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(71) Applicant: **TI Automotive Engineering Centre (Heidelberg) GmbH**
69123 Heidelberg (DE)

(72) Inventors:
• **Garrisi, Matt**
Canton, Michigan 48188 (US)
• **Thrift, Charles**
Farmington Hills, MI 48331 (US)
• **Kempf, Dominik**
60318 Frankfurt am Main (DE)
• **Liers, Denny**
55595 Weinsheim (DE)

(74) Representative: **Reiser & Partner**
Patentanwälte
Weinheimer Straße 102
69469 Weinheim (DE)

(54) **Internal heat exchanger for an air conditioning system**

(57) An internal heat exchanger (1) for an air conditioning system (2), comprising an outer tube (3) and a line structure (4) arranged inside the outer tube (3), characterized the line structure (4) includes a first flow chan-

nel (5), and wherein a second flow channel (6) is formed between the outer tube (3) and line structure (4), wherein the first flow channel (5) has a meandering configuration.

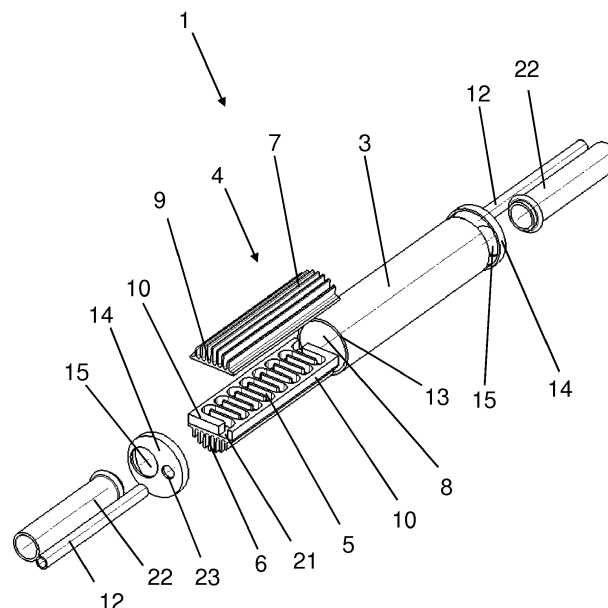


Fig. 4

Description

[0001] The invention relates to an internal heat exchanger for an air conditioning system, comprising an outer tube and a line structure arranged inside the outer tube, wherein the line structure includes a first flow channel, and wherein a second flow channel is formed between the outer tube and the line structure.

[0002] Such an internal heat exchanger is known from DE 10 2007 015 186 A1. An internal heat exchanger integrated into the coolant circuit of an air conditioning system makes it possible to increase the efficiency of an air conditioning system by transferring the heat of the coolant from its high-pressure side to the low-pressure side. The coolant is liquid on the high-pressure side, and gaseous on the low-pressure side, wherein the coolant on the high-pressure side is routed through the first flow channel, and the coolant on the low-pressure side is routed through the second flow channel. Due to the low pressure and gaseous state, the coolant routed through the second flow channel exhibits a comparatively small heat absorption capacity, which limits the overall transfer capacity of the internal heat exchanger.

[0003] Most of the time, both the outer tube forming the second flow channel and the line structure forming the first flow channel arranged inside the outer tube are designed with a circular cross section, wherein the length of the outer tube and the tubular line structure are identical. Since the internal heat exchanger is designed for installation in mobile air conditioning systems, for example in a vehicle, it is problematic that the size, in particular the length of the internal heat exchanger, is limited. For this reason, the overall heat transfer capacity is limited as well.

[0004] It is object of the invention to provide an internal heat exchanger having a high heat transfer capacity while having a compact structural design.

[0005] This object is achieved with the features of claim 1. Subclaims draw reference to advantageous embodiments.

[0006] In order to achieve this object, the first flow channel has a meandering, serpentine configuration. It is advantageous that the effective tube length usable for heat exchange purposes can be significantly enlarged inside the internal heat exchanger. As a result, the heat transfer capacity of the heat exchanger increases, while its overall length simultaneously remains low. At the same time, the meandering configuration of the first flow channel yields a particularly compact structural design for the internal heat exchanger, making the latter especially suitable for installation in a mobile air conditioning system, for example in a vehicle.

[0007] The exterior of the line structure forming the first flow channel can include heat conducting ribs. The heat conducting ribs preferably proceed from the structure forming the first flow channel centrally in the outer tube and extend in the direction toward the inner wall of the outer tube. The heat conducting ribs extend longitudinally

relative to the outer tube, perpendicular to the line structure forming the first flow channel so that the fluid guided in the second flow channel streams along the heat conducting ribs, and absorbs the heat emitted by the heat conducting ribs. They increase the outer surface of the line structure of the first flow channel thereby improving the heat transfer capacity. The heat conducting ribs are integrated with the structure forming the first flow channel, so that heat can be directly transferred from the fluid carried by the first flow channel to the heat conducting ribs.

[0008] The heat conducting ribs can extend to the region of the inner wall of the outer tube. However, in order to simplify installation, the heat conducting ribs are designed in such a way as not to touch the inner wall of the outer tube. A gap advantageously arises between the heat conducting ribs and the inner wall of the outer tube, wherein the gap width preferably measures between 0.5 mm and 2.5 mm, preferably 1.5 mm. It is especially advantageous in this embodiment that the heat conducting ribs extend nearly completely through the second flow channel. As a result, channels form between the heat conducting ribs, and a particularly effective heat transfer is brought about. At the same time, the heat conducting ribs, and hence the line structure as such, are spaced apart from the inner wall of the outer tube in such a way that the line structure can be easily installed through insertion into the outer tube.

[0009] The line structure forming the first flow channel can consist of multiple parts. This improves the manufacturability of the line structure, since the first flow channel has a complex shape due to its meandering, serpentine configuration.

[0010] The line structure can include shells that are provided at least with heat conducting ribs, and interconnected by way of channel elements. In order to manufacture such a line structure, the shells and channel elements are first prepared and fabricated, for example by extrusion. The heat conducting ribs are formed onto the shell in a materially uniform manner as a single piece. A planar surface of the shell forms an inner wall of the first flow channel, section by section. As a consequence, shaping the side of the shell determines the shape of the flow channel.

[0011] The channel elements are preferably comb-shaped with spaced projections. Two channel elements are preferably placed in face-to-face relation with the transverse walls, which establish the meandering serpentine shape on the one hand, and also forms lateral bordering walls of the first flow channel on the other. The channel elements include a planar base that forms the lateral bordering walls of the first flow channel, and has needle-shaped projections situated on it. In order to manufacture the line structure and the first flow channel, two channel elements are arranged opposite each other, wherein the projections face each other. Laterally shifting the channel elements gives rise to the meandering structure.

[0012] The first flow channel formed by the line structure can exhibit a cross section that is rectangular, at least in sections. Such a channel is easy to manufacture, and has a larger surface area than a circular channel.

[0013] The elements of the line structure can consist of a metallic material. In particular, materials that are easy to process and have a high thermal conductivity come into consideration. Such advantageous materials include aluminum alloys, which exhibit a high thermal conductivity on the one hand, and can be processed by extrusion on the other, making the line structure simple and cost-effective to manufacture.

[0014] The elements of the line structure can be materially bonded with each other. In this way, it is possible to join the elements through adhesive bonding or soldering. The material bond enables a tight and durable connection of elements, in order to prevent leaks. In addition, the method is simple and cost-effective.

[0015] The line structure can be inserted into the outer tube. This makes the internal heat exchanger particularly simple to manufacture.

[0016] The opposite ends faces of the line structure can have pipe sockets the first flow channel so as to be able to carry a flow through the first flow channel. The piping on the high-pressure side of the air conditioning system may be hooked up to these pipe sockets.

[0017] The outer tube can be sealed with a lid on each end face, wherein each includes a pipe joint for connection between system piping and the second flow channel. The piping on the low pressure side of the air-conditioning system can be hooked up to these pipe sockets. The lids preferably also exhibit a through hole for piping connected to the pipe sockets connected with the first flow channel. The through hole is here designed in such a way as to prevent leakage. As a consequence, the pipe sockets form connecting elements for integrating the internal heat exchanger into the air conditioning system.

[0018] The inner diameter of the outer tube preferably measures between 25 mm and 35 mm. The width of the first flow channel preferably measures between 3.5 mm and 5.5 mm. These dimensions yield an especially compact internal heat exchanger, which is especially well suited for integration into a mobile air conditioning system of a vehicle. At the same time, however, the heat transfer capacity is high at about 600 W (watts), proceeding from a length of roughly 500 mm for the heat exchanger.

[0019] The internal heat exchanger according to the invention is preferably used in a mobile air conditioning system, in particular in a vehicle air conditioning system. The compact structural design, tubular shape and high heat transfer capacity make the internal heat exchanger according to the invention especially well suited for integration into a mobile air conditioning system of a vehicle.

[0020] Several embodiments of the internal heat exchanger according to the invention will be described in greater detail below in reference to the accompanying drawings which schematically depict:

Fig. 1 the air conditioning circuit of a mobile air conditioning system with an internal heat exchanger;

Fig. 2 a cross section of the internal heat exchanger;

5 Fig. 3 a first exploded perspective view of the internal heat exchanger;

Fig. 4 a second exploded perspective view of the internal heat exchanger;

10 Fig. 5 a third exploded perspective view of the internal heat exchanger;

Fig. 6 a fourth exploded perspective view of the internal heat exchanger;

Fig. 7 an assembled perspective view of the internal heat exchanger.

[0021] Fig. 1 presents a schematic view of the air conditioning circuit of a mobile air conditioning system 2, in particular the air conditioning system of a vehicle. The air conditioning system consists of a closed circuit piping arrangement between system components, in which a coolant circulates. The coolant is compressed by a compressor 17, and flows to a condenser 18, where the coolant is liquefied. After exiting the condenser, the coolant is liquid, and exhibits a temperature of 30°C to 50°C (Cen-
25 tigrade) at a pressure of 7 bar to 15 bar (Barometers). The liquefied coolant is now supplied to the first flow channel 5 of internal heat exchanger 1 according to the invention, where the coolant exiting the condenser 18 releases heat to the gaseous coolant exiting the evaporator 20 passes through the second flow channel 6. The liquid coolant then streams into the expansion valve 19, where the coolant pressure is reduced. The coolant absorbs heat in the evaporator 20, wherein it is evaporated and then becomes gaseous. The heated, gaseous coolant has a temperature of -1°C to 15°C at a pressure of 2.5 bar to 4 bar. The gaseous coolant flows through the second flow channel 6 of internal heat exchanger 1, and absorbs heat from the liquid coolant routed along the first flow channel 5.

40 **[0022]** Fig. 2 shows a sectional view of the internal heat exchanger 1 for an air conditioning system 2, in particular for a mobile air conditioning system for use in a vehicle. The internal heat exchanger 1 is tubular in design, and encompasses an outer tube 3 and a line structure 4 arranged inside the outer tube 3. The line structure 4 is shown inserted into the outer tube 3.

[0023] The line structure 4 forms first flow channel 5. Second flow channel 6 is formed between the outer tube 3 and line structure 4. The line structure 4 is here configured in such a way that the first flow channel 5 has a meandering serpentine design of rectangular cross section. The inner diameter of the outer tube 3 measures 30 mm, and the width of the first flow channel 5 measures 4.5 mm.

55 **[0024]** Fig. 3 to 6 each present exploded perspective views of the internal heat exchanger 1 according to the invention in various stages of assembly. As evident from the figures, the outside of the line structure 4 exhibits

heat conducting ribs 7, which extend from the portions of the line structure 4 forming the first flow channel 5 into the region of the inner wall surface of the outer tube 3. The heat conducting ribs 7 extend longitudinally along the direction of flow of the second flow channel so that the coolant routed through the second flow channel 6 streams along the heat conducting ribs 7 and absorbs heat.

[0025] The distance between the outer edges of the heat conducting ribs 7 and inner wall 8 of the outer tube 3 is here selected in such a way that the line structure 4 can be easily installed through insertion. The distance in this embodiment measures 1.5 mm.

[0026] As is shown in Figs. 3 to 5, the line structure 4 consists of multiple parts, and includes two shells 9 provided with the heat conducting ribs 7 extending perpendicularly to a base and joined together by two channel elements 10. Because the ribs 7 are perpendicular to a base, the ribs are of varying length to follow the shape of the inner cylindrical wall surface of the outer tube 3.

[0027] The channel elements 10 are comb-shaped in design, and joined with the base of each shell 9 on the upper and lower side surfaces of the channel elements. The channel elements 10 include projections 16, wherein the channel elements 10 are joined by the shells with the channel elements offset relative to each other in such a way as to yield the serpentine meandering structure forming the first flow channel 5.

[0028] The line structure 4 defining the first flow channel 5 is thus comprised of multiple components bonded together to form a unitary structure. These components include two shells 9 each with a base having a planar base surface. Ribs 7 extend perpendicularly to each base. The line structure 4 further includes two channel elements 10 that include a series of spaced projections 16 defining a series of parallel walls joined by semi-circular curved walls.

[0029] As best seen in Fig. 2, the channel elements 10 are disposed with the projections 16 of one channel element 10 interengaged between the projections 16 of the other channel element 10 to form the serpentine first flow channel 5. That is, the ends of the spaced projections 16 of one channel element 10 are disposed facing the center of the semi-cylindrical curved wall surfaces of the other channel element 10.

[0030] The planar surface of the base of each shell 9 is adhered to one of the side walls of the facing channel elements 10 to form the fluid tight first flow channel 5.

[0031] The elements of the line structure 4, the shells 9 and the channel elements 10 may consist of a metallic material, in this exemplary embodiment an aluminum alloy shaped by an extrusion process. The elements 9 and 10 of the line structure 4 are firmly bonded with each other by means of a soldered connection. Other materials and manufacturing processes may be used.

[0032] The opposite end faces 11 of the line structure 4 include pipe sockets 27 to receive pipes 12 of the air conditioning system 2 in fluid tight relation. The pipe sock-

ets 27 receive an end of a pipe 12 in fluid tight relation and communicate with the first flow channel 5 so as to be able to carry a flow through the first flow channel 5.

[0033] The ends of the outer tube 3 are sealed with lids 14 which include pipe sockets 15 communicating with the second flow channel 6. The pipe sockets 15 each receive a tube end of pipe 22 in fluid tight relation to carry flow to and from the second flow channel 6. Lids 14 also include ports 23 through which extend in fluid tight relation the pipes 12 of the system connected to the first flow channel 5.

[0034] Fig. 7 presents a spatial view of the internal heat exchanger 1. The internal heat exchanger 1 is tubular in design, and has a heat transfer capacity of 600 W at a diameter of 40 mm and length of 130 mm. As a result, the internal heat exchanger 1 is suitable for integration into a mobile air conditioning system 2.

Claims

1. An internal heat exchanger (1) for an air conditioning system (2), comprising an outer tube (3) and a line structure (4) arranged inside the outer tube (3), wherein the line structure (4) includes a first flow channel (5), and wherein a second flow channel (6) is formed between the outer tube (3) and line structure (4), **characterized in that** the first flow channel (5) has a meandering configuration.
2. The internal heat exchanger according to claim 1, **characterized in that** the first flow channel (5) has a serpentine configuration.
3. The internal heat exchanger according to claim 1, **characterized in that** the outside of the line structure (4) includes heat conducting ribs (7).
4. The internal heat exchanger according to claim 3, **characterized in that** the heat conducting ribs (7) extend until into the region of the inner wall of the outer tube (3).
5. The internal heat exchanger according to one of claims 1 to 4, **characterized in that** the line structure (4) consists of multiple parts.
6. The internal heat exchanger according to one of claims 1 to 5, **characterized in that** the line structure (4) interconnected by way of channel elements (10) includes shells and are provided with heat conducting ribs (7).
7. The internal heat exchanger according to claim 6, **characterized in that** there are two channel elements (10) which are comb-shaped with projections defining a series of parallel walls joined by semi-circular curved walls.

8. The internal heat exchanger according to claim 7,
wherein said projection of one channel element (10)
is spaced between the projection of the other chan-
nel element (10). 5
9. The internal heat exchanger according to one of
claims 1 to 8, **characterized in that** the elements of
the line structure (4) consist of metallic material.
10. The internal heat exchanger according to one of 10
claims 1 to 9, **characterized in that** the elements of
the line structure (4) are firmly bonded with each oth-
er.
11. The internal heat exchanger according to one of 15
claims 1 to 10, **characterized in that** the line struc-
ture (4) is inserted into the outer tube (3).
12. The internal heat exchanger according to one of
claims 1 to 11, **characterized in that** faces of the 20
line structure (4) accommodate pipe sockets (12),
wherein the pipe sockets (12) are connected with
the first flow channel (5) so as to be able to carry a
flow. 25
13. The internal heat exchanger according to one of
claims 1 to 12, **characterized in that** faces (13) of
the outer tube (3) are sealed with a respective lid
(14), wherein the lids (14) exhibit pipe joints (15),
which are connected with the first flow channel (5) 30
and the second flow channel (6).
14. The internal heat exchanger according to one of the
claims 1 to 13, **characterized in that** the inner di- 35
ameter of the outer tube measures (3) between 25
mm and 35 mm.
15. The internal heat exchanger according to one of the
claims 1 to 14, **characterized in that** the width of
the first flow channel (5) measures between 3.5 mm 40
and 5.5 mm.
16. The internal heat exchanger according to one of the
claims 1 to 15, **characterized in that** the first flow
channel (5) includes at least sections having a cross 45
section that is rectangular.
17. The internal heat exchanger according to one of the
claims 1 to 16, **characterized in that** the first flow
channel (5) has a cross section that is rectangular. 50
18. The internal heat exchanger according to the claims
1 to 17, **characterized in that** it is designed for use
in a mobile air conditioning system (2). 55

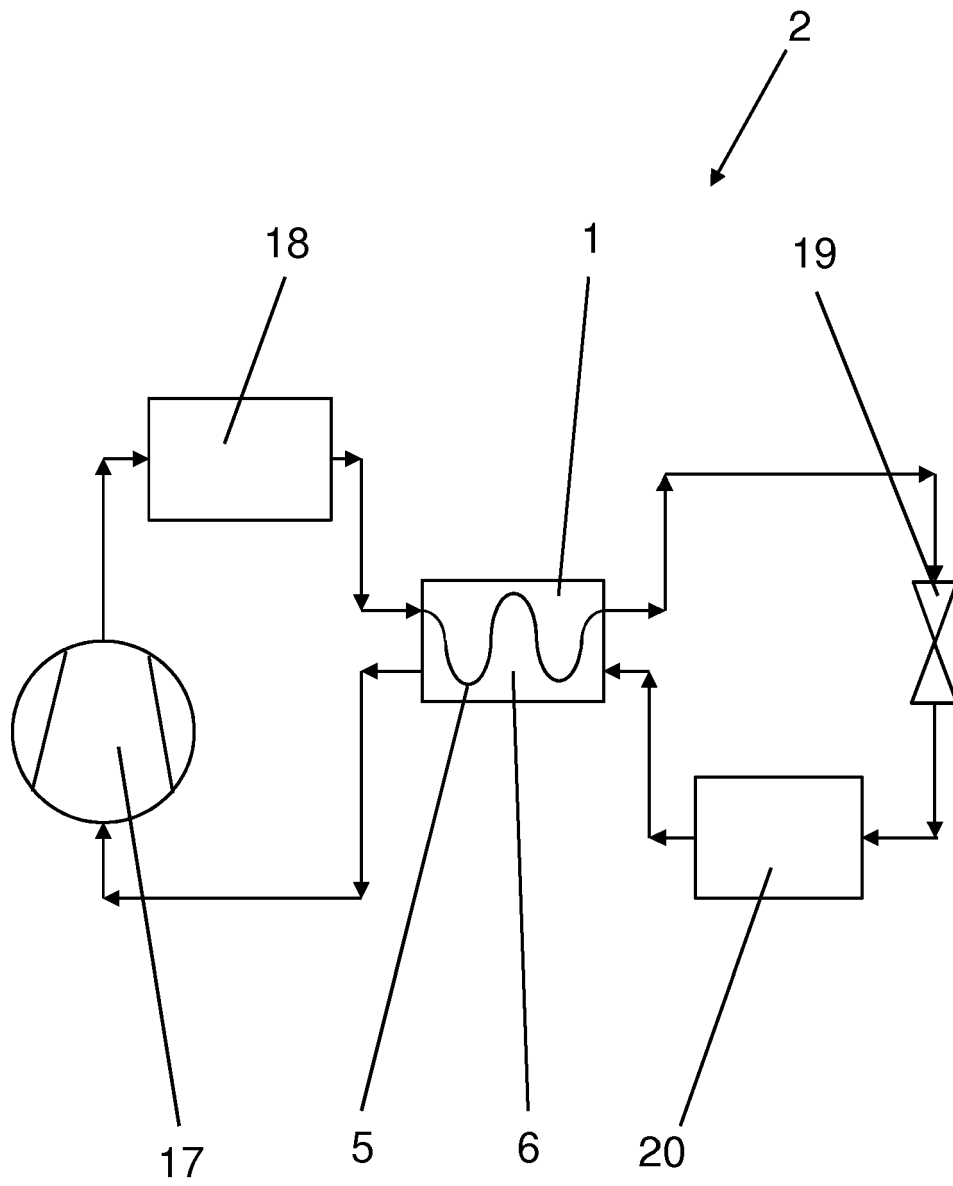


Fig. 1

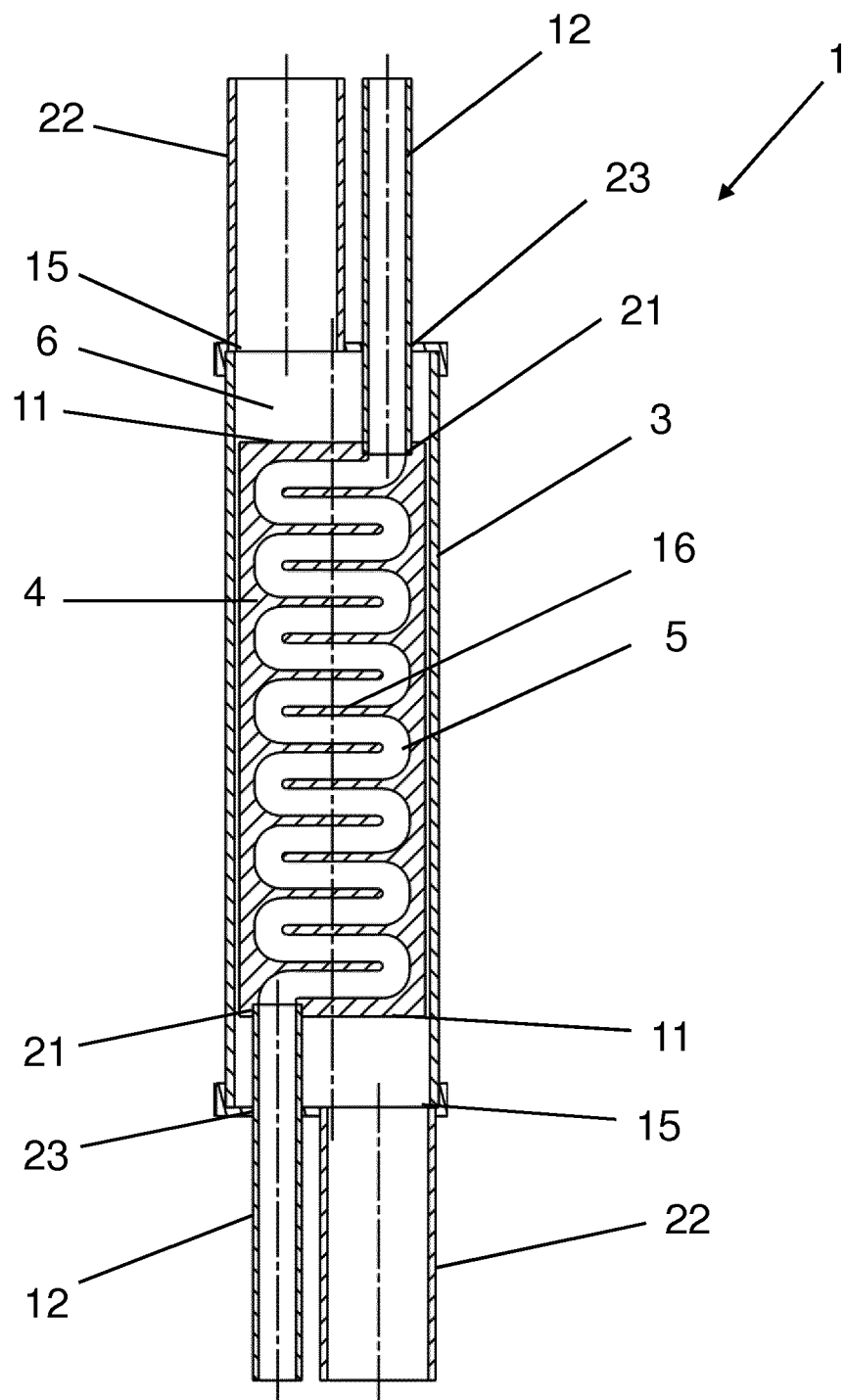


Fig. 2

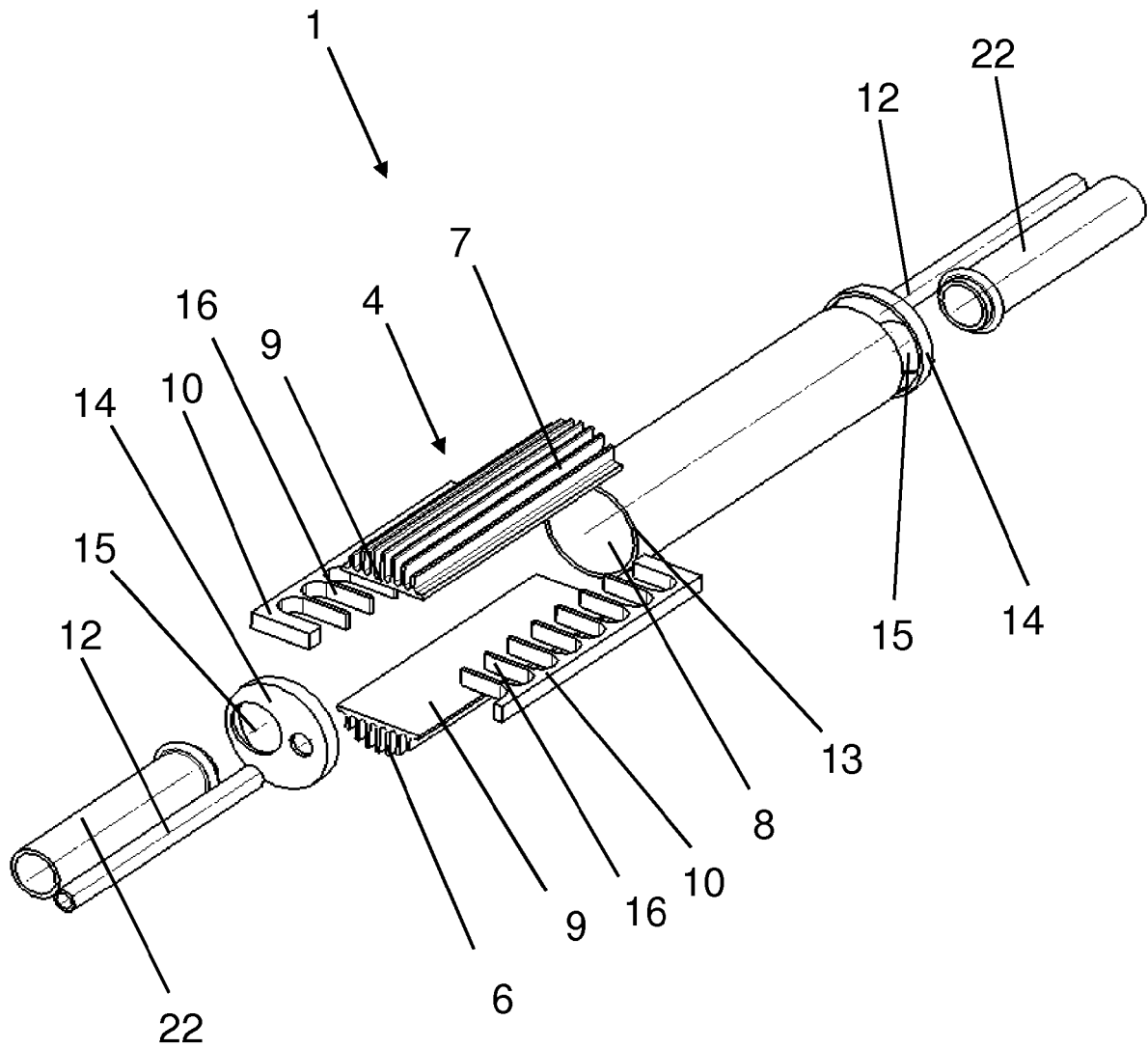


Fig. 3

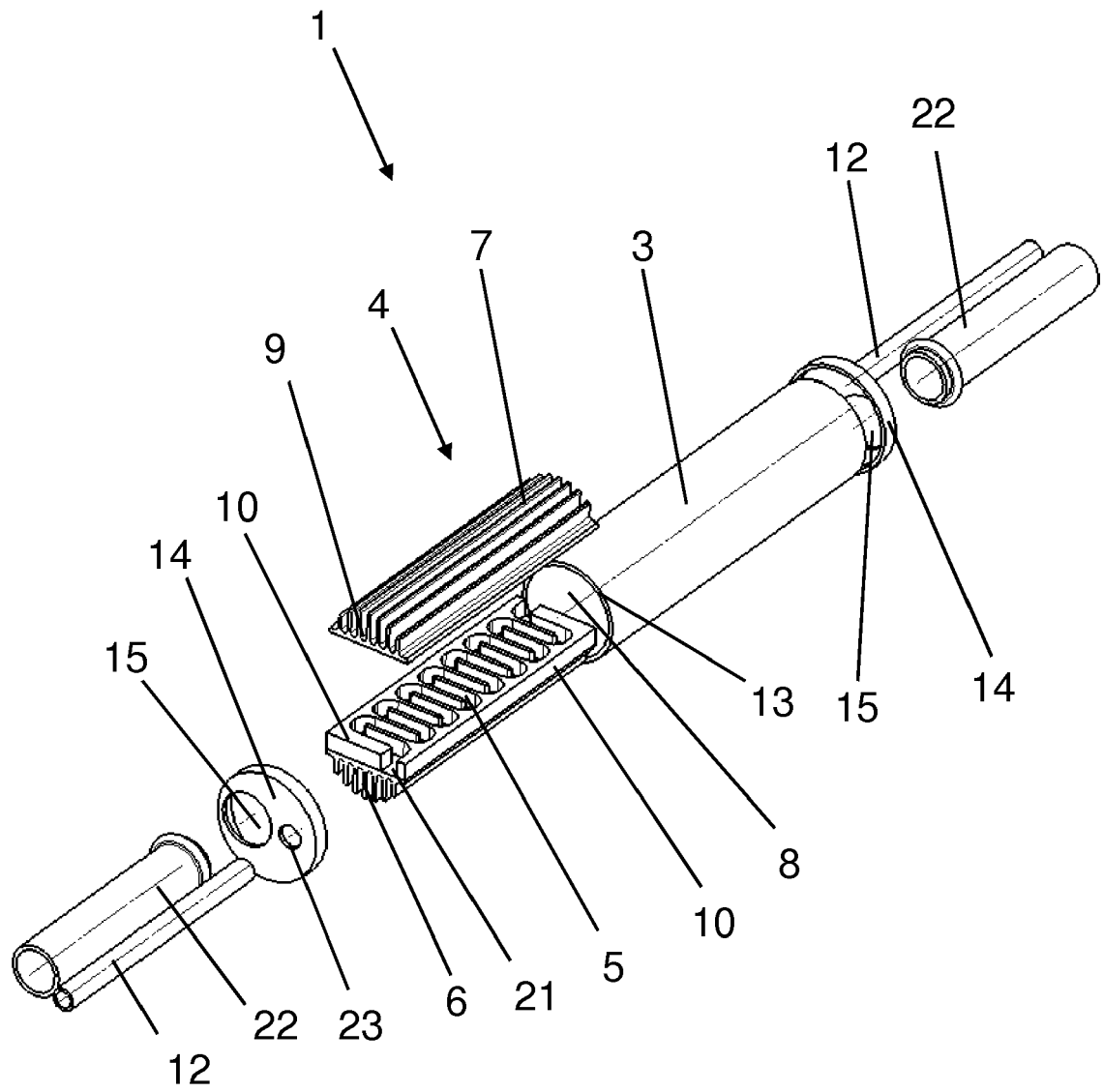


Fig. 4

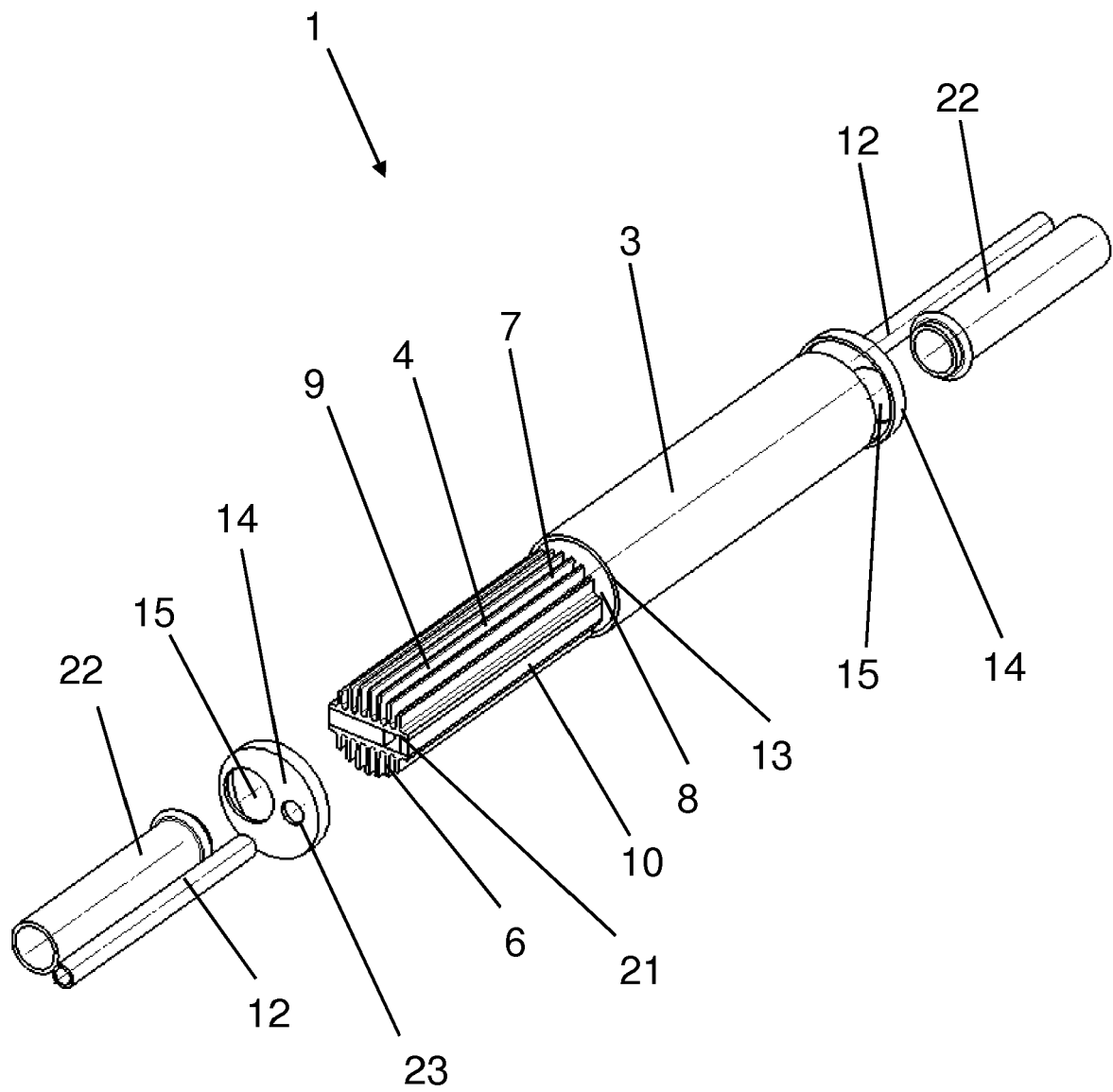


Fig. 5

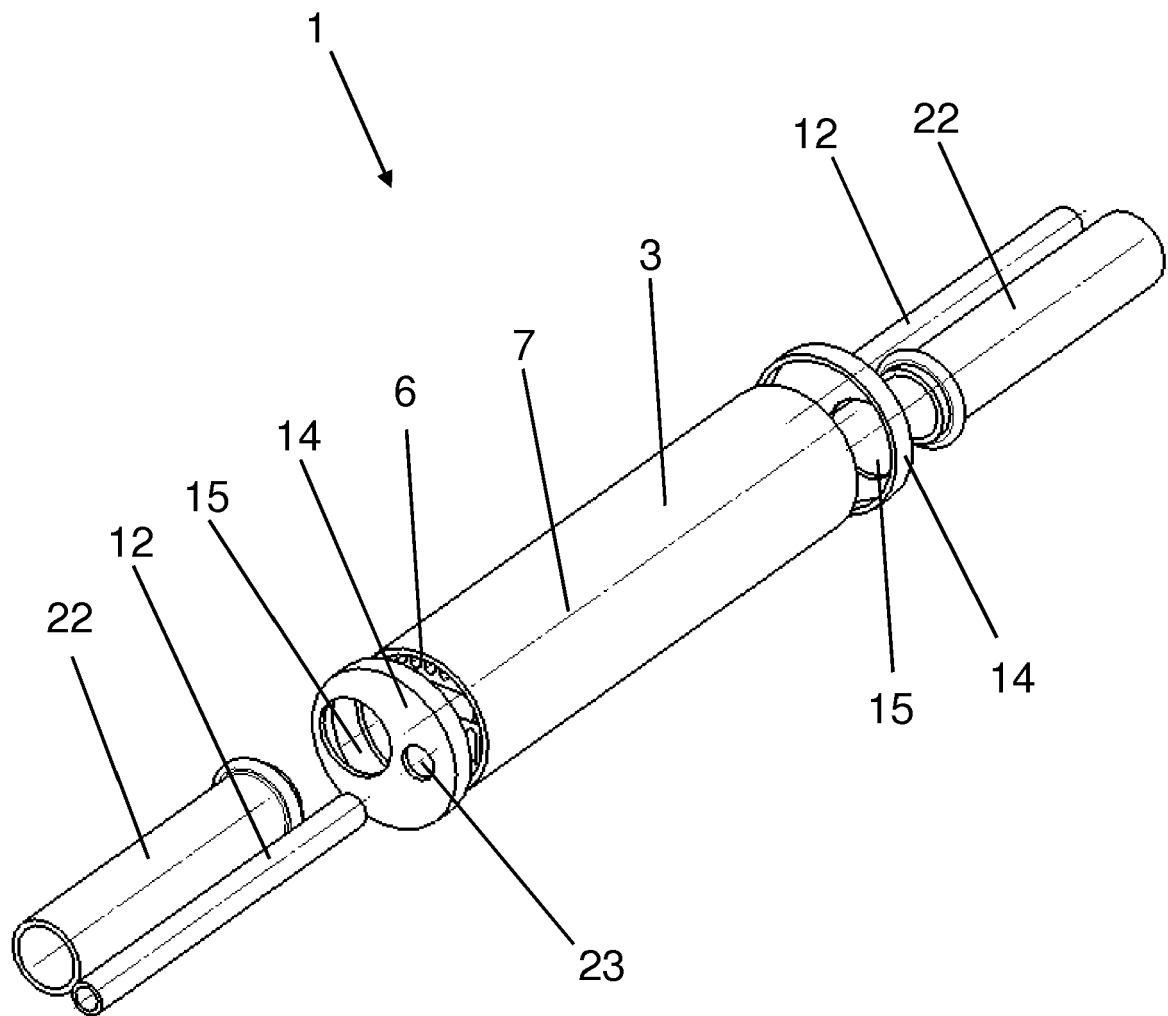


Fig. 6

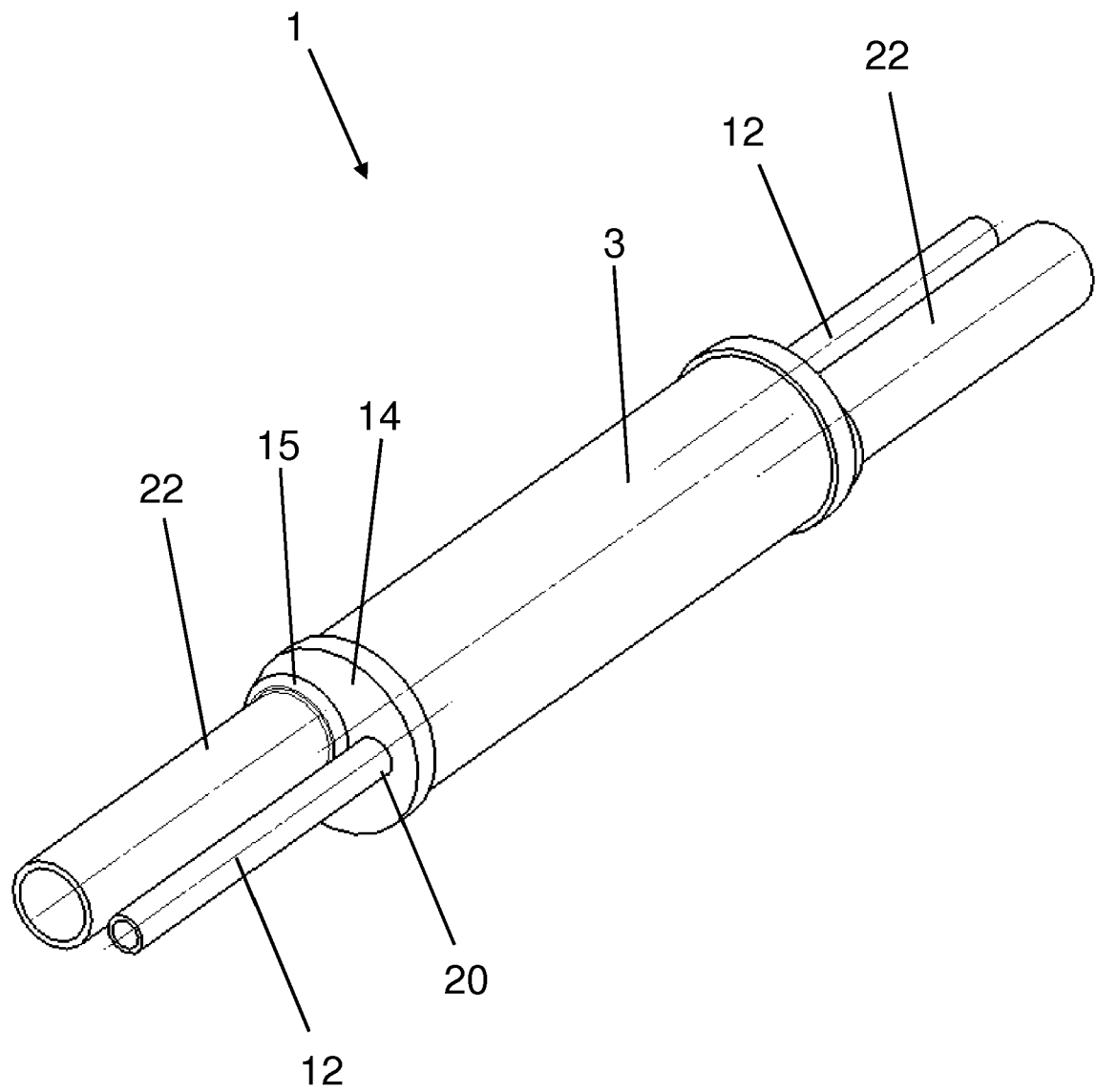


Fig. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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