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(54) HEAT EXCHANGER

(57) A heat exchanger (1) comprises a core (2), which defines first and second fluid circuits therein. Both fluid circuits are divided into two flow sections (21C, 22C and 21R, 22R). The first fluid circuit is split into first and second sub-circuits. A direction of a first flow of a first fluid through the first flow section (21C) of the first fluid circuit is opposite to a direction of flow of a second fluid through the second flow section (22R) of the second fluid circuit and a direction of a second flow of the first fluid through the second flow section (22C) of the first fluid circuit is opposite to the direction of flow of the second fluid through the first flow section (21R) of the second fluid circuit.

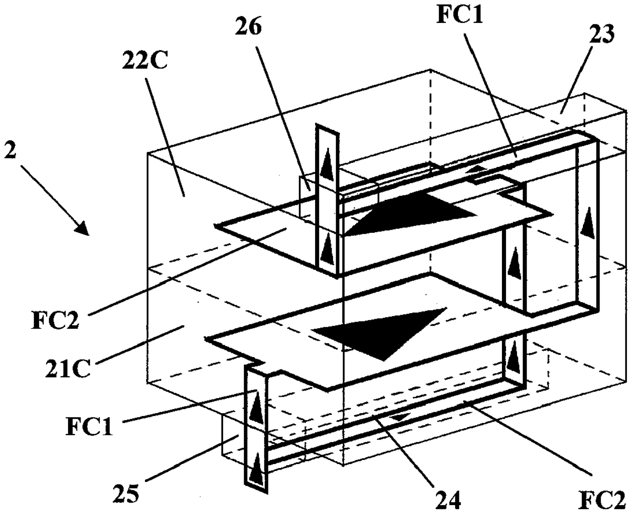

Fig. 4

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Description

FIELD OF INVENTION

[0001] The present invention relates to a heat exchanger, especially to a heat exchanger with improved flow scheme of two working fluids.

PRIOR ART

[0002] Prior art heat exchangers comprise a core, which defines two fluid circuits therein. A first working fluid flows through a first fluid circuit, while a second working fluid flows through a second fluid circuit. Both fluid circuits can be divided into one or more distinctive flow sections of the same or different sizes, through which the working fluids can flow in the same or opposing directions. Examples of such heat exchangers are disclosed in DE 10 2016 001 607 A1, US 2017/0122669 A1, US 2016/0010929 A1, US 2015/0226469 A1 or US 2013/0213624 A1.

[0003] In order to increase heat exchange efficiency and prolong time when a coolant and a refrigerant exchange heat between each other known heat exchangers are divided into multiple flow sections, which increases the length of both fluid circuits. This, however, poses a series of associated problems like pressures drops of the working fluids or increase in the size and weight of the heat exchanger.

AIM OF INVENTON

[0004] One aim of the present invention is to provide a heat exchanger with reduced pressure drops of the coolant, while improving heat exchange efficiency.

[0005] In particular, the aim of the present invention is to provide a heat exchanger with reduced dimensions and increased power and at the same time offering good balance between power and size.

SUMMARY OF INVENTION

[0006] A heat exchanger comprises a core. The core defines a first fluid circuit and a second fluid circuit. The first fluid circuit is divided into first and second flow sections and the second fluid circuit is divided into first and second flow sections. The first flow section of the first fluid circuit coincides with the second flow section of the second fluid circuit and the second flow section of the first fluid circuit coincides with the first flow section of the second fluid circuit. The first fluid circuit is split into first and second sub-circuits connected to each other at an inlet and an outlet of the first fluid circuit, respectively, so that flow of a first fluid is divided into first and second flows throughout the core. The first sub-circuit extends through the first flow section of the first fluid circuit. The second sub-circuit extends through the second flow section of the first fluid circuit. The flow sections of the first fluid circuit and the second fluid circuit, respectively, are configured so that a direction of the first flow of the first fluid through the first flow section of the first fluid circuit is opposite to a direction of flow of a second fluid through the second flow section of the second fluid circuit and a direction of the second flow of the first fluid through the second flow section of the first fluid circuit is opposite to the direction of flow of the second fluid through the first flow section of the second fluid circuit.

[0007] The present invention allow the weight and the size of the heat exchanger to be reduced, while maintaining the same heat exchange efficiency. As the working fluids are used more efficiently the number of the flow passages can be reduced as compared to known heat exchangers.

[0008] In the heat exchanger according to the present invention pressure drops are significantly lower. It means that less power is needed to ensure fluid flow, which lead to costs savings not in terms of the heat exchanger itself but in terms of associated equipment, like pumps, which may be less efficient.

[0009] The heat exchanger according to the present invention provides very good balance between power and size/mass. Moreover, although the first fluid circuit is divided into two sub-circuits pressure drops and flow resistance are kept low.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

Fig. 1 shows a side view of a heat exchanger of the present invention;

Fig. 2 shows schematically a longitudinal section view of the heat exchanger of the present invention, showing schematically coolant flow paths through a core, a total flow of a coolant flowing into and out of the core being shown with black-filled arrows;

Figs. 3a and 3b show top views of two examples of shaped plates used in the heat exchanger of the present invention;

Fig. 4 and 5 show a perspective schematic view and a vertical diagram, respectively, of a coolant flow through a core of the heat exchanger; and

Fig. 6 and 7 show a perspective schematic view and a vertical diagram, respectively, of a refrigerant flow through the core of the heat exchanger.

EMBODIMENTS OF INVENTION

[0011] A heat exchanger 1 of the present invention comprises a core 2 where heat exchange between two fluids takes place. The heat exchanger 1 also comprises a plurality of inlet and outlet ports 3 to deliver a coolant/first fluid and a refrigerant/second fluid to and out of the core 2.

[0012] The core 2 defines therein two fluid circuits, namely a first fluid circuit for the coolant and a second fluid circuit for the refrigerant. Both fluid circuits are fluidly separated from each other. It means that both fluids do not mix. For this purpose the core 2 includes a plurality of shaped plates 4 stacked on top of one another. Each pair of two adjacent shaped plates 4 defines a flow passage 5 therebetween. The first and second fluids, coolant and refrigerant respectively, flow through the flow passages 5. To maximize the heat exchange efficiency the flow passages should be used alternatively, namely a first flow passage for the first fluid, a second flow passage for the second fluid, a third flow passage for the first fluid, etc.

[0013] The core 2 also comprises first and second bypass channels 23, 24. Generally, these two bypass channels 23, 24 do not participate in heat exchange between two fluids. The bypass channels 23, 24 are mostly used to split the coolant flow into two parts at an inlet 25 of the first fluid circuit to the core 2 and bring these two parts of the coolant flow back together at an outlet 26 of the first fluid circuit from the core 2. The inlet 25 and the outlet 26 of the first fluid circuit can be in many cases simply one(s) of the inlet and outlet ports 3. The inlet 25 is connected to the second bypass channel 24 and one vertical channel. The outlet 26 is connected to the first bypass channel 23 and one vertical channel. The inlet 25 and the outlet 26 can be situated at the same or different longitudinal ends of the core 2.

[0014] Generally, the shaped plate 4 comprises a bottom 41 and a peripheral wall 42 protruding from the bottom 41. The shaped plate 4 is provided at both its ends with openings 43. The openings 43 of the stacked shaped plates 4 define vertical channels throughout the core 2 at both longitudinal ends of the core 2. The vertical channels formed by the openings 43 are in fluid communication with selected flow passages 5 formed between the shaped plates 4. For this purpose the shaped plate 4 comprises a number of additional features. For example, the shaped plate 4 can comprise a ridge 44 enclosing one or more openings 43. When the shaped plates 4 are stacked the ridge 44 of one shaped plate 4 is in sealed contact with the shaped plate 4 located above it. Thus, a fluid flowing through the opening 43 enclosed by the ridge 44 cannot flow into the fluid passage 5 shown in fig. 3a and can only flow in a vertical direction of the core 2. To allow for the flow of the fluids to the fluid passage 5 in a longitudinal direction of the core 2 the configuration of the ridge 44 is changed so that it no longer encloses the opening 43 concerned, see fig. 3b. Instead, the opening 43 is encircled by a series of spaced-apart protrusions 45, which allow the fluid to flow therebetween, or even the opening 43 may not be obscured by additional elements so that the opening 43 is in fluid communication with the flow passage 5. The openings 43 of the outermost shaped plates 4 can be connected to the inlet and outlet ports 3.

[0015] To terminate the vertical channels at a given level the openings 43 can be closed by plugs or even may not be present in the shaped plates 4. The number of the openings 43 as well as their position and configuration at both longitudinal ends of the shaped plates 4 can be chosen voluntary, depending on the configuration of the core 2 and a flow scheme to be obtained. With the core 2 formed in this way the first and second fluids do not mix and they flow in respective flow passages 5 formed between the shaped plates 4.

[0016] As discussed earlier, the core 2 defines two fluid circuits. The first fluid circuit is used for the coolant/first fluid, while the second fluid circuit is used for the refrigerant/second fluid. The coolant flow is shown schematically in figs. 4 and 5. The first fluid circuit is divided by an appropriate configuration of the vertical channels/openings 43 into two flow sections 21C, 22C. The coolant is split at the inlet 25 into two flows FC1, FC2 throughout the core 2. The first flow FC1 is directed to the first flow section 21C of the first fluid circuit through one of the vertical channels formed at a first longitudinal end of the core 2. Next, the first flow FC1 of the coolant flows in the longitudinal direction of the core 2 through the first flow section 21C of the first fluid circuit and its all flow passages 5. Subsequently, at a second longitudinal end of the core 2 the first flow FC1 of the coolant flows through one of the vertical channels and into the first bypass channel 23 and the outlet 26.

[0017] The second flow FC2 of the coolant, having left the inlet 25, flows first through the second bypass channel 24 and then through one of the vertical channels at the second longitudinal end of the core 2. When it leaves the vertical channel the second flow FC2 of the coolant flows into the second flow section 22C of the first fluid circuit. Here, the second flow FC2 of the coolant flows in the longitudinal direction of the core 2 through the second flow section 22C and its all flow passages 5. Finally, the second flow FC2 of the coolant flows out of the second flow section 22C of the first fluid circuit through one of the vertical channels at the first longitudinal end of the core 2 and flows into the outlet 26.

[0018] At the outlet 26 the first and the second flows FC1, FC2 of the coolant meet again and mix and a resultant total flow is discharged from the outlet 26 and the core 2 itself.

[0019] In other words, the first fluid circuit is divided into two sub-circuits at the position where the coolant enters the core 2 (namely the inlet 25) and the two sub-circuits merge together at the position where the coolant leaves the core 2 (namely the outlet 26).

[0020] Generally, the two sub-circuits of the first fluid circuit are connected parallel to each other at the inlet 25 and at outlet 26 of the first fluid circuit to and from the core 2. It means that the total flow of the coolant is divided into two flows FC1, FC2 where the two sub-circuits separates from one another and the two flows FC1, FC2 mix together where the two sub-circuits combine back again.

[0021] The first sub-circuit of the first fluid circuit extends from the inlet 25 to the outlet 26 as follows: the inlet 25 at the first longitudinal end of the core 2, one vertical channel at the first longitudinal end of the core

2, the first flow section 21C of the first fluid circuit, one vertical channel at the second longitudinal end of the core 2, the first bypass channel 23 and the outlet 26 at the first longitudinal end of the core 2. The second sub-circuit of the first fluid circuit extends from the inlet 25 to the outlet 26 as follows: the inlet 25 at the first longitudinal end of the core 2, the second bypass channel 24, one vertical channel at the second longitudinal end of the core 2, the second flow section 22C of the first fluid circuit, one vertical channel at the first longitudinal end of the core 2 and the outlet 26 at the first longitudinal end of the core 2. Generally, one vertical channel, which delivers a fluid from one flow section to another is in fact part of both flow sections.

[0022] The second fluid circuit for the refrigerant is shown schematically in figs. 6 and 7. The second fluid circuit is divided into first and second flow sections 21R, 22R. The refrigerant flows via one inlet port 3 and one vertical channel at the first longitudinal end of the core 2 into the first flow section 21R of the second fluid circuit and flows in the longitudinal direction of the core 2 through the first flow section 21R of the second fluid circuit and its all flow passages 5 towards the second longitudinal end of the core 2. Next, the refrigerant is directed through one vertical channel at the second longitudinal end of the core 2 to the second flow section 22R of the second fluid circuit. Here, the refrigerant flows in the longitudinal direction of the core 2 through the second flow section 22R of the second fluid circuit and its all flow passages 5 towards the first longitudinal end of the core 2 where it enters one vertical channels and flows out of the core 2.

[0023] The first flow section 21C of the first fluid circuit coincides with the second flow section 22R of the second fluid circuit and the second flow section 22C of the first fluid circuit coincides with the first flow section 21R of the second fluid circuit. By the term "coinciding" it should be understood that two flow sections overlap so that they occupy essentially the same volume/have the same size (length and cross-section). It does not mean that two flow sections are connected to one another or are in fluid communication so that two working fluids mix.

[0024] It should be noted that a direction of the first flow FC1 of the coolant in the first flow section 21C of the first fluid circuit is opposite to a direction of flow of the refrigerant in the second flow section 22R of the second fluid circuit. Additionally, a direction of the second flow FC2 of the coolant in the second flow section 22C of the first fluid circuit is opposite to a direction of flow of the refrigerant in the first flow section 21R of the second fluid circuit. In other words, it is always ensured that the direction of the coolant flow is opposite to the direction of the refrigerant flow in all the flow sections 21C, 22C, 21R, 22R. Moreover, as the coolant flow is split into two flows FC1, FC2 before entering the first flow section 21C of the first fluid circuit, the first and second flows FC1, FC2 of the same temperature flow into the first and second flow sections 21C, 22C of the first fluid circuit and interact indirectly with the refrigerant flow in both flow sections 21R, 22R of the second fluid circuit. This greatly increases heat exchange efficiency of the heat exchanger 1.

[0025] Moreover, as the coolant flow is split into the first and second flows FC1, FC2 the coolant flow inside each of the first and second flow sections 21C, 22C of the first fluid circuit is two times slower that the total flow at the inlet 25 and the outlet 26 of the first fluid circuit and this have a positive effect on pressure drops.

[0026] Preferably, the first and second flow sections 21C, 22C of the first fluid circuit, as well as the first and second flow sections 21R, 22R of the second fluid circuit, have the same size (length and cross-section). However, if desirable, it is possible to design the heat exchanger 1 with the first and second flow sections 21C, 22C of the first fluid circuit having different sizes in order to benefit from a pressure drop difference. Preferably, as the flow sections 21R, 22R of the second fluid circuit essentially coincide with and have the size as the flow sections 21C, 22C of the first fluid circuit the flow sections 21R, 22 can also have different sizes compared to one another.

[0027] The present invention discussed above is not limited only to heat exchangers consisting of a plurality of shaped plates. The innovative principle of the present invention can be applied to heat exchangers, where flow passages are defined by, for example, a series of flat hollow flow tubes stacked in a pile and defining flow passages therein, a first set of the flat hollow flow tubes being passed by the coolant while the other being passed by the refrigerant. Another example is a heat exchanger, which incorporates a combination of flat hollow flow tubes and shaped plates. A first set of flow passages is defined inside the flat hollow flow tubes and a second set of flow passages is defined between successive shaped plates. The flat hollow flow tubes and the shaped plates are stacked in a pile so that one flat hollow flow tube is arranged between two successive shaped plates. The coolant flows, for example, through the flat hollow flow tubes and the refrigerant flows through passages defined by two successive shaped plates, or vice versa. In each of these two solutions the fluid circuits each can easily be divided into two flow sections with different directions of flow. The flow sections can be fluidly connected to one another by a variety of additional elements, like hoses, manifolds, etc.

[0028] Preferably, all components of the heat exchanger 1 are made of materials suitable for brazing, for example aluminum and its alloys, and are connected to one another by brazing.

Claims

1. A heat exchanger (1) comprising a core (2), said core (2) defining a first fluid circuit and a second fluid circuit, said first fluid circuit being divided into first and second flow sections (21C, 22C) and said second fluid circuit being divided into first and second flow

sections (21R, 22R), said first flow section (21C) of said first fluid circuit coinciding with said second flow section (22R) of said second fluid circuit and said second flow section (22C) of said first fluid circuit coinciding with said first flow section (21R) of said second fluid circuit,

characterized in that

said first fluid circuit is split into first and second sub-circuits connected to each other at an inlet (25) and an outlet (26) of said first fluid circuit, respectively, so that flow of a first fluid is divided into first and second flows (FC1, FC2) throughout said core (2), said first sub-circuit extending through said first flow section (21C) of said first fluid circuit, said second sub-circuit extending through said second flow section (22C) of said first fluid circuit,

wherein said flow sections (21C, 22C, 21R, 22R) of said first fluid circuit and said second fluid circuit, respectively, are configured so that a direction of said first flow (FC1) of said first fluid through said first flow section (21C) of said first fluid circuit is opposite to a direction of flow of a second fluid through said second flow section (22R) of said second fluid circuit and a direction of said second flow (FC2) of said first fluid through said second flow section (22C) of said first fluid circuit is opposite to said direction of flow of said second fluid through said first flow section (21R) of said second fluid circuit.

2. The heat exchanger (1) according to claim 1, **characterized in that** said flow sections (21C, 22C, 21R, 22R) all have the same size.

3. The heat exchanger (1) according to claim 1, **characterized in that** said first flow section (21C) of said first fluid circuit and said second flow section (22R) of said second fluid circuit have the same size and said second flow section (22C) of said first fluid circuit and said first flow section (21R) of said second fluid circuit have the same size, said size of said first flow section (21C) of said first fluid circuit and said second flow section (22R) of said second fluid circuit being different than said size of said second flow section (22C) of said first fluid circuit and said first flow section (21R) of said second fluid circuit.

4. The heat exchanger (1) according to any of the preceding claims, **characterized in that** it comprises first and second bypass channels (23, 24), which split said first fluid circuit into said first and second sub-circuits, said first sub-circuit extending from said inlet (25) to said outlet (26) through said first flow section (21C) of said first fluid circuit and said first bypass channel (23), said second sub-circuit extending from said inlet (25) to said outlet (26) through said second bypass channel (24) and said second flow section (22C) of said first fluid circuit.

5. The heat exchanger (1) according to any of the preceding claims, **characterized in that** said core (2) comprises a plurality of stacked shaped plates (4).

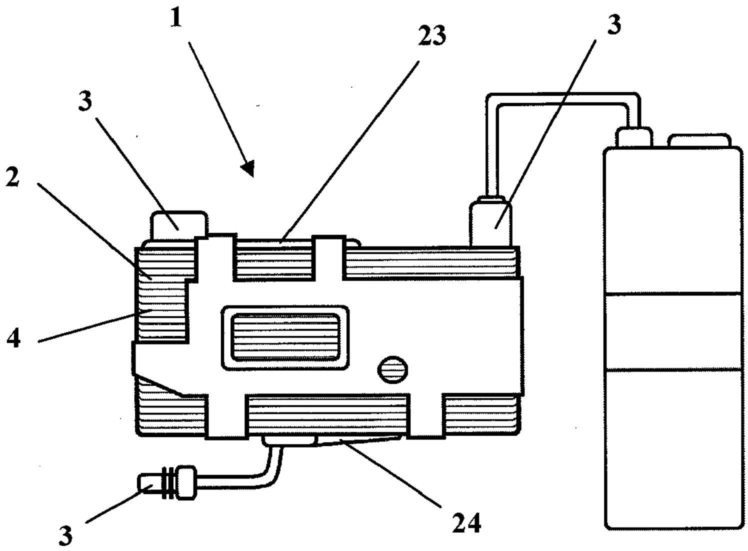

Fig. 1

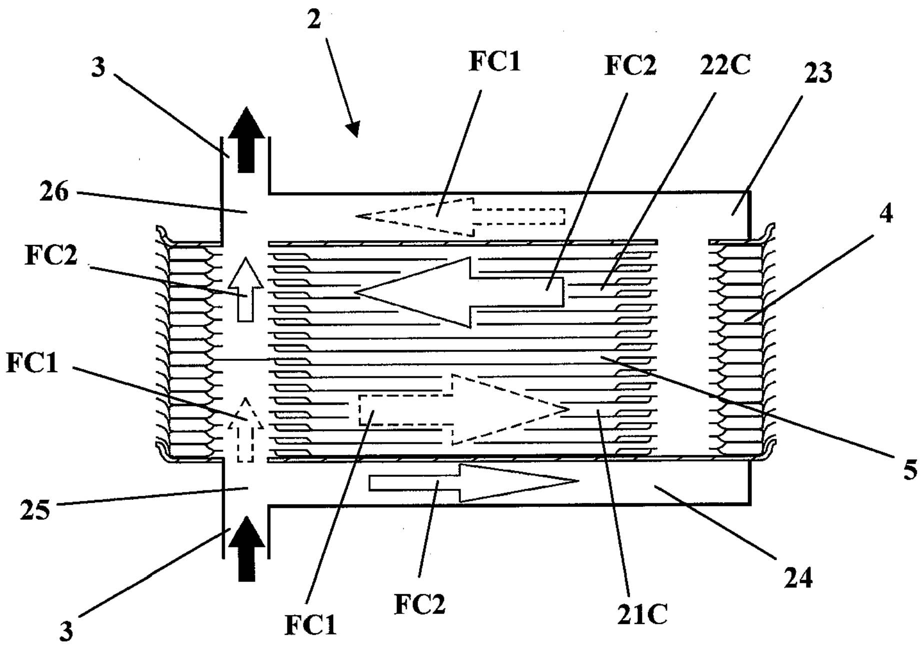

Fig. 2

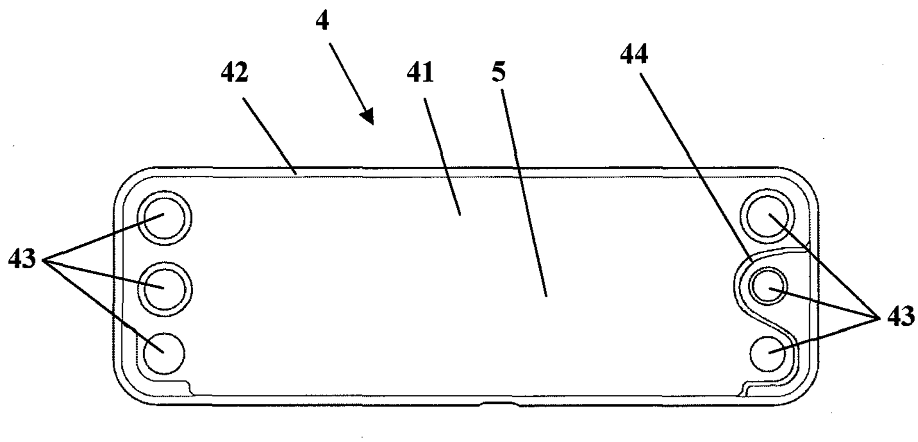

Fig. 3a

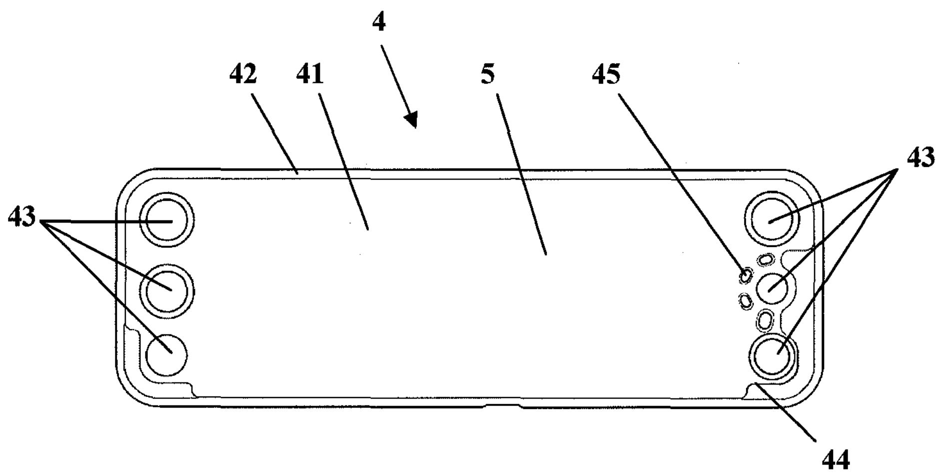

Fig. 3b

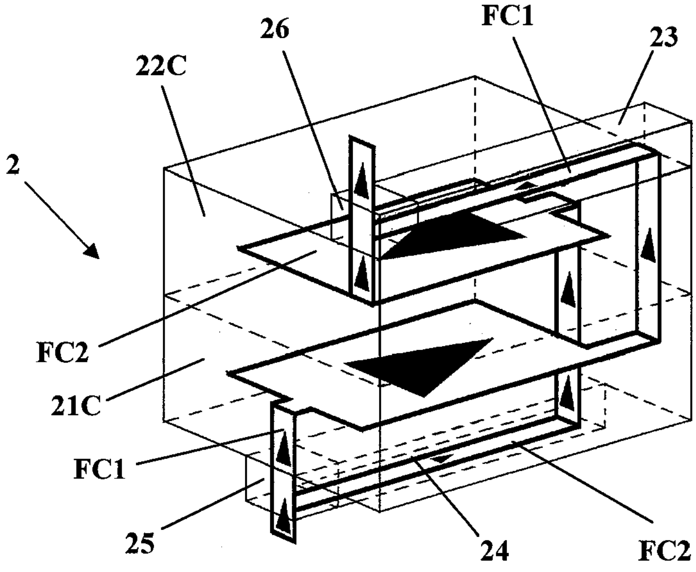
2
22C
26
FC1
23
FC2
21C
FC1
25
24
FC2

Fig. 4

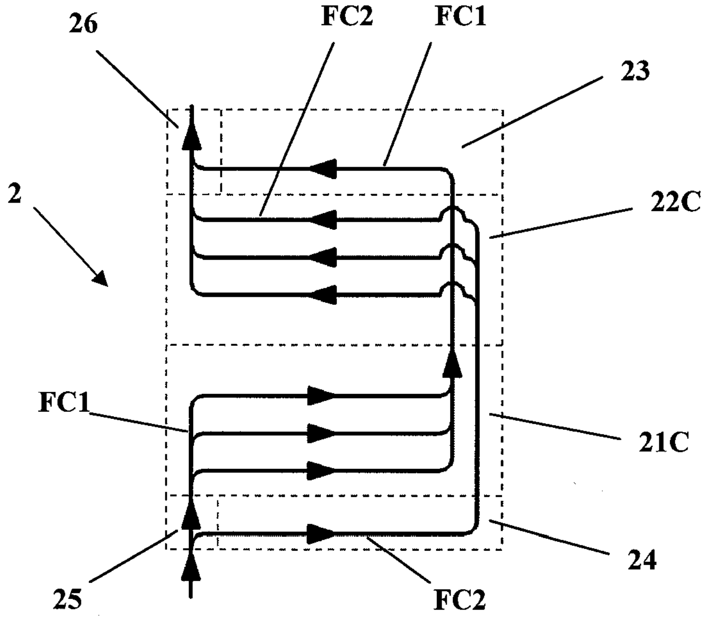
26
FC2
FC1
23
2
22C
FC1
21C
24
25
FC2

Fig. 5

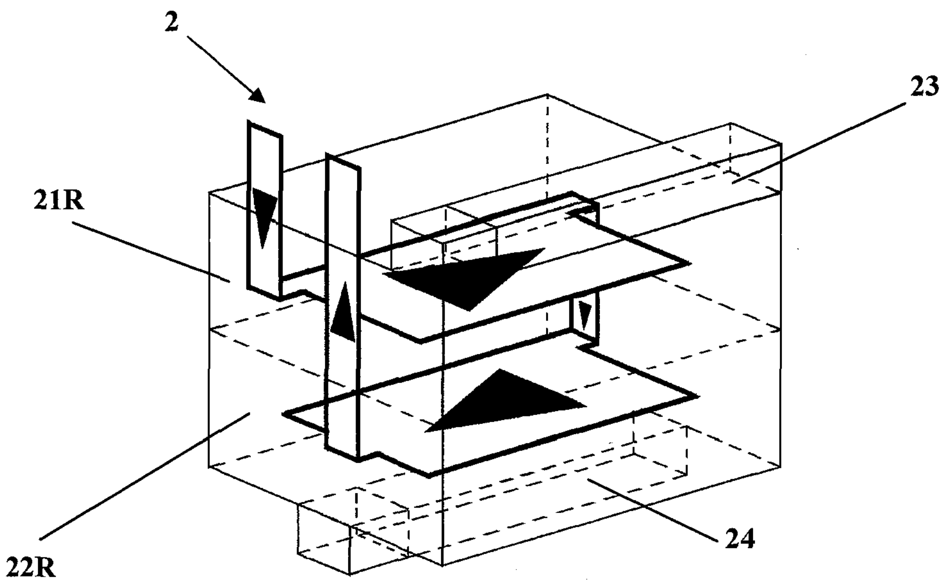

Fig. 6

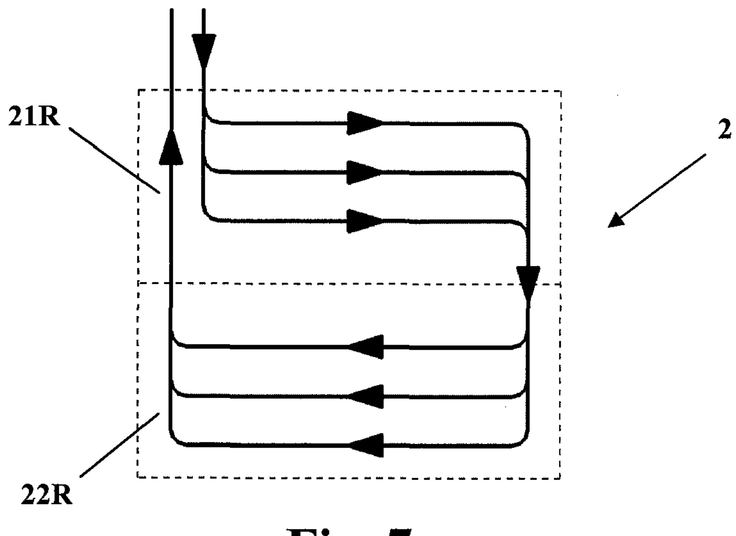

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 18 46 1560

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TECHNICAL FIELDS SEARCHED (IPC)

F28D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	14 November 2018	Axters, Michael

CATEGORY OF CITED DOCUMENTS

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