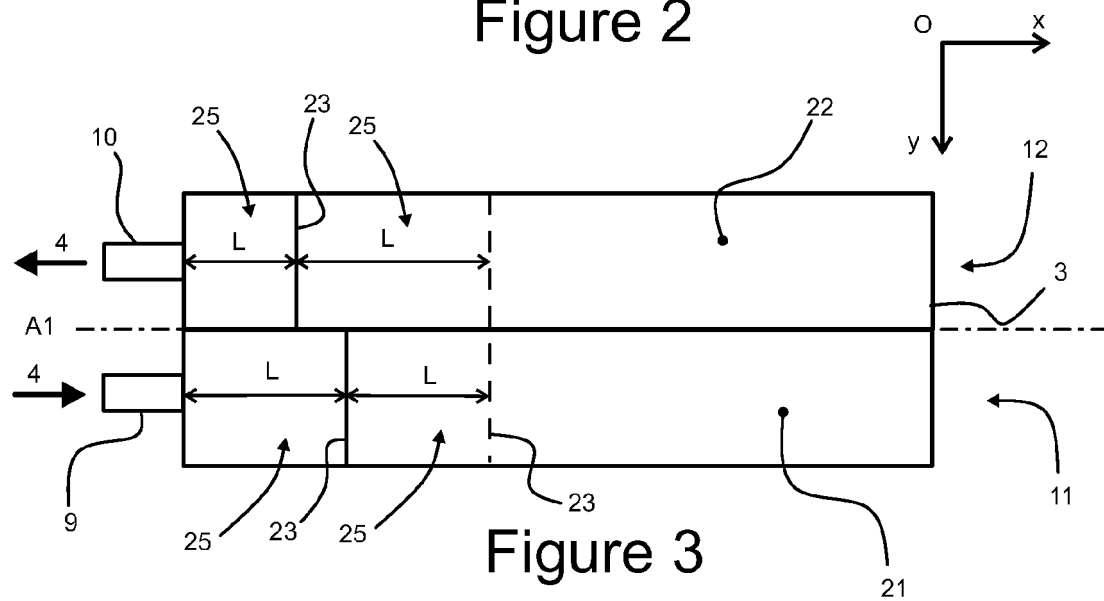


Figure 3

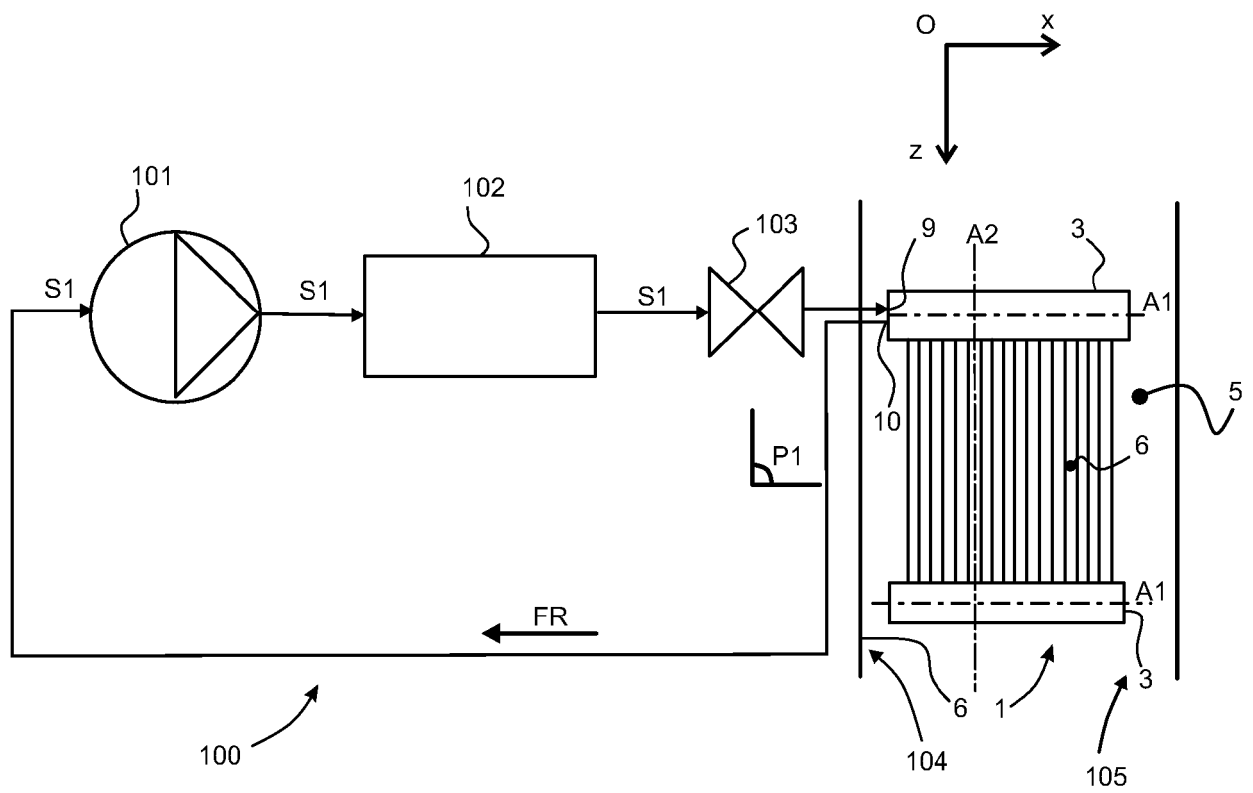


Figure 4



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