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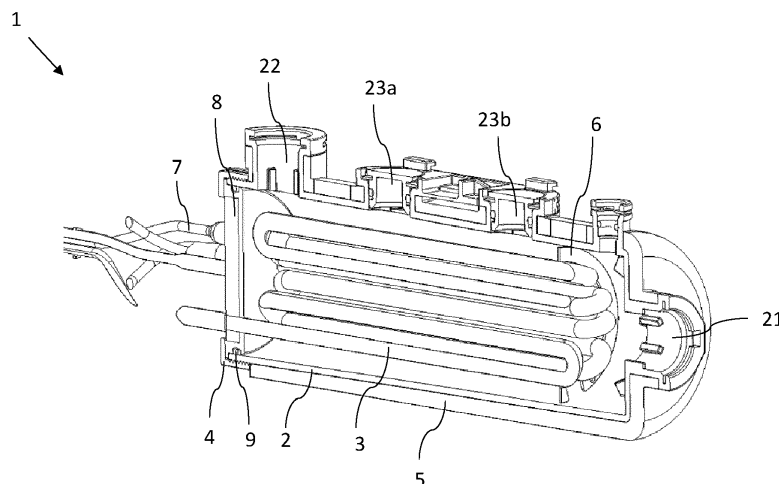
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(54) **BACK-UP HEATING FOR A HEAT PUMP SYSTEM**

(57) Providing a back-up heater for heating water in a heat pump system, wherein the back-up heater comprises a tank, a heating element inside the tank, a removable cap positioned over an end of the tank, wherein the tank comprises an inlet for a main water flow at a side of the tank and an outlet for a main water flow at a side

of the tank, wherein tank and removable cap are made from plastic and wherein the tank is formed as a single piece of plastic. Such a back-up heater allows for a design of the back-up heater wherein the back-up heater is easy to assemble, can be construed into a variety of shapes and can be build-up in a modular fashion.



**FIG. 1**

## Description

**[0001]** The invention relates to a back-up heater for heating water in a heat pump system, wherein the back-up heater comprises a tank, a heating element inside the tank, a removable cap positioned over an end of the tank, wherein the tank comprises an inlet for a main water flow at a side of the tank, and an outlet for a main water flow at a side of the tank, wherein tank and removable cap are made from plastic and wherein the tank is formed as a single piece of plastic. Such a back-up heater allows for a design of the back-up heater wherein the back-up heater is easy to assemble, can be construed into a variety of shapes and can be build-up in a modular fashion. The invention further relates to a heat pump system comprising such a back-up heater.

**[0002]** Heating of water in buildings, such as heating water of a central heating system or heating of water for domestic use, may be accomplished by means of a heat pump system. Such a heat pump system may either be a ground source heat pump (GSHP) system or an air source heat pump (ASHP) system. In a GSHP system, calories are exchanged between the ground, or ground water, and a fluid, the fluid in particular being air or water. The calories in the ground may be extracted by capturing calories in a water table or by circulating a water-based circuit in the ground. In an ASHP system calories are exchanged between the air and a fluid, in particular air or water.

**[0003]** A heat pump system may comprise an indoor unit that allows the management of the hot water supply within a building. The indoor unit typically comprises a heat pump circuit with a refrigerant in case of a split heat pump system or without a refrigerant in case of a mono-bloc heat pump system. The indoor unit usually comprises at least one fluid supply, such as a refrigerant or hot water, and several hot water outlets. The indoor unit comprises several components, such as, a heater, a heat exchanger, an expansion tank, a pump, a three-way valve, a venting device, and an electronic control unit.

**[0004]** Often, an indoor unit needs an electrical back-up heating for additional heating of the water. For instance, when the outside air temperature is too low, a heat pump system without an electrical back-up heating cannot extract enough calories from the air to heat the water to a predefined and desired temperature. Thus, an electrical back-up heating is required to assist the heat exchanger circuit within a heat pump system for reaching the predefined and desired temperature. Such electrical back-up heaters usually comprise a small tank and a flange, with a resistive heating element that will be immersed into the water. Typically, these electrical back-up heaters are made from a stainless steel material. The flange is usually welded onto the tank. The resistive heating elements can reach a surface temperature well above 350°C, usually up to 750°C. Thus, the use of stainless steel assures compatibility and safety in case the resistive heating element and the stainless steel walls are in

close proximity to each other. Using stainless steel, however, limits the shapes, the assembly process and the modularity of the electrical back-up heater. Such a back-up heater thus has to be made by welding stainless steel into a one-part solution of a particular design. This will as such require at least two parts to be welded or screwed together, potentially causing a risk of leakage and as such deterioration of the back-up heater as a whole. This may lead to a drop in performance due to loss of heated water, or even shortcutting the entire heat pump system when water leaks on any of the electrical components outside the back-up heater. It is therefore desired to have a back-up heater that is easier to assemble, can be made in various shapes and has a modular character.

**[0005]** The object of the invention is obtained by means of a back-up heater for heating water in a heat pump system, wherein the back-up heater comprises a tank, a heating element inside the tank, a removable cap positioned over an end of the tank, wherein the tank comprises an inlet for a main water flow at a side of the tank and an outlet for a main water flow at a side of the tank, wherein the tank and removable cap are made from plastic and wherein the tank is formed as a single piece of plastic.

**[0006]** The tank may have an external screw thread that interlocks with an internal screw thread of the removable cap. The tank may hold a fluid such as water. The heating element inside the tank enables water, residing within the tank, to be heated. The heating element may be any kind of heating element suitable to heat water to a temperature of at least 35°C, preferably at least 60°C. The removable cap may have through holes for the heating element, or electrical wiring of the heating element, to pass through. The removable cap may have an internal screw thread that interlocks with an external screw thread on the tank. The tank and the removable cap, together, may form the entire enclosure of the back-up heater.

**[0007]** The tank has an opening on one side to accommodate for the insertion of the heating element. At the side of the opening, the tank may have an external thread shape to allow for interaction with an internal thread of the removable cap, thus allowing a screw or tap system between the tank and the removable cap. As such, the removable cap can be mounted to the tank in a reversible manner. This allows for assembling and disassembling the back-up heater, allowing the heating element residing within the tank to be placed, replaced or removed from the inner side of the tank thus allowing for maintenance or repairs of any of the back-up heater components without too much hassle. Furthermore, it allows the heating element to be replaced by an element of a different power. This makes it possible to have several heating elements with different powers to be used with the same tank, thus to have a standardized solution.

**[0008]** The inlet and the outlet for a main water flow may be of any size and shape suitable to promote sufficient water flow through the tank. The tank and the removable cap are both made from plastic, preferably from the same plastic. By having the tank and the removable

cap both made from plastic, a greater freedom of shape and geometry is realized. During operation, both parts are exposed to the same temperature changes during operation of the heat pump system.

**[0009]** By using the same material for both the tank and the removable cap, the compatibility and sealing between both parts is improved as both expand and contract in the same manner during operation of the heat pump system.

**[0010]** By having the tank made from a single piece of plastic, there is no need for welding of the tank. Thus there is no risk of leakage along any welded spot. As the single piece tank may be made by means of abutting two molds to each other, a molding flash might still be visible on the outer side of the single piece tank. The molding flash, which essentially is an excess material attached to a molded product, may be removed by polishing the outer surface of the single piece tank.

**[0011]** As the back-up heater is essentially assembled by means of providing a tank made from a single piece of plastic, inserting a heating element into the tank and closing off the tank by means of a removable cap, the assembly of the back-up heater is made easier. Thus, by making the tank and the removable cap from plastic, and forming the tank as a single piece of plastic, the object of the invention is achieved.

**[0012]** In an embodiment, the tank and removable cap are made by means of injection molding or three-dimensional printing. Injection molding and three-dimensional printing both allow for a variety of different shapes to be made for both the tank and the removable cap. Injection molding has the advantage that plastics may be used that can withstand high water temperatures. With injection molding, two or more molds may be abutting each other to form the outer shape of the tank. A molding flash, being an excess material attached to a molded product where two molds abutted each other, may still be visible.

**[0013]** The molding flash may be removed by means of polishing. Three-dimensional printing has the advantage of creating odd shapes that are expensive or impractical to make with injection molding.

**[0014]** In an embodiment, the plastic is a composite material comprising plastic and fiber materials. Depending on the capacity of the heating element used, and depending on the temperature target set for heating the water in the back-up heater, the water may reach substantially high temperatures. As such, the tank should preferably withstand temperatures of about 100°C to 200°C. Using a composite material of plastic and fiber materials, may improve the temperature resistance of composite. Suitable fiber materials may be, amongst others, glass fiber, mineral fiber or carbon fiber.

**[0015]** In an embodiment, the heating element is a hot water pipe or an electric resistance. In case of a hot water pipe, a pipe is provided within the tank wherein the pipe is heated by means of water running within the pipe. The pipes run through the removable cap. The water within the pipe may be externally heated using an electrical

heating system or a boiler, such as a gas or oil-fired boiler. In case of an electric resistance, an electrical heating system is provided within the tank. The electric resistance may run through the removable cap, or the wires to the electric resistance are run through the removable cap. The electrical resistance may be attached to the removable cap and provided as a combined piece. When the removable cap is attached to the tank, the wires or part of the electrical resistance exposed on the outer side of the back-up heater may be shielded to prevent direct contact to the wires or the electrical resistance. Furthermore, the electrical resistance may be an electric wire, such as a copper wire, surrounded by an electrical insulator and further encapsulated in a sheath. The electrical insulator may be a mineral powder, such as talcum powder. The sheath may be a stainless steel or enameled steel tube. The electrical insulator and the sheath prevents corrosion of the copper wire when the electrical resistance is immersed into water.

**[0016]** In an embodiment, the removable cap comprises a flange and a seal wherein the flange is made from stainless steel, enameled steel or coated metal. As the removable cap may be abutting the heating element, or pass parts of the heating element through the cap, heat from the heating element may likely be transferred directly to the removable cap. The flange may be used to mount the heating element to the flange, where the flange together with the heating element are locked into a position by means of the removable cap. As such, the flange may have a plate shape which freely rotates within the removable cap freeing up the degree of rotation of the removable cap. If the heating element and its electrical wiring were integrated directly into the cap, the wiring would get entangled while screwing the removable cap to the tank. This in turn could lead to a degradation of the wires. As the heating element may be an electric resistance with a power of about 3kW to 16kW, in general, the heating element radiates quite some heat. The flange may as such absorb the heat from the heating element. As such, the flange is made from stainless steel, enameled steel or coated metal. The seal ensures a water tight sealing between the removable cap and the tank. The seal may be a rubber seal suitable to withstand higher temperatures.

**[0017]** In an embodiment, the tank further comprises at least two ports for a secondary water flow. The secondary water flow may be, for instance, a water flow for the hydraulic heater of a heat pump system. This way, two water flows can be run through the tank at the same time and heating both water flows simultaneously.

**[0018]** In an embodiment, the back-up heater further comprises a thermal insulation on the outer side of the tank. The tank of the back-up heater may reach temperatures up to 200°C. Depending on the place of installation, it is desired to protect the surroundings against direct or indirect contact with these high temperatures of the tank. As such, a thermal insulation may reduce the amount of heat exposed to the surroundings. Further-

more, by thermally insulating the outer side of each part of the tank, less heat and thus less energy will be wasted by radiation of heat to the outer side of the tank.

**[0019]** In an embodiment, the back-up heater further comprises a spacer positioned between the heating element and the inner wall of the tank. As the tank is made from plastic, the tank may not withstand high temperatures such as the high temperatures at the surface of the heating element. The plastic used may be compliant with temperatures of the water up to 200°C, but not with direct contact with the surface of the heating element which may reach temperatures of 500°C to 750°C. While the removable cap should hold heating element in its place, in case of a failure the heating element may touch the surface of the tank. Therefore, a spacer is used to prevent the heating element to directly touch the inner wall of the tank, thus preventing the heating element to directly melt or burn away the tank that is made from plastic. As the spacer is in direct contact with the water in the tank, any heat absorbed from the heating element is mainly transferred to the water and not to the inner wall. The spacer may consist of a single piece or comprise two or more individual pieces working together as a spacer on at least two sides of the heating element. The spacer may have a circular shape. The spacer may be a ring. The ring may be one continuous ring or a ring with a gap in between, forming a c-shaped ring. The spacer may also be construed from two half rings or four quarter-part rings. When using a c-shaped ring or a spacer made from multiple parts of a ring, a discontinued ring is used. This allows for deformation or dilation of the spacer due to temperature changes without generating radial stress onto the tank. The spacer may be fixed to the inner side of the tank prior to installing the heating element, or may be fixed to the heating element itself. The spacer may be fixed in a reversible manner by means of, for instance, keying elements corresponding with the shape of the spacer.

**[0020]** In an embodiment, the spacer is made from a material to withstand temperatures of above 200°C, preferably above 500°C, and wherein the contact area between the spacer and the tank is minimal. Depending on the type of heating element used, the surface of the heating element may reach temperatures of above 200°C, even well above 500°C and up to 750°C. This is especially the case when there is no flow of the water, or if there is no water present in the tank while the heating element is active. To ensure that the spacer itself does not melt or burn away, and to prevent heat being transferred to the inner wall of the tank via the spacer, the spacer should be made from a material to withstand such high temperatures and have a minimal contact with the inner wall. The contact area between the spacer and the tank is considered minimal when the spacer rest on less than 50 percent of its outer edge, or peripheral, is in contact with the inner wall of the tank, preferably even less than 15 percent. A continued or discontinued ring with two or more small protrusions on the outer edge of the

spacer may ensure such minimal contact between the spacer and the inner wall of the tank.

**[0021]** In an embodiment, the spacer has through holes or recesses on its surface area. As the spacer is in direct contact with the water in the tank, any heat absorbed from the heating element is transferred to the water. By using through holes on the surface area of the spacer, the contact area between the spacer and the water is increased and thus increased the heat transferred from the spacer to the water. Recesses on the surface area may also provide additional contact area, but may also reduce the amount of contact area between the heating element and the spacer, between the spacer and the inner wall, or both.

**[0022]** In an embodiment, the is made from metal or a ceramic material. Both metal and ceramic material may withstand the high temperatures of the heating element while absorbing heat from the heating element and transferring it to the water in the tank.

**[0023]** In an embodiment, the back-up heater further comprises a temperature sensor. The temperature sensor may reside within the tank to ensure the water temperature does not reach a temperature exceeding the melt temperature of the plastic of the at least one of the parts of the tank. When the temperature sensor detects a temperature of above 200°C, it may enable a controller to shut of the heating element to prevent any melting of the tank. The temperature sensor may also be used to regulate the heating element or the heating system of the heat pump system in which the back-up heater is present.

**[0024]** In an embodiment, the tank, when closed off with the removable cap has an inner volume to accommodate a volume of water between 0,5 and 10,0 liters, under a pressure of between 1 to 12 bars, and wherein the tank can hold water with a temperature ranging between -15°C and 85°C, preferably between -20°C and 200°C.

**[0025]** In an aspect of the invention, a heat pump system for heating water in a building is provided wherein the heat pump system comprises a heat exchanging circuit and a back-up heater as described previously. By providing a heat pump system comprising a heat exchanging circuit and the previously described back-up heater, a heat pump system is realized that can capture calories from an external source, such as water or air, to heat water while at the same time can also rely upon the back-up heater in case the external source cannot provide sufficient calories to heat the water. Typically, the back-up heater is provided within an indoor unit of a heat-pump system. When the back-up heater would be provided in an outdoor unit of a heat-pump system, the back-up heater requires additional insulation to prevent too much thermal loss when the outdoor unit operates in a cold environment. As the back-up heater is made, at least partially, from plastic, the back-up heater can be construed into any shape suitable for the design of the heat pump system.

**[0026]** In another aspect of the invention, a process for assembling a back-up heater is provided wherein the process comprises the steps of providing a tank formed from a single piece of plastic and attaching a removable cap onto the provided tank, wherein a heating element is attached to the removable cap and the heating element resides within the tank after attaching the removable cap onto the tank, and wherein the tank comprises an inlet and an outlet for a main water flow.

**[0027]** In the figures, the subject-matter of the invention is schematically shown, wherein identical or similarly acting elements are usually provided with the same reference signs.

Figure 1 shows a schematic representation of a cross section of a back-up heater according to the present invention.

Figure 2 shows a schematic representation of another cross section of a back-up heater according to the present invention.

Figure 3 shows a schematic representation of a back-up heater according to the present invention.

**[0028]** With reference to Figure 1, a cross-section of back-up heater 1 is shown comprising the tank 2, a heating element 3, a removable cap 4, thermal insulation 5 covering the tank 2, and a spacer 6 to prevent the heating element 3 from touching the inner side of the tank 2. Furthermore, it can be seen that the cap 4 comprises a flange 8 and a seal 9. On the outer side of the back-up heater 1, an electrical connection 7 is present and connected to the heating element 3. Also, an inlet 21 and an outlet 22 of a main water flow are shown together with ports 23a and 23b for a secondary water flow. As such, a main and secondary water flow can run through the inside of the tank 2 and be heated by means of the heating element 3. The tank 2 is made from plastic and is construed as a single piece of plastic including the inlet 21, the outlet 22 and the ports 23a and 23b, without the need of shaping and welding any steel or metal materials into such a complex shape.

**[0029]** In Figure 2, another cross-section is shown if the back-up heater 1 wherein it can be clearly seen that the spacer 6 prevents any contact between the heating element 3 and the inner wall of tank 2.

**[0030]** Figure 3 shows the back-up heater 1 as a whole with the removable cap 4, the thermal insulation 5, the electrical connection 7, the inlet 21, the outlet 22, and ports 23a and 23b clearly visible. Furthermore, a seam 30 of the thermal insulation 5 can be seen after folding the thermal insulation 5 around the tank 2.

#### Reference Signs

#### [0031]

1 back-up heater  
2 tank

3 heating element  
4 removable cap  
5 thermal insulation  
6 spacer  
7 electrical connection  
8 flange  
9 seal  
21 inlet of main water flow  
22 outlet of main water flow  
23a, 23b ports for secondary water flow  
30 thermal insulation seam

#### Claims

1. A back-up heater (1) for heating water in a heat pump system, wherein the back-up heater (1) comprises:

- a tank (2);
  - a heating element (3) inside the tank (2); and
  - a removable cap (4) positioned over an end of the tank (2);
- wherein the tank comprises an inlet (21) for a main water flow at a side of the tank (2) and;
- an outlet (22) for a main water flow at a side of the tank (2);
- wherein the tank (2) and the removable cap (4) are made from plastic and wherein the tank is formed as a single piece of plastic.

2. The back-up heater (1) according to claim 1, wherein the tank (2) and removable cap (4) are made by means of injection molding or three-dimensional printing.

3. The back-up heater (1) according to claim 2, wherein the plastic is a composite material comprising plastic and fiber materials.

4. The back-up heater (1) according to any of the preceding claims, wherein the heating element (3) is a hot water pipe or an electric resistance.

5. The back-up heater (1) according to any of the preceding claims, wherein the removable cap (4) comprises a flange (8) and a seal (9) wherein the flange (8) is made from stainless steel, enameled steel or coated metal.

6. The back-up heater (1) according to any of the preceding claims, wherein the tank (2) further comprises at least two ports (23a, 23b) for a secondary water flow.

7. The back-up heater (1) according to any of the preceding claims, wherein the back-up heater (1) further comprises a thermal insulation (5) on the outer side of the tank (2).

8. The back-up heater (1) according to any of the preceding claims, wherein the back-up heater (1) further comprises a spacer (6) positioned between the heating element (3) and the inner wall of the tank (2). 5
9. The back-up heater (1) according to claim 8 wherein the spacer (6) is made from a material to withstand temperatures of above 200°C, preferably above 500°C, and wherein the contact area between the spacer (6) and the tank (2) is minimal. 10
10. The back-up heater (1) according to claim 9, wherein the spacer (6) has through holes or recesses on its surface area. 15
11. The back-up heater according to claims 8 to 10, wherein the spacer (6) is made from metal or a ceramic material.
12. The back-up heater (1) according to any of the preceding claims, wherein the back-up heater (1) further comprises a temperature sensor. 20
13. The back-up heater (1) according to any of the preceding claims, wherein the tank (2), when closed off with the removable cap (4), has an inner volume to accommodate a volume of water between 0,5 and 10,0 liters, under a pressure of between 1 to 12 bars, and wherein the tank (2) can hold water with a temperature ranging between -15°C and 85°C, preferably between -20°C and 200°C. 25 30
14. A heat pump system for heating water in a building, wherein the heat pump system comprises: 35
- a heat exchanging circuit; and
  - a back-up heater (1) according to any of the claims 1 to 10.
15. Process for assembling a back-up heater (1) according to claim 1, wherein the process comprises the steps of: 40
- providing a tank (2) formed from a single piece of plastic; and 45
  - attaching a removable cap (4) onto the provided tank (2);
- wherein a heating element (3) is attached to the removable cap (4) and the heating element (3) resides within the tank (2) after attaching the removable cap (4) onto the tank (2), and wherein the tank (2) comprises an inlet (21) and an outlet (22) for a main water flow. 50 55

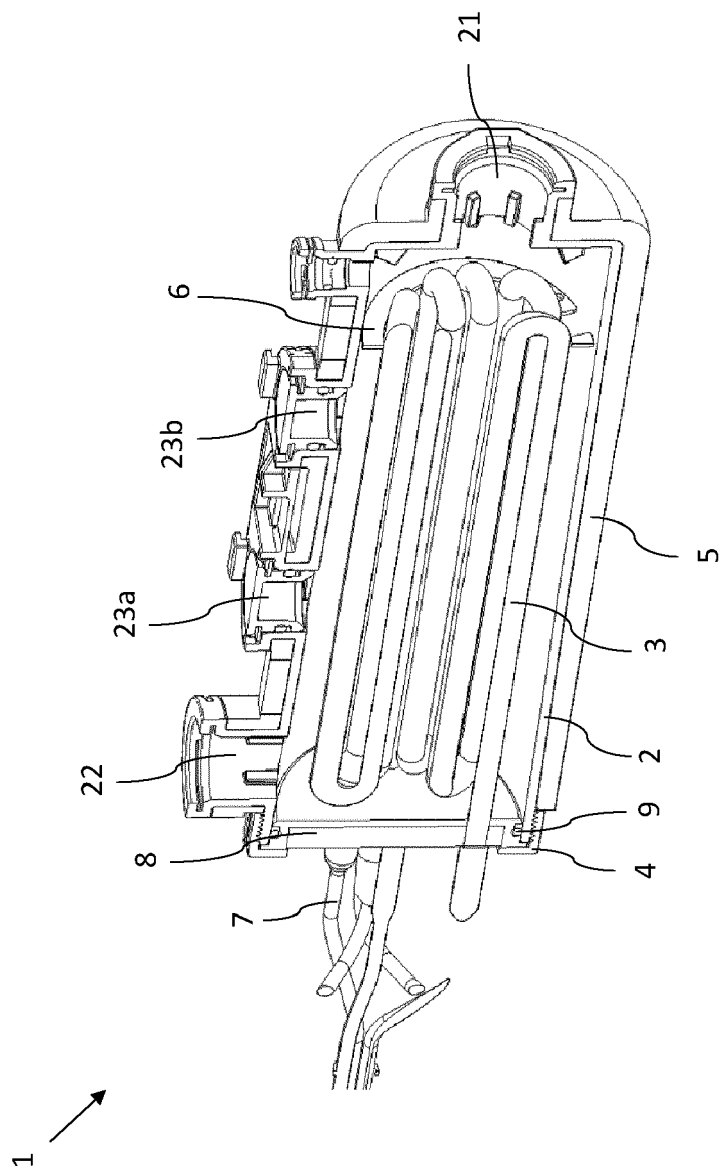


FIG. 1

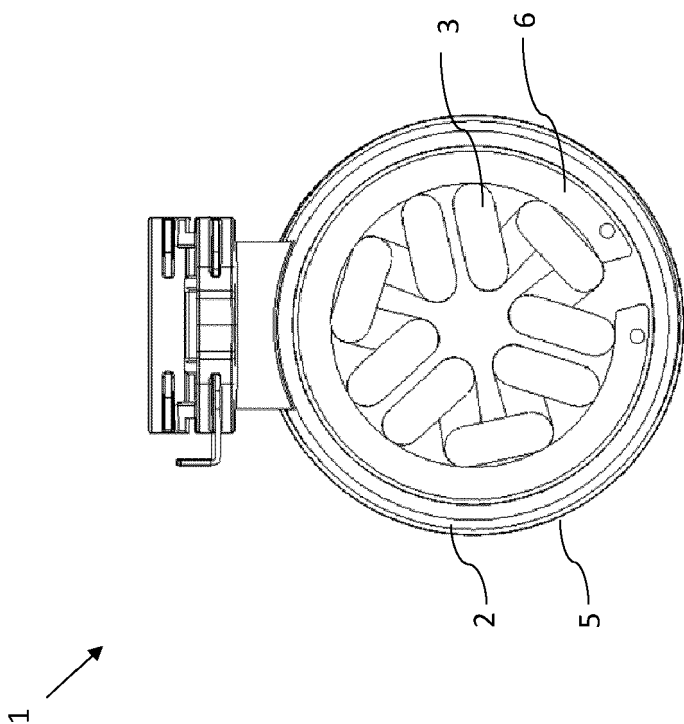


FIG. 2



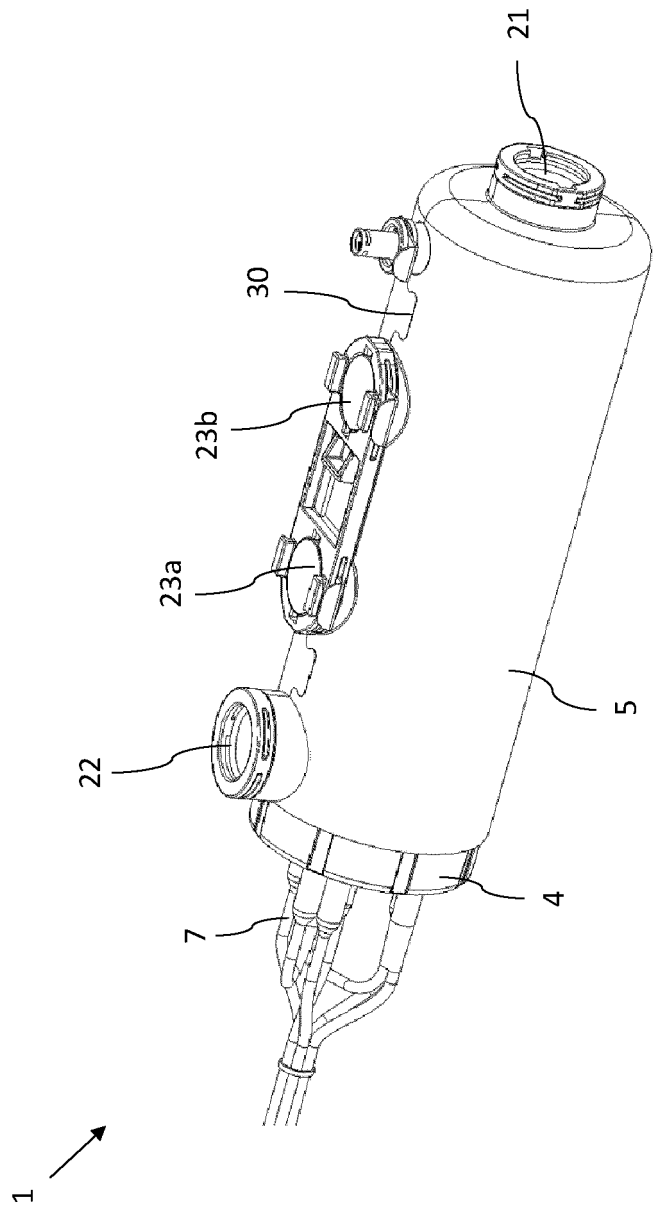


FIG. 3



## EUROPEAN SEARCH REPORT

Application Number

EP 22 20 3603

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