(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

**(19) World Intellectual Property Organization**
International Bureau

**(43) International Publication Date**
**02 September 2021 (02.09.2021)**

WIPO | PCT

**(10) International Publication Number**
**WO 2021/170438 A1**

**(51) International Patent Classification:**
*F28F 9/02* (2006.01) *F28D 1/053* (2006.01)

**(21) International Application Number:**
PCT/EP2021/053631

**(22) International Filing Date:**
15 February 2021 (15.02.2021)

**(25) Filing Language:** English

**(26) Publication Language:** English

**(30) Priority Data:**
20461516.5 28 February 2020 (28.02.2020) EP

**(71) Applicant: VALEO AUTOSYSTEMY SP. Z O.O.** [PL/PL]; ul. Przemyslowa 3, 32 050 SKAWINA (PL).

**(72) Inventors: AUGUSTYN, Milosz**; C/o Valeo Autosystemy Sp. z o.o., UL. PRZEMYSLOWA 3, 32 050 SKAWINA (PL). **BELZOWSKI, Michal**; C/o Valeo Autosystemy Sp. z o.o., UL. PRZEMYSLOWA 3, 32 050 SKAWINA (PL). **STRAMECKI, Tomasz**; C/o Valeo Autosystemy Sp. z o.o., UL. PRZEMYSLOWA 3, 32 050 SKAWINA (PL). **SZOSTEK, Dawid**; C/o Valeo Autosystemy Sp. z o.o., UL. PRZEMYSLOWA 3, 32 050 SKAWINA (PL).

**(74) Agent: BERNARD, Sophie**; VALEO SYSTEMES THERMIQUES, 8 rue Louis Lormand, ZA l'Agiot, CS 80517 La Verrière, 78322 Le Mesnil Saint Denis Cedex (FR).

**(81) Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

**(84) Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

**(54) Title:** A HEAT EXCHANGER

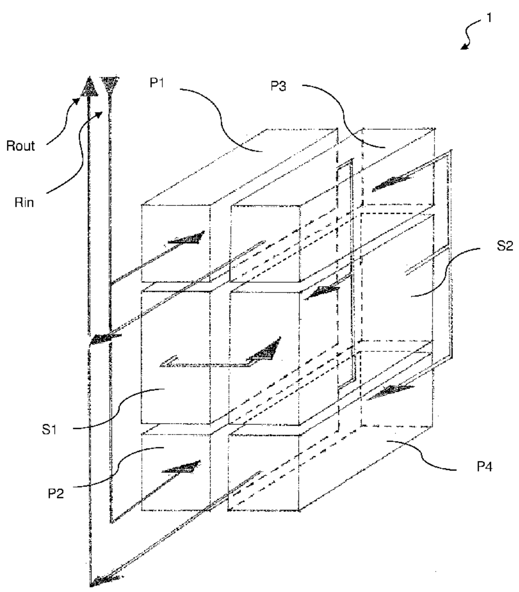


Fig. 2

**(57) Abstract:** A heat exchanger (1), in particular for a motor vehicle, comprising: a first manifold (2) comprising a first tank (2a) and a first header (2b), a second manifold (3), comprising a second tank (3a) and a second header (3b), a connection block (7) comprising an inlet Rin and an outlet Rout for a fluid, wherein the connection block (7) is fluidly connected with the first manifold (2), a plurality of tubes (4) forming at least one stack deployed between the first manifold (2) and the second manifold (3), the tubes (4) comprising open ends received in the manifolds (2, 3), wherein the first manifold (2) and the second manifold (3) are fluidly connected with each other forming a primary pass (10) and a secondary pass (20) for a fluid, characterised in that the primary pass (10) is defined by at least two tubes (4) located on the terminal ends of the stack and the secondary pass (20) is located between the tubes (4) forming the primary pass (10).

WO 2021/170438 A1

*[Continued on next page]*

**Published:**
— *with international search report (Art. 21(3))*

# A HEAT EXCHANGER

## FIELD OF THE INVENTION

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

## BACKGROUND OF THE INVENTION

Heat exchangers commonly used in the industry may comprise means for redirecting the fluid inside the core in order to increase the distance traveled by the fluid and consequently to increase the overall performance of the heat exchanger. Sometimes, the fluid is transmitted between the neighboring sections to avoid complex solutions. Oftentimes, creating several passes inside the core of the heat exchanger is problematic, because of increased pressure drop and limited packaging. Excessive pressure drop may also impact the performance in an indirect manner, due to increased power consumption by compressor. In case of heat exchangers with two manifolds connected by heat exchange tubes, so-called “dead zones” can occur, wherein the flow of the heat exchange fluid is limited. Thus, it is problematic to provide a homogenous distribution of the fluid in the heat exchanger, including manifolds.

One of the known solutions to promote the optimized and homogenous distribution of the fluid circulating through the heat exchanger is dividing heat exchanger into sections by blocking or limiting the flow of the fluid inside the manifolds. However, currently known solutions do not suggest providing homogeneity of the fluid distribution, what usually has a negative impact on efficiency of the whole heat exchanger. Sometimes the fluid is not delivered to the tubes evenly, what may suggest the homogeneity problems particularly in that area. This concerns in particular the scenario in which cross section conducting fluid from first to second pass is much smaller which may result in significant pressure drops.

Therefore it would be desirable to provide a heat exchanger that would increase the efficiency and decrease the pressure drop.

## SUMMARY OF THE INVENTION

The object of the invention is a heat exchanger in particular for a motor vehicle, comprising:

- a first manifold comprising a first tank and a first header,

- a second manifold, comprising a second tank and a second header,

- a connection block comprising an inlet $R_{in}$ and an outlet $R_{out}$ for a fluid, wherein the connection block is fluidly connected with the first manifold,

- a plurality of tubes forming at least one stack deployed between the first manifold and the second manifold, the tubes comprising open ends received in the manifolds,

wherein the first manifold and the second manifold are fluidly connected with each other forming a primary pass and a secondary pass for a fluid, characterised in that the primary pass is defined by at least two tubes located on the terminal ends of the stack and the secondary pass is located between the tubes forming the primary pass.

Preferably, the tubes are arranged in a first stack comprising a first stacking direction, the second stack comprising a second stacking direction being parallel to the first stacking direction, wherein the second stack is distanced from the first stack in a third direction being perpendicular to the first stacking direction and the second stacking direction.

Preferably, at least two tubes located on the terminal ends of the first stack are at the same level as at least two tubes located on the terminal ends of the second stack.

Preferably, the first stack and second stack are fluidly connected with the first manifold to provide at least one U-turn for the fluid, wherein the U-turn is formed between at least one tube of the first stack and the corresponding tube of the second stack.

Preferably, the first stack comprises tube portions P1, P2 and S1, wherein tube portion P1 and tube portion P2 form the primary pass within the first stack and tube portion S1 forms the secondary pass for the first stack.

Preferably, the second stack comprises secondary tube portions P3, P4 and S2, wherein tube portion P3 and tube portion P4 form the primary pass for the second stack and tube portion S2 forms the secondary pass for the second stack, wherein the tube portion S2 is located between the tube portions P3, P4 forming the primary pass.

Preferably, the first manifold is divided into an inlet channel and an outlet channel, wherein the inlet channel is fluidly connected with the inlet $R_{in}$ of the connection block and the primary pass of the first stack of tubes, and the outlet channel is fluidly connected with the outlet $R_{out}$ of the connection block and the primary pass of the second stack of tubes.

Preferably, the first tank comprises at least one dividing portion configured to block fluidal communication between the secondary pass, inlet channel and outlet channel.

Preferably, the tube portion and tube portion are fluidly connected with the inlet $R_{in}$ through the inlet channel.

Preferably, the tube portion P3 and tube portion P4 are fluidly connected with the outlet $R_{out}$ through the outlet channel.

Preferably, the tube portion P1 and tube portion P2 are fluidly isolated from tube portions P3 and P4 within the second manifold.

Preferably, the tube portion S1 is fluidly connected with tube portion S2 to form at least one U-turn within the first manifold.

Preferably, the tube portion S1 is adapted to collect the fluid from tube portions P1 and P2 within the second manifold.

Preferably, the tube portion S2 is adapted to distribute the fluid between the tube portions P3 and P4 within the second manifold.

Preferably, the first manifold comprises at least one hump configured to form at least one channel for the fluid inside the first tank.

## BRIEF DESCRITPTION OF DRAWINGS

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

Fig. 1 shows flow arrangement through the heat exchanger in the first example,

Fig. 2 shows the schematic view of flow arrangement in the heat exchanger,

Fig. 3 shows the exploded view of the heat exchanger in the second example,

Fig. 4 shows the first manifold assembly and the second manifold assembly in the second example.

## DETAILED DESCRIPTION OF EMBODIMENTS

Invention relates to heat exchangers, wherein at least two media are guided through predetermined paths to exchange the heat between one another. The subject of the invention relates specifically to a heat exchanger 1 that may be applied in a motor vehicle comprising, for example, an internal combustion engine, an electric motor, or a combination of both those types.

The heat exchanger may serve for example as an air cooled condenser (ACDS), a water cooled condenser (WCDS), an air gas cooler, or a chiller - a device for chilling the water and/or coolant fluid that has been heated while cooling down the batteries in electric vehicle.

Fig. 1 presents the heat exchanger 1 that may be used in a motor vehicle. Such heat exchangers usually comprise several key elements, inter alia, a first manifold 2 and a second manifold 3. The manifolds 2, 3 may be of different shapes and forms, but the most generic ones usually have a tubular or rectangular shape. Depending on the type of heat exchanger 1, the manifolds 2, 3 may comprise other elements, such as an inlet $R_{in}$, an outlet $R_{out}$, an integrated connection block 7, mounting brackets, so- called jumper lines, caps for closing the manifolds, baffles, and other. Furthermore, the first manifold 2 is not necessarily built the same way as the second manifold 3 as they may be optimized to increase the overall performance of heat exchanger 1. There may be different types of manifolds 2, 3 disclosed in the following embodiments of the invention, therefore the invention in not limited only to one particular type of sub-components forming the heat exchanger 1.

The heat exchanger 1 further comprises a plurality of tubes 4 forming at least one stack deployed between the first manifold 2 and the second manifold 3. Despite the fact that the tubes 4 may be of different form and shape depending on the type of the heat exchanger 1, all types of the tubes 4 usually comprise open ends received in the manifolds 2, 3. The first manifold 2 usually comprises a plurality of slots configured to receive one end of the tubes 4, and the second manifold 3 also comprises plurality of slots configured to receive the other open ends of the corresponding tubes 4. This enables fluidal connection between the manifolds 2, 3 and the tubes 4. The tubes 4 may be in form of extruded tubes, folded tubes, the plates comprising micro channels and the channels for fluid formed by stamped plates.

One of the ways to optimize the efficiency of the heat exchanger 1 is to force the fluid to flow through an organized, predetermined path. The path of the fluid flowing through the heat exchanger may be regarded as the sum of the passes between the inlet $R_{in}$ and the outlet $R_{out}$ of the heat exchanger 1 during its operational mode. The term "pass" is to be understood to mean a group or sub-group of tubes 4 in which the fluid follows one and the same direction in one and the same sense. In the tubes 4 of one and the same pass, the open ends of the tubes 4 are situated, in particular, in two opposite manifolds 2, 3. While moving from one pass to the another, the sense in which the fluid circulates may be reversed. Thus it is possible to lengthen the path of the fluid through the heat exchanger 1.

The heat exchanger 1 may comprise at least two passes, wherein the primary pass 10 is defined by at least two tubes 4 located on the terminal ends of the particular stack. In other words, if at least one tube 4 is the top first tube of the particular stack and the other tube 4 is the bottom tube of the same stack, and in these tubes 4 the fluid follows one and the same direction in one and the same sense, then these tubes 4 form a primary pass 10. At least one secondary pass 20 is located between the tubes 4 forming the primary pass 10.

As shown in Fig. 1, a part of the primary section 10 is located in the vicinity of inlet $R_{in}$, wherein the arrows indicate the direction of the flow. In this example, the primary pass 10 and the secondary pass 20 share the same first manifold 2 on one side and the second manifold 3 on the other. The fluid entering the heat exchanger 1 through the inlet $R_{in}$ is distributed across the primary pass 10 located on the top and the bottom of the stack by the first manifold 2. The top portion of the first manifold 2 may be fluidly connected with the bottom portion of the first manifold 2 by e.g. jumper line, as shown in Fig. 1. This allows even distribution of the fluid across the first manifold 2, and consequently across the primary pass 10. The fluid travels along the primary pass 10 until it reaches the second manifold 3 wherein it is collected from the top and the bottom portion thereof, and it is further reversed to flow into the secondary pass 20. The heat exchanger 1 may comprise only one secondary pass 20, but in other embodiments of the invention it could comprise two or more secondary passes 20. Next, the fluid is collected and directed towards the outlet $R_{out}$ of the heat exchanger 1.

Fig. 2 shows the schematic view of refrigerant flow arrangement in heat exchanger 1 comprising a first stack and a second stack of the tubes 4.

The first stack is formed by tube portions P1, P2 and S1, wherein tube portion P1 and tube portion P2 form the primary pass 10 within the first stack, and tube portion S1 forms the secondary pass 20 for the first stack. Analogically, the second stack is formed by secondary tube portions P3, P4 and S2, wherein tube portion P3 and tube portion P4 form the primary pass 10 for the second stack and tube portion S2 forms the secondary pass 20 for the second stack.

The fluid enters the heat exchanger 1 though inlet $R_{in}$ and then enters primary pass 10 simultaneously through tube portion P1 and tube portion P2. Next, the fluid enters tube portion S1 located between the tube portion P1 and tube portion P2, wherein P1, P2 and S1 are arranged in the first stack. The fluid performs a U-turn within the first stack, between the tube portion P1 and tube portion S1, and between the tube portion P2 and tube portion S1. Next, the fluid flows through tube portion S1 of the first stack. The fluid performs a U-turn between the tube portion S1 and tube portion S2. It is to be noted that the U-turn is performed between the first stack and the second stack, yet within the tubes 4 forming the secondary pass 20. The fluid flows further through the tube section S2 and is splitted into two streams, wherein one stream performs a U-turn with respect to the tube portion S2 and it flows into tube portion P3, and the other stream also performs a U-turn with respect to tube portion S2, but it enters tube portion P4. It is to be noted that the U-turns are preformed between the secondary section 20 and the primary section 10, within the second manifold 3. Finally, the fluid is directed towards an outlet $R_{out}$ in order to leave heat exchanger 1.

Fig. 3 shows an exploded view of heat exchanger 1 suitable for cooling down one medium (e.g. coolant) using the other (e.g. R744 refrigerant), wherein both media are encapsulated in one device. This type of heat exchanger 1 involves two fluid circuits encapsulated within one housing 30. In this type of heat exchanger 1, the coolant fluid delimited by a plastic housing 30 usually flows through and around the metallic core for refrigerant encapsulated within said housing 30.

The refrigerant circuit of the heat exchanger 1 may comprise the connection block 7, the first manifold 2, the second manifold 3, and plurality of tubes in-between 4.

The connection block 7 may be made of a unitary block of material, e.g. the lightweight metal alloy such as aluminum. The shape of the connection block 7 usually corresponds to the shape of an opening 31 located on the housing 30, so that the connection block 7 may partially project from the housing 30. Preferably, the connection block 7 is substantially rectangular. Further, the connection block 7 comprises at least one inlet $R_{in}$ and at least one outlet $R_{out}$, wherein the inlet $R_{in}$ is configured to introduce the first fluid into the first manifold 2 and the outlet $R_{out}$ is configured to collect the first fluid from the first manifold 2. The inlet $R_{in}$ and the outlet $R_{out}$, which usually penetrate through the body of the connection block 7 from its top portion towards the first manifold 2. The inlet $R_{in}$ and the outlet $R_{out}$ may have a circular cross-section. The connection block 7 may also comprise notches 8 that may serve to tightly connect the connector block 7 to the refrigerant circuit. The notches 8 may have different shape depending on desired connection type. The notches 8 presented in Fig 2 are cutouts in the connection block 7 material, however other shapes adapted to tightly connect the connector block 7 to the rest of the loop are also envisaged.

The connection block 7 may also comprise a sealing region suitable for receiving sealing means, e.g. a synthetic gasket. The sealing region may be in a form of cutout along the perimeter of the connection block 7. The sealing region ought to be deployed in the vicinity of the opening 31 located on the housing body 7 to provide the fluid-tight connection.

As Fig.3 shows, the tubes 4 are deployed between the first manifold 2 and the second manifold 3. The tubes 4 may be in a form of plates, and may comprise open ends introduced into the slots of respective headers 2b, 3b. The tubes 4 may comprise top and bottom sides and two lateral sides, wherein the top and bottom sides are have bigger surface than the lateral ones. The tubes 4 may further comprise a general plane that is parallel to the top and bottom sides thereof. The tubes 4 may be arranged in at least two parallel stacks, each of them comprising a top terminal tube and a bottom terminal tube wherein the top terminal tube and the bottom terminal tube are deployed on the terminal end of the same stack to form the primary pass 10. The term “parallel stacks” should be regarded as at least two stacks of tubes 4 arranged in parallel next to each other so that top and bottom sides are parallel to each other.

The open ends of the tubes 4 forming each stack are connected to the first manifold 2 on one side and with the second manifold on the other side. Further, tubes of each stack may be interlaced with heat dispersion portions 9, e.g. fins, turbulator fins, and other, wherein the stacks do not share the same set of dispersion portions 9. This allows the neighboring stacks to be materially separated, so that the gap between the stacks is created. The heat dispersion portions 9 may be interlaced between all tubes

4 forming the stack. Further, the tubes 4 may comprise bended ends that allow forming pairs of tubes 4, which can be introduced into corresponding slots. This enables reducing the amount of connection areas between the tubes 4 and the manifolds 2, 3 which are mostly vulnerable to leakage. Moreover, it facilitates the coolant fluid flow between the tubes 4 and the first manifold 2. Alternatively, the tubes 4 may be straight; however, the quantity of slots in the first manifold 2 and the second manifold 3 ought to be increased accordingly.

The first manifold 2 and the second manifold 3 may fluidly cooperate with each other in order to provide primary pass 10 and secondary pass 20 in the heat exchanger 1.

In the basic embodiment of an invention the total number of tubes 4 forming primary pass 10 is equal to the total number of tubes 4 forming second pass 20. This provides moderately uniform distribution of the fluid between the passes 10, 20. However, the total number of the tubes 4 forming the primary pass 10 may be different than the total number of the tubes 4 forming the second pass 20. For example, the number of tubes 4 forming the primary pass 10 could be greater than the number of tubes forming at least one secondary pass 20. It enables to further optimise the performance of the heat exchanger 1 in some applications.

As mentioned in the previous paragraphs, the heat exchanger 1 may comprise different types of tubes 4, depending on its type. As shown in Figs 2 and 3, the manifolds 2, 3 receive the pair of tubes 4 in one slot, in particular two tubes 4 both having a specific shape. This facilitates the production process, increases the efficiency of the heat exchanger, and most importantly, it reduces the risk of leakage from the most vulnerable area i.e. the connection between the tube 4 and the slot of the manifold 2, 3.

Fig. 4 shows in detail the sub-components forming the manifolds 2, 3. The connection block 7 may be fluidly connected with the first manifold 2, wherein the first manifold 2 participates in distribution and collection of the first fluid. The fluid is distributed by an inlet channel 21 which corresponds to the inlet $R_{in}$ in the connector 7, and it is collected by an outlet channel 22 which corresponds to the outlet $R_{out}$ of the connector 7. The first manifold 2 may comprise a first tank 2a and a first header 2b which are configured to determine the flow path to the tubes 4. The first tank 2a may be in a form of a unitary block of material comprising openings for fluid, which enable fluidal communication between the connection block 7 and the first manifold 2. Naturally, the first tank 2a is closed on the bottom by e.g. end plate 2c. The first tank 2a is fluidly connected with the first header 2b which comprises several sub- components. The first header 2b may comprise a first plate comprising slots for receiving the tubes 4, e.g. the single slot of the first plate may receive a pair of tubes 4. Alternatively, the slots are configured to receive only one tube 4, so that the quantity of slots deployed on the first plate is equal to the quantity of tubes 4. The first header 2b is tightly connected, for example crimped, with the first tank 2a to ensure proper positioning of the first header 2b with respect to the first tank 2a and to facilitate creation of the fluid-tight connection after e.g. brazing one to the other. Further, the first header 2b comprises at least one second plate deployed between the first plate and the first tank 2a. The second plate may comprise at least one opening configured to enable fluidal communication between the adjacent stacks of tubes 4. This enables fluidal communication between the second passes 20 inside the first manifold 2.

The first manifold 2 may further comprise at least one hump 6 which forms inlet channel 21 and outlet channel 22 for the fluid. The number of humps 6 may be equal to the number of channels 21, 22.

The passes 10, 20 may be defined by the first manifold 2 which comprises at least one dividing portion 5 located on the first tank 2a. The dividing portion 5 is configured to guide the refrigerant fluid through the first header 2b into desired tubes 4 forming the primary pass 10. The dividing portion 5 may block the fluidal communication between the inlet channel 21 of the first tank 2a and the tubes 4 forming the secondary pass 20. Further, the primary tank 2a is configured to collect the fluid and guide it towards the outlet $R_{out}$ of the connection block 7. The primary header 2b not only may fluidly connect first tank 2a and the tubes 4 forming the primary pass 10, but also fluidly connect the tubes 4 forming secondary passes 20 of neighboring stacks of tubes 4. Therefore, the first manifold 2 provides at least one U-turn for the refrigerant fluid.

The dividing portions 5 may be in a form of leftover material from the process of forming the inlet channel 21 and/or outlet channel 22 in the first tank 2a. The material forming the manifold is partially removed to provide fluidal communication between the first manifold 2 and one of the passages 10, 20. Consequently, the remaining material may form one or more dividing portions 5.

The second manifold 3 may comprise a second tank 3a and a second header 3b, wherein the second manifold 3 plays role of refrigerant fluid distributor. In other words, the second manifold 3 receives the fluid from one portion of the tubes 4 and transfers it to the other portion of the tubes 4.

The second header 3b may comprise at least one third plate comprising slots for receiving the tubes 4, e.g. the single slot of the third plate may receive a pair of tubes 4. Alternatively, the slots are configured to receive only one tube 4, so that the quantity of slots deployed on the third plate is equal to the quantity of tubes 4 received therein. As shown in Fig. 4, the second header comprises two third plates.

The second tank 3a comprises, inter alia, a cover plate which is substantially flat and provides closure of the second manifold 3 and at least one fourth plate configured to convey the first fluid from the top portion to the bottom portion of the second manifold 3. One of the ways to create the fourth plate may be forming a plate with a plurality of parallel openings extending from the top to the bottom portion thereof that will provide a fluidal communication with the sub-components of the second manifold 3.

The second header 3b is tightly connected, for example crimped, with the second tank 3a to ensure proper positioning of the second header 3b with respect to the second tank 3a and to facilitate creation of the fluid-tight connection after e.g. brazing one to the other.

To provide a fluid-tight and rigid connection between the tubes 4 and the manifolds 2, 3, the ends of each tube 4 are introduced into their respective manifolds 2, 3, so that they entirely penetrate the first plate and the third plate, and partially penetrate the second plate and the fourth plate.

Fig. 4 further comprises exemplary location of primary pass 10 and secondary pass 20. In particular, the primary passes 10 will be fluidly connected to four slots of each stack, two of them located on the top and another two on the bottom portion of the headers 2b and 3b. The second pass 20 is formed from four slots deployed in-between the slots forming primary pass 10.

In one example, two tubes 4 located on the top of each stack and two tubes 4 located on the bottom of each stack may be fixed (e.g. brazed) with six heat dispersion portions 9 interlaced in-between these tubes 4, whereas the top and the bottom tubes 4 may comprise the heat dispersion portions 9 fixed to the peripheral ends of the stack. Further, four tubes 4 located in the middle of the stack may be fixed to five inner heat dispersion portions 9. The features mentioned above does apply in particular to water chiller heat exchanger, but other types of heat exchangers are also envisaged, as they obey the same principles as the water chiller. For instance, air cooled condenser and air gas cooler comprise the top and the bottom tubes 4 which do not participate in fluid circulation, in water cooled condenser the first and the last passes are conducting coolant to improve resistance to high pressures which means, that the tubes 4 located on the top of the stack and the tubes 4 located on the bottom of the stack conduct refrigerant of greater heat exchange surface with second medium (e.g.) comparing to other passes.

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:

- a first manifold (2) comprising a first tank (2a) and a first header (2b),

- a second manifold (3), comprising a second tank (3a) and a second header (3b),

- a connection block (7) comprising an inlet $R_{in}$ and an outlet $R_{out}$ for a fluid, wherein the connection block (7) is fluidly connected with the first manifold (2),

- a plurality of tubes (4) forming at least one stack deployed between the first manifold (2) and the second manifold (3), the tubes (4) comprising open ends received in the manifolds (2, 3),

wherein the first manifold (2) and the second manifold (3) are fluidly connected with each other forming a primary pass (10) and a secondary pass (20) for a fluid, characterised in that the primary pass (10) is defined by at least two tubes (4) located on the terminal ends of the stack and the secondary pass (20) is located between the tubes (4) forming the primary pass (10).

2. The heat exchanger (1) according to claim 1, wherein the tubes (4) are arranged in a first stack comprising a first stacking direction, the second stack comprising a second stacking direction being parallel to the first stacking direction, wherein the second stack is distanced from the first stack in a third direction being perpendicular to the first stacking direction and the second stacking direction.

3. The heat exchanger (1) according to claim 2, wherein at least two tubes (4) located on the terminal ends of the first stack are at the same level as at least two tubes (4) located on the terminal ends of the second stack.

4. The heat exchanger (1) according to any of the preceding claims, wherein the first stack and second stack are fluidly connected with the first manifold (2) to provide at least one U-turn for the fluid, wherein the U-turn is formed between at least one tube (4) of the first stack and the corresponding tube (4) of the second stack.

5. The heat exchanger (1) according to any of the preceding claims, wherein the first stack comprises tube portions (P1), (P2) and (S1), wherein tube portion (P1) and tube portion (P2) form the primary pass (10) within the first stack and tube portion (S1) forms the secondary pass (20) for the first stack.

6. The heat exchanger (1) according to any of the preceding claims, wherein the second stack comprises secondary tube portions (P3), (P4) and (S2), wherein tube portion (P3) and tube portion (P4) form the primary pass (10) for the second stack and tube portion (S2) forms the secondary pass (20) for the second stack, wherein the tube portion (S2) is located between the tube portions (P3), (P4) forming the primary pass (10).

7. The heat exchanger (1) according to any of the preceding claims, wherein the first manifold (2) is divided into an inlet channel (21) and an outlet channel (22), wherein the inlet channel (21) is fluidly connected with the inlet $R_{in}$ of the connection block (7) and the primary pass (10) of the first stack of tubes (4), and the outlet channel (22) is fluidly connected with the outlet $R_{out}$ of the connection block (7) and the primary pass (10) of the second stack of tubes (4).

8. The heat exchanger (1) according to claim 7, wherein the first tank (2a) comprises at least one dividing portion (5) configured to block fluidal communication between the secondary pass (20), inlet channel (21) and outlet channel (22).

9. The heat exchanger (1) according to any of the preceding claims, wherein the tube portion (P1) and tube portion (P2) are fluidly connected with the inlet $R_{in}$ through the inlet channel (21).

10. The heat exchanger (1) according to any of the preceding claims, wherein the tube portion (P3) and tube portion (P4) are fluidly connected with the outlet $R_{out}$ through the outlet channel (22).

11. The heat exchanger (1) according to any of the preceding claims, wherein the tube portion (P1) and tube portion (P2) are fluidly isolated from tube portions (P3) and (P4) within the second manifold (3).

12. The heat exchanger (1) according to any of the preceding claims, wherein the tube portion (S1) is fluidly connected with tube portion (S2) to form at least one U-turn within the first manifold (2).

13. The heat exchanger (1) according to any of the preceding claims, wherein the tube portion (S1) is adapted to collect the fluid from tube portions (P1) and (P2) within the second manifold (2).

14. The heat exchanger (1) according to any of the preceding claims, wherein the tube portion (S2) is adapted to distribute the fluid between the tube portions (P3) and (P4) within the second manifold (3).

15. The heat exchanger (1) according to any of the preceding claims, wherein the first manifold (2) comprises at least one hump (6) configured to form at least one channel (21, 22) for the fluid inside the first tank (2a).

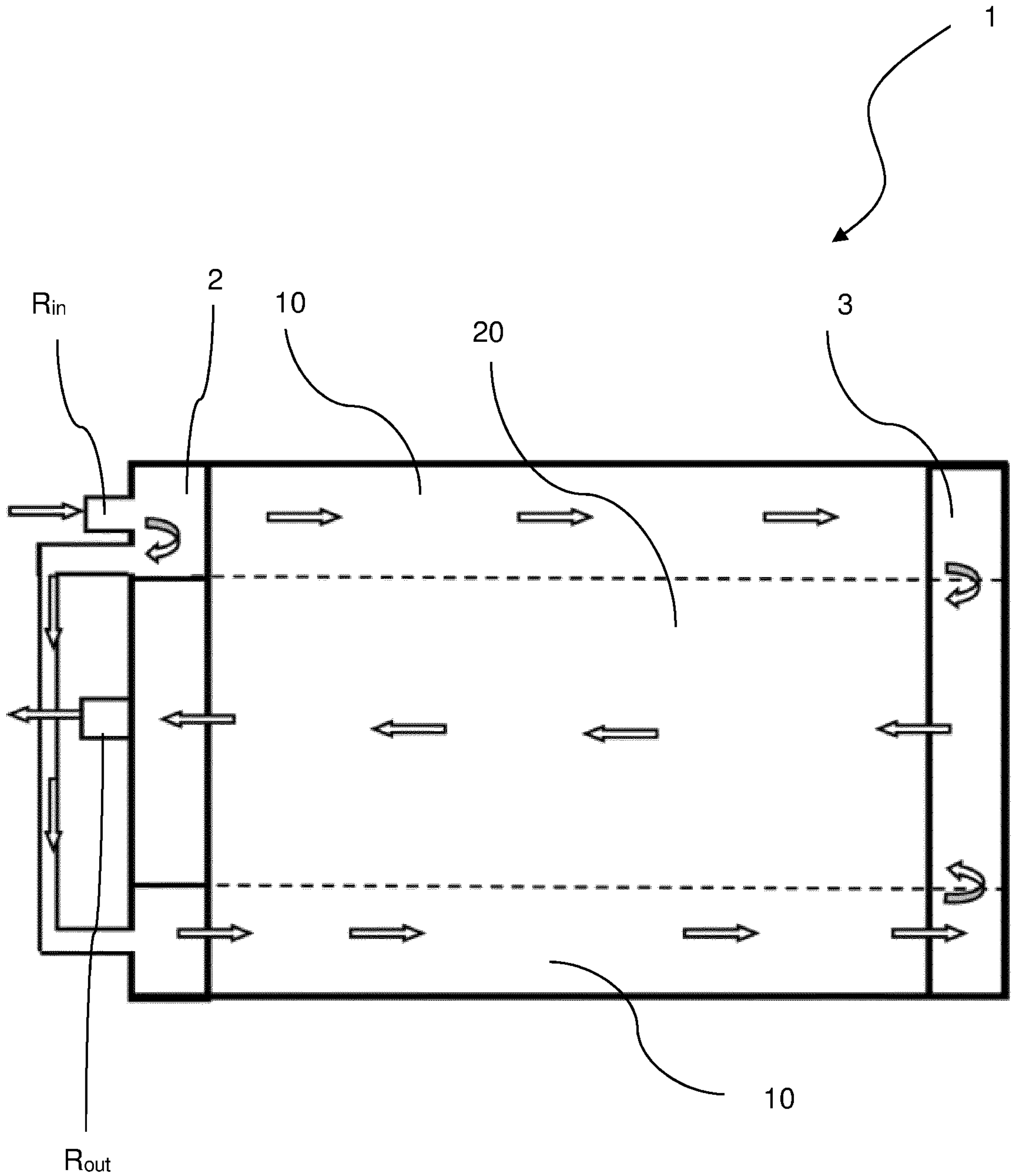


Fig. 1

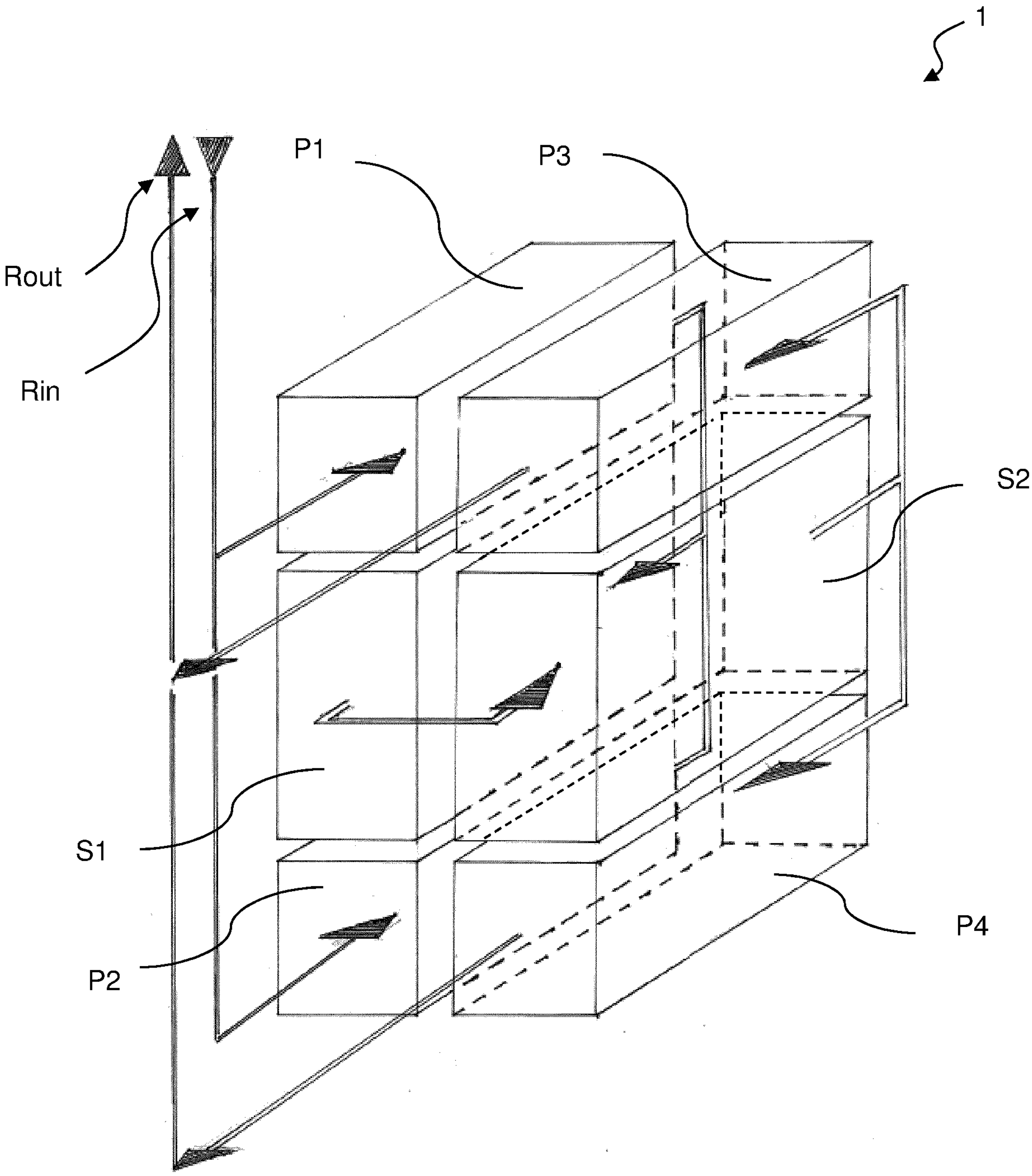


Fig. 2

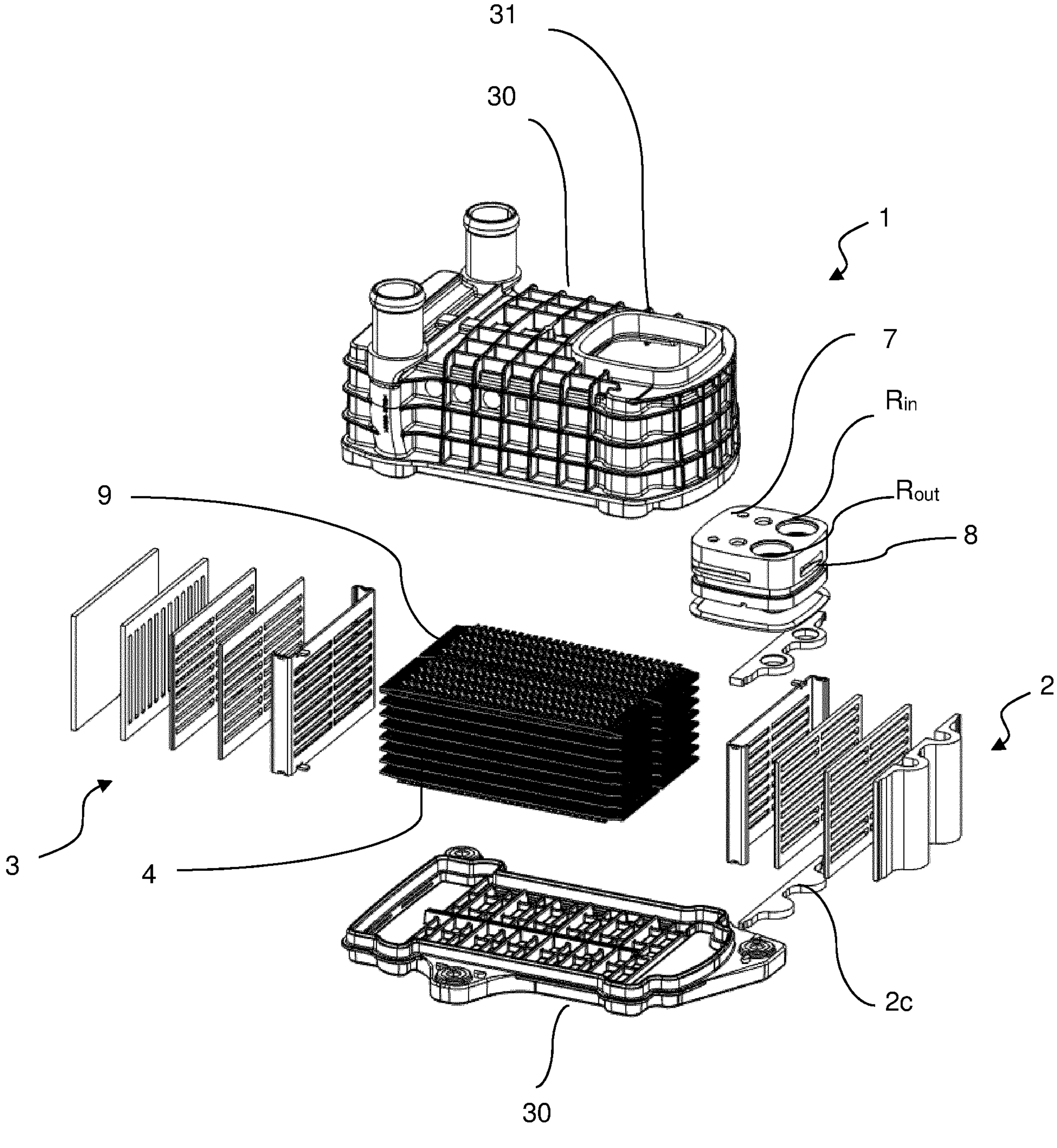


Fig. 3

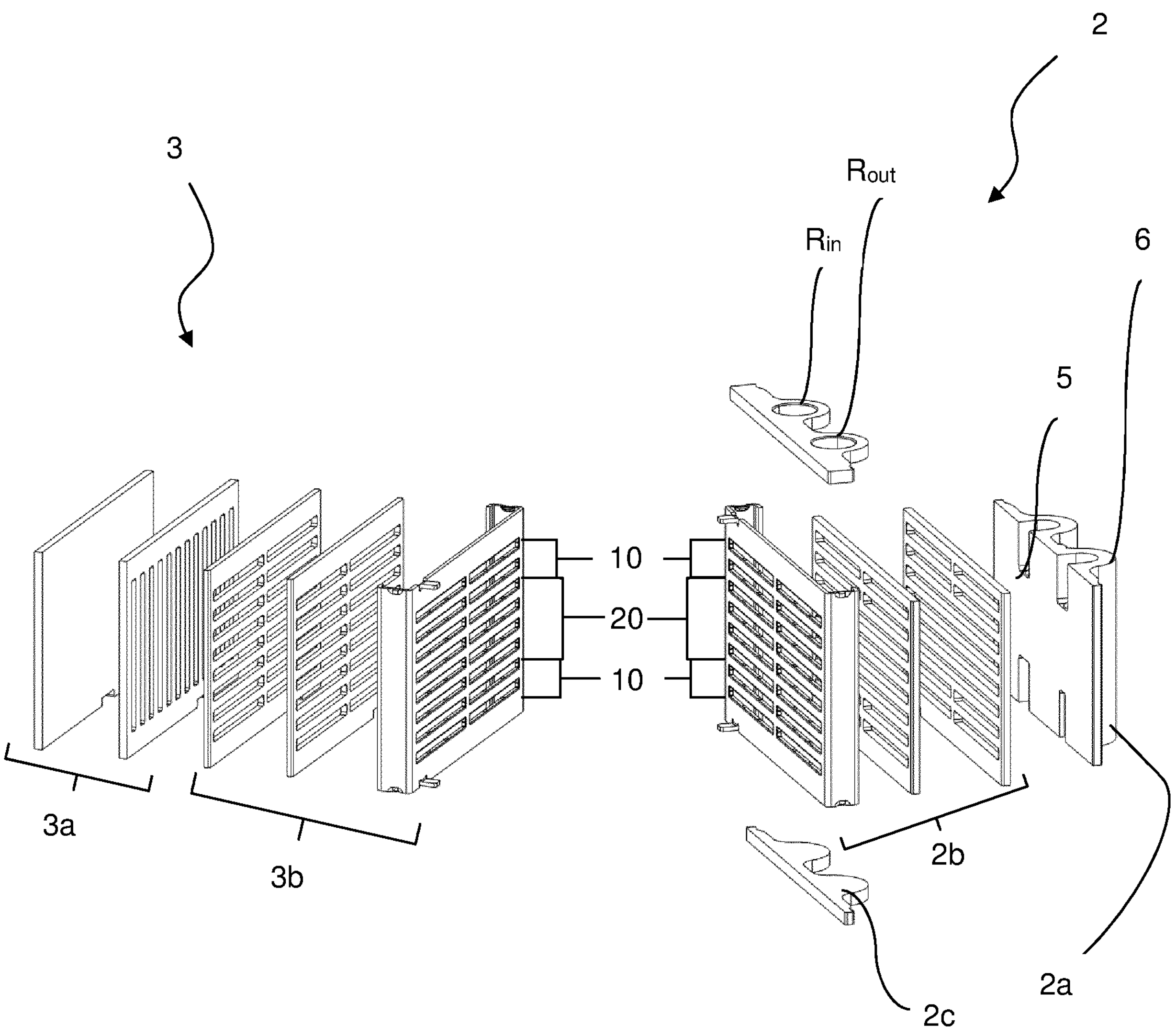


Fig. 4

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2021/053631

**A. CLASSIFICATION OF SUBJECT MATTER**
INV. F28F9/02 F28D1/053
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)
F28F 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. |
|---|---|---|
| X<br>Y<br>A | US 2019/107313 A1 (SAITO KAZUO [US] ET AL) 11 April 2019 (2019-04-11)<br>figure 5B<br>----- | 1,3-5, 7-9,15<br>2<br>6,10-14 |
| X | US 7 703 282 B1 (MEISSNER ALAN PAUL [US] ET AL) 27 April 2010 (2010-04-27)<br>figure 1<br>----- | 1 |
| X | EP 1 410 929 A2 (DENSO CORP [JP]) 21 April 2004 (2004-04-21)<br>figure 1<br>----- | 1 |
| X | US 2011/030420 A1 (KIRKWOOD ALLEN C [US]) 10 February 2011 (2011-02-10)<br>figure 2<br>----- | 1 |
| | -/-- | |

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 8 March 2021 | 17/03/2021 |

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

1

## INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2021/053631

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | DE 11 2013 005408 T5 (DENSO CORP [JP]) 30 July 2015 (2015-07-30) figure 3 ----- | 2 |

1

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2021/053631

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| US 2019107313 A1 | 11-04-2019 | US 2016054077 A1 | 25-02-2016 |
| | | US 2019107313 A1 | 11-04-2019 |
| US 7703282 B1 | 27-04-2010 | NONE | |
| EP 1410929 A2 | 21-04-2004 | DE 60306291 T2 | 03-05-2007 |
| | | EP 1410929 A2 | 21-04-2004 |
| | | ES 2269892 T3 | 01-04-2007 |
| | | JP 3982379 B2 | 26-09-2007 |
| | | JP 2004138260 A | 13-05-2004 |
| US 2011030420 A1 | 10-02-2011 | CN 102016484 A | 13-04-2011 |
| | | EP 2291600 A2 | 09-03-2011 |
| | | ES 2689931 T3 | 16-11-2018 |
| | | US 2011030420 A1 | 10-02-2011 |
| | | WO 2009137226 A2 | 12-11-2009 |
| DE 112013005408 T5 | 30-07-2015 | CN 104781627 A | 15-07-2015 |
| | | DE 112013005408 T5 | 30-07-2015 |
| | | JP 5920175 B2 | 18-05-2016 |
| | | JP 2014098498 A | 29-05-2014 |
| | | US 2015292820 A1 | 15-10-2015 |
| | | WO 2014076874 A1 | 22-05-2014 |