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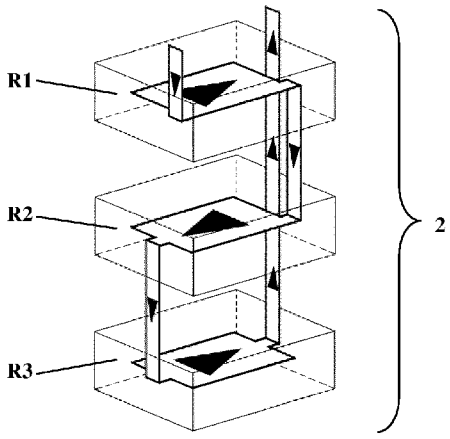


Fig. 5

(57) Abstract: A heat exchanger (1) comprises a core (2) defining first and second fluid circuits. The first fluid circuit includes one flow section (C) and the second fluid circuit is divided into three flow sections (R1, R2, R3). The flow sections are defined by a plurality of flow passages (5). A direction of flow in the first and third flow sections (R1, R3) is opposite to a direction of flow in the one flow section (C) of the first fluid circuit and a direction of flow in the second flow section (R2) is the same as the direction of flow in the one flow section (C) of the first fluid circuit. A number NR3 of the flow passages (5) of the third flow section (R3) is greater than a number NR2 of the flow passages (5) of the second flow section (R2) and the number NR3 of the flow passages (5) of the third flow section (R3) is smaller than or equal to a number NR1 of the flow passages (5) in the first flow section (R1).

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Heat exchanger

FIELD OF INVENTION

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

PRIOR ART

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 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.

The cores of the heat exchangers known from the prior art are divided into many flow sections to increase power output and heat exchange efficiency. Such configuration, however, results in significant pressure drops of the working fluids, which is unacceptable in some applications. Moreover, the larger the number of the flow sections, the larger the size and complexity of the heat exchanger. Very often, in known heat exchangers each successive flow

section is narrower that a preceding one and this leads to the increase in flow resistance and pressure drops.

AIM OF INVENTION

One aim of the present invention is to provide a heat exchanger with a limited number of flow passages but at the same with unchanged heat exchange efficiency.

Another aim of the present invention is to provide a heat exchanger with increased power output and pressure drop values kept at an acceptable level.

BRIEF DESCRIPTION OF INVENTION

A heat exchanger according to the present invention comprises a core. The core defines a first fluid circuit and a second fluid circuit. The first fluid circuit includes one flow section through which a first fluid flows in one direction. The second fluid circuit is divided into flow sections, which are in fluid communication to one another and through which a second fluid flows in different directions. The one flow section of the first fluid circuit and the flow sections of the second fluid circuit are defined by a plurality of flow passages. The second fluid circuit is divided into a first flow section, a second flow section and a third flow section. The first, second and third flow sections are configured so that the first flow section is in fluid communication with the second flow section and the second fluid section is in fluid communication with the third flow section and a direction of flow in the first and third flow sections is opposite to the direction of flow in the one flow section of the first fluid circuit and a direction of flow in the second flow section is the same as the direction of flow in the one flow section of the first fluid circuit. A number of the

flow passages of the third flow section is greater than a number of the flow passages of the second flow section and the number of the flow passages of the third flow section is smaller than or equal to a number of the flow passages in the first flow section.

Further advantageous embodiments of the present invention are defined in dependent claims.

The present invention ensures that as much as possible of the flow of the second fluid is in counter-flow with the first fluid, which increases heat exchange efficiency. Simultaneously, although the number of the flow passages of the second flow section for the second fluid is as low as possible pressure drops of the second fluid are kept at an acceptable level.

The power output of a heat exchanger adopting the principles of the present invention is significantly increased, even by 350-620 W.

Additionally, as the number of flow passages in the narrowest flow section, namely the second flow section, of the second fluid circuit is kept as low as possible a part of the core where both fluids are in common flow is minimized and a part of the core where both fluids are in counter-flow is maximized, which has an advantageous effect on heat exchange efficiency.

The heat exchanger according to the present invention comprises a reduced number of flow passages compared to the heat exchangers known from the prior art, while maintaining or improving basis properties of the heat exchanger like power output, heat exchange efficiency, etc. It also means the heat exchanger according to the present invention is cheaper.

The present invention can easily be applied to heat exchangers adopting different types of cores, for example cores made of shaped plates and/or flat hollow flow tubes.

BRIEF DESCRIPTION OF DRAWINGS

The present invention in described in more detail below, with reference to the accompanying drawings, which present its non-limiting embodiment, wherein:

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

Figs. 2a and 2b show top views of two examples of shaped plates used in the heat exchanger of the present invention;

Fig. 3 and 4 show a perspective schematic view and a vertical diagram, respectively, of a coolant flow through a core of the heat exchanger; and

Fig. 5 and 6 show a perspective schematic view and a vertical diagram, respectively, of a refrigerant flow through the core of the heat exchanger.

EMBODIMENTS OF INVENTION

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.

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 define 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.

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. 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 flow passage 5 shown in fig. 2a and can only flow in a vertical direction of the core 2. To allow for the flow of the fluids to the flow 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. 2b. 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.

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 fluid passages 5 formed between the shaped plates 4.

As discussed earlier, the core 2 defines two fluid circuits. One fluid circuit is used for the coolant/first fluid, while the other is used for the refrigerant. The coolant flow is shown in figs. 3 and 4. This fluid circuit comprises only one flow section C, which includes a plurality of the flow passages 5 to be passed by the coolant. The coolant flows into the core 2 at one of its longitudinal ends, flows through one of the vertical channels and then is directed longitudinally to all flow passages 5 intended to be passed by the coolant. The coolant flows through all related flow passage 5 in the same one direction. Next, the coolant is directed to one vertical channel at the other longitudinal end of the core 2 and is subsequently discharged out of the core 2. The coolant may flow into and out of the core 2 at two opposite longitudinal ends of the core 2, but depending on the external configuration of the heat exchanger 1 the coolant can flow into and out of the core at the same end of the core 2. For this purpose the core 2 can be provided with an

additional bypass 21, which directs the coolant from one longitudinal end of the core 2 to the other.

Figs. 5 and 6 show schematically the flow of the refrigerant/second fluid. In this case the core 2 can virtually be divided into three flow sections R1, R2, R3. Each of the flow sections R1, R2, R3 comprises a plurality of the flow passages 5 to be passed by the refrigerant. The flow sections R1, R2, R3 jointly coincide with one flow section C shown in figs. 3 and 4. The flow sections R1, R2, R3 are defined by an appropriate configuration of a set of the openings 43. The flow section R1 is in fluid communication with the flow section R2 and the flow section R2 is in fluid communication with the flow section R3. Generally, one can say that one flow section is in fluid communication with a preceding flow section (if present) and a subsequent flow section (if present). The refrigerant enters first the flow section R1, flows longitudinally through the flow section R1 and its all flow passages 5 in one direction and then flows through one of the vertical channels into the flow section R2. Here, the refrigerant flows longitudinally through the flow section R2 and its all flow passages 5 in one direction, which is opposite to the direction of flow in the flow section R1. Subsequently, the refrigerant is directed through one vertical channel at the other longitudinal end of the core/flow section R2, opposite to the end where the refrigerant enters the flow section R2, to the flow section R3. In the flow section R3, the refrigerant flows longitudinally through the flow section R3 and its all flow passages 5 in one direction, which is opposite to the direction of flow in the flow section R2 and is the same as the direction of flow in the

flow section R1. Next, the refrigerant, depending on the external configuration of the heat exchanger 1, especially its inlet and outlet ports 3, can be discharged out of the core 2 either directly at the flow section R3 or the refrigerant can be directed by one of the vertical channels, which is not in fluid communication with the flow passages 5 of the flow sections R1 and R2, through the flow sections R1 and R2 and can flow out of the core 2 at the flow section R1, as shown in figs. 5 and 6.

Generally, the coolant flows longitudinally through the core 2 only in one direction, whereas the refrigerant flows longitudinally through the core 2 in two opposing directions. The direction of flow of the refrigerant in the flow section R1 is opposite to the direction of flow of the coolant in the flow section C. The direction of flow of the refrigerant in the flow section R2 is the same as the direction of flow of the coolant in the flow section C. The direction of flow of the refrigerant in the flow section R3 is opposite to the direction of flow of the coolant in the flow section C. In other words, the refrigerant in the flow sections R1 and R3 is in counter-flow compared to the coolant in the flow section C. Also, the refrigerant in the flow section R2 is in common flow compared to the coolant in the flow section C.

The number NR2 of the flow passages 5 in the flow section R2 should be as low as possible to get acceptable pressure drop of the refrigerant and should be preferably 15-25 % of the total number TNR1R2R3 of the flow passages 5 passed by the refrigerant (namely total number TNR1R2R3 of the flow passages 5 in the flow sections R1, R2 and R3). The number NR3 of the flow passages 5 in the flow section

R3 should be greater than the number NR2 of the flow passages 5 in the flow section R2. The total number TNR1R3 of the flow passages 5 in the flow sections R1 and R3 should be preferably 75-85 % of the total number TNR1R2R3 of the flow passages 5 passed by the refrigerant (total number TNR1R2R3 of the flow passages in the flow sections R1, R2 and R3). The number NR3 of the flow passages 5 in the flow section R3 should be the same or smaller that the number NR1 of the flow passages 5 in the flow section R1 and should be preferably 20-42,5 % of the total number TNR1R2R3 of the flow passages 5 passed by the refrigerant (namely total number TNR1R2R3 of the flow passages in the flow sections R1, R2 and R3).

In other words:

$NR3 > NR2$ and

$NR3 \leq NR1$

Preferably, the ratio of the numbers of the flow passages 5 of the flow section R1/flow section R2/flow section R3, respectively, is 9/6/9. In another embodiments of the present invention the ratio of the numbers of the flow passages 5 of the flow section R1/flow section R2/flow section R3, respectively, is 10/6/8 or 11/5/8.

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 circuit for the refrigerant can easily be divided into three sections with different directions of flow.

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 including one flow section (C) through which a first fluid flows in one direction, said second fluid circuit being divided into flow sections, which are in fluid communication to one another and through which a second fluid flows in different directions, said one flow section (C) of said first fluid circuit and said flow sections of said second fluid circuit being defined by a plurality of flow passages (5),

characterized in that

said second fluid circuit is divided into a first flow section (R1), a second flow section (R2) and a third flow section (R3), said first, second and third flow sections (R1, R2, R3) being configured so that said first flow section (R1) is in fluid communication with said second flow section (R2) and said second flow section (R2) is in fluid communication with said third flow section (R3) and a direction of flow in said first and third flow sections (R1, R3) is opposite to said direction of flow in said one flow section (C) of said first fluid circuit and a direction of flow in said second flow section (R2) is the same as said

direction of flow in said one flow section (C) of said first fluid circuit;

wherein a number NR3 of said flow passages (5) of said third flow section (R3) is greater than a number NR2 of said flow passages (5) of said second flow section (R2) and said number NR3 of said flow passages (5) of said third flow section (R3) is smaller than or equal to a number NR1 of said flow passages (5) in said first flow section (R1).

2. The heat exchanger (1) according to claim 1, **characterized in that** said core (2) comprises a plurality of stacked shaped plates (4), said shaped plates (4) defining therebetween said flow passages (5).

3. The heat exchanger (1) according to any of the preceding claims, **characterized in that** said number NR2 of said flow passages (5) of said second flow section (R2) is 15-25 % of a total number TNR1R2R3 of said flow passages (5) of said first, second and third flow sections (R1, R2, R3) of said second fluid circuit, a number NR1R3 of said flow passages (5) of said first and third flow sections (R1, R3) jointly is 75-85 % of said total number TNR1R2R3 of said flow passages (5) of said first, second and third flow sections (R1, R2, R3) of said second fluid circuit, and said number NR3 of said flow passages (5) of said third flow section (R3) is 20-42,5 % of said total number TNR1R2R3 of said flow passages (5) of said first, second and third flow sections (R1, R2, R3) of said second fluid circuit.

4. The heat exchanger (1) according to any of the preceding claims, **characterized in that** a ratio of said numbers of said flow passages (5) of said first flow section (R1)/said second flow section (R2)/said third flow section (R3), respectively, is 9/6/9.

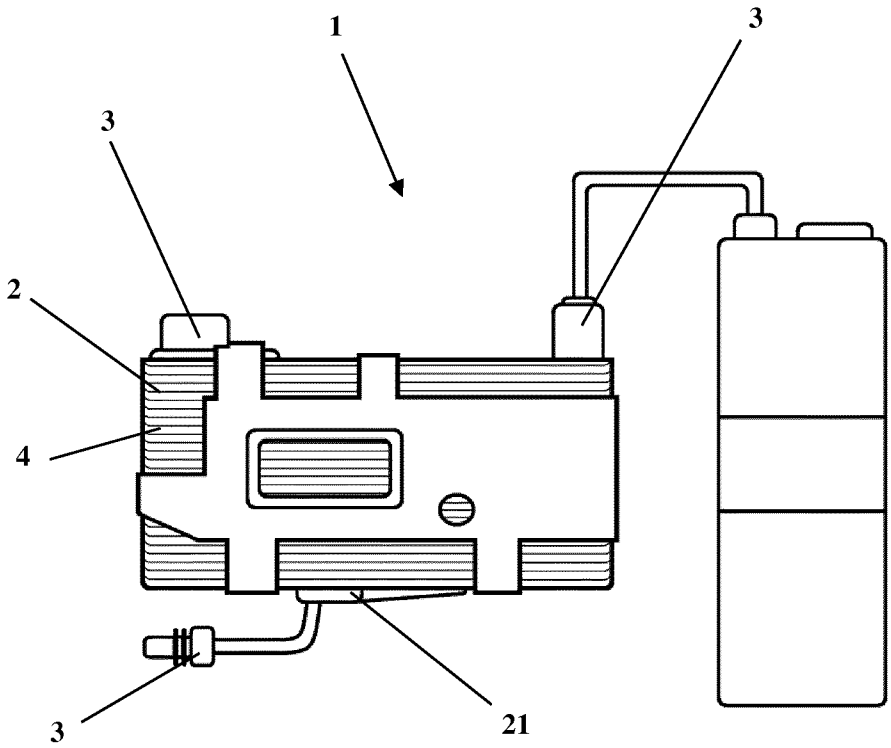


Fig. 1

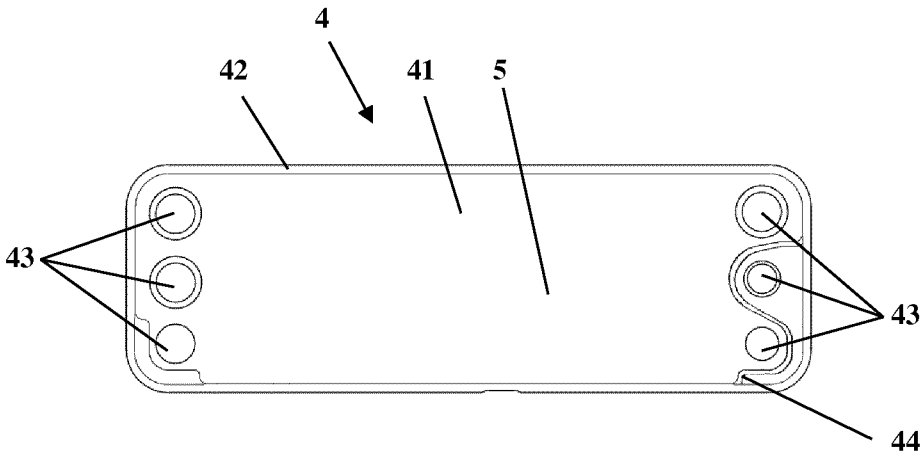


Fig. 2a

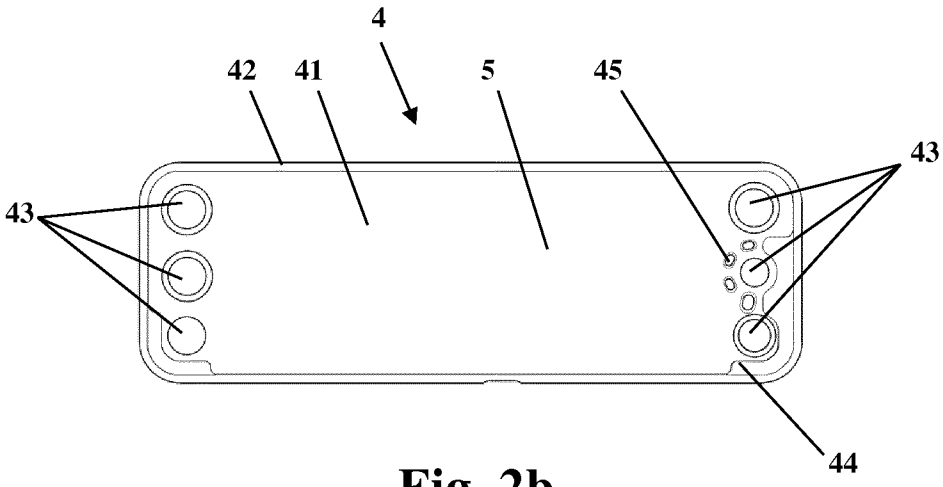


Fig. 2b

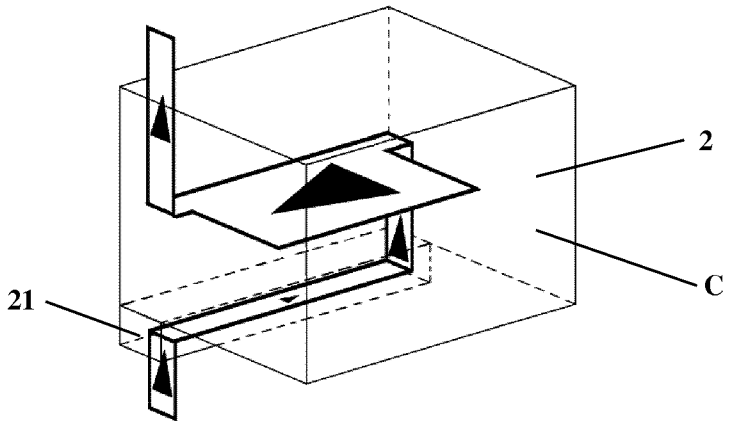


Fig. 3

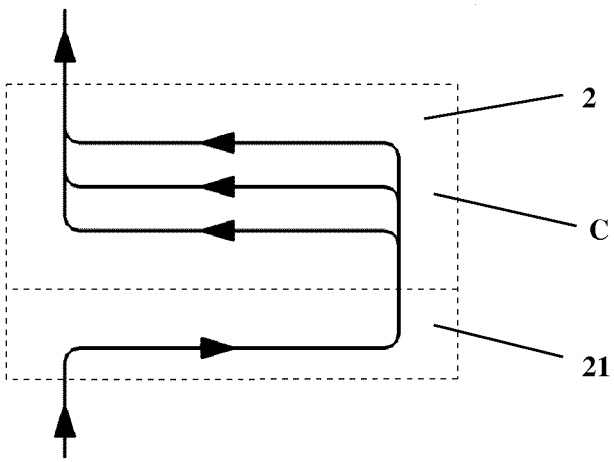


Fig. 4

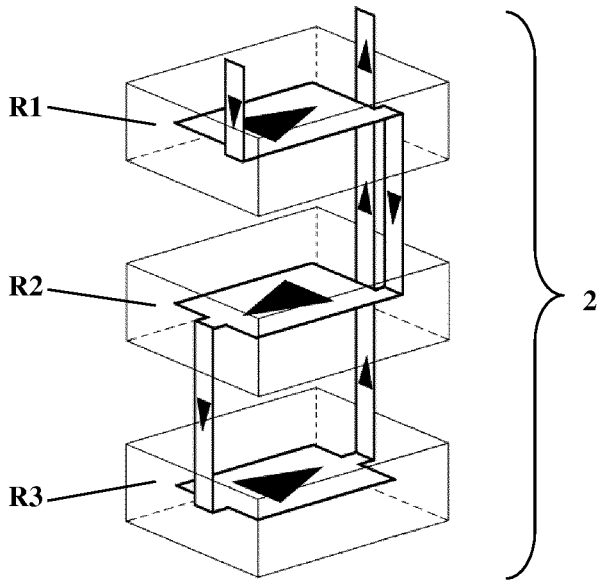


Fig. 5

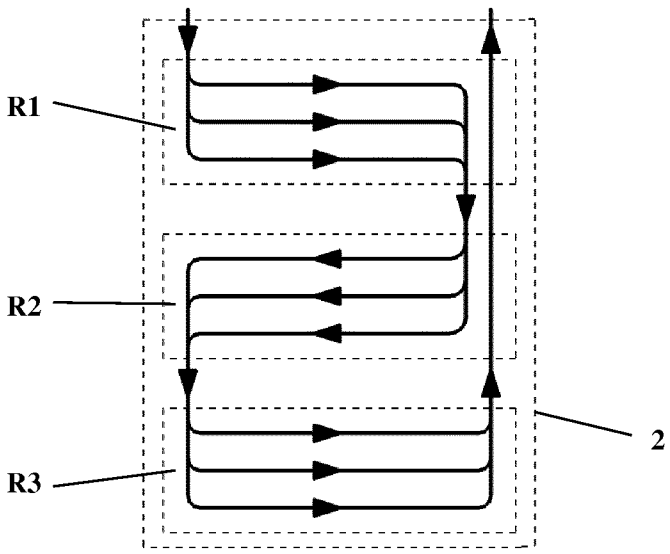


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/062257

A. CLASSIFICATION OF SUBJECT MATTER
INV. F28D9/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F28D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 10 2012 223722 A1 (BEHR GMBH & CO KG [DE]) 27 June 2013 (2013-06-27) paragraphs [0041] - [0043]; figure 3	1-4
A	WO 2014/184323 A1 (BEHR GMBH & CO KG [DE]) 20 November 2014 (2014-11-20) abstract	1-4
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A	WO 2008/061362 A1 (DANA CANADA CORP [CA]; SO ALLAN K [CA]; KOZDRAS MARK S [CA]) 29 May 2008 (2008-05-29) the whole document	1-4

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
13 August 2019	26/09/2019

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Axters, Michael

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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