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(54) Heat exchanger with a mixing chamber

(57) A heat exchanger (10), in particular for a motor vehicle, comprises a collector box (18) and at least one longitudinal row (R1, R2) of multi-channel flat tubes (12) through which a first fluid can flow. The collector box (18) is made up of stacked plates (22, 24, 26) including:
a header plate (26) with at least one row of mounting slots (32) receiving an end portion of each tube (12),
a distribution plate (24) comprising at least one row of distribution slots (36),
a cover plate (22) comprising at least one row of collecting apertures (46, 48) which connect at least some of the distribution slots (36) to a manifold (28, 30), at least one collecting aperture (46, 48) being arranged between two adjacent distribution slots (36).

Said collecting aperture (46, 48) is arranged in a main recess (50) provided in the bottom face (52) of the cover plate (22).

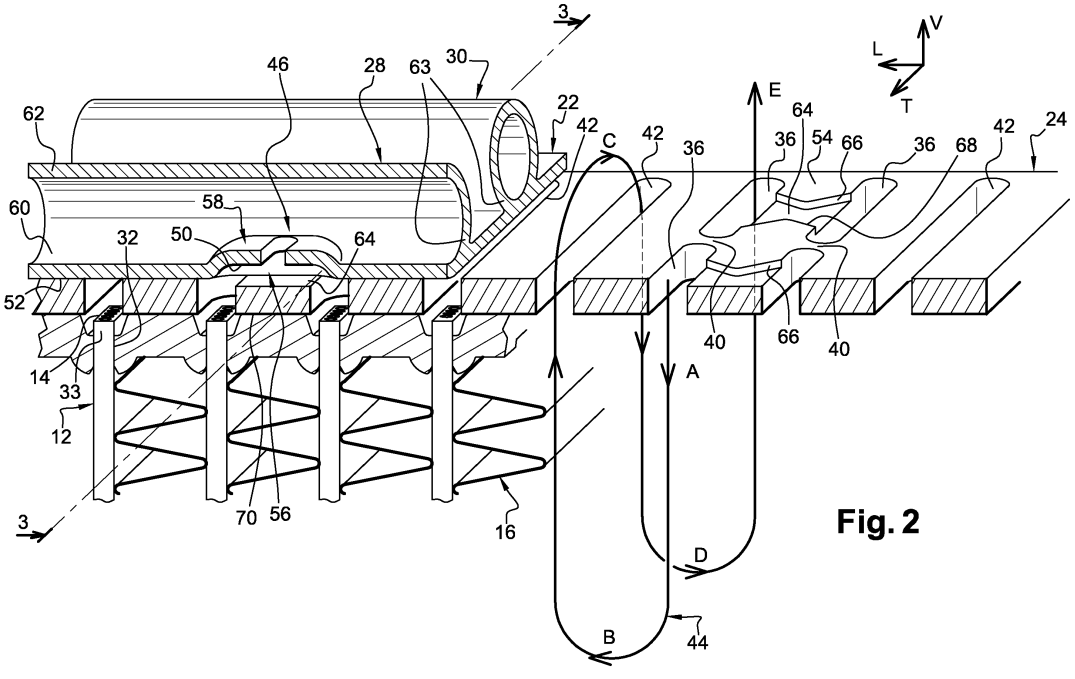

Fig. 2

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Description

TECHNICAL FIELD

[0001] The present invention relates generally to heat exchanger for motor vehicles.

BACKGROUND OF THE INVENTION

[0002] The present invention relates more particularly to a heat exchanger such as an evaporator, comprising a collector box and at least one longitudinal row of multi-channel flat tube portions through which a first fluid such as a refrigerant fluid can flow and around which a second fluid such as air can flow, said tube portions being flat along a transverse direction and being connected to the bottom face of the collector box, wherein the collector box is made up of stacked plates including:

a distribution plate comprising at least one row of distribution slots which distribute the first fluid in the collector box,
a cover plate comprising at least one row of collecting apertures which connect at least some of the distribution slots to a manifold, at least one collecting aperture being a collecting aperture arranged between two adjacent distribution slots in order to connect jointly said two adjacent distribution slots to the manifold.

[0003] The heat exchanger relates to multi layers collector box assemblies for two phases flow products with high pressure withstanding.

[0004] Such a heat exchanger is disclosed for example in US 2005/0039901. Nonetheless, the fluid circulation in the collector box is not optimized. More particularly, the two phases flow is not homogeneously mixed creating pressure drops and efficiency loss in the heat exchanger.

[0005] It is known, for example from figure 8, reference 545, in US 2005/0039901, to provide the distribution plate with a cutoff portion between two adjacent distribution slots in order to connect the two distribution slots. However, such a cutoff portion tends to weaken the collector box assembly and to decreases its high pressure withstanding capability.

SUMMARY OF THE INVENTION

[0006] An object of the invention is to provide a heat exchanger with a more uniform distribution of the first fluid to the tubes and a more pressure-stable construction. The heat exchanger should avoid flow stratification by improving the flow mixing in the collector box.

[0007] This object is achieved by a heat exchanger of the above mentioned type characterized in that said collecting aperture is arranged in a main recess provided in the bottom face of the cover plate in order to form with the upper face of the distribution plate a mixing chamber for the first fluid, said mixing chamber extending at least partially above said two adjacent distribution slots.

[0008] Thanks to the main recess forming the mixing chamber, the fluid distribution is better and there is no need to provide the distribution plate with a large and deep cutoff in order to create a mixing chamber. The advantage of avoiding cutoff in the distribution plate is to maximize the brazing surface between the distribution plate and the header plate which provides stronger attachment forces between the plates allowing the use of thinner plates, for example a thinner distribution plate.

[0009] According to other features of the invention:

- said collector box includes a header plate with at least one row of mounting slots receiving an end portion of each tube portion, said distribution plate being arranged between said header plate and said cover plate,
- said collecting aperture is of oblong shape along an axis parallel to the distribution slots,
- said main recess is of oblong shape along the manifold axis,
- said manifold is made of one piece with said cover plate,
- said main recess is stamped in the bottom face of the cover plate such as to form a bump on the inner surface of the manifold which creates a section reduction in the manifold,
- it comprises two rows of tubes and it comprises an inlet manifold and an outlet manifold,
- the portion of the distribution plate which faces said collecting aperture is provided with an additional recess for enlarging said mixing chamber towards the distribution plate,
- said additional recess is delimited transversally by two lateral surfaces which are facing each other, said lateral surfaces defining an increasing flow section towards each of the two adjacent distribution slots;

[0010] The present invention provides also a cover plate for a heat exchanger, comprising at least one longitudinal row of collecting apertures, each collecting aperture being adapted to connect one manifold of the heat exchanger with two distribution slots of a distribution plate of the heat exchanger, characterized in that at least one collecting aperture is arranged in a main recess provided in the bottom face of the cover plate in order to form a mixing chamber when the cover plate is fitted in the heat exchanger.

[0011] The present invention provides also a method for manufacturing a heat exchanger according to the above mentioned features, comprising the steps of:

- extruding the cover plate,
- forming the main recesses in the bottom face of the cover plate by stamping process,
- piercing the collecting apertures in the main recess-

es.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The present invention is now described by way of example with reference to the accompanying drawings in which:

- figure 1 is an exploded perspective view showing an evaporator according to a preferred embodiment of the invention;
- figure 2 is a perspective view including partial cross-section and longitudinal-section along 2-2 showing a portion of the evaporator of figure 1;
- figure 3 is a perspective view including a cross-section along 3-3 showing the evaporator of figure 1;
- figure 4 is a perspective view showing the cover plate of the evaporator of figure 1 provided with recesses;
- figure 5 is a view similar to figure 1 showing an alternative embodiment of the evaporator including U-tubes.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] FIG. 1 and 2 show an evaporator 10 for a motor vehicle air-conditioning system which is operated with CO_2 as refrigerant according to a preferred embodiment of the present invention. This evaporator 10 is designed as a two rows flat-tube evaporator and has a multiplicity of flat tubes 12 arranged along two longitudinal rows R1, R2, a front row R1 on the front side of the evaporator 10 and a rear row R2 on the rear side of the evaporator 10. These flat tubes 12 can be designed as extruded multi-channel flat tubes, which have a multiplicity of flow passages 14. All the flat tubes 12 have the same length along a vertical axis V and the same depth D along a transverse axis T.

[0014] In the following description, for the purpose of better understanding, we will use an orientation along the vertical axis V, the longitudinal axis L, and the transverse axis T, as can be seen on figure 1.

[0015] Preferably, the flat tubes 12 are multiport extruded flat tubes.

[0016] Between the individual flat tubes 12 there are corrugated fins 16, which are acted on by ambient air in the direction of the arrow F, i.e. along a transverse axis.

[0017] The tubes 12 are fitted between an upper end member constituted of a collector box 18 and a lower end member constituted of a diverter box 20.

[0018] The collector box 18 comprises a stack of individual plates bearing against one another and including successively a cover plate 22 at the top, an intermediate distribution plate 24, and a header plate 26 at the bottom. The collector box 18 comprises also an inlet manifold 28 and an outlet manifold 30 which extends along a longitudinal axis, in parallel to each other, and which are made of one piece with the cover plate 22, the cover plate 22 and the manifolds 28, 30 being extruded.

[0019] As an alternative embodiment, the cover plate 22 could be stamped and the manifolds 28, 30 could be made from rolled and welded process, and then these separates parts would be brazed together.

[0020] In the drawings, the header plate 26, in which a front row and a rear row of mounting slots 32 are arranged, is illustrated above the flat tubes 12, the two parallel rows of mounting slots 32 corresponding to the two rows R1, R2 of flat tubes 12. The mounting slots 32 are located one behind the other in the transverse direction and in each case leave between them webs 34 which separate two adjacent flat tubes 12 in the transverse direction. The total number of mounting slots 32 matches with the total number of flat tubes 12, each flat tube upper end 33 being inserted into the header plate 26 through a mounting slot 32.

[0021] The distribution plate 24, or diverter plate, is arranged above the header plate 26 and has distribution slots 36 for refrigerant passage similar to the mounting slots 32. The distribution plate 24 comprises, in alternation, two distribution slots 36 forming through passages which lie one behind the other in the transverse direction, leaving a web 40 between them, and a diverter passage 42 which continues through in the transverse direction.

[0022] The configuration of distribution slots 36 and diverter passages 42 adopts a pattern which repeats itself after four longitudinally adjacent tubes 12, said pattern corresponding to two flow paths 44 through the heat exchanger 10. In each case two adjacent flow paths 44 are arranged mirror-symmetrically with respect to one another along the longitudinal axis L. This means that either the distribution slots 36 of a flow path 44 come to lie next to the distribution slots 36 of an adjacent flow path 44, or a diverter passage 42 of a flow path 44 comes to lie next to a diverter passage 42 of an adjacent flow path 44. The diverter passages 42 have a cross-over function, allowing the refrigerant to transfer from one row R1 to the next R2 within air stream direction F.

[0023] A flow path 44 of the refrigerant follows the direction of the arrows along the dashed-line 44, i.e. the refrigerant enters the front tube 12 at A passing into the distribution slot 36, initially flows downward, is diverted at the bottom B, then flows upward through a longitudinally adjacent front tube 12 and passes into the diverter passage 42 at C, where it is diverted, before then flowing downward on the rear side of the evaporator 10, where it is diverted at D and then flows upward again in order to pass through the distribution slot 36 of the adjacent rear tube 12 as indicated by arrow E. The supply and discharge of the refrigerant is described on the basis of figure 2.

[0024] According to the present embodiment, each flow path 44 is diverted at the bottom part of the evaporator 10 thanks to the diverter box 20 which is aimed to redirect (at B and D) the flow coming downward through a flat tube 12 towards the longitudinally adjacent flat tube 12 in the upward direction as if the evaporator was formed from individual U-tubes. An example of a similar diverter

box 20 is disclosed in US 2005/0039901 in connection with figure 1 where it is used for diverting the flow from the front row of tubes towards the rear row of tubes (paragraphs [74] and [75]).

[0025] According to an alternative embodiment, the diverter box 20 could be omitted by providing the heat exchanger 10 with U-tubes 21, as shown on figure 5, instead of straight flat tubes 12. The U-tube 21 comprises two vertical portions linked at the bottom by a bended portion extending longitudinally.

[0026] What is referred to as a cover plate 22, which includes two parallel rows of collecting apertures 46, 48 is illustrated in the drawing above the distribution plate 24. The collecting apertures 46, 48 comprise a first row of refrigerant inlet apertures 46 connecting the distribution slots 36 underneath to the inlet manifold 28 and a second row of refrigerant outlet apertures 48 connecting the distribution slots 36 underneath to the outlet manifold 30.

[0027] According to the present embodiment, each collecting aperture 46, 48 is arranged above and between two longitudinally adjacent distribution slots 36 in order to connect jointly said two adjacent distribution slots 36 to the corresponding manifold 28, 30.

[0028] The above-described individual parts of the evaporator 10 are assembled in the following way. The header plate 26 is fitted onto the flat-tube ends 33. Then, the distribution plate 24 and the cover plate 22 with the manifolds 28, 30 are stacked on top of the header plate 8.

[0029] The different plates constituting the diverter box 20 at the bottom of the evaporator are assembled in a similar way.

[0030] As an alternative embodiment, the distribution plate 24 could be integrated into the header plate 26 to save one plate.

[0031] After the evaporator 10 has therefore been assembled, it is soldered to form a fixed block in a soldering furnace. During the soldering process, the plates 22, 24, 26 are held in position with respect to one another by a positive or non positive clamping action. However, it is also possible firstly to assemble the end member comprising header plate 26, distribution plate 24, and cover plate 22, and then to connect it to flat tubes 12.

[0032] According to the invention, each collecting aperture 46, 48 is arranged in a main recess 50 provided in the bottom face 52 of the cover plate 22 in order to form, with the upper face 54 of the distribution plate 24, a mixing chamber 56 for the refrigerant. As can be seen on figure 2, said mixing chamber 56 extends partially above the two adjacent distribution slots 36 and said main recess 50 is made longitudinally larger than the collecting aperture 46, 48.

[0033] Preferably, the recess 50 is made by stamping process into the bottom face 52 of the cover plate 22 which provides the corresponding manifold 28, 30 with a bump 58 on its inner surface 60. The bump 58 is delimited transversally by the inner transversal dimension of the manifold 28, 30. More particularly, the bump 58 is delimited transversally by the longitudinal tubular wall 62 of the manifold 28, 30, at the location 63 where the tubular wall 62 is linked to the cover plate 22. The vertical depth of the main recess 50 may be approximately the thickness of the metal plate constituting the cover plate 22.

[0034] Advantageously, the main recess 50 has a dome shape which allows an optimized distribution.

[0035] According to the embodiment shown, the main recess 50 is of longitudinal oblong shape so that it extends longitudinally from the middle of one distribution slot 36 to the middle of the adjacent distribution slot 36.

[0036] The collecting apertures 46, 48 are preferably designed as bores of transversal oblong shape with dimensions matched to the desired refrigerant distribution and quantitative flow. The oblong shape extends transversally which allows a better distribution/collection of the refrigerant into all the channels 14.

[0037] The section of the collecting apertures 46, 48 is preferably ranged between 30% and 60% of the total open area of the tubes 12 to feed. This restriction is done by purpose to make sure the refrigerant flow is more or less constant up to the far end of the manifolds 28, 30. The section restriction is adjusted longitudinally, from one collecting aperture 46, 48 to the others, depending on the manifold 28, 30 length and/or depending on refrigerant flow length in the tubes 12.

[0038] In addition to the preferred range 30% - 60%, the evaporator 10 is designed for obtaining good performances at some predefined operating points which help to define the final value for the section of those collecting apertures 46,48.

[0039] Thanks to the mixing chambers 56 connected to the inlet manifold 28, the refrigerant is able to mix before flowing into the two connected tubes 12 which makes the refrigerant more homogenous, in terms of pressure and in terms of fluid consistency, all along the evaporator 10 and all along each flow path 44, thus avoiding risks of flow stratification. Flow homogeneity contributes for an optimized distribution in the evaporator 10.

[0040] After entering into the collecting aperture 46 and before entering into the corresponding flat tubes 12, the refrigerant flow impacts on the portion of the distribution plate 24 which faces the collecting aperture 46, thus contributing to mixing.

[0041] According to a preferred embodiment, the portion of the distribution plate 24 which faces the collecting aperture 46, 48 is provided with an additional recess 64 for enlarging vertically the mixing chamber 56. The additional recess 64 is delimited longitudinally by two adjacent distribution slots 36 and transversally by two lateral surfaces 66, 68 which are facing each other. The greater transversal dimension of said additional recess 64 is inferior to the transversal depth of the corresponding through-passages 38.

[0042] Said lateral surfaces 66, 68 define an increasing flow section towards each of the two adjacent distribution slots 36, the distance between said lateral surfaces 66, 68 increasing towards each of the distribution slots 36.

As can be seen on figure 2, each lateral surface 66, 68 has a triangular profile from an elevation view. The vertical thickness of the additional recess 64 is inferior to the thickness of the main recess 50.

[0043] Thanks to the additional recess 64, the mixing chamber 56 is enlarged backwards and allows better distribution in the tubes 12 of the front row R1, and better collection from the tubes 12 of the rear row R2. However, the invention could be implemented without additional recesses 64.

[0044] The use of an additional recess 64 and a main recess 50 instead of providing the distribution plate 24 with a cut-off or aperture between the two adjacent distribution slots 36 allows a more strong attachment between the distribution plate 24 and the header plate 26 since the contact surface 70 for brazing is maximized.

[0045] The flow restriction provided in the manifolds 28, 30 by the bumps 58 promotes flow turbulences in the manifold 28, 30 which ensure that the refrigerant remain biphasic with an improved flow homogeneity versus stratified one. The bumps 58 provide some kind of diaphragm which improves the flow mixing in the manifolds 28, 30.

[0046] The use of a bump 58 of oblong shape along the axis of the manifolds 28, 30 allows not deforming the longitudinal wall of the manifolds 28, 30.

[0047] The main recesses 50, the bumps 58, and the additional recesses 64 have been described mainly in connection with the inlet manifold 28 and the inlet apertures 46, i.e. in connection with the inlet side or front side of the evaporator 10. Symmetrically, the main recesses 50, the bumps 58, and the additional recesses 64 can be provided, all together or selectively, on the outlet side or rear side of the evaporator 10, in connection with the outlet manifold 28 and the outlet apertures 48.

[0048] The present invention has been described in part on the basis of the example of an evaporator 10. However, it should be noted that the heat exchanger according to the invention is also suitable for other uses.

Claims

1. Heat exchanger (10), in particular for a motor vehicle, comprising a collector box (18) and at least one longitudinal row (R1, R2) of multi-channel flat tube portions (12) through which a first fluid such as a refrigerant fluid can flow and around which a second fluid such as air can flow, said tube portions (12) being flat along a transverse direction and being connected to the bottom face of the collector box (18), wherein the collector box (18) is made up of stacked plates (22, 24, 26) including:

   a distribution plate (24) comprising at least one row of distribution slots (36) which distribute the first fluid in the collector box (18),
   a cover plate (22) comprising at least one row of collecting apertures (46, 48) which connect at least some of the distribution slots (36) to a manifold (28, 30), at least one collecting aperture (46, 48) being arranged between two adjacent distribution slots (36) in order to connect jointly said two adjacent distribution slots (36) to the manifold (28, 30),

   characterized in that said collecting aperture (46, 48) is arranged in a main recess (50) provided in the bottom face (52) of the cover plate (22) in order to form with the upper face (54) of the distribution plate (24) a mixing chamber (56) for the first fluid, said mixing chamber (56) extending at least partially above said two adjacent distribution slots (36).

2. Heat exchanger (10) according to claim 1, **characterized in that** said collector box (18) includes a header plate (26) with at least one row of mounting slots (32) receiving an end portion of each tube portion (12), said distribution plate (24) being arranged between said header plate (26) and said cover plate (22).

3. Heat exchanger (10) according to claim 1 or 2, **characterized in that** said collecting aperture (46, 48) is of oblong shape along an axis parallel to the distribution slots (36).

4. Heat exchanger (10) according to any of the preceding claims, **characterized in that** said main recess (50) is of oblong shape along the manifold axis.

5. Heat exchanger (10) according to anyone of the preceding claims, **characterized in that** said manifold (28, 30) is made of one piece with said cover plate (22).

6. Heat exchanger (10) according to claim 5, **characterized in that** said main recess (50) is stamped in the bottom face (52) of the cover plate (22) such as to form a bump (58) on the inner surface (60) of the manifold (28, 30) which generates a section reduction in the manifold (28, 30).

7. Heat exchanger (10) according to anyone of the preceding claims, **characterized in that** it comprises two rows (R1, R2) of tubes (12) and **in that** it comprises an inlet manifold (28) and an outlet manifold (30).

8. Heat exchanger (10) according to anyone of the preceding claims, **characterized in that** the portion of the distribution plate (24) which faces said collecting aperture (46, 48) is provided with an additional recess (64) for enlarging said mixing chamber (56) towards the distribution plate (24).

9. Heat exchanger (10) according to claim 8, **charac-**

terized in that said additional recess (50) is delimited transversally by two lateral surfaces (66, 68) which are facing each other, said lateral surfaces (66, 68) defining an increasing flow section towards each of the two adjacent distribution slots (36).

10. Cover plate (22) for a heat exchanger (10), comprising at least one longitudinal row of collecting apertures (46, 48), each collecting aperture (46, 48) being adapted to connect one manifold (28, 30) of the heat exchanger (10) with two distribution slots (36) of a distribution plate (24) of the heat exchanger (10), **characterized in that** at least one collecting aperture (46, 48) is arranged in a main recess (50) provided in the bottom face (52) of the cover plate (22) in order to form a mixing chamber (56) on the distribution plate side when the cover plate (22) is fitted in the heat exchanger (10).

11. Cover plate (22) according to claim 10, **characterized in that** said collecting aperture (46, 48) is of oblong shape extending along a transversal axis.

12. Cover plate (22) according to claim 10 or 11, **characterized in that** said main recess (50) is of oblong shape extending along a longitudinal axis.

13. Method for manufacturing a heat exchanger (10) according to anyone of claims 1 to 9, comprising the steps of:

- extruding the cover plate (22),
- forming the main recesses (50) in the bottom face (52) of the cover plate (22) by stamping process,
- piercing the collecting apertures (46, 48) in the main recesses (50).

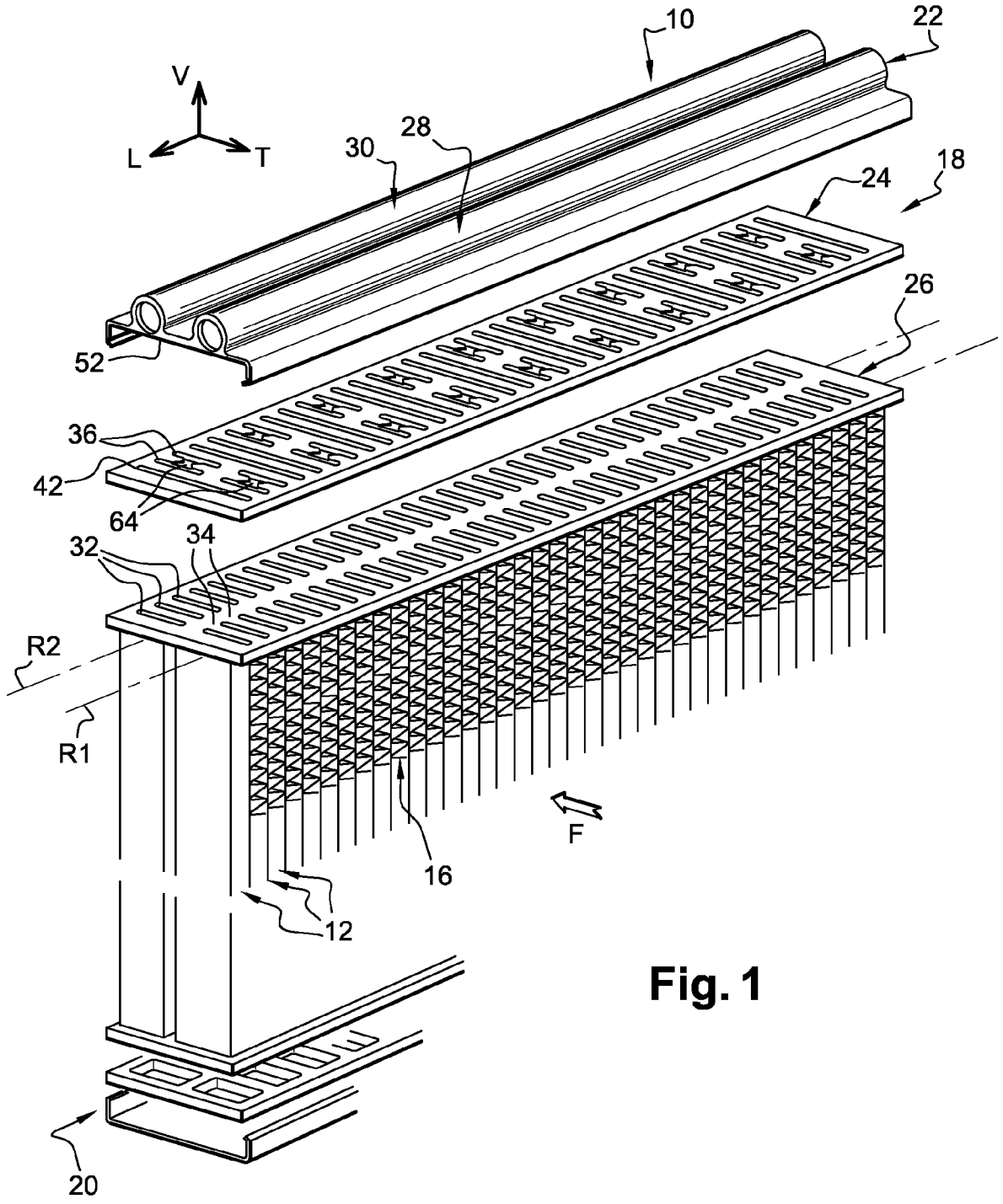

Fig. 1

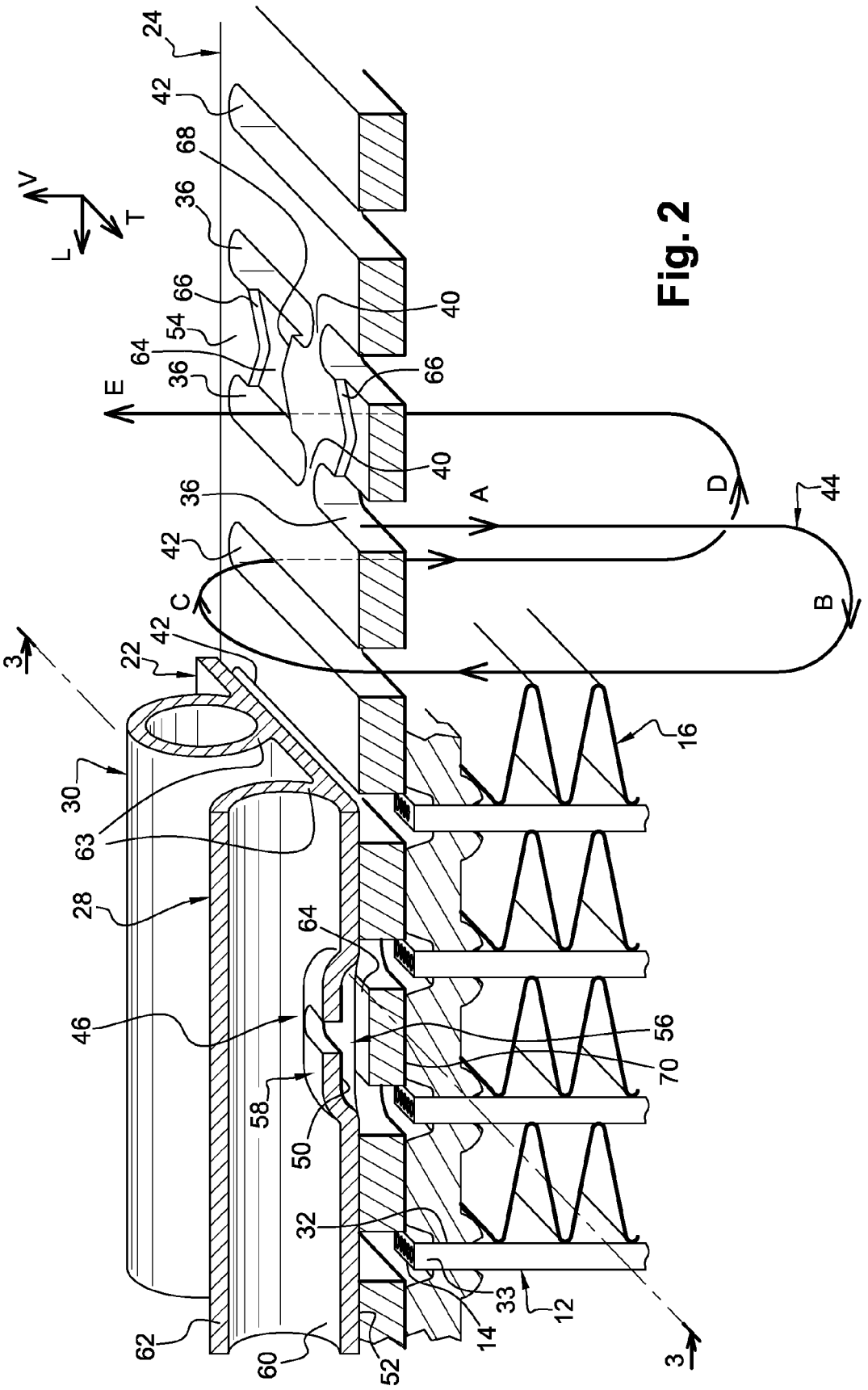
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Fig. 2

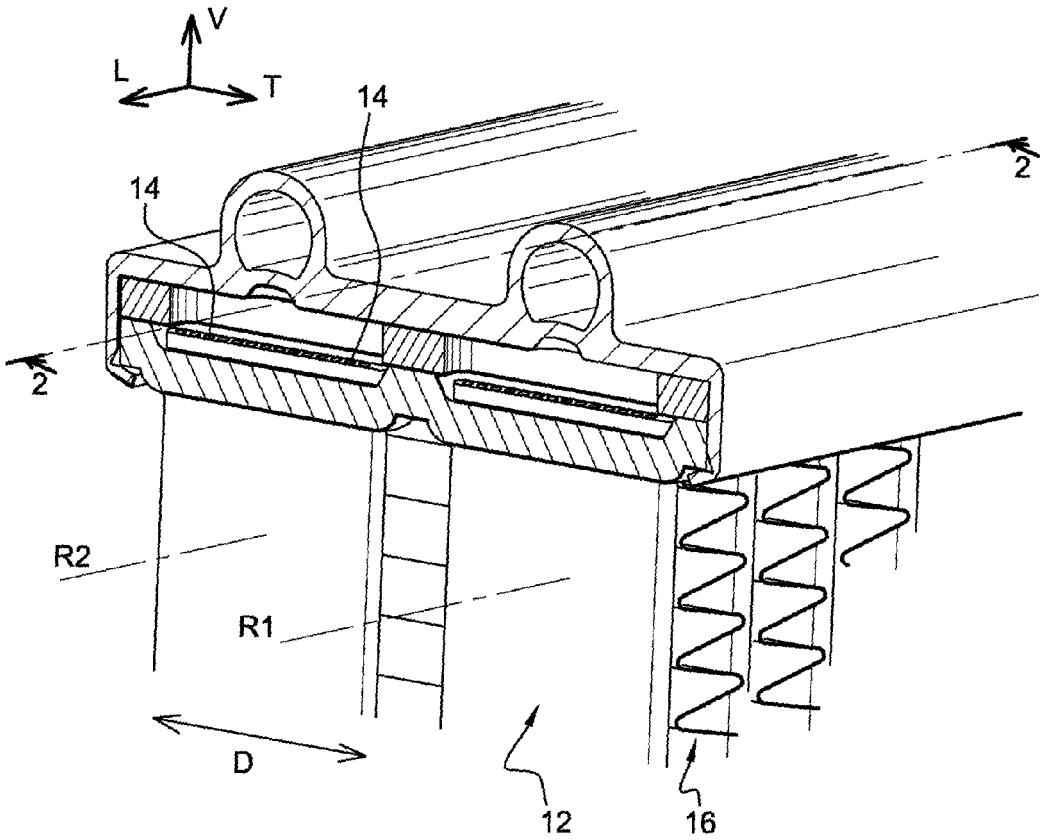

Fig. 3

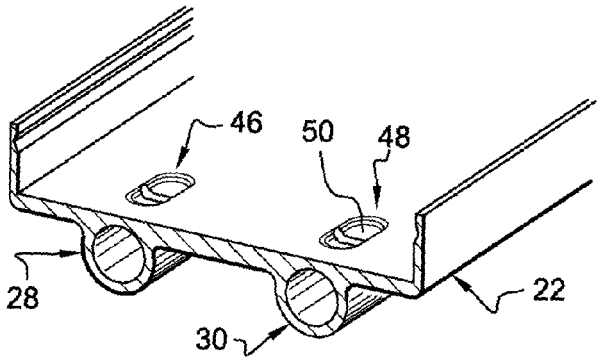

Fig. 4

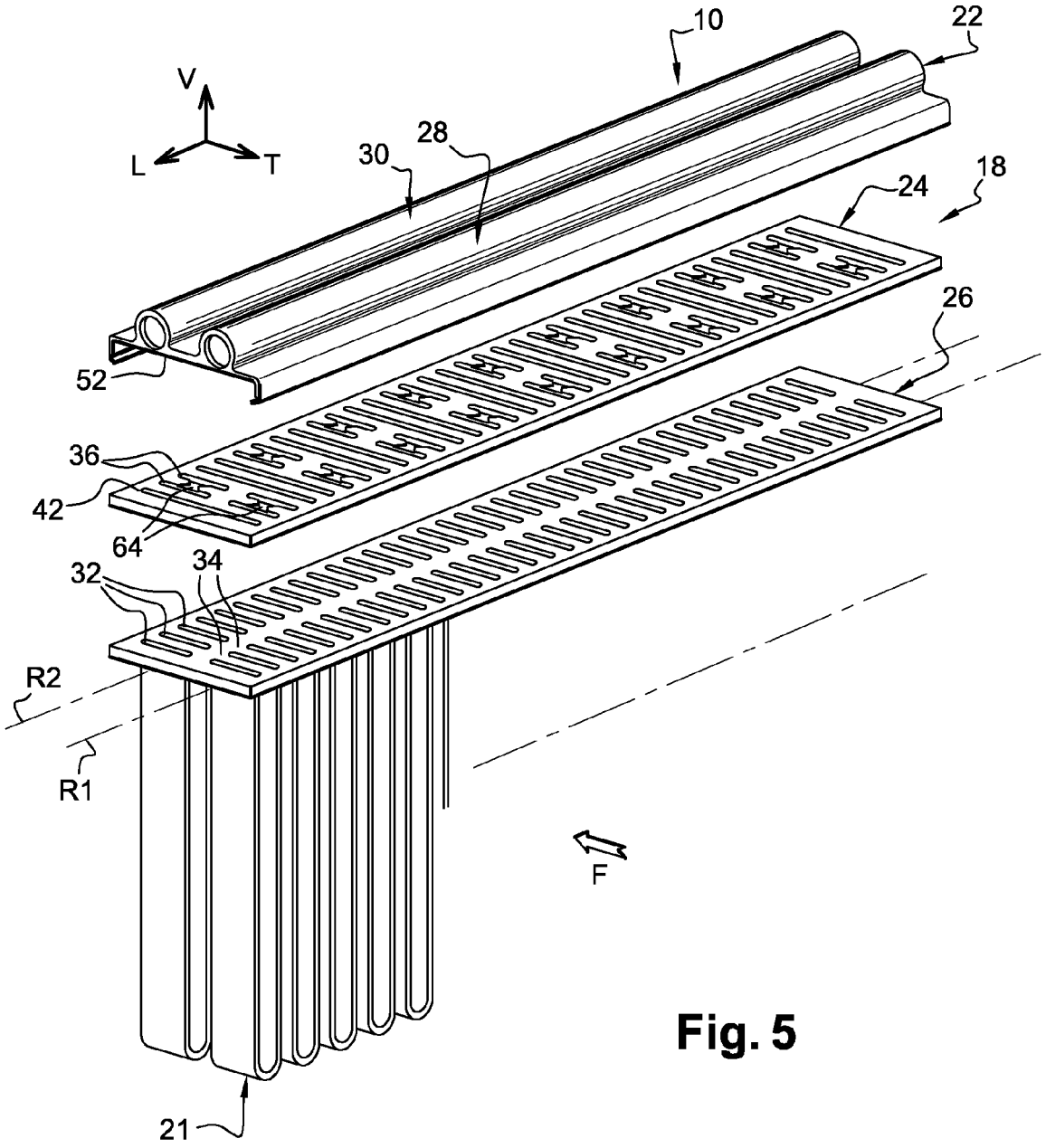

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 08 15 1505

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 1 798 507 A (BEHR GMBH & CO KG [DE]) 20 June 2007 (2007-06-20) * the whole document * -----	1-13	INV. F25B39/02 F28F27/02 F28D1/053
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TECHNICAL FIELDS SEARCHED (IPC)

F25B
F28F
F28D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	6 October 2008	Bain, David

CATEGORY OF CITED DOCUMENTS

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