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(54) **HEAT EXCHANGER, PARTICULARLY A INNER CONDENSER FOR HEAT PUMP HVAC SYSTEMS**

(57) A heat exchanger comprises a first heat exchange row (10) and a second heat exchange row (20), and also comprises a fluid connection element (40; 40'; 40"; 40''') that connects a first row distributor (11) to a second row distributor (21). The fluid connection element is an element (40) which is fixedly connected to the lateral walls (11a, 21a) of the first row distributor (11) and of the second row distributor (21) and in which a plurality of conduits (41) is formed that fluidically connect the first row distributor (11) to the second row distributor (21), or is an element (40'; 40"; 40''') which is fixedly connected at the top to ends (11e, 21e) of the first row distributor (11) and of the second row distributor (21) and in which a conduit (41'; 41''') is formed that fluidically connects the first row distributor (11) to the second row distributor (21).

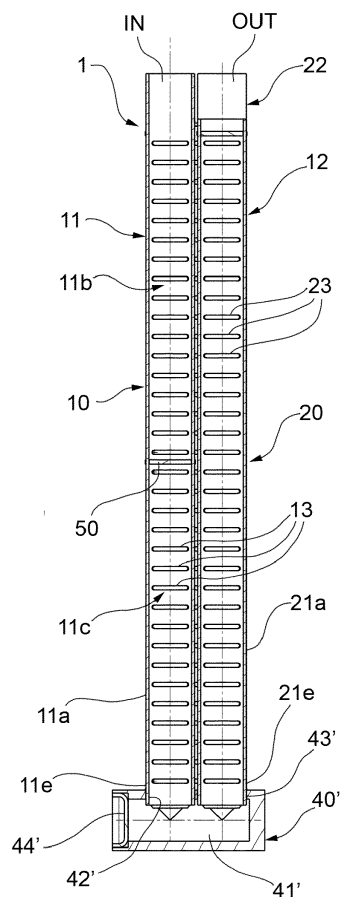


FIG. 7

Description

[0001] This invention relates in general to HVAC systems of motor vehicles, more specifically to HVAC systems of electric vehicles.

[0002] Heat pump systems are increasingly being used for air conditioning in electric vehicles. In terms of space requirements, one critical element is the inner condenser.

[0003] The object of the invention is to provide as compact a solution as possible for an inner condenser for a heat pump HVAC system.

[0004] This object is achieved according to the invention by a heat exchanger comprising a first heat exchange row and a second heat exchange row overlapping with each other, wherein each heat exchange row comprises a first distributor and a second distributor and a plurality of parallel, coplanar tubes interconnecting the first distributor and the second distributor,

wherein each of said distributors has a tubular body, on a lateral wall of which a plurality of slots is formed, in each of which slots one end of a relevant tube is inserted,

wherein one of said first distributor and second distributor of the first heat exchange row has an inlet of the heat exchanger and one of said first distributor and second distributor of the second heat exchange row has an outlet of the heat exchanger,

wherein the heat exchanger further comprises a fluid connection element connecting one of said first distributor and second distributor of the first heat exchange row, hereinafter referred to as the first row distributor, to one of said first distributor and second distributor of the second heat exchange row, hereinafter referred to as the second row distributor, wherein said fluid connection element is an element which is fixedly connected at the top to ends of the first row distributor and of the second row distributor and in which a conduit is formed that fluidically connects the first row distributor to the second row distributor,

wherein the fluid connection element is formed as a hollow block in which two openings are formed, in which openings the ends of the first row distributor and of the second row distributor are inserted, respectively, or is formed as a hollow plug inserted into the ends of the first row distributor and of the second row distributor.

[0005] Although this invention has been designed in particular for use with heat pump HVAC systems, it is evident how it may be applied more generally to double-row heat exchangers, in particular in cases where the heat exchanger needs to have a particularly compact structure.

[0006] Preferred embodiments of the invention are defined in the dependent claims, which are to be understood

as an integral part of this description.

[0007] Further features and advantages of the invention will become clearer from the following detailed description of an embodiment of the invention, made with reference to the accompanying drawings, provided purely for illustrative and non-limiting purposes, in which:

- Fig. 1 is a perspective view of a heat exchanger which is not claimed;
- Fig. 2 and 3 are, respectively, a front view and a sectional view of the heat exchanger in Fig. 1;
- Fig. 4 is a perspective view of a fluid connection element of the heat exchanger in Fig. 1;
- Fig. 5 is a perspective view of a heat exchanger according to the invention;
- Fig. 6 and 7 are, respectively, a front view and a sectional view of the heat exchanger in Fig. 5;
- Fig. 8 and 9 are, respectively, a perspective view and a sectional view of a fluid connection element of the heat exchanger in Fig. 5;
- Fig. 10 and 11 are perspective views, respectively, of a second and a third embodiment of the invention;
- Fig. 12 and 13 are, respectively, a perspective view and a sectional view of a fluid connection element of the heat exchanger in Fig. 11;
- Fig. 14 and 15 are perspective views, respectively, of an example which is not claimed; and
- Fig. 16 is a simplified diagram which shows an example of a heat pump HVAC system.

[0008] With reference to Fig. 1 to 3, a heat exchanger is shown, indicated as a whole by reference sign 1. In the example shown, the heat exchanger 1 is a heat transfer fluid/air heat exchanger, in particular an inner condenser of a heat pump HVAC system for an electric vehicle. An example of this system is shown in Fig. 16. IC denotes an inner condenser with which a fan B is associated, which fan is provided for supplying heated air to the interior of the passenger compartment of the vehicle. C denotes a compressor for circulating the heat transfer fluid inside the circuit of the heat pump. EV denotes an expansion valve, and OC denotes an outer condenser provided to absorb energy from the outside air. Lastly, WHE denotes a recovery heat exchanger which is provided to recover waste heat from the electronic components and the battery of the vehicle.

[0009] With reference again to Fig. 1 to 3, the heat exchanger 1 is a double-row heat exchanger; it therefore comprises a first heat exchange row 10 and a second heat exchange row 20 which overlap with each other. The overlapping relationship relates to the direction of the air which flows through the heat exchanger 1 and exchanges heat with the heat transfer fluid inside the heat exchanger 1; this direction is orthogonal to the main faces of the heat exchanger 1. The first heat exchange row 10 comprises a first distributor 11 and a second distributor 12 and a plurality of parallel, coplanar tubes 13 interconnecting the first distributor 11 and the second

distributor 12. Fins 14 are arranged between adjacent tubes 13, which fins are not shown in detail. The second heat exchange row 20 comprises a first distributor 21 and a second distributor 22 and a plurality of parallel, coplanar tubes (not shown in the figures) interconnecting the first distributor 21 and the second distributor 22. Fins are arranged between adjacent tubes, which fins are not visible in the figures. Two lateral plates 31 and 32 are fixedly connected to the opposite sides of the mass formed by the tubes 13 of the first heat exchange row 10 and by the tubes of the second heat exchange row 20.

[0010] The aforementioned elements are joined to each other in a manner known per se, for example by means of braze-welding.

[0011] Each of the distributors 11, 12, 21, 22 has a tubular body, for example having a circular cross section, on a lateral wall 11a, 12a, 21a, 22a of which a plurality of slots is formed, in each of which slots one end of a relevant tube 13 is inserted.

[0012] The first distributor 11 of the first heat exchange row 10 has an inlet I of the heat exchanger 1.

[0013] The second distributor 22 of the second heat exchange row 20 has an outlet OUT of the heat exchanger 1. For convenience, hereinafter reference will only be made to this arrangement. However, the arrangement of the inlet and outlet may be different to that described herein.

[0014] The heat exchanger 1 also comprises a fluid connection element 40 which connects the first distributor 11 of the first heat exchange row 10 to the first distributor 21 of the second row 20. For convenience, hereinafter reference will only be made to this arrangement. However, the arrangement of the fluid connection element may be different to that described herein.

[0015] A partition 50 is arranged within the first distributor 11 of the first heat exchange row 10, which partition divides the first distributor 11 of the first heat exchange row 10 into an inlet chamber 11b and an outlet chamber 11c. For convenience, hereinafter reference will only be made to this arrangement. However, the arrangement of the partition may be different to that described herein, or the partition may even be absent.

[0016] The fluid connection element 40 connects the outlet chamber 11c of the first distributor 11 of the first heat exchange row 10 to the first distributor 21 of the second heat exchange row 20. For convenience, hereinafter reference will only be made to this arrangement. However, the arrangement of the fluid connection element may be different to that described herein.

[0017] In the heat exchanger 1 described above, the heat transfer fluid follows a U-shaped path in the first heat exchange row 10, by entering from the inlet IN of the first distributor 11 of the first heat exchange row 10 and flowing through the inlet chamber 11b of the first distributor 11 of the first heat exchange row 10, the tubes 13 connected thereto, the second distributor 12 of the first heat exchange row 10, and the tubes 13 which connect the second distributor 12 of the first heat exchange

row 10 to the outlet chamber 11c of the first distributor 11 of the first heat exchange row 10. The heat transfer fluid flows from the outlet chamber 11c of the first distributor 11 of the first heat exchange row 10, through the fluid connection element 40, to the first distributor 21 of the second heat exchange row 20. The heat transfer fluid thus follows a single-pass path in the second heat exchange row 20, by flowing through the first distributor 21 of the second heat exchange row 20, the tubes of the second heat exchange row 20, and the second distributor 22 of the second heat exchange row 20, and finally exiting from the outlet OUT of the second distributor 22 of the second heat exchange row 20.

[0018] With reference again to Fig. 4, the fluid connection element 40 is a monolithic element which is made of metal material and fixed to the lateral walls 11a and 21a of the relevant first row distributor and second row distributor, which in the example shown are the first distributor 11 of the first heat exchange row 10 and the first distributor 21 of the second heat exchange row 20. A plurality of conduits 41 is formed in the fluid connection element 40, which conduits fluidically connect the first row distributor 11 and the second row distributor 21.

[0019] The fluid connection element 40 is joined to the lateral walls 11a and 21a of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20 by means of material coupling, for example by means of braze-welding. For this purpose, the fluid connection element 40 comprises two junction surfaces 42 and 43 which correspond, respectively, to the lateral wall 11a of the first distributor 11 of the first heat exchange row 10 and to the lateral wall 21a of the first distributor 21 of the second heat exchange row 20. The opposite ends of each of the conduits 41 lead, respectively, into one and the other of the junction surfaces 42 and 43, and correspond to respective holes made in the lateral walls 11a and 21a of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20.

[0020] With reference to Fig. 5 to 7, a heat exchanger according to another embodiment of the invention is shown. Elements corresponding to those of the preceding embodiment have been assigned the same reference signs; these elements will not be described again. In Fig. 7, it is also possible to see the tubes of the second heat exchange row, which tubes are denoted by reference sign 23.

[0021] The heat exchanger in Fig. 5 to 7 differs from that in Fig. 1 to 3 on account of the structure of the fluid connection element, which is now denoted by reference sign 40' and is also shown in Fig. 8 and 9.

[0022] The fluid connection element 40' is a hollow monolithic block which is made of metal material and fixedly connected at the top to ends 11c and 12e, respectively, of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20. A conduit or cavity 41' is formed in the fluid connection element 40', which conduit or cavity flu-

idically connects the first distributor 11 of the first heat exchange row 10 to the first distributor 21 of the second heat exchange row 20.

[0023] The fluid connection element 40' is joined to the ends 11e and 21e of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20 by means of material coupling, for example by means of braze-welding. For this purpose, two openings or seats 42' and 43' are formed in the fluid connection element 40' and connected to the conduit 41', in which openings or seats the ends 11e and 21e of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20 are inserted, respectively. The conduit or cavity 41' of the fluid connection element 40' is also closed by a cover 44' (shown in Fig. 5 to 7).

[0024] With reference to Fig. 10, a further embodiment of the invention is shown. Elements corresponding to those of the preceding embodiments have been assigned the same reference signs; these elements will not be described again. For simplicity, Fig. 10 shows only the detail of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20, which distributors are connected at the end to the fluid connection element, now denoted by 40".

[0025] The fluid connection element 40" is a hollow monolithic plug which is made of metal material, is fork-shaped, and is inserted into the ends 11c and 12e of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20. The fluid connection element 40" is joined to the ends 11c and 21e of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20 by means of material coupling, for example by means of braze-welding. A conduit or cavity (not shown in Fig. 10) is formed in the fluid connection element 40", which conduit or cavity fluidically connects the first distributor 11 of the first heat exchange row 10 to the first distributor 21 of the second heat exchange row 20. This conduit or cavity is closed, at the opposite end to the ends 11c and 21e of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20, by a cover 44".

[0026] With reference to Fig. 11 to 13, a further embodiment of the invention is shown. Elements corresponding to those of the preceding embodiments have been assigned the same reference signs; these elements will not be described again. For simplicity, Fig. 11 shows only the detail of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20, which distributors are connected at the end to the fluid connection element, now denoted by 40'''.

[0027] The fluid connection element 40''' is a hollow monolithic plug which is made of metal material, is fork-shaped, and is inserted into the ends 11c and 12e of the first distributor 11 of the first heat exchange row 10 and

of the first distributor 21 of the second heat exchange row 20. The fluid connection element 40''' is joined to the ends 11c and 21e of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20 by means of material coupling, for example by means of braze-welding. A conduit or cavity 41''' is formed in the fluid connection element 40''', which conduit or cavity fluidically connects the first distributor 11 of the first heat exchange row 10 to the first distributor 21 of the second heat exchange row 20. This conduit or cavity 41''' is closed, at the opposite end to the ends 11e and 21e of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20, by a cover 44'''.

[0028] Respective notches 11n and 21n are formed on the lateral walls 11a and 21a of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20, at the ends 11c and 21e of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20, in which notches the fluid connection element 40''' is inserted. This arrangement makes it possible for an axial extension of the joint between the connection element and distributors to be smaller than the embodiment in Fig. 10 or even equal to zero in the event that the fluid connection element 40''' is completely inserted within the bulk of the distributors 11 and 21, as in the example shown.

[0029] With reference to Fig. 14, a further embodiment of the invention is shown. Elements corresponding to those of the preceding embodiments have been assigned the same reference signs; these elements will not be described again. For simplicity, Fig. 14 shows only the detail of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20, which distributors are connected at the end to the fluid connection element, now denoted by 40''''.

[0030] The fluid connection element 40'''' is an elbow tube which is made of metal material and has opposite ends inserted into the ends 11c and 12e of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20. The fluid connection element 40'''' is joined to the ends 11e and 21e of the first distributor 11 of the first heat exchange row 10 and of the first distributor 21 of the second heat exchange row 20 by means of material coupling, for example by means of braze-welding.

[0031] Fig. 15 shows a further embodiment of the invention which is analogous to that in Fig. 14 but in which the fluid connection element 40''''', instead of being monolithic, is formed by two shells 42'''' and 43'''' which are fixedly connected to each other, for example by means of crimping.

Claims

1. A heat exchanger comprising a first heat exchange

row (10) and a second heat exchange row (20) overlapping with each other, wherein each heat exchange row (10, 20) comprises a first distributor (11, 21) and a second distributor (12, 22) and a plurality of parallel, coplanar tubes (13, 23) interconnecting the first distributor (11, 21) and the second distributor (12, 22),

wherein each of said distributors (11, 21, 12, 22) has a tubular body, on a lateral wall (11a, 21a, 12a, 22a) of which a plurality of slots is formed, in each of which slots one end of a relevant tube (13, 23) is inserted, wherein one of said first distributor and second distributor of the first heat exchange row has an inlet (IN) of the heat exchanger and one of said first distributor and second distributor of the second heat exchange row has an outlet (OUT) of the heat exchanger, wherein the heat exchanger further comprises a fluid connection element (40') connecting one of said first distributor and second distributor of the first heat exchange row, hereinafter referred to as the first row distributor (11), to one of said first distributor and second distributor of the second heat exchange row, hereinafter referred to as the second row distributor (21), wherein said fluid connection element is an element (40') which is fixedly connected at the top to ends (11e, 21e) of the first row distributor (11) and of the second row distributor (21) and in which a conduit (41') is formed that fluidically connects the first row distributor (11) to the second row distributor (21), wherein the fluid connection element (40') is formed as a hollow block in which two openings (42', 43') are formed, in which openings the ends (11e, 21e) of the first row distributor (11) and of the second row distributor (21) are inserted, respectively.

2. The heat exchanger according to claim 1, wherein the first distributor (11) of the first heat exchange row (10) has the inlet (IN) of the heat exchanger,

wherein the second distributor (22) of the second heat exchange row (20) has the outlet (OUT) of the heat exchanger, wherein a partition (50) is arranged within the first distributor (11) of the first heat exchange row (10), which partition divides the first distributor (11) of the first heat exchange row (10) into an inlet chamber (11b) and an outlet chamber (11c), wherein the first row distributor is the first distributor (11) of the first heat exchange row (11) and the second row distributor is the first distributor (21) of the second heat exchange row (20), and wherein the fluid connection element (40')

connects the outlet chamber (11c) of the first distributor (11) of the first heat exchange row (10) to the first distributor (21) of the second heat exchange row (20).

3. A heat exchanger comprising a first heat exchange row (10) and a second heat exchange row (20) overlapping with each other, wherein each heat exchange row (10, 20) comprises a first distributor (11, 21) and a second distributor (12, 22) and a plurality of parallel, coplanar tubes (13, 23) interconnecting the first distributor (11, 21) and the second distributor (12, 22),

wherein each of said distributors (11, 21, 12, 22) has a tubular body, on a lateral wall (11a, 21a, 12a, 22a) of which a plurality of slots is formed, in each of which slots one end of a relevant tube (13, 23) is inserted, wherein one of said first distributor and second distributor of the first heat exchange row has an inlet (IN) of the heat exchanger and one of said first distributor and second distributor of the second heat exchange row has an outlet (OUT) of the heat exchanger, wherein the heat exchanger further comprises a fluid connection element (40"; 40''') connecting one of said first distributor and second distributor of the first heat exchange row, hereinafter referred to as the first row distributor (11), to one of said first distributor and second distributor of the second heat exchange row, hereinafter referred to as the second row distributor (21), wherein said fluid connection element is an element (40"; 40''') which is fixedly connected at the top to ends (11e, 21e) of the first row distributor (11) and of the second row distributor (21) and in which a conduit (41''') is formed that fluidically connects the first row distributor (11) to the second row distributor (21), wherein the fluid connection element (40"; 40''') is formed as a hollow plug inserted into the ends (11e, 21e) of the first row distributor (11) and of the second row distributor (21).

4. The heat exchanger according to claim 3, wherein respective notches (11n, 21n) are formed on the lateral walls (11a, 21a) of the first row distributor (11) and of the second row distributor (21), at the ends (11e, 21e) of the first row distributor (11) and of the second row distributor (21), in which notches the fluid connection element (40''') is inserted.

5. The heat exchanger according to claim 3 or 4, wherein the first distributor (11) of the first heat exchange row (10) has the inlet (IN) of the heat exchanger,

wherein the second distributor (22) of the sec-

ond heat exchange row (20) has the outlet (OUT) of the heat exchanger, wherein a partition (50) is arranged within the first distributor (11) of the first heat exchange row (10), which partition divides the first distributor (11) of the first heat exchange row (10) into an inlet chamber (11b) and an outlet chamber (11c), wherein the first row distributor is the first distributor (11) of the first heat exchange row (11) and the second row distributor is the first distributor (21) of the second heat exchange row (20), and wherein the fluid connection element (40"; 40") connects the outlet chamber (11c) of the first distributor (11) of the first heat exchange row (10) to the first distributor (21) of the second heat exchange row (20).

6. A heat pump HVAC system for a vehicle, comprising an inner condenser (IC), wherein said inner condenser is a heat exchanger according to any of the preceding claims.
7. The system according to claim 6, further comprising a compressor (C) for circulating the heat transfer fluid inside a circuit of the heat pump, an expansion valve (EV), an outer condenser (OC) provided to absorb energy from the outside air, and a recovery heat exchanger (WHE) provided to recover waste heat from electronic components and the battery of the vehicle.

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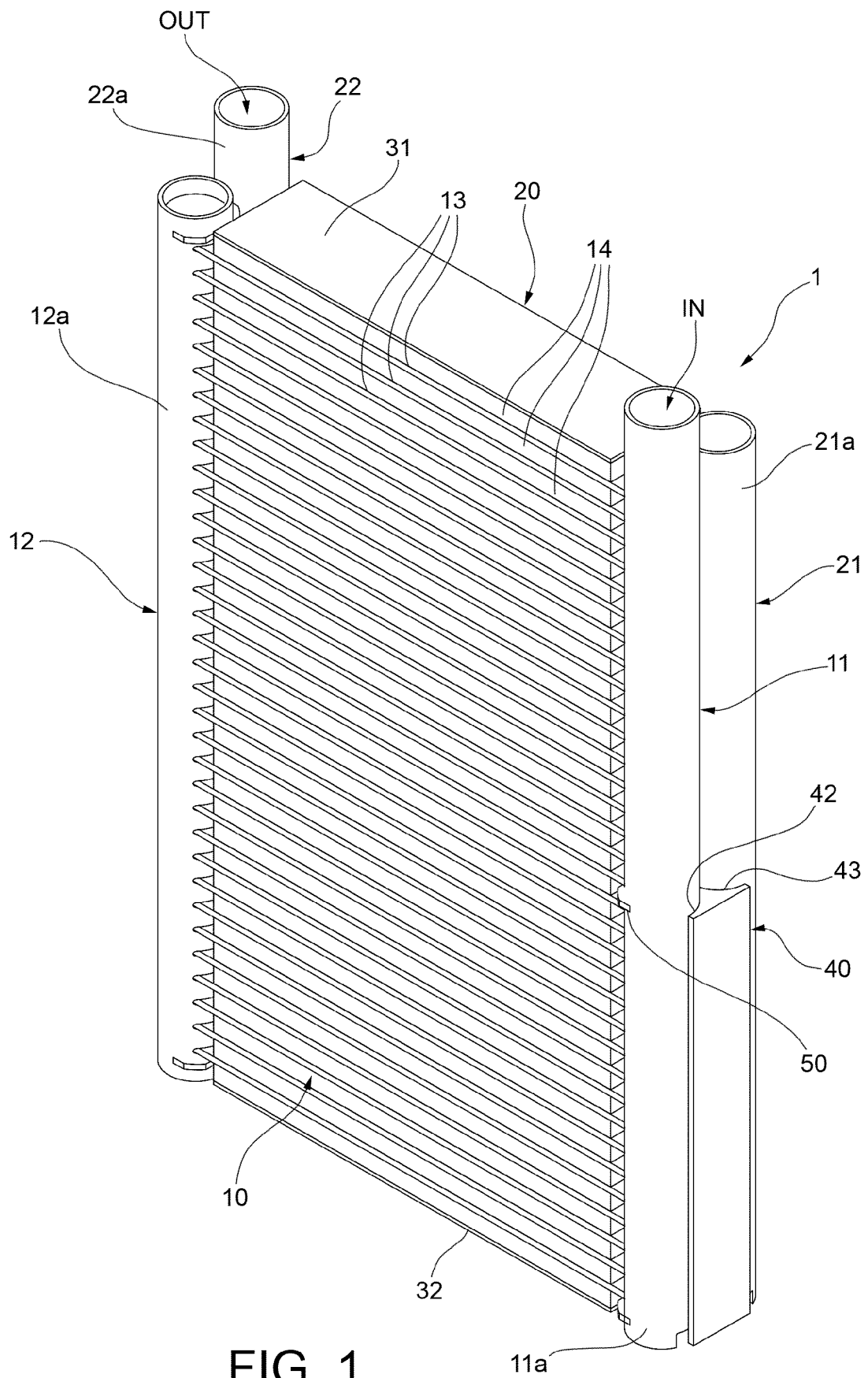


FIG. 2

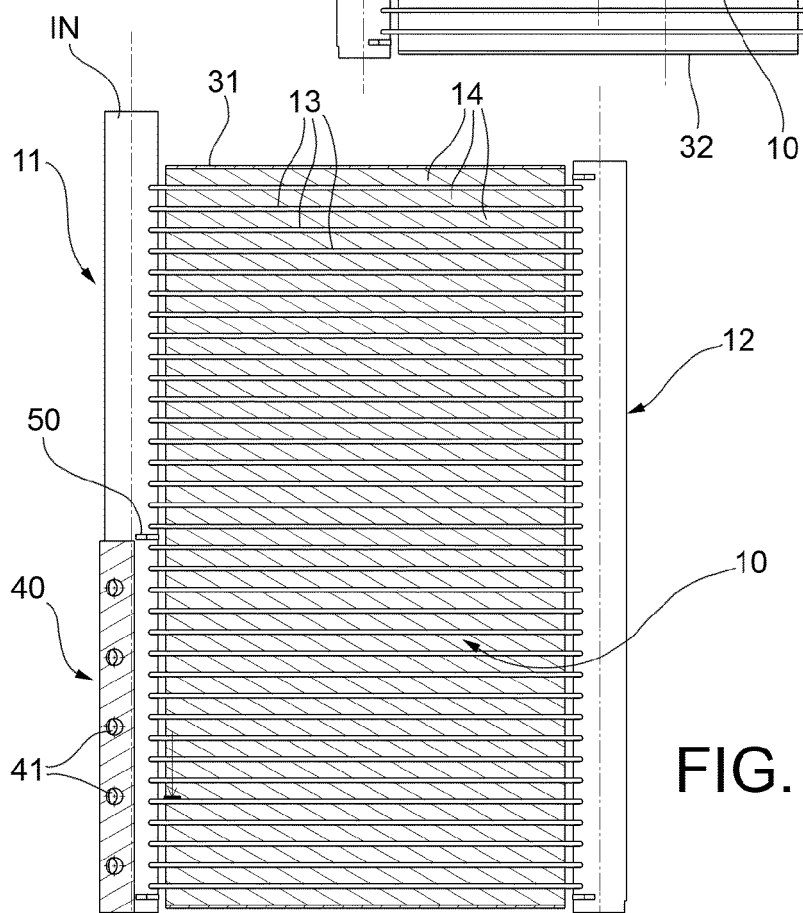
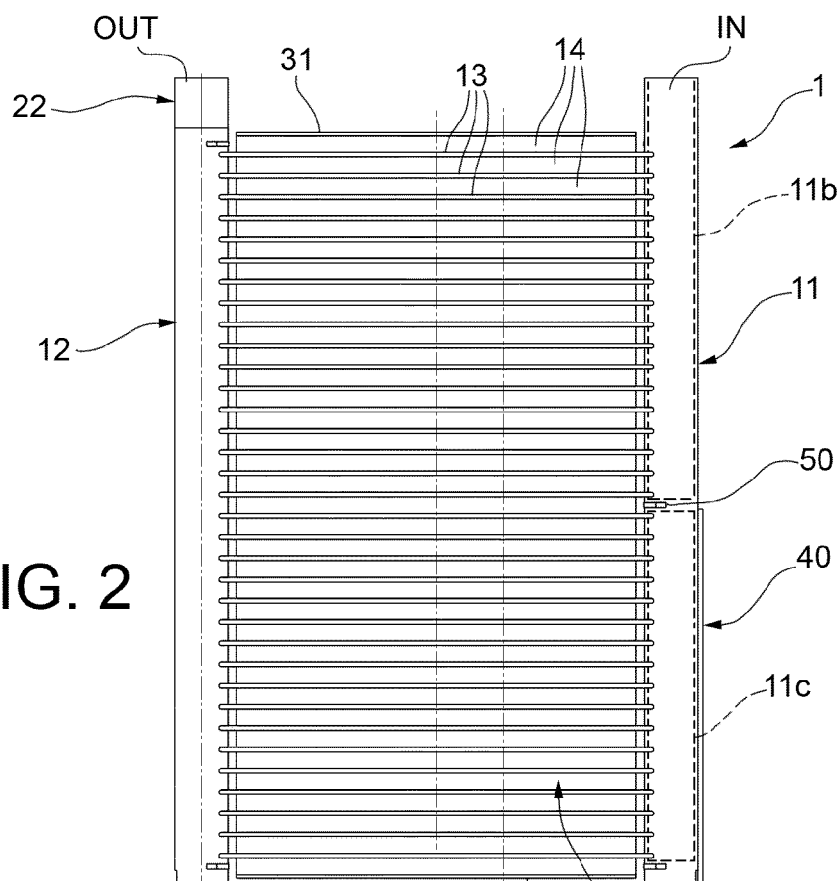


FIG. 3

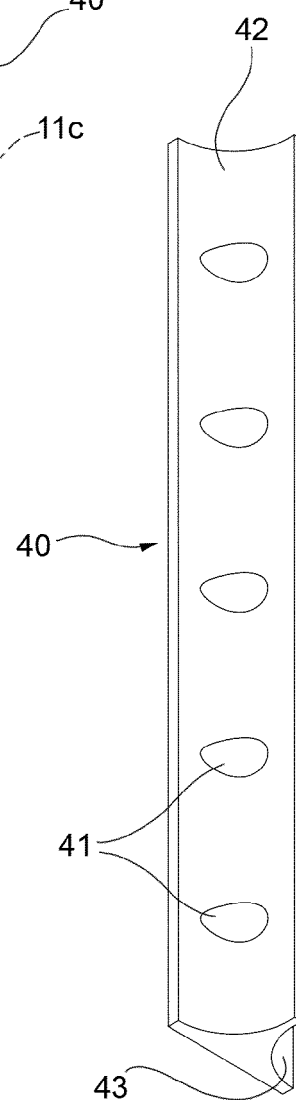
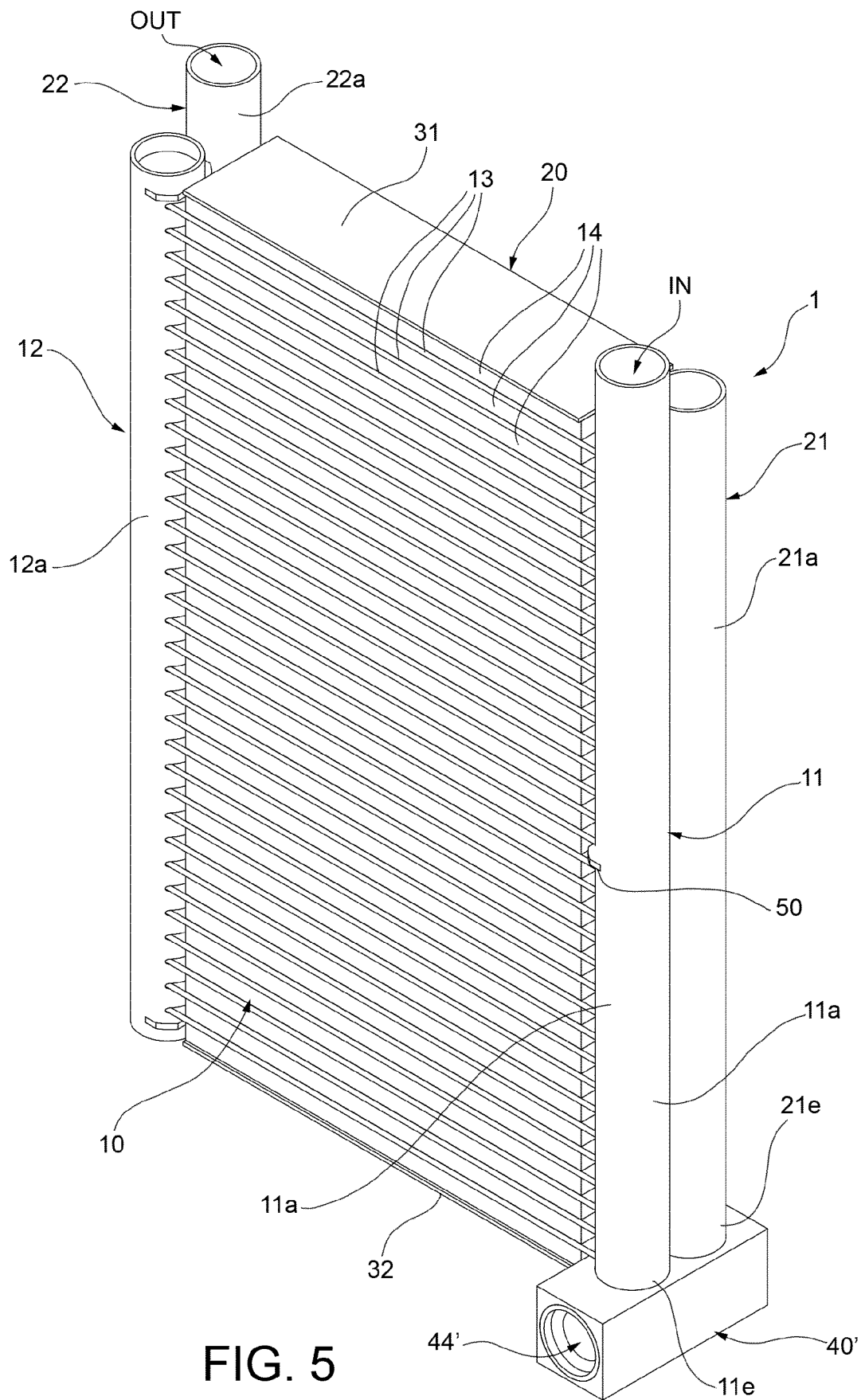
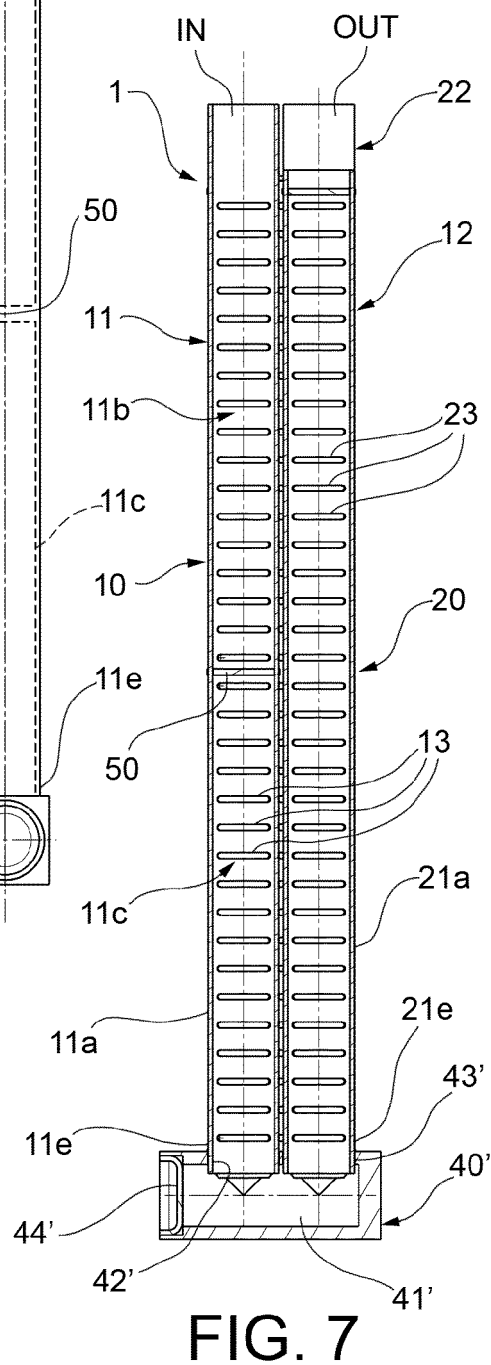
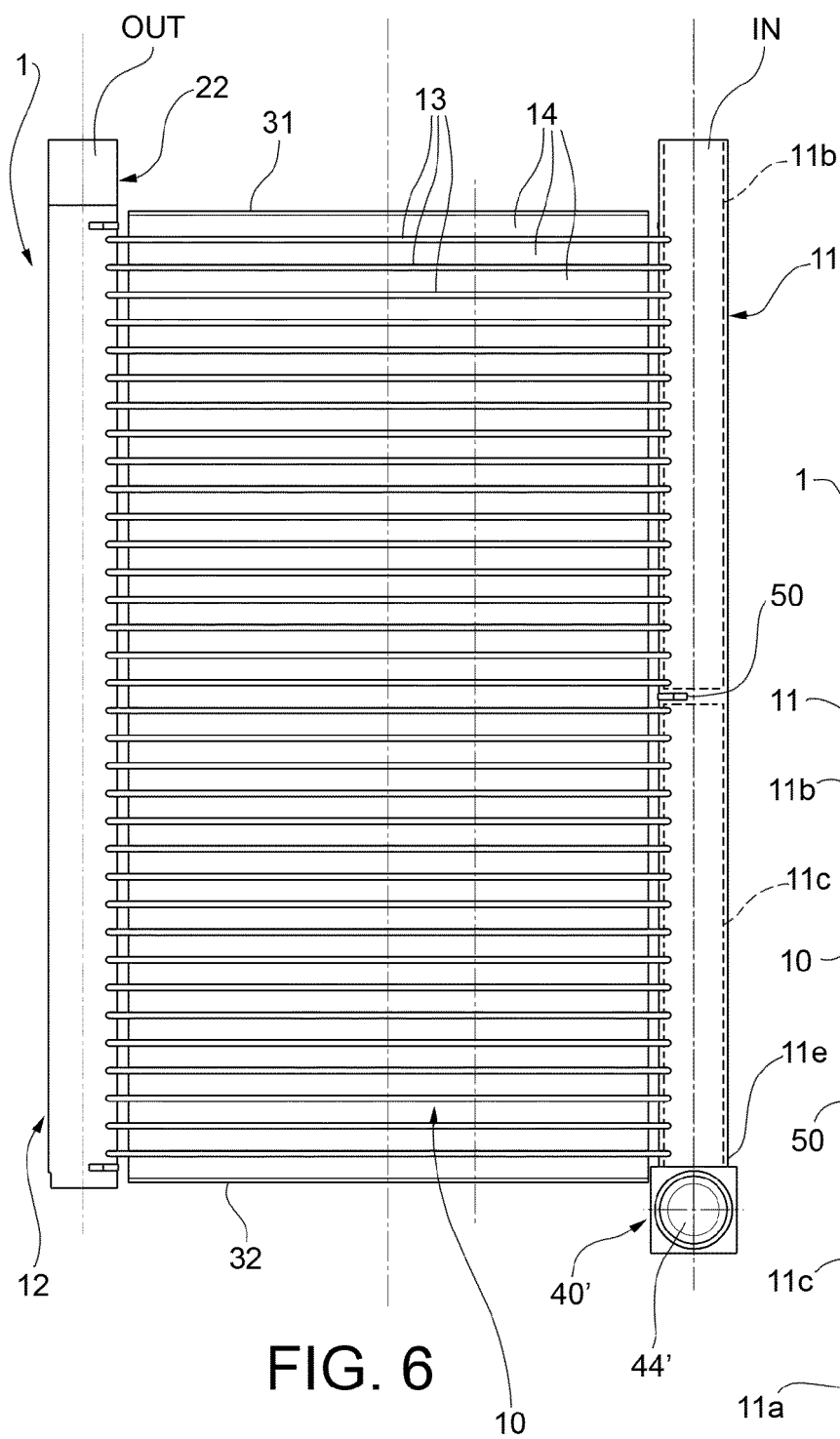
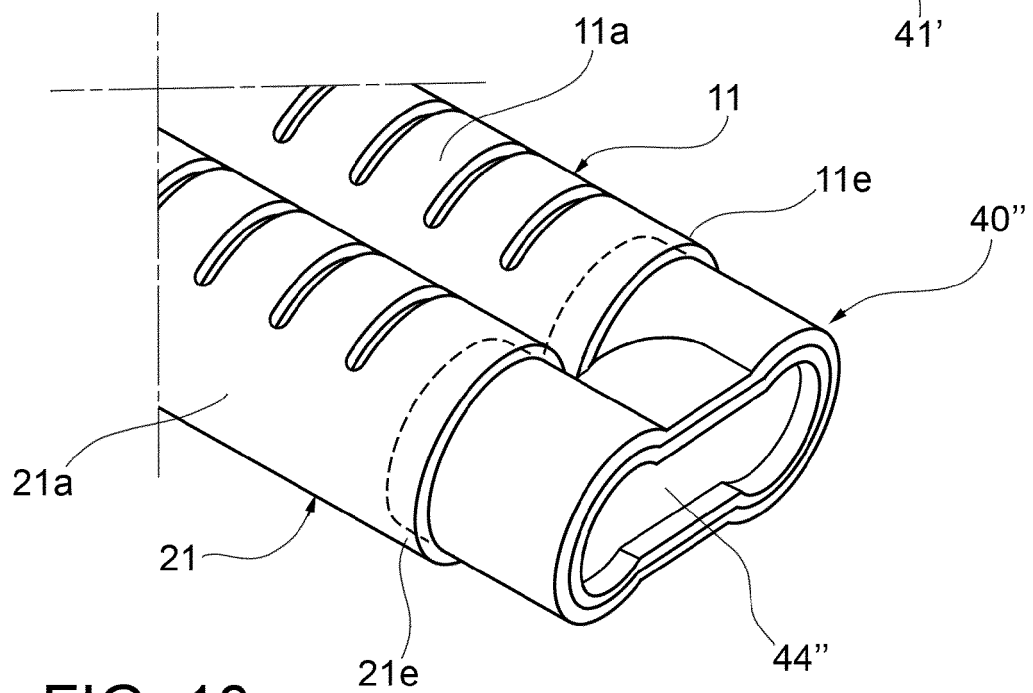
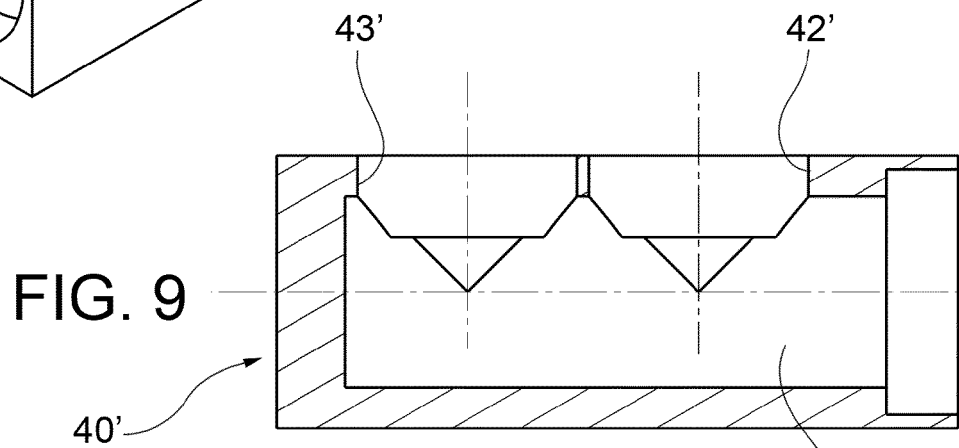
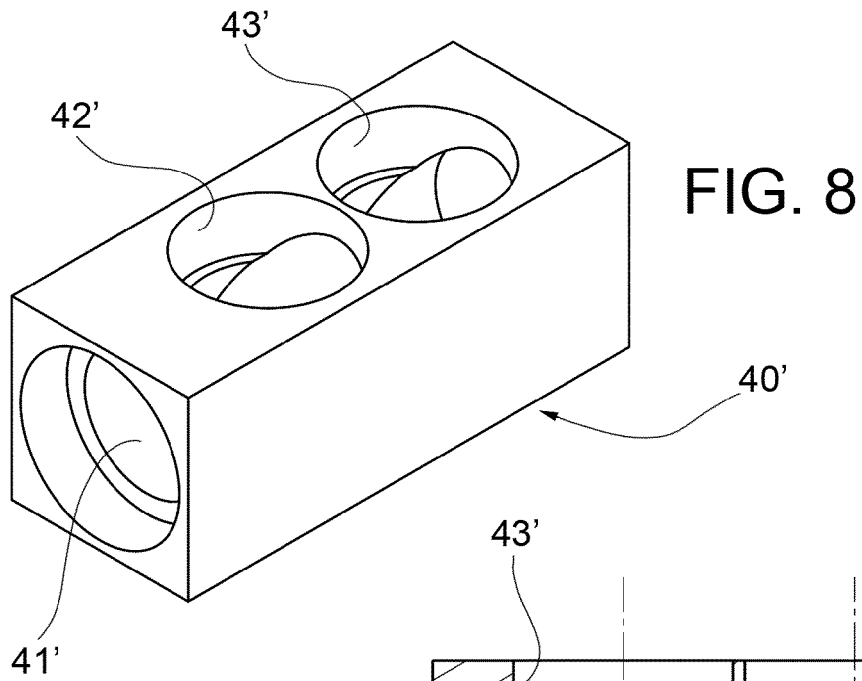


FIG. 4







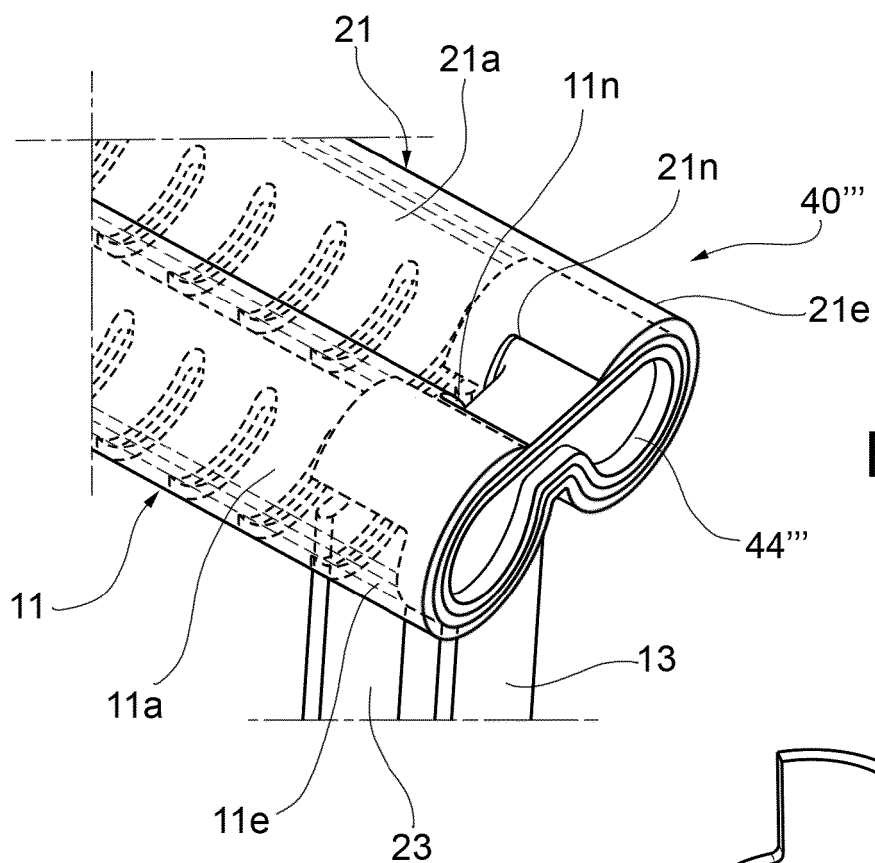


FIG. 11

FIG. 12

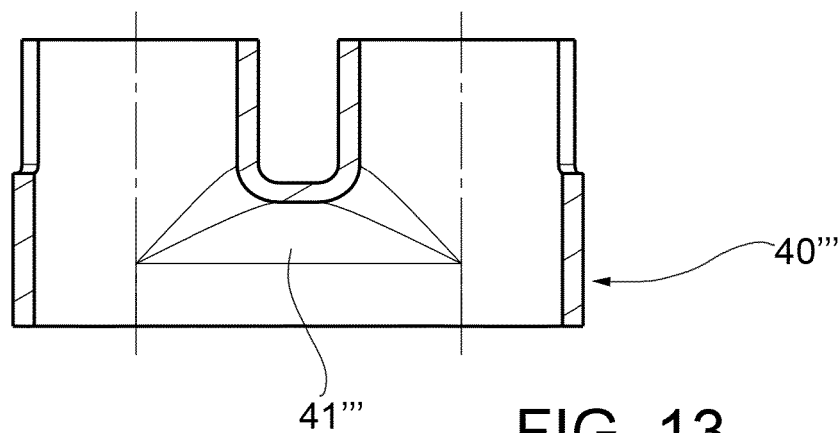
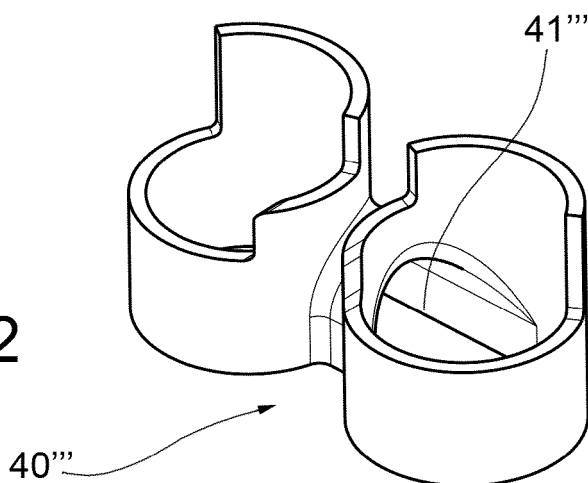


FIG. 13

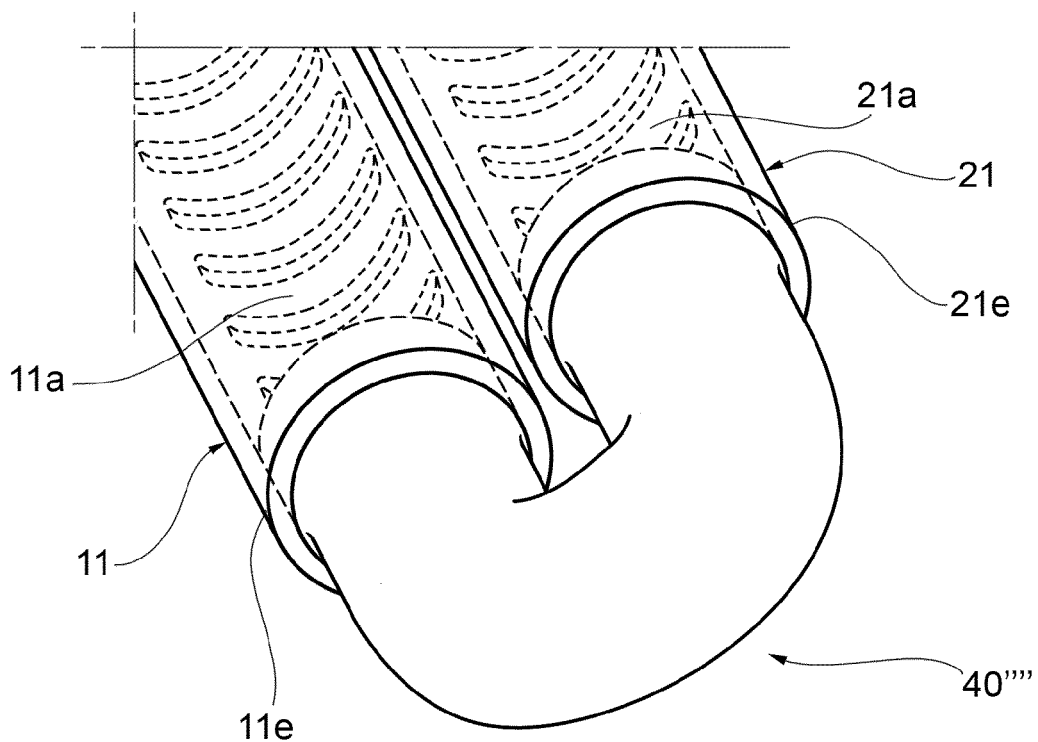


FIG. 14

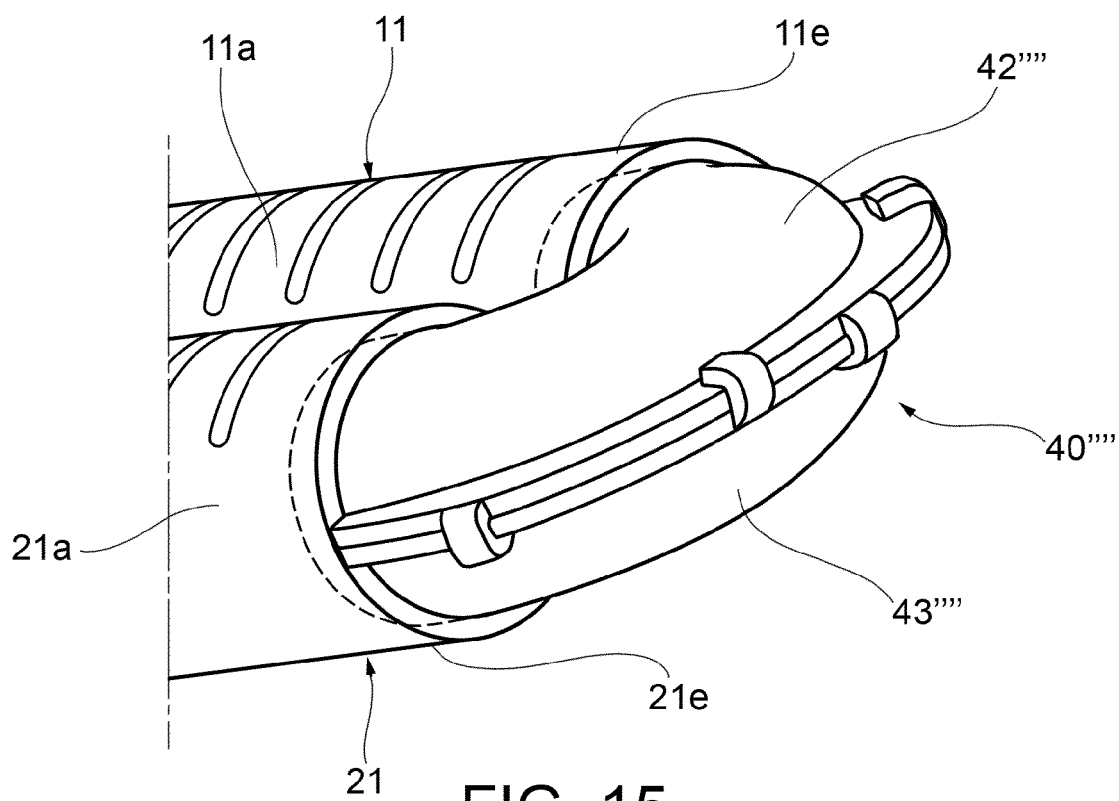


FIG. 15

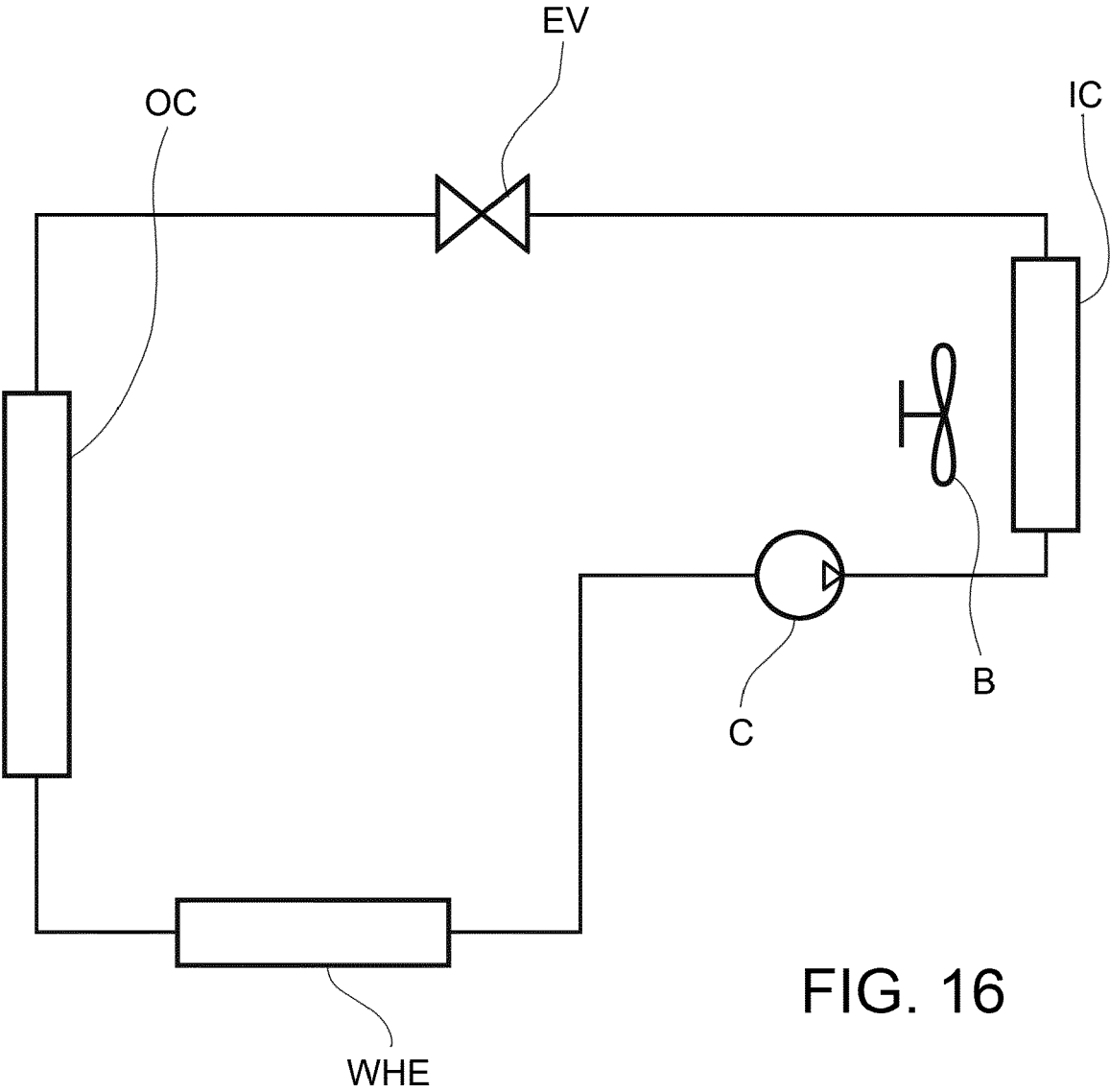


FIG. 16