

(19)



(11)

EP 3 819 579 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
12.05.2021 Bulletin 2021/19

(51) Int Cl.:
F28D 7/00 (2006.01) **F28F 9/02** (2006.01)
F25B 40/00 (2006.01)

(21) Application number: **19461603.3**

(22) Date of filing: **07.11.2019**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

Designated Extension States:

BA ME

Designated Validation States:

KH MA MD TN

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(54) **A HEAT EXCHANGER**

(57) The invention comprises a heat exchanger, in particular for a motor vehicle comprising: at least two manifolds, a primary tubes, a secondary tubes, characterised in that, the secondary tubes are shifted with re-

spect to the primary tubes along their axial direction and the manifolds are configured to receive and fluidly isolate the primary tubes from the secondary tubes.

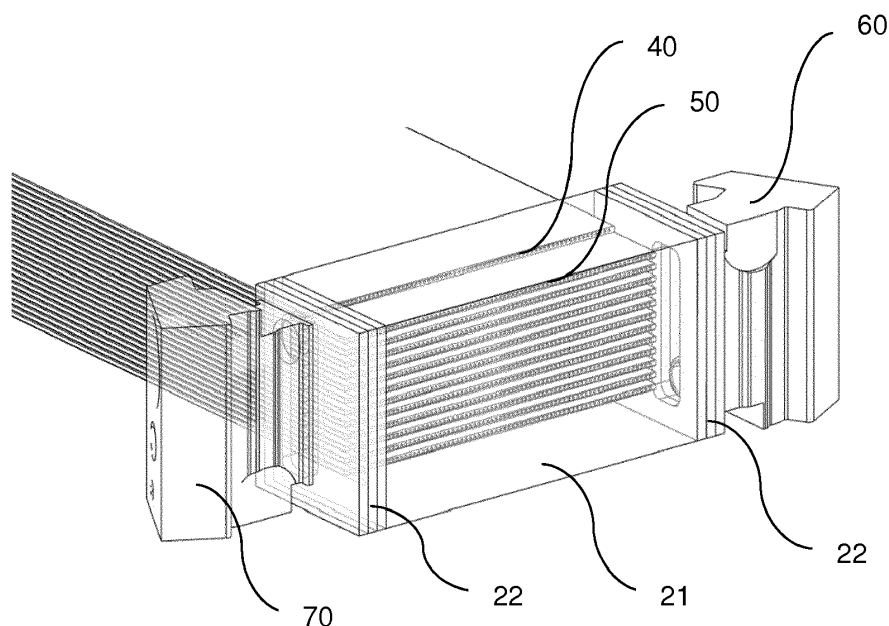


Fig. 4

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Description

FIELD OF THE INVENTION

[0001] The invention relates to a heat exchanger, in particular the heat exchanger for a motor vehicle.

BACKGROUND OF THE INVENTION

[0002] To reduce the impact on climate change and under international pressure to reduce the CO₂ emissions for vehicle refrigerants used in mobile HVAC and refrigerant systems, the new refrigerant such as R744 (carbon dioxide or CO₂) has been introduced.

[0003] Thermodynamically, the R1234yf refrigerant has similar properties to R134a. However, its global warming potential or GWP is only 4, as opposed to 1430. The refrigerant R744 has been assigned a GWP value of 1 and functions as the reference gas.

[0004] Systems designed for use with R744 have pressures up to ten times higher than those intended for R1234yf. In summer, the peak pressure is around 100 bar, which is above the critical pressure level (supercritical process). This makes controlling the system more difficult, but not problematic. The coefficient of performance or COP is the same in moderate climate conditions, but slightly poorer in hot, moist climate zones. The system can be designed to compensate for this, as the components are smaller because of the higher volumetric cooling capacity of R744.

[0005] In comparison to R134a and R1234yf systems, the R744 refrigerant is at a disadvantage as R744 absorbs slightly less energy per unit of flow in a refrigerant cycle. In order to increase the performance level to that of R134a or R1234yf it is advised to use an Internal Heat exchanger (IHx).

[0006] An Internal Heat exchanger (IHx) is used to transfer heat between the low side pressure and the high pressure flow circuits. Its function is to improve system performance by further sub-cooling the refrigerant being supplied to the evaporator through the refrigerant control device.

[0007] Commonly used internal heat exchangers usually comprise, for example, a coaxial tube heat exchanger and a stacked heat exchanger.

[0008] The coaxial heat exchanger is usually designed as a "tube in tube" structure. Usually the outer tube is made of steel/copper, and the inner tube can be titanium, copper, copper-nickel depending on the requirements of working conditions. The coaxial heat exchanger usually conveys two fluids through separate circuits, wherein one circuit is conveyed in the opposite direction with respect to the other fluid.

[0009] The stacked plate heat exchanger design is usually suited to transferring heat between medium- and low-pressure fluids. Welded, semi-welded and brazed heat exchangers are used for heat exchange between high-pressure fluids or where a more compact product

is required. In place of a pipe passing through a chamber, there are instead two alternating chambers, usually thin in depth, separated at their largest surface by a corrugated metal plate. The plates used in a plate and frame heat exchanger are obtained by one piece pressing of metal plates. Stainless steel is a commonly used metal for the plates because of its ability to withstand high temperatures, its strength, and its corrosion resistance.

[0010] Due to its structure, both coaxial and plate heat exchangers are not suitable for high-pressure R744 refrigerant. In spite of enhancing their structure and improving the sealing they are still prone to leakage when the high-pressure fluid is introduced. Further, the heat exchangers such as coaxial tube heat exchanger require its components to be large enough to efficiently transfer the heat between the media. Consequently, the heat exchangers described above are inconvenient in terms of packaging, costs of production and weight reduction.

[0011] It would be desired to produce an internal heat exchanger that would sustain the pressure of high-pressure fluids, such as R744. The sub-components should preferably be made of inexpensive materials while maintaining high quality of the final product. Further, the production process of sub-components should be simple and efficient i.e. it would be desired to manufacture each sub-component using a method that does not require complicated production process.

SUMMARY OF THE INVENTION

[0012] The object of the invention is, among others, a heat exchanger, in particular for a motor vehicle comprising at least two manifolds, a primary tubes, a secondary tubes, characterised in that the secondary tubes are shifted with respect to the primary tubes along their axial direction and the manifolds are configured to receive and fluidly isolate the primary tubes from the secondary tubes.

[0013] Preferably, the primary tubes and the secondary tubes are deployed alternately and in parallel with respect to each other between the first manifold and the second manifold.

[0014] Preferably, the primary tubes and the secondary tubes form a unitary core.

[0015] Preferably, the quantity of the primary tubes is equal to the quantity of the secondary tubes.

[0016] Preferably, the quantity of the primary tubes is different than the quantity of the secondary tubes.

[0017] Preferably, the primary tubes and the secondary tubes comprise a plurality of micro channels.

[0018] Preferably, the primary tubes are configured to convey different media than the secondary tubes between the manifolds.

[0019] Preferably, the quantity of micro channels comprised within the primary tubes is equal to the quantity of micro channels comprised within the secondary tubes.

[0020] Preferably, the quantity of micro channels comprised within the primary tubes is different than the quan-

tity of micro channels comprised within the secondary tubes.

[0021] Preferably, at least one manifold, in particular both manifolds comprises a header, wherein the header is of substantially cuboidal shape.

[0022] Preferably, at least one header in particular both headers are complementary with respect to the primary tubes and the secondary tubes.

[0023] Preferably, at least one header, in particular both headers comprises a plurality of cavities and a plurality of respective protrusions.

[0024] Preferably, the cavities are deployed alternately with the protrusions.

[0025] Preferably, the header comprises a chamber configured to receive the primary tubes and the secondary tubes, wherein at least a part of a chamber remains fluidly communicated with at least one type of the tubes.

[0026] Preferably, at least one header, in particular both headers assembled with the primary tubes and the secondary tubes create a primary passage and a secondary passage, respectively.

[0027] Preferably, the protrusions assembled with respective group of tubes that are introduced into cavities form a separation wall.

[0028] Preferably, the separation wall fluidly isolates the primary passage from the secondary passage.

[0029] Preferably, the primary passage has the same dimensions as the secondary passage.

[0030] Preferably, the primary passage has different dimensions than the secondary passage.

[0031] Preferably, at least one manifold, in particular both manifolds comprises at least two covers.

[0032] Preferably, the covers are assembled with two side walls of the headers.

[0033] Preferably, the covers are assembled with the side walls of the headers having a smallest cross section.

[0034] Preferably, each cover comprises a set of stacked plates having substantially identical outer perimeters, whereas the cross- section of at least one plate is different than the cross- sections of the other plates.

[0035] Preferably, at least one plate forming a cover comprises at least one essentially rectangular opening.

[0036] Preferably, at least one plate forming a cover comprises at least one essentially circular opening.

[0037] Preferably, at least one cover, in particular both covers comprise at least one inlet and/ or at least one outlet.

[0038] Preferably, at least one manifold, in particular both manifolds comprises at least one inlet and/ or outlet fluidly communicated with at least one passage thereof.

[0039] Preferably, a first circuit and a second circuit, wherein each circuit comprises at least one connection block, at least one passage comprised within at least one manifold, and at least one type of tubes.

[0040] Preferably, the first circuit conveys the media in the same direction with respect to the second circuit

[0041] Preferably, the first circuit conveys the media in the counter direction with respect to the second circuit.

[0042] Preferably, a length of the primary tubes is substantially equal to the a length of the secondary tubes.

[0043] Preferably, the length of the primary tubes is different than the length of the secondary tubes.

BRIEF DESCRIPTION OF DRAWINGS

[0044] Examples of the invention will be apparent from and described in detail with reference to the accompanying drawings, in which:

Fig. 1 shows a perspective view of heat exchanger assembly in one of the embodiments.

Fig. 2 shows a perspective view of standalone header in one of the embodiments.

Fig. 3 shows a cross- section view of the tubes-header assembly in one of the embodiments.

Fig. 4 shows a partially transparent perspective view of one side of the heat exchanger in one of the examples.

DETAILED DESCRIPTION OF EMBODIMENTS

[0045] The invention comprises a heat exchanger 1 assembled using multiple sub-components cooperating in a fluidal manner in order to enable heat transfer between two or more circuits, wherein each circuit comprises two substantially different fluids. Phrase "substantially different" means that the fluid in one circuit has different chemical and/or physical properties than the fluid in other circuit. In particular, the heat exchanger 1 comprises fluids having different pressure and temperature in their respective circuits. One of the many examples of such fluid may be a refrigerant such as a liquid carbon dioxide also known as R744. The heat exchanger (1) may be suitable for an automobile, in particular an internal combustion vehicle as well as for an electric vehicle.

[0046] Fig. 1 presents the heat exchanger 1 comprising, inter alia, at least two manifolds 20, 30, a primary tubes 40, and a secondary tubes 50. The manifolds 20, 30 are fluidly connected with at least one inlet 60 and/or outlet 70. The deployment of the inlet 60 and/or the outlet 70 on the manifold 20, 30 depends on the predetermined refrigerant flow arrangement. Possible deployments of the inlet 60 and/or outlet 70 will be described in further paragraphs.

Each manifold 20, 30 comprises also a header 21, 31 and at least one cover 22, 32. The heads 21, 31 and the covers 22, 32 may be substantially identical elements, however due to their different orientation they are cross-referenced as different elements of the heat exchanger 1. The headers 21, 31 and the covers 22, 32 will be described in detail in further paragraphs.

[0047] The heat exchanger 1 in this particular example may be suitable for heat exchange process between at

least two circuits, in particular between a high pressure circuit and a low pressure circuit. The term "circuit" may refer to the fluid communication path starting from one of the inlets 60 and ending at one of the respective outlets 70 of the heat exchanger 1. Further, the heat exchanger 1 may comprise e.g. two circuits, wherein each circuit comprises corresponding inlet 60 and outlet 70. Usually one circuit conveys the media in the opposite direction with respect to the other circuit, due to increased efficiency, however, the same direction of fluid flow in both neighbouring circuits is also envisaged.

[0048] As shown in Fig. 1 the inlets 60 and the outlets 70 may be deployed on the side walls of the manifolds 20, 30 which have smallest surface. The inlet 60 and/or outlet 70 may be in a form of e.g. a connection block. The connection blocks may be in a form predetermined by e.g. the customer, as the means of connecting the inlet 60 and/or the outlet 70 to the respective manifolds 20, 30 are universal. The connection block may be made of metallic material, preferably a lightweight metal alloy, e.g. aluminum. As shown in Fig. 1, the connection blocks are inclined in the same direction with respect to the respective manifolds 20, 30, however, the direction of the connectors may vary depending on desired configuration. The inlet 60 and the outlet 70 connection blocks could be also deployed outwardly with respect to the tubes 40, 50. Alternatively, the inlet 60 and the outlet 70 connection blocks could be also deployed inwardly with respect to the tubes 40, 50. Alternatively, the inlet 60 and the outlet 70 connection blocks could be also deployed outwardly with respect to the tubes 40, 50. Alternatively, one inlet 60 and one outlet 70 deployed on one longer side of the heat exchanger 1 could be facing one direction, whereas the other inlet 60 and the other outlet deployed on the opposite longer side of the heat exchanger 1 could be facing the other direction. The inlets 60 and/or the outlets 70 may be connected with the manifolds 20, 30 by the means of e.g. brazing, yet other means of connection that will provide fluid-tight connection are also envisaged.

[0049] Fig. 2 shows a standalone header 21, 31 shown in a perspective view to disclose its essential features. The header 21, 31 is of essentially cuboidal shape. Term "essentially cuboidal" means that the header 21, 31 is formed out of initially cuboidal block of material, wherein the material is preferably a lightweight metal alloy, e.g. aluminum. This shape and form allows preparing a block that is feasible in terms of packaging, rigidity and production process.

The header 21, 31 comprises a chamber 26 formed in a block of material which is created by partial material reduction in the middle portion thereof. After forming a chamber 26, the header 21, 31 is essentially C-shaped, as shown in Fig. 2. Term "essentially C-shaped" means that the header 21, 31 comprises at least one cross-section that forms a letter C or inverted letter C. Further, the header 21, 31 comprises a plurality of cavities 23, 33 and a plurality of protrusions 24, 34 formed in the body of the

essentially C-shaped header 21, 31. The protrusions 24, 34 and cavities 23, 33 form a comb-like structure, i.e. the cavities 23, 33 are deployed alternately with the protrusions 24, 34. The protrusions 24, 34 have their ends facing the chamber 26.

[0050] The header 21, 31 comprising the aforementioned features enables assembling it with the tubes (not shown). In other words, the chamber 26 is configured to receive the primary tubes 40 and the secondary tubes 50, wherein at least a part of a chamber 26 remains fluidly communicated with at least one type of the tubes. The other type of the tubes 40, 50 may enter the cavities 23, 33. This kind of assembly will be described in further paragraphs.

[0051] Fig. 3 shows a cross-sectional view through the part of the assembly comprising, inter alia, the primary tubes 40, the secondary tubes 50, and the headers 21, 31. The inlets 60, outlets 70, and covers 22, 32 are omitted for the sake of clarity.

[0052] The primary tubes 40 and the secondary tubes 50 are usually stacked one on another. The tubes 40, 50 are usually deployed alternately and in parallel with respect to each other between the first header 21 and the second header 31. Further, the secondary tubes 50 may be shifted with respect to the primary tubes 40 along their axial direction. The axial direction of the tubes 40, 50 is parallel to the direction in which said tubes 40, 50 convey fluid or fluids. This allows forming two fluidly isolated circuits in the heat exchanger 1. One of the ways to achieve this effect is to form at least one header 21, 31, in particular two headers 21, 31 which would be complementary with respect to the primary tubes 40 and the secondary tubes 50. Term "complementary" should be regarded as combined in such a way as to enhance or emphasize the qualities of each other or another. In other words, the alternate arrangement of the primary tubes 40 and the secondary tubes 50 determines the arrangement of cavities 23, 33 and protrusions 24, 34 on the headers 21, 31. The dotted line shown in Fig. 3 indicates that the tubes 40, 50 are materially continuous. The two halves separated by the dotted line are not symmetrical though.

[0053] The primary tubes 40 may usually be stacked parallelly with respect to the secondary tubes 50. The quantity of the primary tubes 40 is usually equal to the quantity of the secondary tubes 50, however, in some applications, the quantity of the primary tubes 40 and quantity of the secondary tubes 50 may be different, e.g. there are more primary tubes 40 than the secondary tubes 50, in particular the difference between the two quantities equals one primary tube 40.

[0054] The tubes 40, 50 usually form a unitary core which improves overall rigidity and water tightness of the heat exchanger 1. Term "unitary" means that the primary tubes 40 are immobilized with respect to the secondary tubes 50 in the desired configuration without using any tertiary sub-components, e.g. the headers 21, 31. The unitary core can be formed, by e.g. brazing the surfaces of the primary tubes 40 to the surfaces of the secondary

tubes 50 stacked thereon.

[0055] The headers 20, 30 may be configured to receive and fluidly isolate the primary tubes 40 from the secondary tubes 50. The protrusions 24, 34 assembled with respective group of tubes 40, 50 that are introduced into cavities 23, 33 may form a separation wall 25. The separation wall 25 is usually limited by the portions of the cavities 23, 24 which are in contact with the portions of the tubes 40, 50 that are introduced therein.

[0056] Usually, at least one header 21, 31, in particular both headers 21, 31 assembled with the primary tubes 40 and the secondary tubes 50 create a primary passage and a secondary passage, respectively. The passages within the manifolds 20, 30 are fluidly isolated by the separation wall 25. The primary passage corresponds to the first fluid circuit and the secondary passage corresponds to the second fluid circuit. The primary passage of one header 21 is usually deployed unsymmetrically with respect to the secondary passage of the other header 31, i.e. the primary passage located in one header 21 is not located in the same place of the second header 31. Consequently, the headers 21, 31 are not arranged symmetrically with respect to each other despite they comprise identical bodies. However, it is possible to form a symmetrical heat exchanger 1 by using tubes 40, 50 of different length e.g. the primary tubes 40 longer than the secondary tubes 50. In such an arrangement the primary passages would be located on outer sides of the headers 21, 31 and the secondary passages would be located on the inner sides of the headers 21, 31.

[0057] Further, the primary passage usually has the same dimensions as the secondary passage. The term "dimensions" can be regarded as specific dimensions of the passage, as well as the volumetric capacity of the passage. Alternatively, the primary passage could have different dimensions than the secondary passage. To change the dimensions of one of the passages, one can, for example, extend or shorten the protrusions 24, 34 of the header 21, 31.

[0058] Fig. 4 presents a perspective view of one side of the heat exchanger 1, wherein some sub-components are partially transparent. The non-transparent sub-components are: the unitary core formed by the primary tubes 40 and the secondary tubes 50, the inlet 60 located on the right side and the cover 22 located on the right side. The partially transparent sub-components are: the header 21, the outlet 70 located on the left side, the cover 22 located on the left side. A pair of covers 32 corresponds to the header 31 on the opposite side of the heat exchanger 1. A pair of covers 22, 32 is usually deployed on the opposite sides of the headers 21, 31, wherein one cover 22 corresponds to the primary passage, and the other cover 32 supports the secondary passage. To enable fluidal connection between the headers 21, 31 and the inlet/outlet 60, 70, the covers 22, 32 may be located on the side walls of the headers 21, 31. The covers 22, 32 usually comprise a plurality of plates having substantially the same outer dimensions. The number of plates

comprised in the single stack may vary, however preferred number of plates in a single stack is three. In this particular example, the cross-section of at least one plate 22, 32 is different than the cross-sections of the other plates 22, 32. First two plates located closer to the header 21, 31 comprise an essentially rectangular openings which facilitates fluid distribution and volumetrically increases the corresponding passages. Term "essentially rectangular" means that the opening comprises two longer walls and two shorter walls. The plate located closest to the inlet 60 or outlet 70 comprises essentially circular opening to facilitate fluid distribution across the header 21, 31 or collecting it. Term "essentially circular" means that the opening may have a cross section in the shape of the circle, oblong or similar, rounded shape.

[0059] As shown in Fig. 4, the primary tubes 40, and the secondary tubes 50 comprise a plurality of micro channels that enable increased heat transfer between the circuits. The micro channels form the open ends on both terminal ends of the tubes 40, 50. Usually, the quantity of micro channels comprised within the primary tubes 40 is equal to the quantity of micro channels comprised within the secondary tubes 50. Alternatively, in some applications the quantity of micro channels comprised within the primary tubes 40 is different than the quantity of micro channels comprised within the secondary tubes 50. The different quantity of micro channels could facilitate optimizing the efficiency of the heat exchanger 1, as well as using variable diameters of the micro channels.

[0060] One must take into account that the heat exchanger 1 described above may be optimized by changing different dimensions or parameters. The dimensions of sub-components described in upper paragraphs may be different, depending on desired heat exchanger 1 architecture, packaging, efficiency and other. The quantity of the tubes 40, 50 as well as the quantity of micro channels therein may vary. The ratio between size of passages within the manifolds 20, 30 may be the same, but it also may be different. Finally, the heat exchanger 1 requires no housing, because the tubes 40, 50 forming a unitary core, and the headers 21, 31 made of metal are resistant to adverse environmental conditions.

[0061] 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) in particular for a motor vehicle comprising:

- at least two manifolds (20, 30),

- a primary tubes (40),
- a secondary tubes (50),

characterised in that,

the secondary tubes (50) are shifted with respect to the primary tubes (40) along their axial direction and the manifolds (20, 30) are configured to receive and fluidly isolate the primary tubes (40) from the secondary tubes (50).

2. The heat exchanger (1) according to all preceding claims, wherein the primary tubes (40) and the secondary tubes (50) are deployed alternately and in parallel with respect to each other between the first manifold (20) and the second manifold (30). 10
3. The heat exchanger (1) according to all preceding claims, wherein at least one manifold (20, 30), in particular both manifolds (20, 30) comprises a header (21, 31), wherein the header (21, 31) is of substantially cuboidal shape. 20
4. The heat exchanger (1) according to all preceding claims, wherein at least one header (21, 31) in particular both headers (21, 31) are complementary with respect to the primary tubes (40) and the secondary tubes (50). 25
5. The heat exchanger (1) according to all preceding claims, wherein the header (21, 31) comprises a chamber 26 configured to receive the primary tubes (40) and the secondary tubes (50), wherein at least a part of the chamber 26 remains fluidly communicated with at least one type of the tubes (40, 50). 30
6. The heat exchanger (1) according to all preceding claims, wherein at least one header (21, 31), in particular both headers (21, 31) comprises a plurality of cavities (23, 33) and a plurality of respective protrusions (24, 34). 35
7. The heat exchanger (1) according to claim 12, wherein the cavities (23, 33) are deployed alternately with the protrusions (24, 34). 40
8. The heat exchanger (1) according to any of the preceding claims, wherein at least one header (21, 31), in particular both headers (21, 31) assembled with the primary tubes (40) and the secondary tubes (50) create a primary passage and a secondary passage, respectively. 45
9. The heat exchanger (1) according to all preceding claims, wherein the protrusions (24, 34) assembled with respective group of tubes (40, 50) that are introduced into cavities (23, 33) form a separation wall (25). 50

10. The heat exchanger (1) according to claim 15, wherein the separation wall (25) fluidly isolates the primary passage from the secondary passage.
11. The heat exchanger (1) according to claim 1, wherein the primary tubes (40) and the secondary tubes (50) form a unitary core. 5
12. The heat exchanger (1) according to all preceding claims, wherein the quantity of the primary tubes (40) is equal to the quantity of the secondary tubes (50). 10
13. The heat exchanger (1) according to claim 2, wherein the quantity of the primary tubes (40) is different than the quantity of the secondary tubes (50). 15
14. The heat exchanger (1) according to claim 6, wherein the primary tubes (40) are configured to convey different media than the secondary tubes (50) between the manifolds (20, 30). 20
15. The heat exchanger (1) according to all preceding claims, wherein each cover (22, 32) comprises a set of stacked plates having substantially identical outer perimeters, whereas the cross-section of at least one plate is different than the cross-sections of the other plates. 25

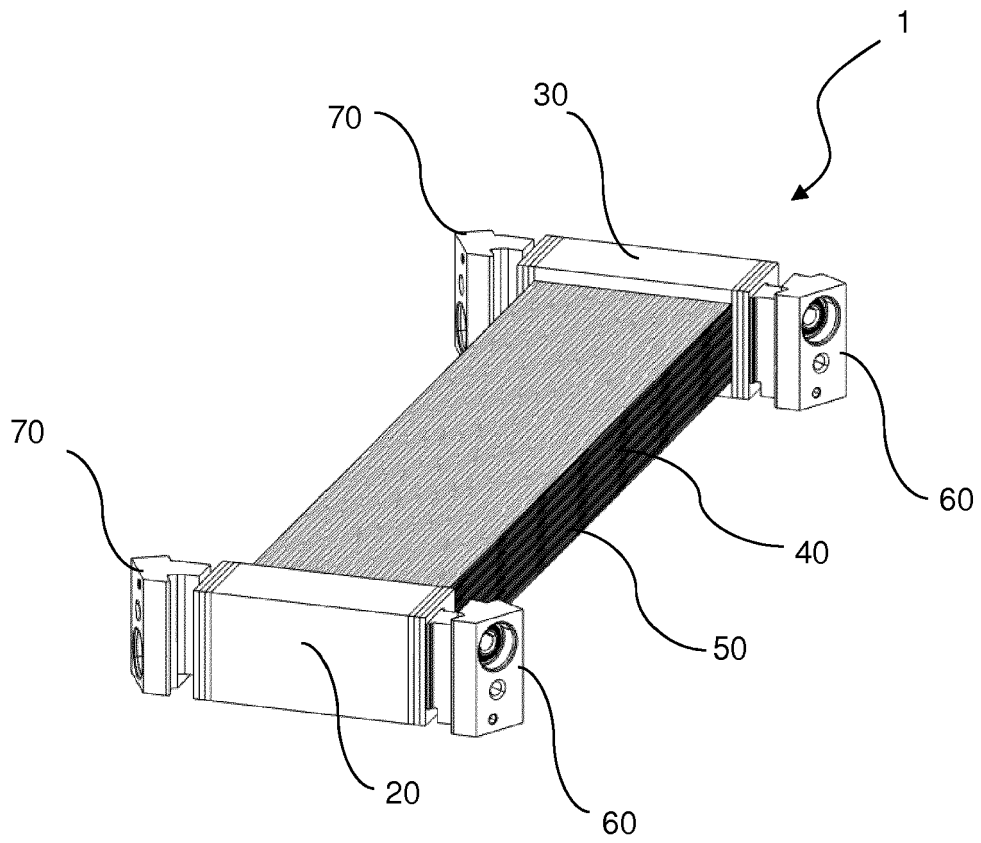


Fig. 1

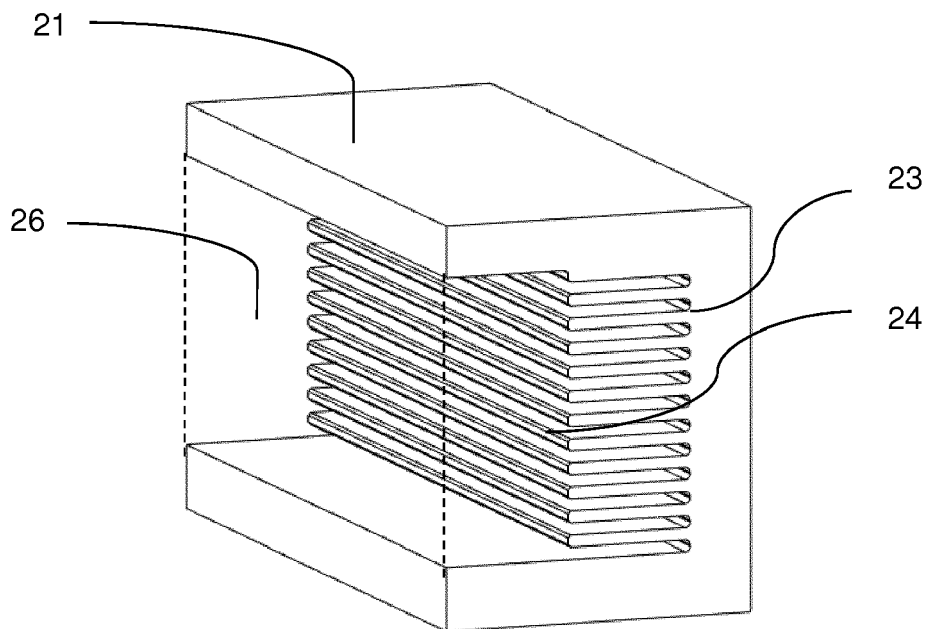


Fig. 2

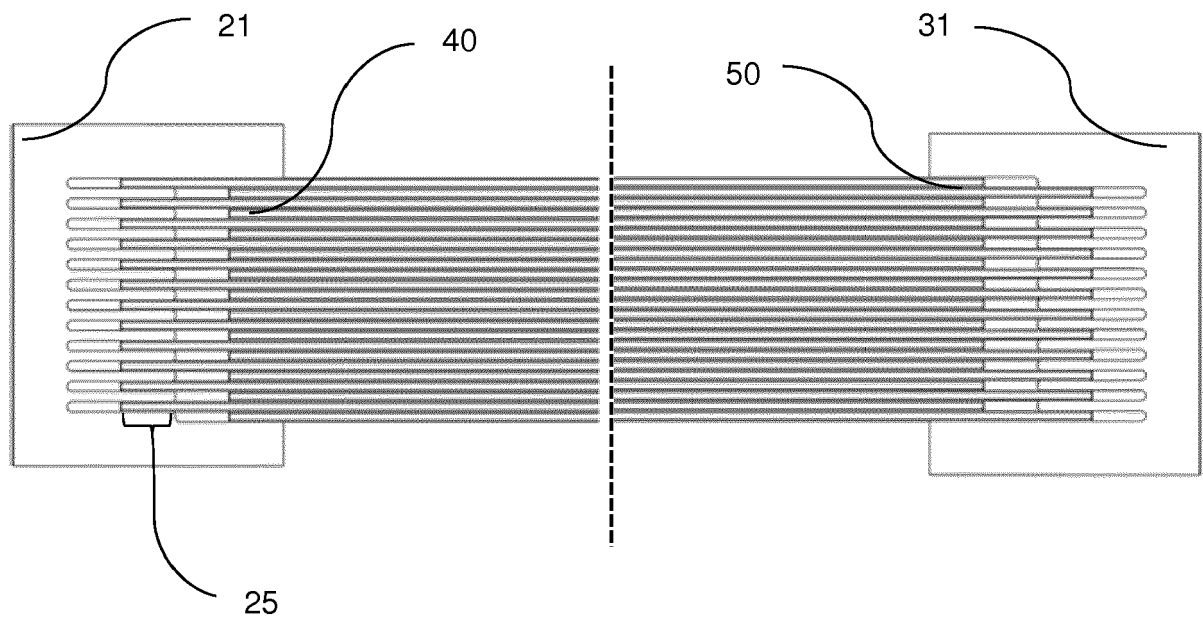


Fig. 3

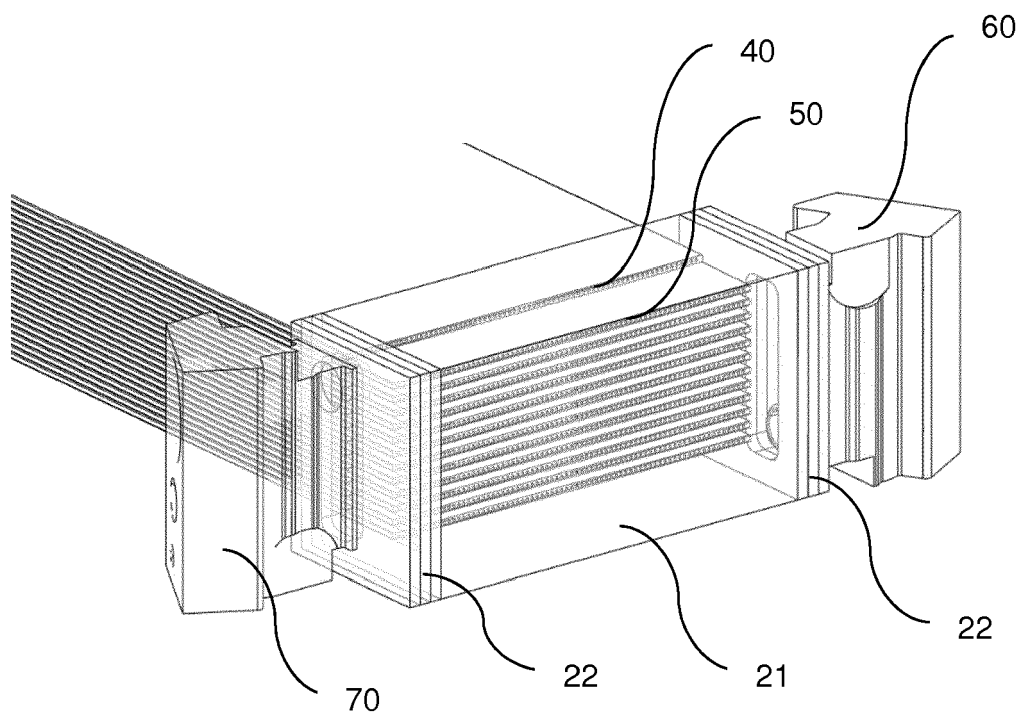


Fig. 4



EUROPEAN SEARCH REPORT

Application Number
EP 19 46 1603

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 27 April 2020	Examiner Jessen, Flemming
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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