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(54) **PTC ELECTRIC HEATER**

(57) An electric liquid heater comprising a plastic container for liquid consisting of an upper cylindrical part (1) and a lower conical part (2), which are water tightly connected to each other. An basically cylindrical plastic concentric wall (5) defining an internal circulation channel (31) and an external circulation channel (32) is firmly arranged inside the plastic container, while the external circulation channel (32) is connected to the outlet (4) of the heated liquids. It also includes a hollow heating module (6), which is equipped with a connection part (61) for supplying the liquid intended for heating, a continuous

cavity (65) for directing the liquid intended for heating and external surfaces (64). The hollow heating module (6) is arranged in the internal circulation channel (31), at least one PTC heating assembly (PTC1, PTC2, PTC3, PTC4, PTC5, PTC6) is arranged on the outer surfaces (64) of the heating module (6), generating heat and each PTC heating assembly (PTC1, PTC2, PTC3, PTC4, PTC5, PTC6) includes a flexible metal electrical conductor (11) to apply electrical voltage and to press the PTC heating assembly to the concentric wall (5) and to the hollow heating module (6).

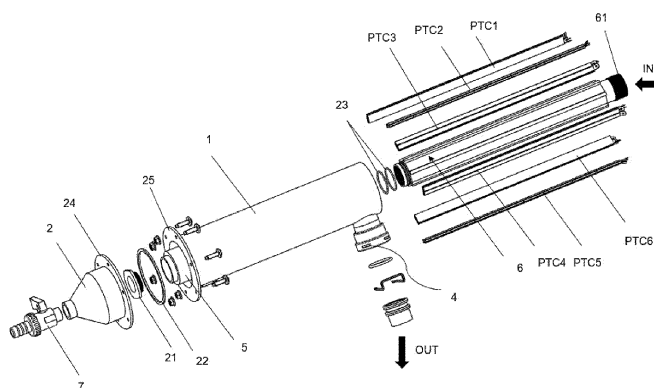


Fig.1

Description

Field of the invention

[0001] The invention relates to an electric heater for heating liquids circulating mainly in heating circuits of residential buildings and in particular in systems with a closed circuit of the heat transfer liquid.

Prior art

[0002] Electric heaters used for heating liquids in heating circuits of residential buildings, such as instantaneous water heaters, back-up electric heaters for heating the heat transfer medium in heat pump systems, and other similar devices, have heating elements generally constructed of resistance wires insulated with a magnesium oxide layer and housed in a stainless steel casing. Their basic feature is that the heating elements provide the power proportional only to the supply voltage and the structure of such a heater is simple.

[0003] On the other hand, the actual use of such simple heating elements for heating the heat transfer medium requires a sophisticated safety concept involving control of the heating based on outputs from temperature sensors, flow sensors, safety temperature limiters and other necessary components, since the temperature of the heating elements can reach temperatures of up to 800°C.

[0004] Such devices are described, for example, in EP 3910260 A1 or EP 3869118 A1.

[0005] Newer electric liquid heaters use other suitable elements to heat the heat transfer medium, preferably so-called PTC heating elements (PTC = positive temperature coefficient).

[0006] The 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 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.

[0007] Heating with the PTC elements is therefore safe due to the automatic temperature control and the fact that the maximum temperature of the heated element is below 300°C. Independent power regulation does not require thermostat control.

[0008] The PTC elements can be made of ceramics or organic polymers, they are mainly produced as plates with two electrically conductive electrodes to connect the supply voltage, heating assemblies made of the PTC elements can contain insulating film and other components, such as electrically conductive adhesives.

[0009] EP 3910260 A1 discloses an electric water heater for a closed-loop heating water system comprising

a water tank connected to a flange, at least one heating element extending from the flange to the water tank, and a concentric wall arranged in the water tank, with the water tank being connected to a cold water inlet and a hot water outlet. The water tank housing comprises a cylindrical part attached to the flange at the top and a conical part, which is connected to the cylindrical part of the water tank housing at the bottom, with the shape of the concentric wall corresponding to the cylindrical part of the water tank. The water tank housing is placed inside the water tank so that an external circulation channel is defined between the water tank housing and the concentric wall. The electric water heater integrates a filter function for solid impurities, which are mainly formed on the heating elements during electric heating, but can also be formed elsewhere in the heating system, by separating the solid particles from the liquid flow when they hit the concentric wall and slowing them down to fall into the conical part of the water tank where they can be settled. The sediments are removed by a drain valve.

[0010] The concentric wall can be made, together with the cylindrical part of the tank housing as an integral part thereof, by moulding from plastic.

[0011] Resistance coils and a safety temperature limiter are used and heating control by an electronic control unit is assumed in the disclosed document.

[0012] The task of the invention is to make an electric heater of similar dimensions and power using PTC elements, so that the function of the integrated filter for solid impurities is preserved.

[0013] In the state of the art, liquid heaters with the PTC heating elements embedded in the tank designed to heat the liquid are known. The existing PTC liquid heating devices generally contain a PTC heating element with a heat transfer structure that is typically very complex and therefore has disadvantages such as a low heat transfer rate and uneven heat transfer.

[0014] The solution published in EP3716730 A2 improves the uniformity of heat transfer, while the particular components of the structure are bonded with conductive adhesive and require placement in a sleeve. However, the heater does not provide the function of a filter integrated in the heated liquid tank, and the manufacturing of the PTC heating assembly is complicated and expensive.

[0015] Another invention with simple integration of a PTC heating assembly is published in CN 210267475. The heating element is made of a hollow body with a passage for liquid, the body has a cross-section of a regular hexagon or square. The body is heated by surfaces equipped with PTC elements. The surfaces are connected with the installation cavities for inserting the PTC elements, during assembly, the PTC heating component is firstly inserted into the installation cavity successively, and then a press for the PTC deformation pressing is used. The outer surface of the heating element is pressed together to form the final product.

[0016] The disadvantage of this solution is that the

pressing can damage the PTC heating component. The arrangement of the continuous cavity with reinforcing ribs throughout the entire volume of the liquid passage causes significant pressure losses as well.

[0017] The present invention addresses the shortcomings of the known state of the art. It is based on the design of an electric heater with an integrated filter function published in EP 3910260 A1, and features thereof are disclosed in the preamble of the Independent Claim, with the concentric wall being conveniently used as an electrical insulator. The electric heater uses a simple PTC heating assembly with an innovative flexible wire arrangement to heat the liquid.

Summary of the Invention

[0018] According to the present invention, the electric heater comprises a plastic liquid tank comprising an upper cylindrical part and a lower conical part, which are watertightly connected to each other, e.g. by a screwed or welded joint; inside the plastic tank there is basically cylindrical plastic concentric wall arranged, defining the internal circulation channel for supplying the liquid to be heated and the external circulation channel for discharging the heated liquid, which is cleared of impurities at the same time. The external circulation channel is arranged between the concentric wall and the cylindrical part of the housing, with the external circulation channel being connected to the heated liquid outlet. In the lower conical part of the tank there is a space for sedimentation of solid impurities, which are separated from the liquid flow by hitting barriers and falling into the area with the lowest flow rate. The conical part has a connection to connect a drain valve to remove the impurities.

[0019] The electric heater includes also a hollow heating module arranged in the internal circulation channel (along the axis of the upper cylindrical part of the water tank). The heating module is equipped with a connection piece for the supply of the liquid to be heated to the heater and a continuous cavity for the liquid routing and heating.

[0020] The hollow heating module is made of metal material, conducting heat and electric current well. Of the suitable materials, extruded aluminium is preferably used for the module due to its light weight, but other materials are also possible. The hollow heating module has surfaces bordered by projections arranged on its outer surface. On its inner surface (in the continuous cavity), it has ribs arranged in the preferable design to increase the heating surface and thus the heating efficiency.

[0021] After the hollow heating module is inserted into the internal circulation channel, installation gaps are created between the plastic concentric wall and the outer surfaces of the hollow heating module for insertion of the PTC heating assembly.

[0022] The concentric plastic wall has pairs of projections arranged on its inner surface, facing the internal circulation channel, which are shaped so that the projections arranged on the outer surface of the hollow heating

module shape-fit between these projections.

[0023] The PTC heating assembly has a layered structure known in the prior state of the art. The PTC plates are arranged in long strips, with the length and number of the strips used determining the power of the heater (e.g. to use a PTC heater as a backup electric heater in heat pump systems, power from 6 to 12 kW is required).

[0024] Each PTC heating assembly in the present invention includes two electrical conductors (the first electrical conductor and the second electrical conductor) that are connected to two opposing surfaces of the PTC layer. The PTC layer is made of PTC plates, with a graphite pad sandwiched between the PTC layer and each electrical conductor to improve electrical and thermal conductivity. The pad can be glued with electrically conductive adhesive, its role is to ensure the best possible contact between the PTC plate and the conductor, eliminating any unevenness on both materials at the point of contact.

[0025] It is an improvement of the prior state of the art that instead of a conventional electrical conductor or conductive strip, a spring, for example a shaped electrically conductive flexible strip, is used as the first electrical conductor in the present solution. The first electrical conductor touches the concentric wall with its flexible part.

[0026] Electrically insulating film (e.g., Kapton film) is applied between the second electrical conductor and the hollow heating module to provide insulation for the second electrical conductor while not preventing heat transfer from the PTC heating assembly to the hollow heating module.

[0027] At least one PTC heating assembly generating heat is arranged on the outer surfaces of the hollow heating module; each PTC heating assembly includes a flexible metal electrical conductor for supplying electrical voltage and for pressing the PTC assembly against the concentric wall and also against the heating module.

[0028] The flexible conductor ensures tight contacts between the layers of the PTC heating assembly. Using a flexible electrical conductor, the entire PTC heating assembly is pressed against the hollow heating module on one side and the plastic concentric wall on the other side. Basically, there is no need for pressing or gluing to ensure good contact of all layers of the PTC heating assembly with each other and to ensure good contact with the heating module and the plastic concentric wall.

[0029] Heating of liquid is accomplished by applying voltage (of appropriate height and polarity) to the two conductors of the PTC heating assembly to generate heat in the PTC plates, which is transferred through the hollow heating module to the liquid.

[0030] In the preferred design, an electrically conductive body of the hollow heating module is used as the second electrical conductor.

Brief description of the Drawings

[0031] The invention is further explained using the fig-

ures below, without limitation thereto.

[0032] They show the following:

Fig. 1 - Electric PTC liquid heater - exploded view

Fig. 2 - Layers of the PTC heating assembly - exploded view

Fig. 3 - Drawing of the hollow heating element and its cross-section

Fig. 4 - Cross-section of the assembled PTC electric heater, with detail of the PTC heating assembly inserted in the installation cavity

Fig. 5 - Schematic diagram of the connection of three-phase electrical voltage to PTC heating assemblies - wiring example

Examples of Embodiment

Example 1

[0033] Fig. 1 shows an electric heater according to the present invention. This includes a plastic liquid tank comprising an upper cylindrical part 1 and a lower conical part 2, which are watertightly connected to each other, with a screwed joint of flanges 24 and 25 and a gasket 22. Inside the plastic tank there is basically cylindrical plastic concentric wall 5 arranged, defining the internal circulation channel 31 for routing the liquid to be heated and the external circulation channel 32 for discharging the heated liquid, which is cleared of solid impurities at the same time. The external circulation channel 32 is arranged between the concentric wall 5 and the cylindrical part of the housing 1, with the external circulation channel 32 being connected to the heated liquid outlet 4. In the lower conical part 2 of the tank there is a space for sedimentation of solid impurities, which are separated from the liquid flow by hitting barriers and falling into the area with the lowest flow rate. The conical part 2 of the tank has a connection for connecting a drain valve 7, which is used to remove the settled impurities from the heater.

[0034] The electric heater includes also a hollow heating module 6 (shown in Fig. 3 and Fig. 1) arranged in the internal circulation channel 31 (along the axis of the upper cylindrical part of the water tank). The heating module 6 is provided with a connection piece 61 with an external thread for the inlet of the liquid to be heated into the heater, a continuous cavity for routing and heating the liquid, and a connection piece 62 with an internal thread for the outlet of the heated water.

[0035] The hollow heating module 6 is watertightly connected to the heater tank by a coupling nut 21, a connection piece 62 and O-rings 23.

[0036] The hollow heating module 6 and its cross-section are shown in Fig. 3. It has arranged surfaces 64

bordered by projections 63 on its outer surface. On its inner surface, the continuous cavity 65 has conveniently arranged ribs 66 to increase the heating surface area.

[0037] The concentric plastic wall 5 has pairs of projections 51 arranged on its inner surface, facing the internal circulation channel 31, which are shaped so that the projections 63 arranged on the outer surface of the hollow heating module 6 shape-fit between these projections 51. A detail of the arrangement is shown in Fig. 4. The pairs of projections 51 are arranged for shape connection of the projections 63, which are arranged on the outer surface of the hollow heating module 6.

[0038] After the hollow heating module 6 is inserted into the internal circulation channel 31, installation gaps 19 are created between the plastic concentric wall 5 and the surfaces 64 of the hollow heating module 6 for insertion of at least one PTC heating assembly PTC1, PTC2, PTC3, PTC4, PTC5, PTC6. The above example allows the use of up to six PTC heating assemblies PTC1, PTC2, PTC3, PTC4, PTC5, PTC6, the number of assemblies is not limited to this number (in other designs).

[0039] Each PTC heating assembly PTC1, PTC2, PTC3, PTC4, PTC5, PTC6 in the present invention includes two electrical conductors (11, 15), the first electrical conductor 11 and the second electrical conductor 15, that are connected to two opposing surfaces of the PTC layer 13. The PTC layer 13 is made of PTC plates, with a graphite pad 12, 14 sandwiched between the PTC layer 13 and each electrical conductor 11, 15 to improve electrical and thermal conductivity. The pad 12, 14 can be glued with electrically conductive adhesive, its role is to ensure the best possible contact between the PTC layer 13 and the electrical conductor 11, 15; the pad 12, 14 eliminates any unevenness on both materials at the point of contact.

[0040] A spring, e.g. a shaped electrically conductive flexible strip, is used as the first electrical conductor 11 in the present solution. The first electrical conductor 11 with its flexible part touches the concentric wall 5.

[0041] Electrically insulating film 16 (e.g., Kapton film) is applied between the second electrical conductor 15 and the hollow heating module 6 to provide insulation for the second electrical conductor 15 while not preventing heat transfer from the PTC heating assembly to the hollow heating module 6.

[0042] At least one PTC heating assembly PTC1, PTC2, PTC3, PTC4, PTC5, PTC6 generating heat is arranged on the outer surfaces 64 of the hollow heating module; each PTC heating assembly PTC1, PTC2, PTC3, PTC4, PTC5, PTC6 includes a flexible metal electrical conductor 11 for supplying electrical voltage and for pressing the PTC assembly PTC1, PTC2, PTC3, PTC4, PTC5, PTC6 against the concentric wall 5 and also against the heating module 6.

[0043] Basically, there is no need for pressing or gluing to ensure good contact of all layers of the PTC heating assembly PTC1, PTC2, PTC3, PTC4, PTC5, PTC6 with each other and to ensure good contact with the heating

module 5 and the plastic concentric wall 6.

[0044] The pair of projections 51 is also shape connected to the projection 63 in order to insulate the electrically conductive parts of the PTC heating assembly PTC1, PTC2, PTC3, PTC4, PTC5, PTC6.

[0045] After insertion of the PTC heating assembly into the installation gap 19, an unfilled, free space, generally filled with air, remains in it. In the preferred solution, the free space between the first electrical conductor 11 and the concentric wall 5 and in the installation gap 19 is filled with a thermally conductive and at the same time electrically insulating filler material.

[0046] Heating of the liquid is accomplished by applying voltage (of appropriate height and polarity) to two electrical contacts 17, 18 of conductors 11, 15 of the PTC heating assembly PTC1, PTC2, PTC3, PTC4, PTC5, PTC6 to generate heat in the PTC layer and the heat is transferred through the hollow heating module 6 to the liquid in the internal circulation channel 31. The ribs 66 are arranged to increase the heating area.

[0047] The plastic concentric wall 5 is also partially heated, and the heat is transferred to the liquid in the external circulation channel 32. Thus, the generated heat is used in the present solution as efficiently as possible and the heated liquid is cleared of solid impurities before leaving the heater.

[0048] The electric heater is preferably used as an electric back-up heater in heat pump systems, for heating less pure liquids, even with glycol content, where applicable.

[0049] Fig. 5 shows an example schematic of the Y-wiring of three-phase voltage to the connection contacts 17, 18 of the electrical conductors 11 and 15 of the PTC heating assemblies PTC1, PTC2, PTC3, PTC4, PTC5, PTC6. The phase voltage L2 is connected to the contacts 17 of the first electrical conductor 11 of the heating assemblies PTC1 and PTC2, the phase voltage L3 is connected to the contacts 17 of the first electrical conductor 11 of the heating assemblies PTC3 and PTC 4, and the phase voltage L1 is connected to the contacts 17 of the first electrical conductor 11 of the heating assemblies PTC5 and PTC 6. The contacts 18 of the second electrical conductor 15 on all heating assemblies PTC1, PTC2, PTC3, PTC4, PTC5, PTC6 are connected to zero potential.

[0050] The electrical wiring may be different, depending on the requirements for heating power.

[0051] The electric PTC heater integrates a solid impurity filter function, the solid impurities are separated from the liquid stream by hitting the ribs 66 arranged in the continuous cavity 65 of the hollow heating module 6 and settle in the conical part 2 of the tank. A drain valve 7 is connected to the tank to drain impurities.

Example 2 (not shown)

[0052] In the other design of the invention, the electrically conductive body of a hollow heating module 5 is

used as the second electrical conductor 15.

[0053] In this case, the PTC heating assembly PTC1, PTC2, PTC3, PTC4, PTC5, PTC6 includes the first electrical conductor 11, the PTC layer 13 and the graphite pads 12, 14, and the conductive surface of the hollow heating module 5 as the second electrical conductor 15.

[0054] Such an arrangement is suitable for use in a pure water instantaneous heater, as a module for measuring the conductivity of the water as well as other safety measures are the mandatory parts of instantaneous heaters.

Industrial applicability

[0055] The electric PTC heater for heating liquids according to the present invention is designed for heating liquids circulating mainly in heating circuits of residential buildings. The PTC electric heaters provide many advantages over resistance wire based systems and simplify heating control.

Claims

1. An electric liquid heater, comprising

a plastic liquid tank, wherein the tank comprises an upper cylindrical part (1) and a lower conical part (2), watertightly connected to each other and wherein a basically cylindrical plastic concentric wall (5) is firmly arranged inside the tank, a hollow heating module (6), with outer surfaces (64) and with a continuous cavity (65) for directing the liquid to be heated, wherein the hollow heating module (6) is provided with a connection piece (61) for supplying the liquid to be heated, and wherein the plastic concentric wall (5) defines an internal circulation channel (31) and an external circulation channel (32) connected to the outlet (4) of the heated liquid,

characterized in that

the hollow heating module (6) is arranged in the internal circulation channel (31), at least one PTC heating assembly (PTC1, PTC2, PTC3, PTC4, PTC5, PTC6) generating heat is arranged on the outer surfaces (64) of the hollow heating module (6), each PTC heating assembly (PTC1, PTC2, PTC3, PTC4, PTC5, PTC6) comprises a flexible metal electrical conductor (11) for supplying electrical voltage and for pressing the PTC heating assembly against the concentric wall (5) and against the hollow heating module (6).

2. The electric liquid heater, according to claim 1, characterized in that

the PTC heating assembly (PTC1, PTC2, PTC3, PTC4, PTC5, PTC6) is assembled as a layered

structure of the layers of the first flexible electrical conductor (11), a first graphite pad (12), a layer (13) of PTC plates, a second graphite pad (14), a second electrical conductor (15) and an electrical insulator (16).

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3. The electric liquid heater, according to claim 1,
characterized in that
the PTC heating assembly (PTC1, PTC2, PTC3, PTC4, PTC5, PTC6) is assembled as a layered structure of the layers of the first flexible electrical conductor (11), the first graphite pad (12), a layer (13) PTC plates and a second graphite pad (14) and the hollow heating module (6) is connected as the second electrical conductor.
4. The electric liquid heater, according to any one of the claims 1 to 3,
characterized in that
the surfaces (64) are defined by projections (63) arranged on the outer surface of the hollow heating module (6) and ribs (66) are arranged in the continuous cavity (65) to increase the heating area.
5. The electric liquid heater, according to any one of the claims 1 to 4,
characterized in that
the concentric plastic wall (5) has pairs of projections (51) arranged on its inner surface, facing the internal circulation channel (31), for the shape connection with the projections (63) arranged on the outer surface of the hollow heating module (6).
6. The electric liquid heater, according to any one of the claims 1 to 5,
characterized in that
installation gaps (19) are arranged between the heating module (6) and the plastic concentric wall (5) for inserting at least one PTC heating assembly (PTC1, PTC2, PTC3, PTC4, PTC5, PTC6).
7. The electric liquid heater, according to any one of the claims 1 to 6,
characterized in that
a free space between the first electrical conductor (11) and the concentric wall (5) in the installation gap (19) is filled with a thermally conductive and electrically insulating filler material.

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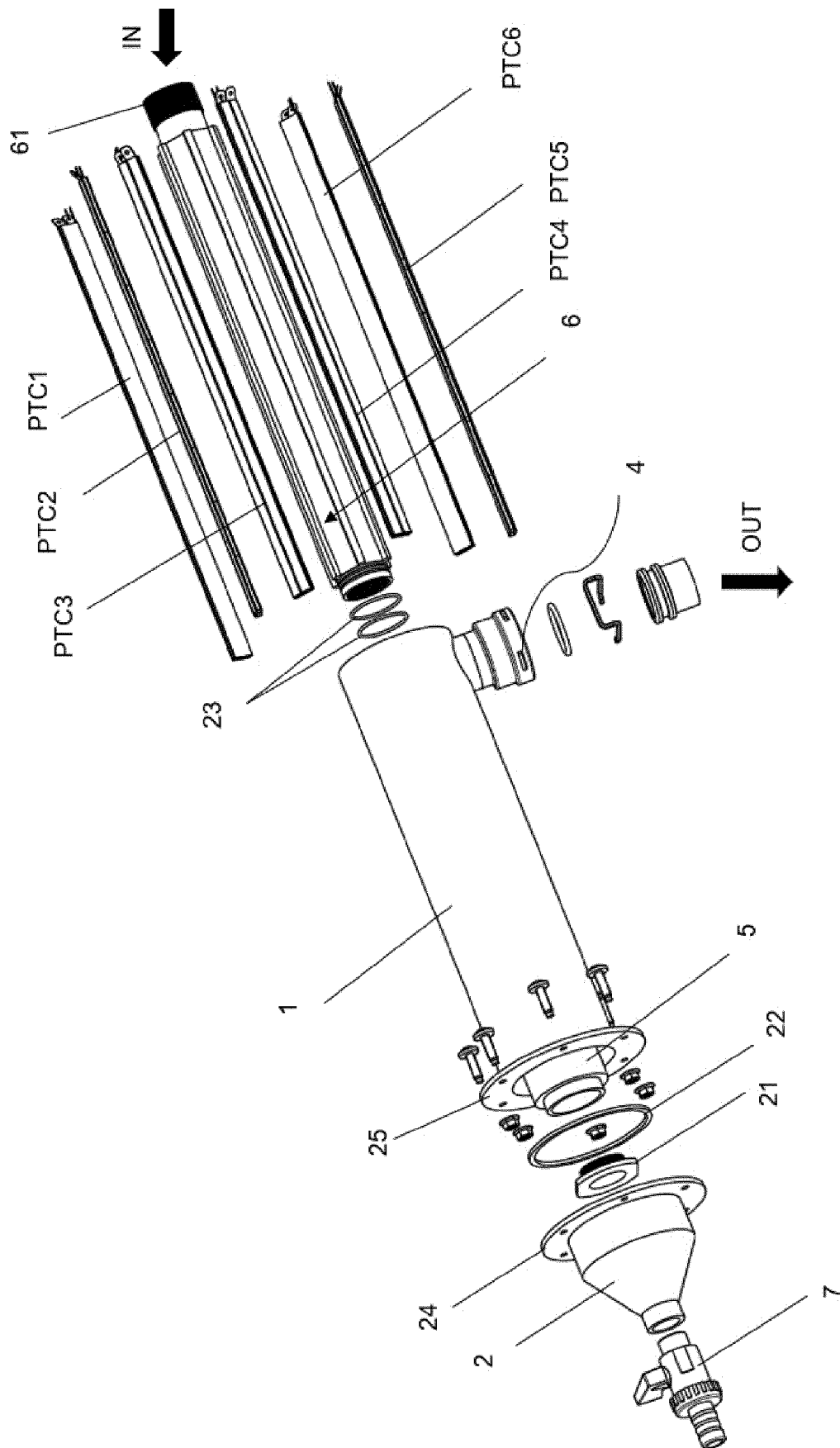


Fig.1

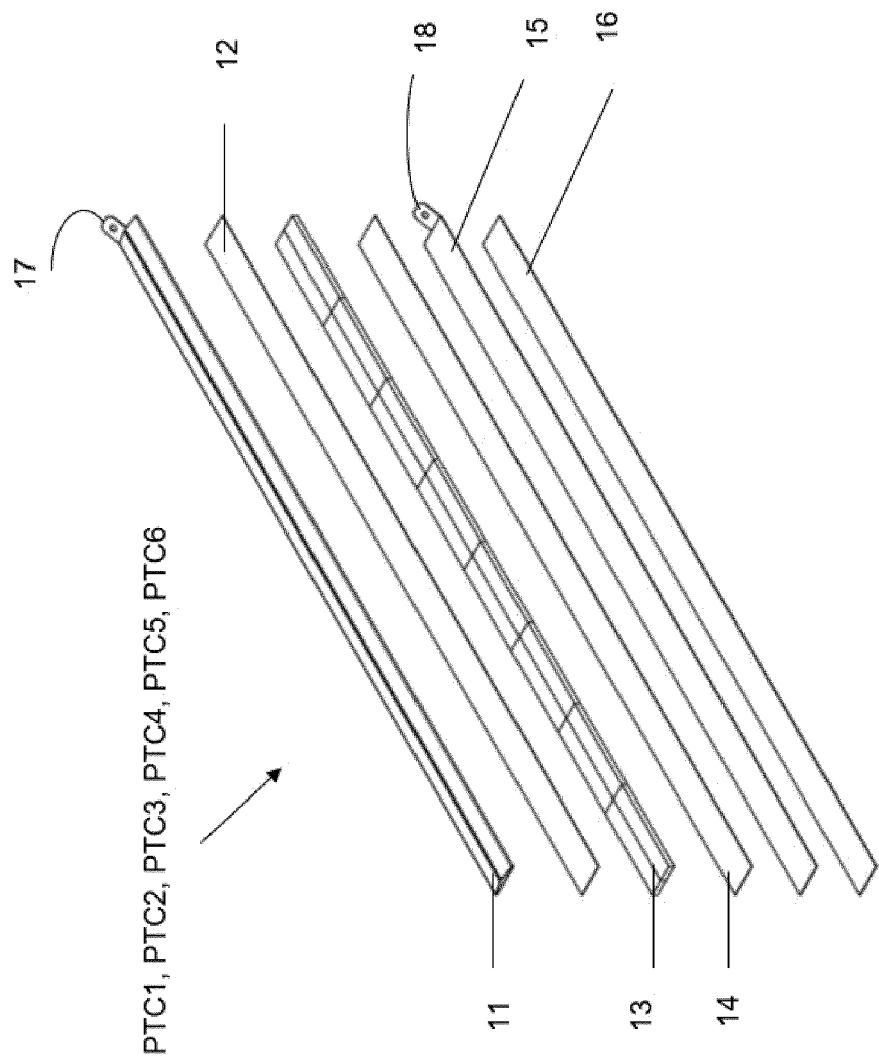


Fig. 2

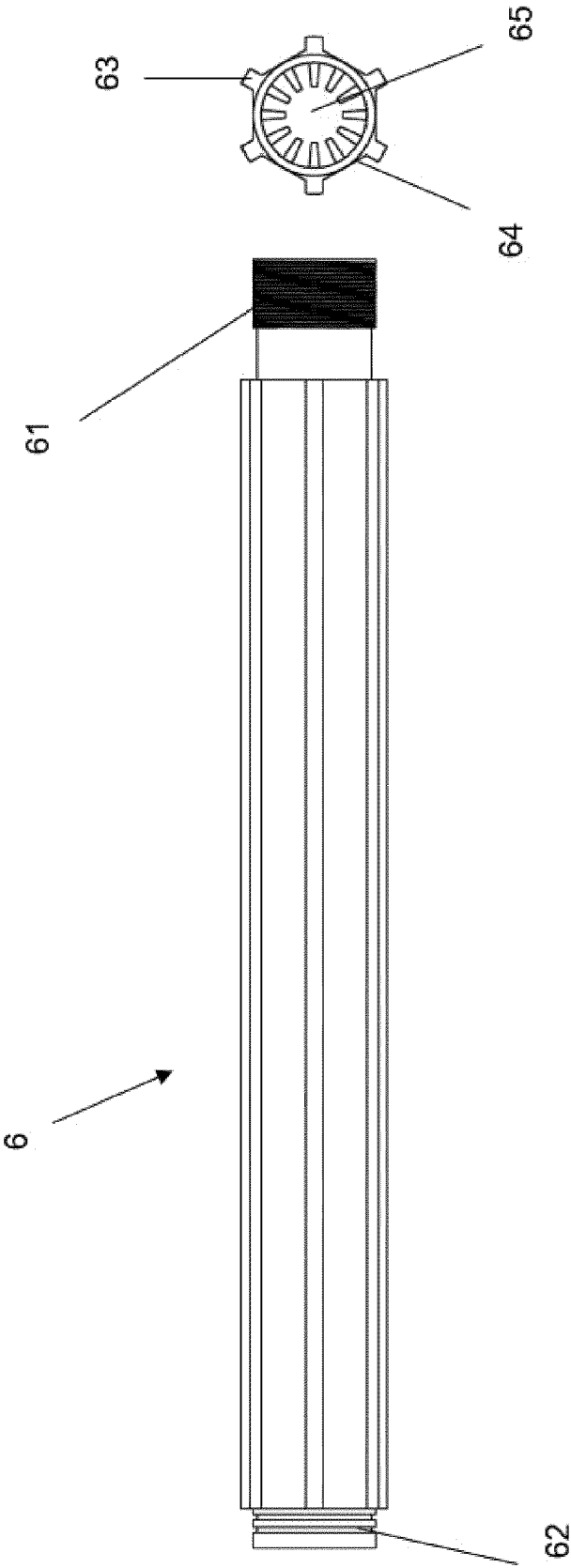


Fig.3

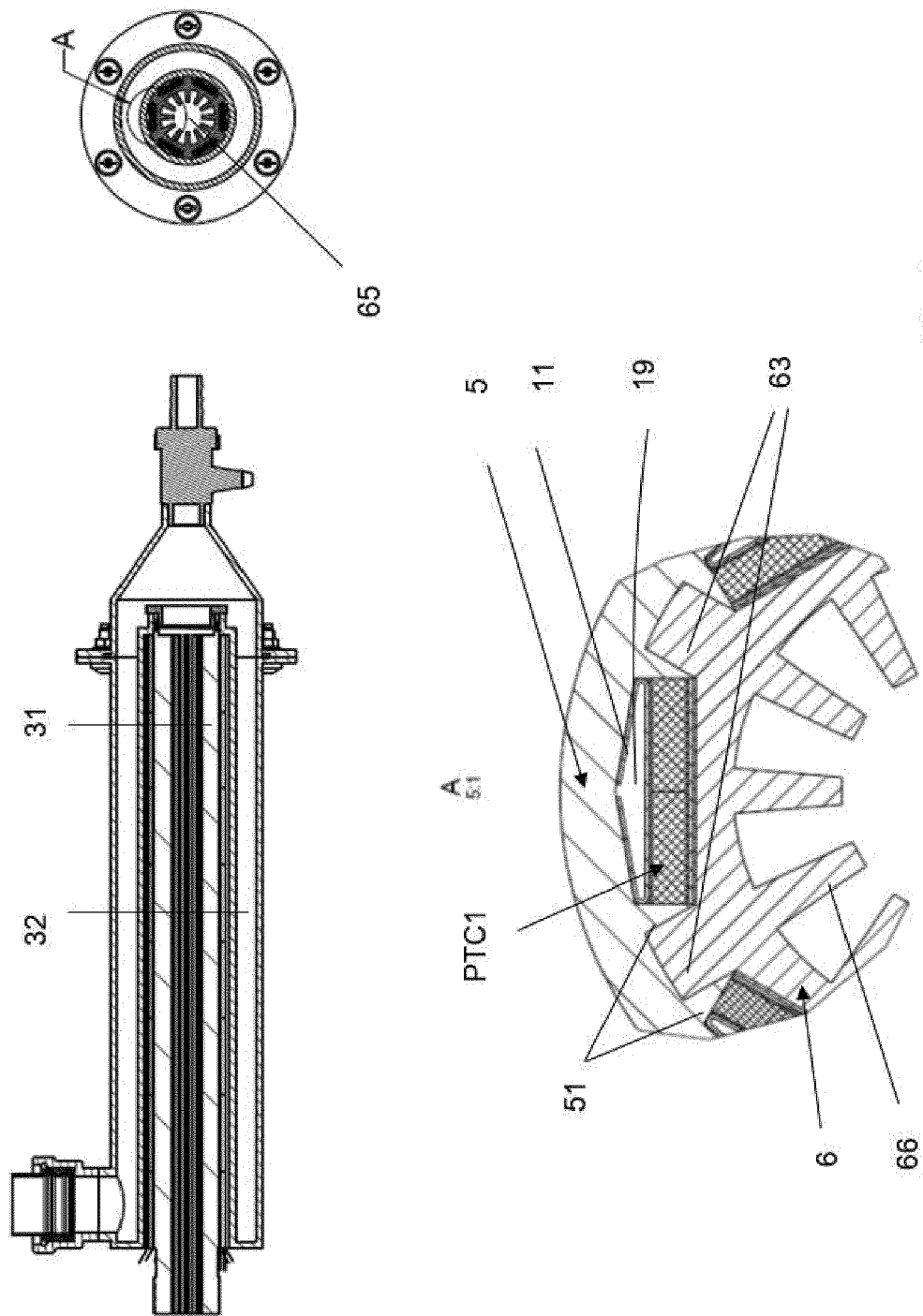


Fig.4

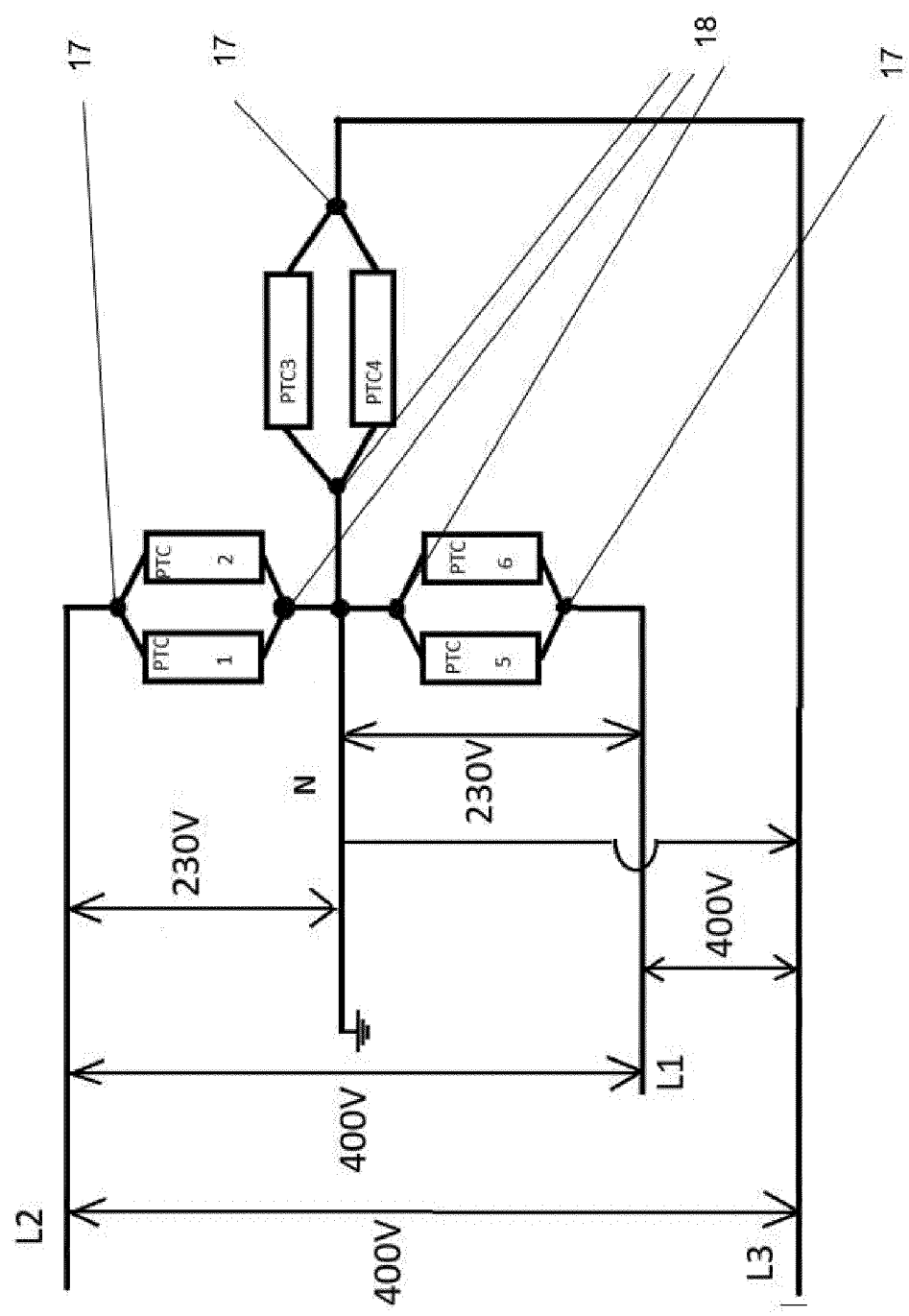


Fig.5



EUROPEAN SEARCH REPORT

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EP 23 17 6250

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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