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(54) **MODULAR PTC ELECTRIC HEATER**

(57) A modular PTC electric heater equipped with a cold liquid inlet (30) and a heated liquid outlet (40) is assembled from at least two structurally identical modules (10). The module (10) is designed as a cylindrical or cuboid tank (1) with a cavity watertight closed by two flanges or plugs (2), while the module (10) has a tubular

inlet opening (3) and a tubular outlet opening (4), both openings are connected with the tank (1) cavity. The modules (10) are interconnected by a connecting part (7) provided with two sealings (71, 72) and each module (10) is equipped with at least one PTC cartridge heating element (5) fixed on at least one flange or plug (2).

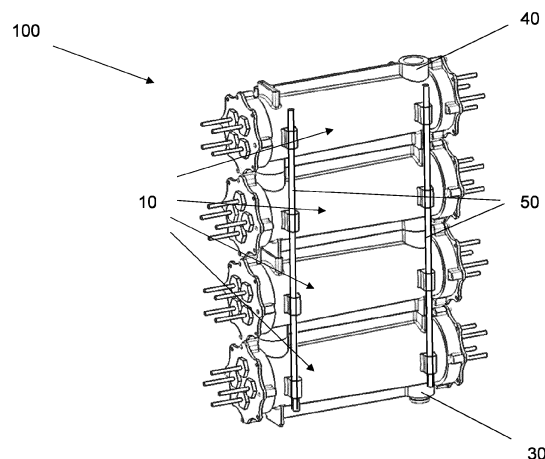


Fig. 6

Description

Field of the invention

[0001] The presented invention concerns an electric heater for heat transfer fluid, in particular water or a mixture of water and antifreeze agent, which is routed in a closed circuit of a building heating system. The invention particularly concerns an auxiliary (back-up) electric heater in heating systems with a heat pump.

Background Art

[0002] Current eco-friendly building heating concepts use heat pump systems in which heat is extracted from the outside environment. The heat pump systems are usually supplemented by an additional heating source - for example, solar heating or an auxiliary (back-up) electric heater, or a combination of several heating sources.

[0003] An auxiliary (back-up) electric heater is used in the heat pump systems especially when the heat extracted from the outside environment is not sufficient for comfortable heating and/or hot water heating, especially in winter months. At the same time, the electric heater also prevents freezing of the heat transfer medium.

[0004] In known auxiliary electric heaters, the heating elements are made as resistive heating elements (rods, coils). The heating coil heats up to a temperature of 850°C, which can cause overheating of adjacent parts if the temperature of the heating source is not properly controlled or monitored. To avoid thermal damage caused by the temperatures of these heating sources, which are significantly higher than the temperature of the fluid to be heated, an expansive safety concept is required.

[0005] The electric resistance coil heaters are described, for example, in EP3910260 A1, EP3869118 A1 and EP3037741 A1 documents.

[0006] An alternative to electric resistance coil heaters is the state-of-the-art electric heater with PTC (Positive Temperature Coefficient) heating elements, the use of which is particularly advantageous due to the fact that the temperature of the heating element does not exceed 300°C, or even less, depending on the specific design of the PTC heating element.

[0007] PTC elements are elements that are electrically conductive at low temperatures, but after a certain temperature barrier is reached, the electrical conductivity drops sharply. Thus, when the temperature of the PTC element increases, its resistance increases. Negative feedback is used, acting on the actual self-heating of the PTC element due to the passing current. When powered from a constant voltage source, this will cause a drop in power on the PTC element, counteracting further temperature rise. The result is simple heating with stabilization of the temperature of the heated space.

[0008] The existing PTC fluid heating devices (for use in automobiles in particular) generally contain a PTC heating element with a heat transfer structure that is typ-

ically very complex and therefore has disadvantages such as a low heat transfer rate and uneven heat transfer. Even modular solutions that allow for the increase in the heater power are typically very complex and not applicable for heating in heating systems. Such devices are described, for example, in EP 2792211 A1 document.

[0009] Document WO 2021/014432 describes an electric cartridge heating element which is simpler in design and function, the electric heating element comprising at least one tubular cartridge comprising at least one PTC resistor therein, further comprises an aluminium or alloy block pressed by die-casting around at least one armoured tubular cartridge, while a coating layer of plastic material being applied around the aluminium block.

[0010] The cartridge heating elements of similar design optimize heat transfer to ensure uniform heating and are also used for heating very small volumes with specific power and high temperatures. The design of the housing made of stainless material (aluminum, aluminum alloy, or steel) with one end closed and power wires coming out of the other end simplifies installation and electrical connection.

[0011] The electric back-up heater for heat pump systems is designed to provide power outputs typically from 5 kW to 12 kW. A commercially produced cartridge heating element provides power of typically up to 450W. Clearly, to achieve the required overall power, the use of multiple PTC cartridge heating elements, suitably arranged to transfer the heating energy as efficiently as possible, will be required.

[0012] The resistance coils used in the previous generation of electric back-up heaters could be arranged in a simple way in a cylindrical exchanger and did not require further increase in dimensions when increasing the power of the back-up heater, i.e. a single exchanger dimension could be used for all performance ranges.

[0013] The use of the cartridge PTC heating elements requires a different spatial arrangement of the heating elements in the heat exchanger.

[0014] The aim of the presented invention is to design a PTC electric heater with a high level of power and dimensional variability using a cartridge PTC heating element. This is achieved by a modular and expandable assembly. A PTC electric heater of smaller power will have smaller dimensions than a more powerful PTC electric heater. The modular assembly will be easily expandable while ensuring the required watertightness of the assembly.

Summary of the Invention

[0015] The expandable modular PTC electric heater is assembled from separate modules that are simply connected by a watertight joint using a sealed connecting piece. All modules have the identical design.

[0016] The module is made as a cylindrical or cuboidal (flattened) tank with a cavity watertight closed by two flanges or plugs. The module has a tubular inlet opening

and a tubular outlet opening, both openings being connected to the cavity.

[0017] On each module, at least one PTC cartridge heating element is mounted on at least one flange (or plug) and is provided with a casing made of a stainless material (such as aluminum, aluminum alloy, or steel) with one end closed and power wires coming from the other end. The casing of the heating element may preferably be coated with an insulating plastic material.

[0018] The casing design does not require any additional casing insulation when installed in the module cavity.

[0019] The cartridge PTC heating element can be provided with parts for fixing in a flange (or in a plug), the fixing of the PTC heating element to the flange is not described in detail as it is part of the state of the art (a fixing nut, silicone gasket, etc. are used).

[0020] The PTC cartridge heating element, mounted and connected to an electrical source, transfers heat to the fluid flowing through the module cavity.

[0021] The module is provided with ribs arranged in the cavity to prevent swirling and to direct the fluid flow from the tubular inlet opening to the tubular outlet opening. The ribs also serve to stiffen the entire module and increase resistance to the pressure of the flowing fluid.

[0022] To connect two modules, a tubular inlet opening of the second module is connected to the tubular outlet opening of the first module, the second module being rotated 180°.

[0023] In this way, the electric heater can be expanded as required.

[0024] The tubular openings have stops for the connecting piece. The connecting piece made of metal or suitable plastic is fitted with two sealing rings, which is inserted into the tubular openings to form a watertight connection.

[0025] Furthermore, the module is provided with a protruding wall on the outer surface with a cut-out for mutual connection and/or fixing the position of the modules.

[0026] In addition, the module is also provided with two holds on the outer surface with openings for threading the connecting rods through. The connecting rod is preferably metal and can have a thread with a nut on both ends to press the modules together and create a tight connection between all modules.

[0027] The module can be made of a suitable metal or plastic material designed for hot heat transfer fluid, also the connecting rod can be made of any firm material.

[0028] In a preferred design, the module is made of plastic by injection molding.

Brief Description of the Drawings

[0029] The invention is further explained using the figures below, without limitation thereto. The figures show:

Fig. 1 - view of the module with PTC cartridge heating elements fitted

Fig. 2 - longitudinal cross-section of the module from Fig. 1

Fig. 3 - front view of the module cavity with ribs (without PTC cartridge heating modules fitted)

Fig. 4 - detail of the connecting piece with two seals and the position of the connecting piece in the tubular opening of the module

Fig. 5 - indicated direction of fluid flow in the modular PTC electric heater

Fig. 6 - modular electric PTC heater assembled from four modules

Example of Embodiment

Example 1

[0030] Fig. 6 shows an expandable modular electric PTC heater 100.

[0031] The expandable modular PTC electric heater 100 is provided with a cold fluid inlet 30 and a heated fluid outlet 40, and is assembled from four separate modules 10, each module 10 being made as a cylindrical tank 1 with a cavity watertight sealed by two flanges 2. The module 10 has a tubular inlet opening 3 and a tubular outlet opening 4, both openings 3, 4 being connected to the tank cavity 1.

[0032] Each module 10 has four PTC cartridge heating elements 5 mounted on each flange 2 and provided with a stainless steel casing with one end sealed, immersed in fluid, and power wires coming from the other end. The PTC casing of the heating element 5 may preferably be coated with an insulating plastic material.

[0033] The module 10 (shown in Fig. 1, 2 and 3) is provided with ribs 9 arranged in the cavity to prevent swirling and to direct the fluid flow from the tubular inlet opening 3 to the tubular outlet opening 4. The ribs 9 simultaneously serve to stiffen the entire module 10 and increase the strength against the pressure of the flowing fluid. The PTC cartridge heating elements 5 are mounted in the flange 2 in such a way they extend into the module cavity 10 between the ribs 9.

[0034] To connect two modules 10 in series, a tubular inlet opening 3 of the second module 10 is connected to the tubular outlet opening 4 of the first module 10, the second module 10 being rotated 180°. The first module 10 means the upstream (preceding) module, and the second module 10 means the downstream (following) module in the fluid flow direction.

[0035] The tubular openings 3, 4 have stops 11 for the connecting piece 7 which is inserted into the openings 3, 4 to make a watertight connection. The connecting piece 7 is provided with two sealing rings 71, 72 (shown in Figure 4).

[0036] After the modules 10 are connected by the con-

necting piece 7, the fluid flows through the cold fluid inlet 30 in the flow direction from the inlet opening 3 of each module 10 to its outlet opening 4, the flow being directed by the ribs 9, and this method of guiding the fluid through the modules 10 shows the smallest pressure losses.

[0037] The direction of flow of the heated fluid through the connected modules 10 is shown by the arrows (in Fig. 5).

[0038] In Fig. 5, the cold fluid inlet 30 is at the lowest point of the modular electric PTC heater 100, such an arrangement being advantageous due to the removal of air bubbles directed upstream to where the vent valve is usually located in the system. Of course, in another design, the cold fluid inlet 30 may be at the highest point of the modular electric PTC heater 100. The illustrated direction of the fluid flow shows that the fluid flows through the connected modules 10 always from the inlet annular opening 3 to the outlet annular opening 4.

[0039] The module 10 provided with a protruding wall 8 on the outer surface with a cut-out for connecting the modules to each other and/or fixing their position prior to connection by means of a connecting piece 7.

[0040] The module 10 is also provided with two holds 6 on the outer surface with openings for threading the connecting rods 50 through. The connecting rod 50 is preferably metal and can be threaded with a nut on both ends for additional pressing the modules 10 together and forming a tight connection between all modules 10 and the respective connecting pieces 5.

[0041] The module 10 can be made of a suitable metal or plastic material designed for hot heat transfer fluid, also the connecting rod 50 can be made of any firm material.

[0042] In a preferred design, the module 10 is made of plastic by injection molding.

[0043] In the example of the design, the modular PTC electric heater 100 is assembled from four modules 10, each having eight of cartridge PTC heating elements 5 having a power of 400 W, and thus the total power output of the modular PTC electric heater is 12.8 kW. The modular electric PTC heater has overall dimensions of 300mm x 110mm x 480mm (length x width x height), which is a suitable power and dimensions for using the modular heater as a back-up electric heater for heat pump systems.

Example 2

(not illustrated)

[0044] The modular PTC electric heater 100 assembled from two modules 10, each of which has eight cartridge PTC heating elements 5 having a power of 400 W, and thus the total power of the modular PTC electric heater is 6.4 kW. By combining just two modules 10 with sixteen cartridge PTC heating elements, a smaller back-up electric heater for heat pump systems is created.

[0045] In a separate claim, a heat pump system for

heating buildings and/or preparing domestic hot water is protected, wherein the back-up electric heater connected in a closed circuit of the heat transfer medium is a modular PTC electric heater according to the presented invention.

Industrial applicability

[0046] The modular PTC electric heater according to the presented solution can replace currently used electric heaters with resistance coils. The invention allows the heater assembly to be easily expanded depending on the required power, with output values ranging from 400W and virtually unlimited from above.

Claims

1. A modular PTC electric heater equipped with a cold fluid inlet (30) and a heated fluid outlet (40), assembled from at least two structurally identical modules (10),

characterized in that,

the module (10) is made as a cylindrical or cuboid tank (1) with a cavity watertight closed by two flanges or plugs (2),

the module (10) has a tubular inlet opening (3) and a tubular outlet opening (4), both openings being connected to the tank (1) cavity,

the modules (10) are connected to each other by a connecting piece (7) provided with two seals (71, 72),

each module (10) is provided with at least one PTC cartridge heating element (5) mounted on at least one flange or plug (2).

2. The modular PTC electric heater according to claim 1,

characterized in that,

the module (10) is provided with ribs (9) arranged in the tank (1) cavity to prevent swirling, to direct the flow of the heated fluid and to increase the strength of the tank (1) against pressure.

3. The modular PTC electric heater according to claim 1 or 2,

characterized in that,

the cold fluid inlet (30) is connected to the tubular inlet opening (3) of the first module (10), and the heated fluid outlet (40) is connected to the tubular outlet opening (4) of the last connected module (10) in flow direction.

4. The modular PTC electric heater according to any of the claims above

characterized in that,

the module (10) is provided with a protruding wall (8) on the outer surface with a cut-out for connecting the

modules (10) together and/or fixing their position prior to connection by means of a connecting piece (7).

5. The modular PTC electric heater according to any of the claims above 5
characterized in that,
 to connect two modules (10) in series, a tubular inlet opening (3) of the second module (10) is connected to the tubular outlet opening (4) of the first module (10), the second module (10) being rotated 180° relative to the first module (10). 10

6. The modular PTC electric heater according to any of the claims above 15
characterized in that,
 the module (10) is provided with two holds (6) with openings for threading the connecting rods (50) through on its outer surface, the connecting rod (50) having a thread with a nut on each end for additionally pressing the modules (10) and the respective connecting parts (7) together. 20

7. A modular PTC electric heater according to any of the claims above 25
characterized in that,
 the module (10), the connecting piece (5) and the connecting rod (50) are made of metal or plastic material designed for hot heat transfer fluid.

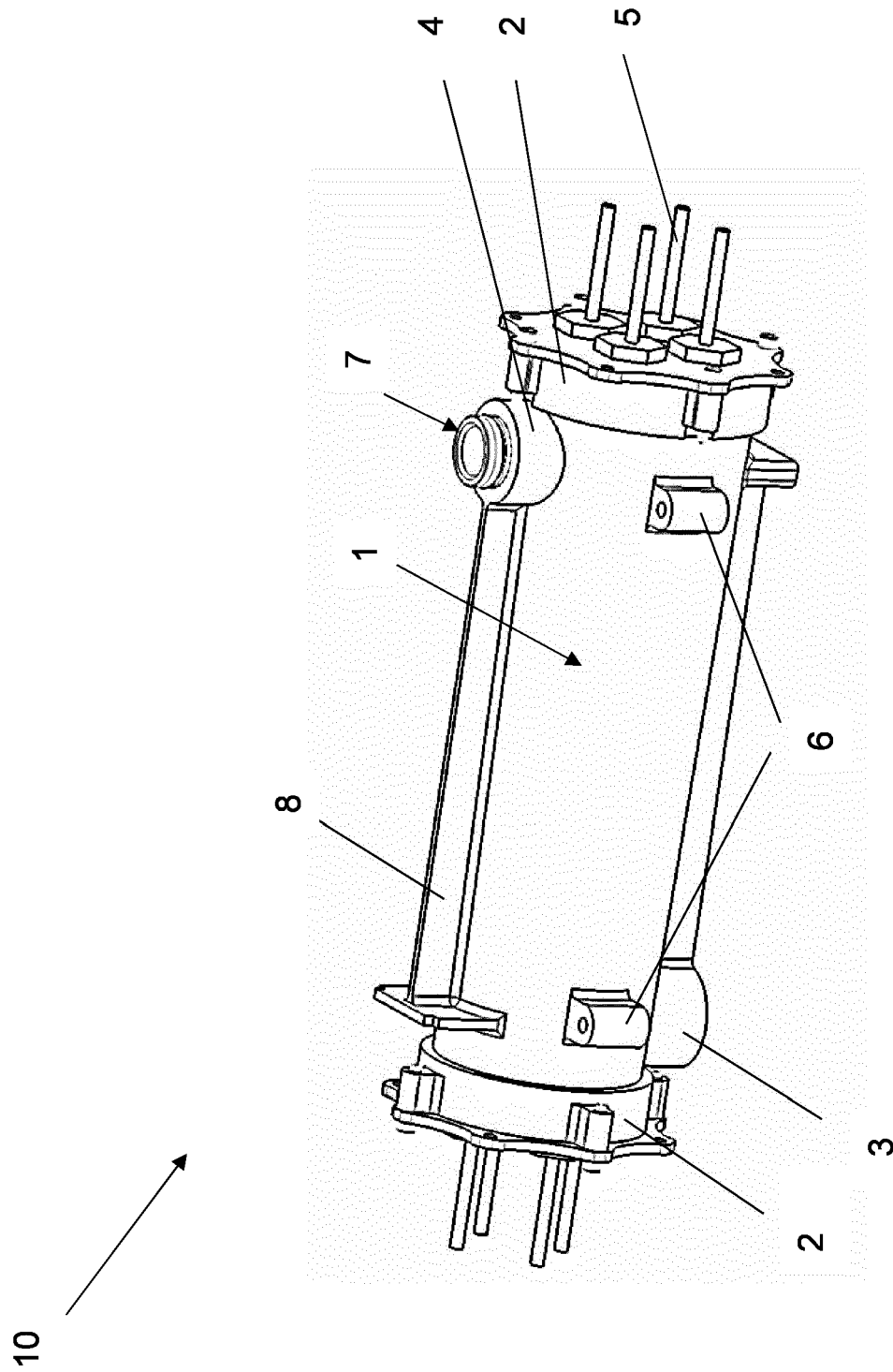
8. A modular PTC electric heater according to any one of claims 1 to 6, 30
characterized in that,
 the module (10) is preferably made of plastic by injection moulding. 35

9. A heat pump system for heating buildings and/or preparing domestic hot water, 40
characterized in that,
 the back-up electric heater connected in the closed circuit of the heat transfer medium is a modular PTC electric heater according to any of the claims above. 45

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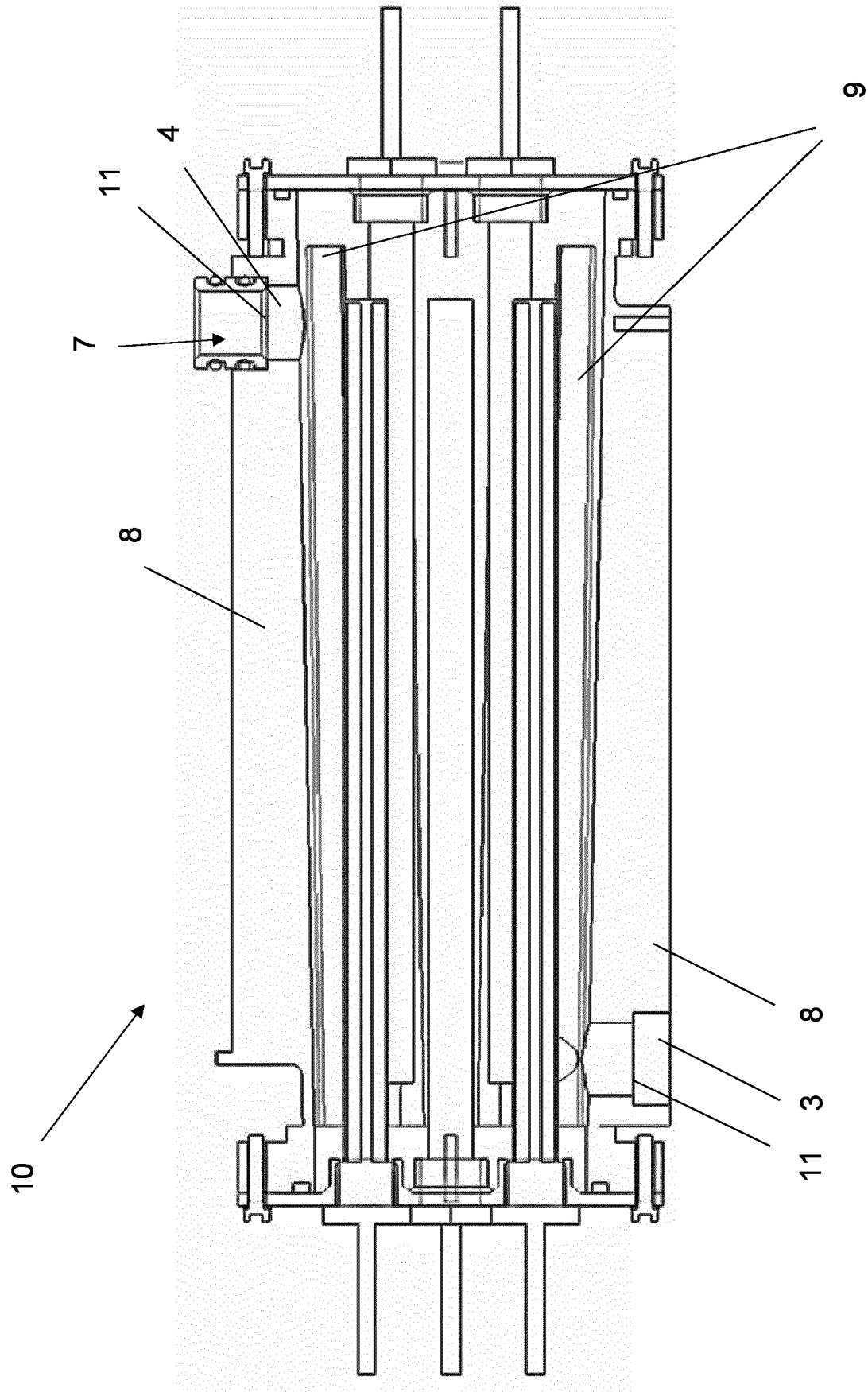


Fig. 2

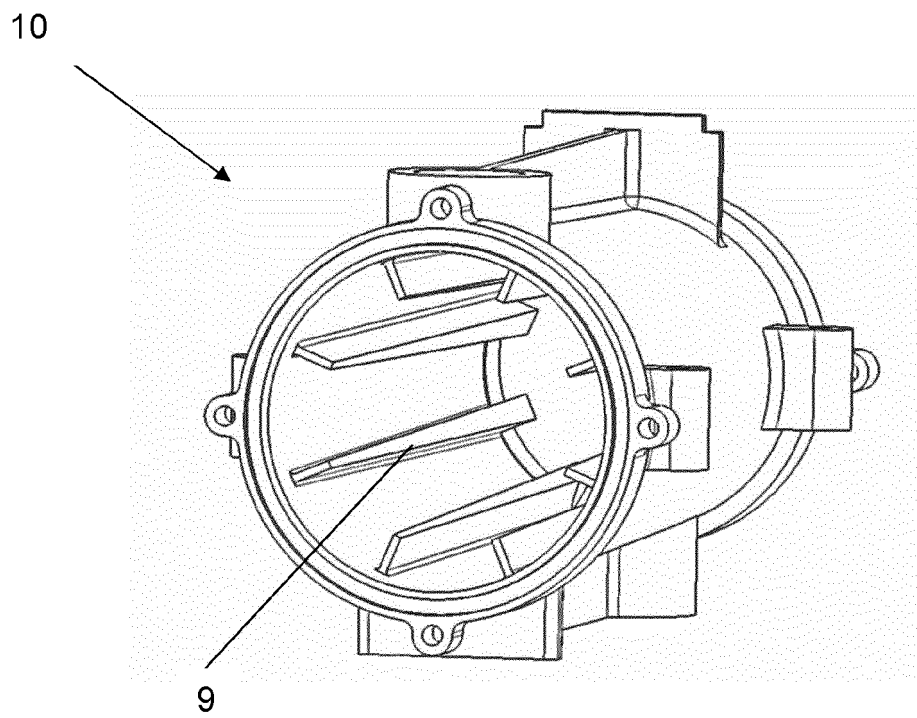


Fig. 3

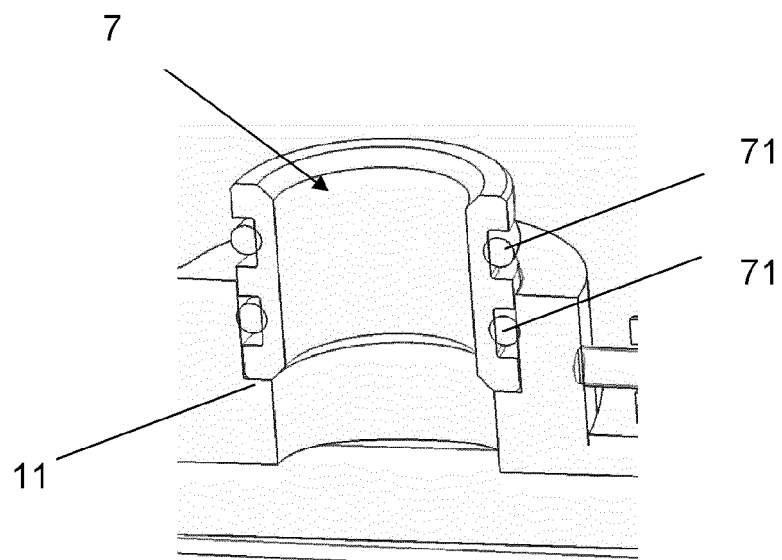


Fig. 4

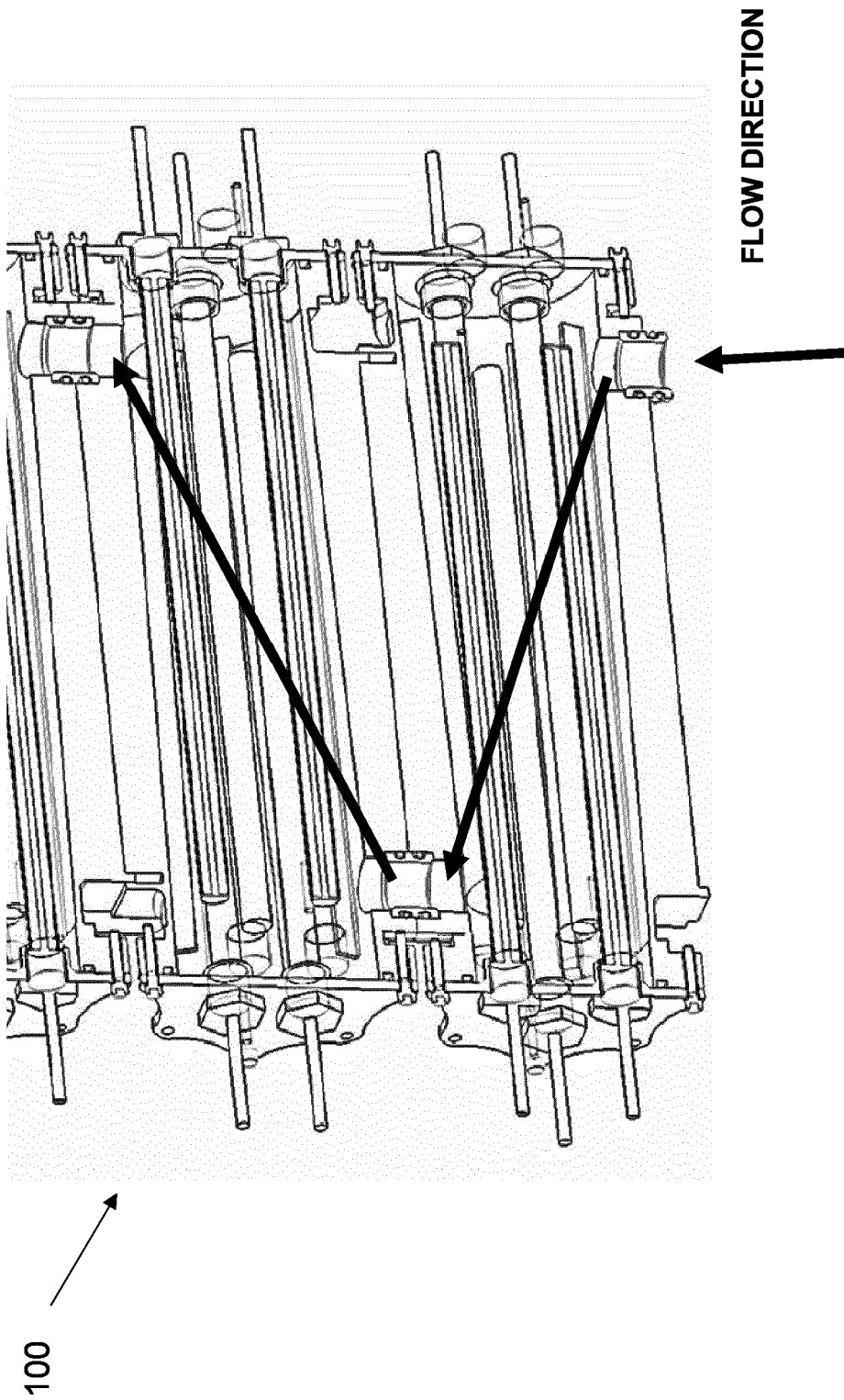


Fig. 5

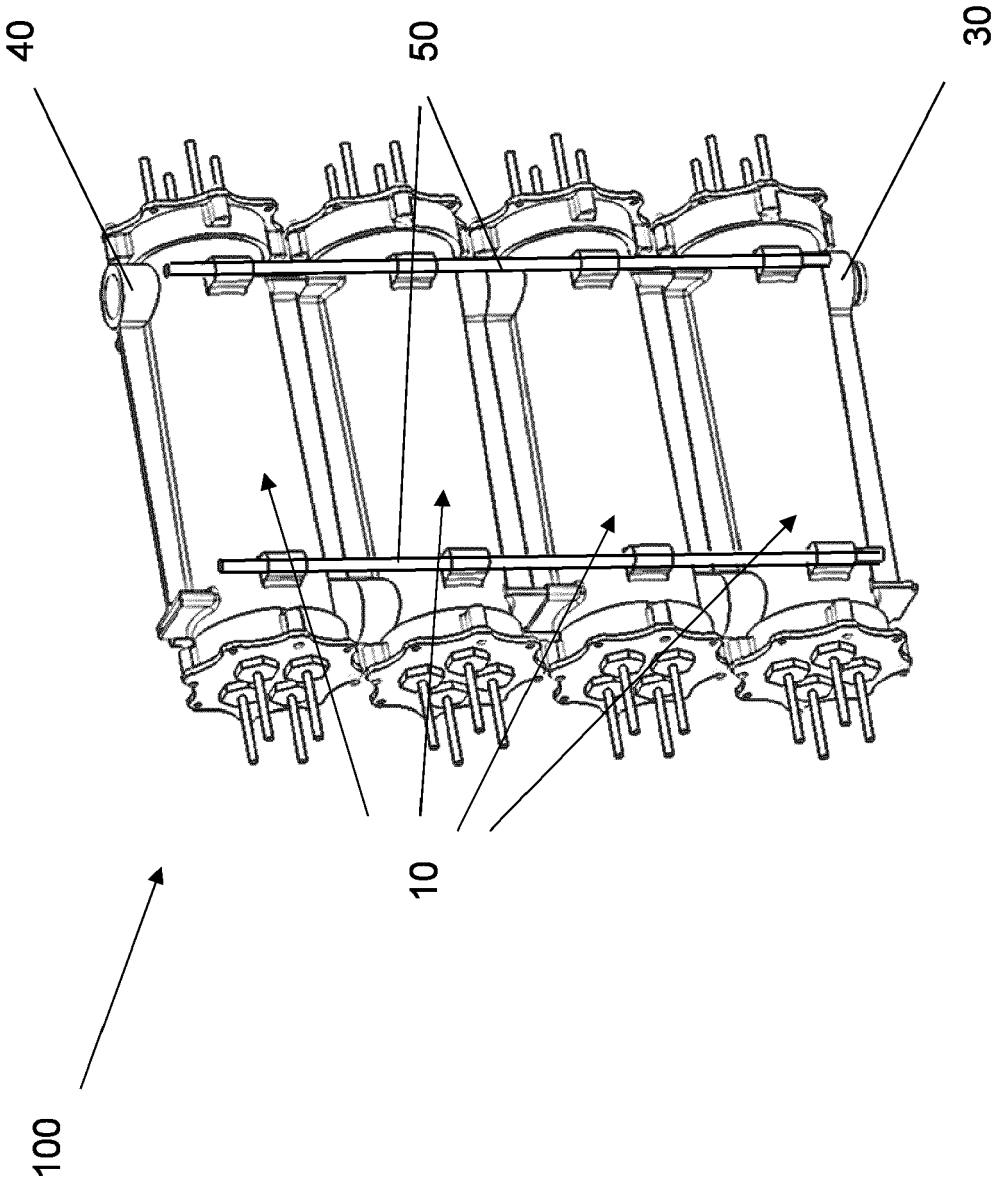


Fig. 6



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Application Number

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EPO FORM 1503 03.82 (P04C01)

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Place of search Munich		Date of completion of the search 30 November 2023	Examiner Riesen, Jörg
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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