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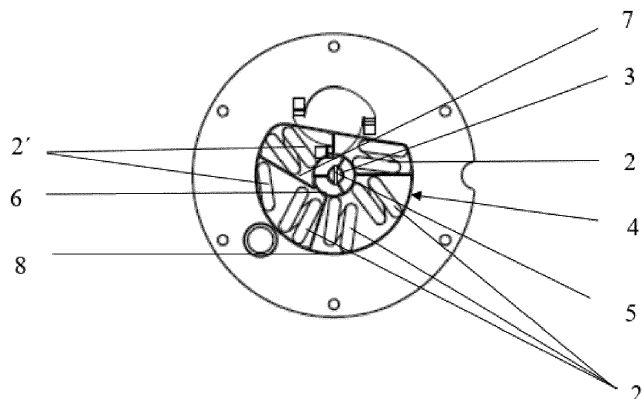
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(54) **ELECTRIC WATER HEATER**

(57) 1. An electric water heater, in particular an electric water heater with a variable heating output for use in a closed-loop water heating system, comprising a water tank with a cold water inlet (10) and a hot water outlet (20), a heating block (1) for heating the water in the water tank, a safety temperature limiter (3) for switching electrical contacts of the electric water heater and thermally conductive means for conducting heat from the heating

block (1) to the safety temperature limiter (3), characterized in that the heating block (1) comprises of a first heating element (2) and at least one further heating element (2'), the safety temperature limiter (3) is surrounded in the tank by heating elements (2, 2'), all the heating elements (2, 2') and the safety temperature limiter (3) are in touch contact with the thermally conductive means.



**Fig. 1**

## Description

### FIELD OF THE INVENTION

**[0001]** The invention relates to an electric water heater with several heating elements and with a safety temperature limiter, for use in a closed - loop water heating system.

### TECHNICAL BACKGROUND

**[0002]** Electric water heaters are devices in which electric heating elements are used for water heating, said electric heating elements are in contact with the heated water during heating.

**[0003]** Various applications of electric water heaters are known in the state of art. They can be used as the main source of heating in electric boilers for space heating and with domestic hot water tanks, or they are used as continuous flow heaters.

**[0004]** At present, electric water heaters are also advantageously used as auxiliary (backup) heating sources in heating systems with heat pumps. Backup heater is connected to a closed-loop water heating system with a cold water inlet and with a hot water outlet.

**[0005]** A common requirement for electric water heaters is the variability of the performance of the electric water heater and the heating of water of a certain volume, with a requested temperature. Performance variability is most often ensured by means of an electric water heater with a heating block equipped with several heating elements, in which the electrical supply can be switched to either individual or all heating elements. This connection can be made manually, for example optionally by not connecting all the heating elements to the power supply or by using a terminal block with so-called jumpers, it being possible to activate certain combinations of heating elements by means of a heater controller.

**[0006]** For the purpose of regulating the temperature of the heated fluid, suitably placed temperature sensors and various thermostats with a safety function are used.

**[0007]** Thus, an electric water heater generally has an electric heating block located in a tank with a certain volume of water, the heating block being mounted in a flange arranged on top of the tank. Furthermore, the electric water heater has a safety temperature limiter which is connected to the electrical contacts for switching the heating elements.

**[0008]** The safety temperature limiter is usually composed of a temperature sensor and a fuse made of solder. The temperature sensor is made in the form of a bimetallic switch and is set in such a way that it opens at a preset temperature. If the temperature sensor cools down over time, the contact will close again. The fuse from the fusion solder melts at a higher melting temperature, the so-called critical temperature.

**[0009]** Another safety temperature limiter used in heating technology is a capillary temperature limiter, which

uses a pressure system operating on the principle of liquid expansion. It consists of an ampule with a liquid, a capillary tube and a membrane. After raising the temperature on the ampule, the liquid in the capillary tube expands and causes the membrane to move. This movement activates the latch switch, which causes the switch contacts to open or close. The switching principle is therefore exclusively mechanical, in contrast to the version with bimetallic and fuse, and in certain circumstances can be considered more reliable.

**[0010]** A crucial condition for reliable operation for all types of safety temperature limiters is the correct sensing of the water temperature in the tank with which the sensor is in contact.

**[0011]** If there is no water in the tank of the electric water heater, there is a risk of dry fire. The term "dry fire" refers to a situation where a heating block is connected to a source of electrical energy to provide heating, while there is no or a very small volume of water in the tank of the electric heater. In this state, the heating elements can be damaged relatively easily by overheating.

**[0012]** Various solutions to prevent dry fire have been disclosed in the prior art.

**[0013]** The document US 2017059208 A1 discloses a water heater having a tank with at least one heating element. The non-invasive water level sensor is arranged in connection with the volume of water containing the volume of the tank. If the signal received from the sensor indicates that at least one heating element is immersed in water, energy is supplied to the heating element. If the signal indicates that at least one heating element is not immersed in water, the supply of energy to the heating element is prevented. This solution is expensive and presupposes a horizontal arrangement of the heating elements in the electric water heater.

**[0014]** The document EP 3037741 B1 describes in detail a method for preventing dry fire in electric instantaneous water heaters equipped with a safety temperature limiter by means of a controller evaluating switching times. In the dry fire state, the fuse with the solder in the safety temperature limiter melts. The fuse with the solder must then be replaced so that the electric heater can be operated again.

**[0015]** The document CN 101014219 A discloses an electric heating element with automatic temperature control inside a water tank and with dry fire prevention. The U-shaped heating coil is connected in parallel to the temperature limiter and is connected to the temperature sensor directly by a tight contact or indirectly via an optional thermally conductive bracket.

**[0016]** The correct indication of the measured temperature is a condition for the correct function of the safety temperature limiter, as is clear from the state of the art.

**[0017]** The present invention relates to an electric water heater with variable heating output, in which several heating elements are located. The aim of the present technical solution is to avoid erroneous or late evaluation of the switching temperature when switching the powers

in the electric water heater and to design such an arrangement of the electric water heater in which effective protection against dry fire is achieved with little effort.

## SUMMARY OF THE INVENTION

**[0018]** If there is water of the required volume in the heater, the temperature sensor in the safety temperature limiter evaluates its temperature with sufficient accuracy. The temperature sensor of the temperature limiter is immersed in the water by means of a thermally conductive housing and the heat transfer from the heating elements to the water and from the water to the sensor takes place mainly by convection and conduction.

**[0019]** In the case of a dry fire, a lack of water leads to overheating of the heating element of the electric water heater. If the heating element is not in direct contact with the safety temperature limiter sensor, it is not possible to correctly evaluate the temperature for closing the safety temperature limiter switch. In this case, the reaction time of the switch is up to 60 seconds, regardless of the switching temperature set value, since the heat transfer from the heating elements to the sensor takes place mainly by radiation. The consequence of this long reaction time is that the heating elements, which are in the heating state, can reach a temperature of more than 800°C. In a short time, the surface of the water heater reaches a temperature of over 300°C, which is undesirable.

**[0020]** Since only one safety temperature limiter is generally used in the electric heater, usually to switch off the heating contacts, then the solution consists of the safety temperature limiter sensor placement in the area with the assumed maximum water temperature, i.e. between the heating elements in the middle of the tank. At the same time, all heating elements are connected to the safety temperature limiter sensor by a suitable thermally conductive means. This will ensure that heat from the heated elements is applied to the sensor in a conductive manner, even in the dry fire state (without the presence of water).

**[0021]** Even if some of the heating elements are not in the heated state, a suitable arrangement of the thermally conductive means conveys the temperature information inside the tank correctly.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0022]** The technical solution is further explained using the following figures, without limitation to these:

Fig. 1 - Cross section of an electric heating block assembly with six heating elements and a capillary safety temperature limiter

Fig. 2a and Fig. 2b - Spatial views of the electric heating block from the Fig. from different perspectives

Fig. 3 - Electric heater according to the invention with the heating block from Fig. 1, Fig. 2a and Fig. 2b. and with a water tank

## EXAMPLE OF EMBODIMENT

**[0023]** Figures 1, 2a, 2b show a heating block 1 which is used to heat water in an electric backup water heater for a heat pump heating system. Figure 3 shows the heating block 1, which is fixed to the electric backup heater flange and the flange is connected in a waterproof manner with the tank. The both - cold water inlet 10 and hot water outlet 20 are placed on the backup heater flange. The electric backup heater with variable heating output for the heat pump heating system is equipped with a heating block 1 composed of at least two heating elements 2, 2'. In the illustrated example, 6 pieces of the heating element are connected and they extend into different depths of the water tank. The safety temperature limiter 3 is located in the water tank such a way, that it is surrounded by the heating elements 2, 2'.

**[0024]** In the example of embodiment, a capillary safety temperature limiter 3 is used, which is electrically connected with an electric terminal contacts of the electric backup heater (not shown in the drawings). The temperature sensing element is an ampule containing a fluid, the fluid increasing its pressure as the temperature sensed by the ampule increases. This pressure is transmitted by the capillary to the switch. When the temperature rises above the set temperature (for example 98°C), the switch causes the contacts to open and disconnects the power supply to the heating elements.

**[0025]** Furthermore, the contacts open and block the heating even if the hydraulic system of the sensor leaks or if the measured temperature falls below -20°C. The contacts will close again if the sensed temperature is lower than the set temperature (98°C) and the reset button is pressed. To ensure greater safety, the professional intervention of a service technician and the exclusion of the possibility of a reset is recommended.

**[0026]** The safety temperature limiter 3 is housed in a water tank in a metal housing which conducts heat well and the temperature sensor of the safety temperature limiter 3 can sense the water temperature in this way.

**[0027]** All heating elements 2, 2' are thermally connected to the safety temperature limiter 3 by a suitable thermally conductive means, in the example of embodiment it is a metal thermally conductive strip 4.

**[0028]** A first circular section 5 of a connecting strip 4 made of a well thermally conductive metal material (e.g. copper) is tightly slid onto the metal housing of the safety temperature limiter 3, and the first circular section 5 is fastened to the second circular section 6 by means of several transverse sections 7.

**[0029]** The third, substantially circular section 8 of the connecting strip 4 is connected to the second circular section 6 of the connecting strip 4 by several transverse sections 7 of the connecting strip 4 so that the heating

elements 2, 2' are located in the space between the second and third circular sections 6, 8 and each of the heating elements 2, 2' is in contact with at least one transverse section 7 and/or with at least one circular section 6, 8 of thermally conductive strip 4. The third, substantially circular section 8 of the connecting strip 4 surrounds the heating elements 2, 2' so that the connecting strip 4 fixes the heating elements 2, 2' and prevents their displacement, which could occur due to deformation of the metallic material of the heating elements 2, 2' during operation.

**[0030]** The thermally conductive connecting strip 4 is immersed in water during normal operation and must be at such a distance from the flange as to ensure a touch connection with each, i.e. also with the shortest heating element.

**[0031]** By contact (or tangential connection in the case of a circular cross-section) of the heating elements 2, 2' and the thermally conductive connecting strip 4, the heat from each heated heating element is conducted sufficiently quickly and reliably to the safety temperature limiter 3 by conduction.

**[0032]** In the case of dry fire, timely disconnection of electric contacts is ensured.

**[0033]** The thermally connecting strip being composed of three circular sections 5, 6, 8 and seven transverse sections 7 causes only a negligible pressure loss in the heating system.

**[0034]** At the same time, the sufficiently strong thermally connecting strip 4 keeps the heating elements 2, 2' in the original (assembly) position and serves as a reinforcement preventing their displacement during normal deformation changes caused by operation.

**[0035]** A preferred embodiment of the electric heater comprises a deflector 9 arranged at the water inlet 10, which evenly directs the cold water supplied to the electric heater to the heating elements 2, 2' and restricts direct cold water flow to the safety temperature limiter 3 (the deflector arrangement is shown in Fig. 2b).

**[0036]** The arrangement of the heating elements and the design of the thermally conductive means as well as the type of safety temperature limiter may differ in other embodiments of the described technical solution, but the contact connection of each heating element to the thermally conductive means must be maintained to ensure conductive heat transfer to the safety temperature limiter sensor in a dry fire state.

#### REFERENCE NUMERALS

##### [0037]

- 1 heating block
- 2 first heating element
- 2' heating element
- 3 safety temperature limiter
- 4 thermally conductive connecting strip
- 5 first circular section

- 6 second circular section
- 7 transverse section
- 8 third circular section
- 9 deflector
- 10 water inlet
- 20 water outlet

#### Claims

1. An electric water heater, in particular an electric water heater with a variable heating output for use in a closed - loop water heating system, comprising a water tank with a cold water inlet (10) and a hot water outlet (20), a heating block (1) for heating the water in the water tank, a safety temperature limiter (3) for switching electrical contacts of the electric water heater and thermally conductive means for conducting heat from the heating block (1) to the safety temperature limiter (3),  
**characterized in that**  
the heating block (1) comprises of a first heating element (2) and at least one further heating element (2'),  
the safety temperature limiter (3) is surrounded in the tank by heating elements (2, 2'),  
all the heating elements (2, 2') and the safety temperature limiter (3) are in touch contact with the thermally conductive means.
2. Electric water heater according to claim 1,  
**characterized in that**  
the means for conducting heat from the heating elements (2, 2') to the safety temperature limiter (3) is a thermally conductive connecting strip (4) composed of circular sections (5, 6, 8) and transverse sections (7),  
each of the heating elements (2, 2') is in touch contact with at least one transverse section (7) and/or with at least one circular section (6, 8) of thermally conductive connecting strip (4),  
the safety temperature limiter (3) is in touch contact with the thermally conductive connecting strip (4).
3. Electric water heater according to claim 1 or 2,  
**characterized in that**  
a deflector (9) is arranged at the cold water inlet (10) for an even distribution of cold water to the heating elements (2, 2').
4. Electric water heater according to any one of claims 1 to 3,  
**characterized in that**  
the safety temperature limiter (3) is equipped with a temperature sensor and a fuse.
5. Electric water heater according to any one of claims 1 to 3,

**characterized in that**

the safety temperature limiter (3) is a capillary temperature limiter.

6. Electric water heater according to any of claims 1 to 5,

**characterized in that,**

the closed-loop water heating system is a heat pump heating system.

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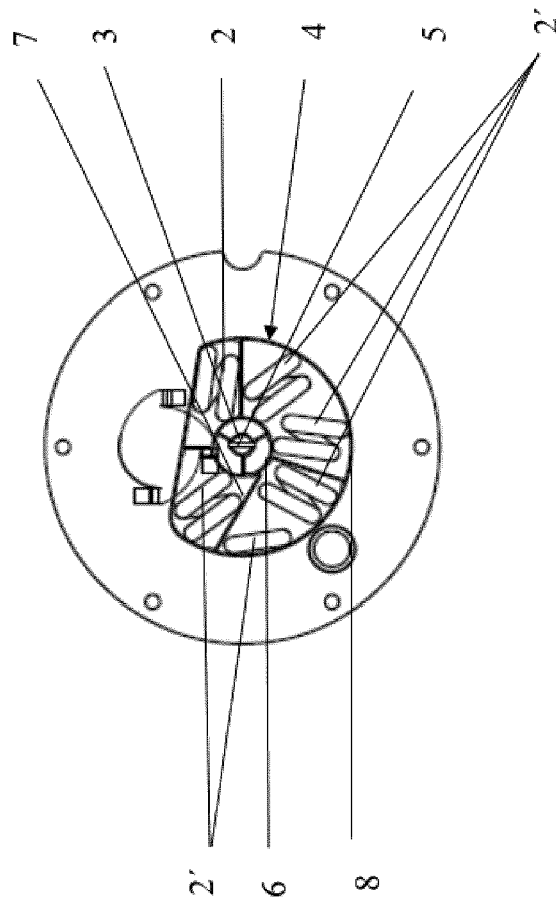


Fig. 1

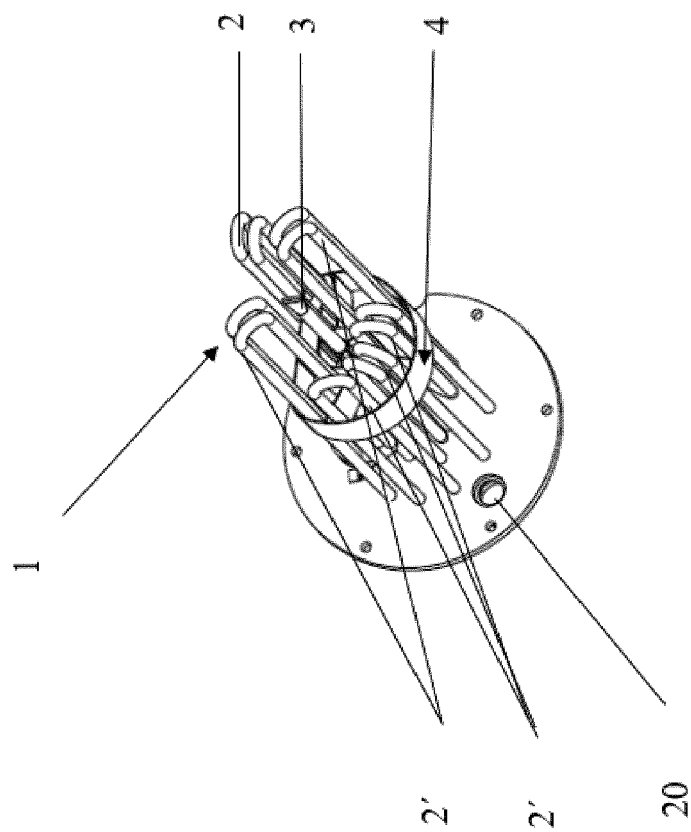


Fig. 2a

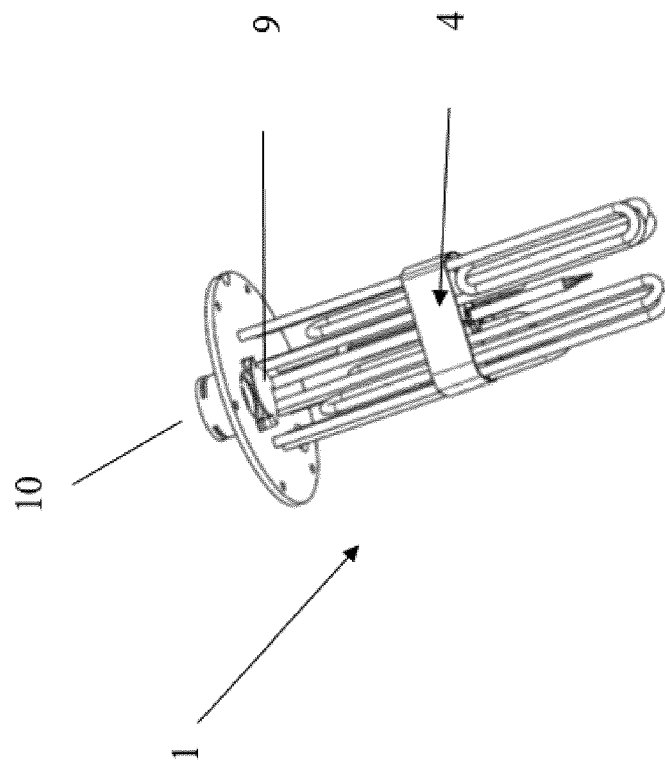
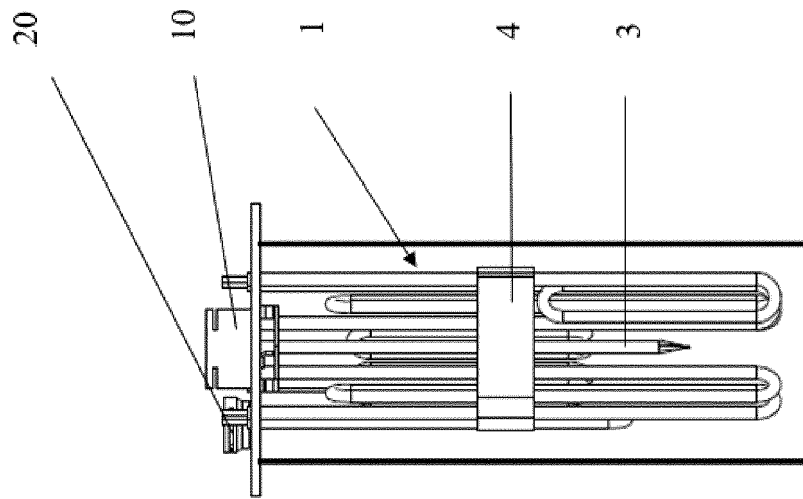


Fig. 2b



**Fig. 3**



## EUROPEAN SEARCH REPORT

Application Number  
EP 21 15 8608

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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                |                                                         |                                                      |
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| Place of search<br><b>Munich</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                | Date of completion of the search<br><b>30 June 2021</b> | Examiner<br><b>Schwaiger, Bernd</b>                  |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document<br>T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                                                                                                |                                                         |                                                      |

EPO FORM 1503 03.82 (P04C01)

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