



(11) **EP 4 253 866 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**04.10.2023 Bulletin 2023/40**

(51) International Patent Classification (IPC):  
**F24H 9/20** <sup>(2022.01)</sup> **F24H 15/184** <sup>(2022.01)</sup>  
**F24H 15/395** <sup>(2022.01)</sup>

(21) Application number: **22164737.3**

(52) Cooperative Patent Classification (CPC):  
**F24H 9/2042; F24H 9/205; F24H 15/184;**  
**F24H 15/395; F24D 2101/60; F24D 2200/04;**  
**F24D 2220/04; F24D 2220/08; F24H 2240/08**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB**  
**GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO**  
**PL PT RO RS SE SI SK SM TR**  
Designated Extension States:  
**BA ME**  
Designated Validation States:  
**KH MA MD TN**

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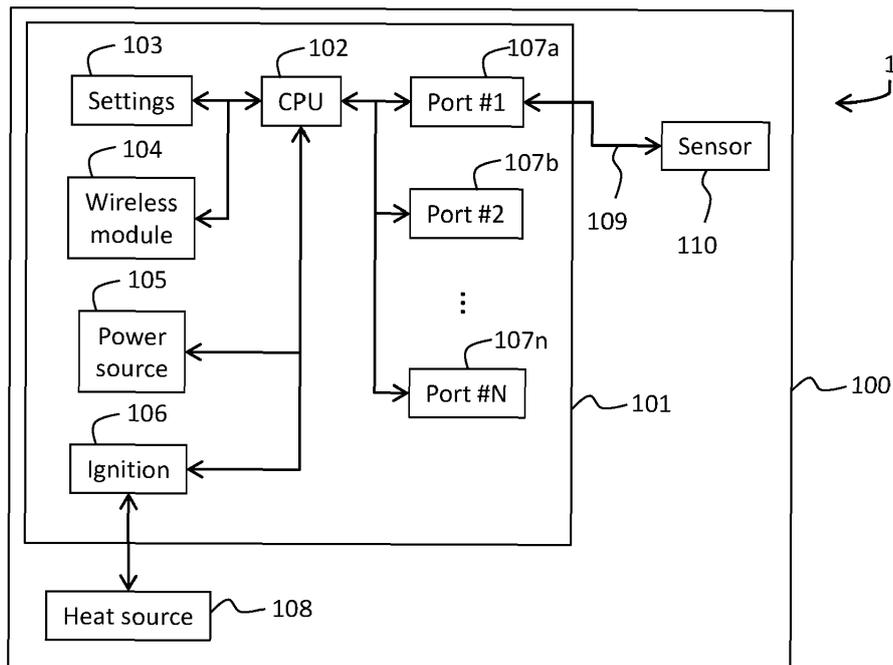
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(54) **SENSOR FOR WATER HEATERS**

(57) A controller for a water heater which has a power source configured to power up the components of the controller, wherein the power source is independent of a battery or mains electricity and uses a thermoelectric effect; and a gas sensor powered from the controller via the power source, wherein the gas sensor is configured

to be positioned externally to the controller and connected to the controller, and wherein the controller is configured to trigger an alarm if a concentration of gas in the vicinity of the gas sensor is above a predetermined threshold.



**Fig 1**

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**Description**

## FIELD OF THE INVENTION

**[0001]** The present invention relates to sensors, e.g. CO sensors, for water heaters that use fuel combustion as a source of energy.

## BACKGROUND OF THE INVENTION

**[0002]** Water heaters, also known as boilers, are devices that are used in variety of contexts to provide hot water. As a source of energy (fuel), some water heaters use natural gas, other fossil fuels or solid fuels. With an example of natural gas, under various adverse circumstances (e.g. failure in equipment, incorrect installation of the water heater, or natural disaster), the natural gas may not be burned fully (incomplete combustion) and thus carbon monoxide (CO) may be produced.

**[0003]** To detect CO in homes, CO sensors are used. CO sensors may be placed in various locations, e.g. close to or on the water boiler. To function properly, an ordinary CO sensor requires an energy source. Providing an energy source may come with difficulties. For example, if the energy source is a battery, the CO sensor is limited by the battery lifetime, and the user has to periodically replace the battery to ensure the CO sensor functions properly. If the energy source is the mains electricity, the sensor may stop working in situations of disrupted electricity supply (e.g. following a storm).

**[0004]** Similarly, instead of or in addition to CO, water heaters may produce or leak other gases. To detect these, dedicated sensors may be used. These sensors may suffer from similar problems with power, i.e. if powered by battery, the battery may need regular changing, and when powered by mains, the sensor may stop working if for some reason mains electricity supply is interrupted.

**[0005]** The present invention aims at mitigating these and other problems.

## SUMMARY OF THE INVENTION

**[0006]** In a first aspect, a controller for a water heater is provided. The controller comprises: a power source configured to power up the components of the controller, wherein the power source is independent of a battery or mains electricity and uses a thermoelectric effect; and a gas sensor powered from the controller via the power source, wherein the gas sensor is configured to be positioned externally to the controller and connected to the controller, and wherein the controller is configured to trigger an alarm if a concentration of gas in the vicinity of the gas sensor is above a predetermined threshold.

**[0007]** In a second aspect, a water heater is provided. The water heater comprises a controller as described in the first aspect and a heat source, wherein the heat source utilizes fuel combustion.

**[0008]** In a third aspect, a method of operating a water heater controller as described in the first aspect is provided. The method comprises the steps of detecting, by the gas sensor, the level of gas in the vicinity of the sensor; generating, by the gas sensor, a signal indicative of the level of gas; transmitting, by the gas sensor, the signal to the controller; determining, by the controller, based on the signal, that the gas level is above threshold; generating, by the controller, an alert message; and stopping, by the controller, the fuel combustion in the water heater.

**[0009]** The independent claims and their dependent claims as well as the below description outline further embodiments.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0010]** Specific embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic representation of a water heater with a controller and a sensor according to the present invention; and

Figure 2 is a flow-chart of an example operation of the water heater controller.

## DETAILED DESCRIPTION

**[0011]** The below description is for illustration only, and is not intended to be limiting. Various elements of embodiments described below may be combined as appropriate. When the description described "water heater", it is to be understood that the invention would also work with other appliances that utilize fuel combustion (fuel-burning appliances). Similarly, when the description refers to a "CO sensor", it is to be understood that a variety of sensors detecting substances other than CO may be used. Similarly, when the description refers to "natural gas", it is to be understood that other fuel may be used (e.g. another fuel in the form of gas or liquid, such as propane, oil and the like).

**[0012]** An example water heater 1 is shown schematically in Fig 1. The water heater 1 may comprise a tank 100 for storing the hot water generated by the water heater 1, a controller 101 and a sensor 108.

**[0013]** The tank 100 may be of any suitable shape and size. The heat source 108 may be combined with the tank 100 into one appliance, or it may be provided as a separate device. In an embodiment, the heat source may be two-part, with a first part to deliver hot water in short time and second part to keep water temperature on certain pre-set level.

**[0014]** The controller 101 comprises a CPU 102. The CPU has memory (not shown) which stores instructions for controlling the water heater 1 and/or various components of the controller 101 and the water heater 1, as described below.

**[0015]** The controller 101 may further comprise a device 103 for changing the settings of the water heater 1. The device 103 may be used e.g. to set the required water temperature, the required times when the water heater heats the water, and the like. The device 103 may be or may comprise e.g. dial(s), control switch(es), selector switch(es), button(s), touch screen and the like.

**[0016]** The controller 101 may further comprise a wireless module 104. The wireless module may serve as a means of communication between the controller 101 and an external device (not shown). The external device may be e.g. a user device such as a remote control, a smart phone, a computer or a tablet. The external device may be a control panel which controls central heating and/or security in a home. In some embodiments, there may be more than one external device. In such case, the external devices may be of the same or different types. The wireless module 104 may communicate settings and other information between the controller and the external device. For example, the wireless module may operate on a protocol such as WiFi, Bluetooth, Zigbee and the like.

**[0017]** The controller 101 may further comprise a power source 105. The power source 105 may utilize thermopile, i.e. a device which converts thermal energy into electrical energy. Thermopile works on the principle of the thermoelectric effect, i.e., generating a voltage when dissimilar metals (thermocouples) are exposed to a temperature difference. In the water heater 1, the temperature difference may come e.g. from the difference of temperatures between the outside of the water heater 1 (this may be e.g. room temperature) and the inside the water heater 1 and close to the heat source 108 (this may be several hundred degrees Celsius, e.g. 600 °C). In embodiments with two-part heat source, the temperature difference may come e.g. from the difference of temperatures between the outside of the water heater 1 and close to the second heat source (the heat source used to keep water temperature on certain pre-set level). The power source 105 operating on this principle may generate enough energy to power the controller 101, all its components and all devices connected to it, including the sensor 110.

**[0018]** In some embodiments, the power source 105 utilizing thermopile may consist of a single thermocouple. Such power source 105 with a single thermocouple may be cheap and/or easy to manufacture and implement and still provide enough power for the controller 101, all its components and all devices connected to it, including the sensor 110. For example, a single-thermocouple power source 105 may generate between 5mW and 30mW. A CO sensor may require between 2 $\mu$ W and 10  $\mu$ W.

**[0019]** In some embodiments, different sensors than a CO sensor may be used. For example, one or more of the following may be used: a CO<sub>2</sub> sensor, a hydrogen sensor, a methane sensor. In some embodiments (e.g. using a CO<sub>2</sub> sensor instead of or in addition to a CO sensor), the sensor 110 may require more energy than

is available from a single thermocouple. In such case, the power source 105 may comprise more than one thermocouple. The number of thermocouples in the power source 105 in such case will be selected based on the type of sensor 110 used.

**[0020]** The controller 101 may further comprise one or more ports 107a-107n. The ports 107a-107n may be used to connect various components to the controller 101 and/or to the CPU 102. For example, the ports 107a-107n may be used to connect one or more sensors to the controller 101 and/or the CPU 102.

**[0021]** The controller 101 may further comprise an ignition control 106, which, based on instructions from the CPU 102, may instruct an igniter (not shown) to initiate the fuel combustion in the heat source 108. The heat source 108 then heats the water. The heated water may be used immediately (for example for washing or heating of a home), or it may be stored in the tank 100 for later use. The igniter may be of any known type, for example piezoelectric.

**[0022]** The heat source 108 obtains energy from fuel combustion. The fuel may be e.g. natural gas, propane, oil or other gas or liquid fuel. Fuel combustion may generate a certain amount of carbon monoxide (CO), e.g. due to incomplete combustion. Independently on this, in certain circumstances, a faulty appliance may leak and/or produce other harmful gasses, including the fuel. To detect the amount of these substances, a sensor 110 may be provided. In the following description, the sensor 110 is described as a CO sensor, but it is to be understood that the invention would work analogously with other sensors, such as hydrogen sensor, methane sensor, and the like.

**[0023]** The sensor 110 preferably detects whether the level (amount) of CO close to the sensor 110 (e.g. in the room where the water heater is located) is above a threshold. The sensor 110 may be a conventional CO sensor. For example, the sensor 110 may be of electrochemical type, with measured voltage used as an indicator of the CO level.

**[0024]** The sensor 110 may be positioned on the surface of the tank 100. The sensor 110 may be positioned in a location where CO is likely to be produced, e.g. close to the heat source 108 or close to the fuel combustion. The sensor 110 may be positioned in a location where CO is likely to accumulate, e.g. at or close to the upper part of the tank 100 (where "upper part" is used in this context to denote the upper part when the tank 100 is installed and in use). The sensor 110 may be positioned in any other suitable location. Preferably, the sensor 100 and the controller 101 are both positioned on the tank 100 of the water heater 1.

**[0025]** The sensor 110 is connected to the controller 101 such that the sensor 110 may report CO levels to the controller 101. The sensor 110 is preferably connected to one of the ports 107a-107n provided on the controller 101. In the example of Fig 1, the sensor 110 is connected to the port 107a and thus to the controller 101

and the CPU 102 via a wire or a cable 109. The wire 109 which connects the sensor 110 to one of the ports 107a of the controller 101 may serve to transfer information from the sensor 110 to the controller 101. It may also serve as a power source for the sensor 110. In other words, the sensor 110 may be also powered from the thermopile power source 105 (described above), together with the controller 101.

**[0026]** The sensor 110 may not have a wireless ability. This reduces the energy consumption of the sensor 110. The sensor 110 may transmit the voltage measured at the sensor 110 to the CPU 102 via the wire 109. Upon receiving the measured voltage, the CPU 102 may determine whether the CO level is above a pre-determined threshold. When the CO level is determined above the threshold, alarm may be triggered.

**[0027]** If dangerous levels of CO are detected (e.g. if the CO level is above a pre-set threshold), the CPU 102 may stop the combustion of the fuel in the heat source 108. In addition, the CPU 102 may use the wireless module 104 to transmit a message to the external device to alert user(s).

**[0028]** Fig 2 illustrates an example operation of the sensor 110 and the controller 101.

**[0029]** In step S1, the sensor 110 detects the CO level. Based on the detected CO level, the sensor 110 generates a signal indicative of the CO level.

**[0030]** In step S2, the sensor 110 transmits the signal indicative of the CO level to the controller 101, preferably via the wire 109.

**[0031]** In step S3, the CPU 102 of the controller 101 determines that the CO level is above a predetermined threshold. The threshold may be e.g. stored in a memory (not shown) of the controller 101. The threshold may be based on the level of CO harmful to humans, and it may be stored in the memory upon manufacture of the controller 101 and/or it may be regularly updated via a connection to an external device (not shown).

**[0032]** In step S4, the CPU 102 generates an alert message. The alert message may comprise information on the level of CO being above threshold. In some embodiments, the alert message may comprise also the detected level of CO.

**[0033]** In step S5, the controller 101 stops fuel combustion to minimize further generation of CO and outputs the alert message. This alert message may be output in a form of sounding an alarm. The alert message may be output in a form of light indication (e.g. a warning light of a specific colour, flashing light and the like). In an embodiment, alarm message in the form of light indication may be advantageous, because it may be energy-efficient and visible even in situations in which a sound alarm would be difficult to hear (e.g. in noisy environment).

**[0034]** Alternatively or in addition, the alert message may be transmitted to the external device, e.g. a remote control, a control panel, a user's smart phone and the like. The external device then may output a sound alarm or use other way of alerting the user the fact that the CO

level is above threshold. The alert message may be transmitted from the controller 101 to the external using the wireless module 104.

**[0035]** It is to be understood that the above-described method is just for illustration. One or more of the above-described method steps may be modified as appropriate. For example, the alert message may be provided in accordance with the regulatory requirements. For example, additional steps may be added to the steps described above.

**[0036]** In some embodiments, the controller 101 may be provided with the sensor 110 upon installation. In such situations, the connection of the sensor 110 to the controller 101 via the wire 109 may be advantageous in that the sensor 110 may be positioned in a different location than the controller 101. The location of the controller 101 may thus be convenient for the user (e.g. easily accessible for the user), while the position of the sensor 110 may be suitable for measuring the CO levels (e.g. close to the combustion where the CO may be generated, or close to the ceiling where the CO accumulates).

**[0037]** In some embodiments, a new sensor 110 may be added to an existing controller 101. In such case, the sensor 110 is connected by a wire 109 to one of the existing ports 107a-107n of the controller 101. The memory of the controller 101 is updated with appropriate instructions on the operation of the sensor 110 and the threshold levels of CO (voltage representative of the level of CO).

**[0038]** The sensor 110 as described herein may be advantageous in situations where autonomy of the sensor 110 is required. As described above, the sensor 110 is powered up by the controller 101 via the wire 109. The controller 101 is in turn is powered by thermopile, which is a source independent on the mains electricity or battery. This may be of advantage in places where mains electricity supply may be cut off (whether it is an unexpected power outage or scheduled maintenance) or where monitoring and exchanging battery may be inconvenient or impossible.

**[0039]** In an embodiment, the water tank 100 may be omitted, and the water heater 1 may be of a continuous heating type. In such embodiment, the controller 101 may be placed directly on the water heater. The sensor 108 and the controller 101 then work in the way outlined above.

## Claims

1. A controller for a water heater comprising:

a power source configured to power up the components of the controller, wherein the power source is independent of a battery or mains electricity and uses a thermoelectric effect; and a gas sensor powered from the controller via the power source, wherein the gas sensor is configured to be positioned externally to the controller

- and connected to the controller, and wherein the controller is configured to trigger an alarm if a concentration of gas in the vicinity of the gas sensor is above a predetermined threshold.
2. The controller of claim 1 wherein the power source uses thermopile, comprising a single thermocouple.
  3. The controller of claim 1 or claim 2, wherein the power source uses thermopile, comprising two or more thermocouples.
  4. The controller of any one of the preceding claims, wherein the gas sensor is a CO sensor, a methane sensor or a hydrogen sensor.
  5. The controller of any one of the preceding claims, further comprising an igniter configured to initiate fuel combustion;
  6. The controller of any one of the preceding claims, wherein the gas sensor is connected to the controller via a wire or a cable connected to a port provided in the controller.
  7. The controller of any one of the preceding claims, further comprising a device for changing the settings of the water heater.
  8. The controller of any one of the preceding claims, further comprising a CPU configured to control the operation of the water heater and/or the components of the controller.
  9. The controller of any one of the preceding claims, further comprising a wireless module configured to communicate with an external device.
  10. The controller of any one of the preceding claims, further comprising a wireless module configured to communicate with an external device.
  11. A water heater comprising:
    - a controller of any one of the preceding claims; and
    - a heat source, wherein the heat source utilizes fuel combustion.
  12. The water heater of claim 11, further comprising a water tank, wherein the controller and the sensor are positioned on the water tank.
  13. The water heater of claim 11 or claim 12, wherein the sensor is positioned in a location where there is a likelihood of the gas being produced or accumulated.
  14. A method of operating a water heater controller from any one of claims 1 to 10, comprising the steps of:
    - detecting, by the gas sensor, the level of gas in the vicinity of the sensor;
    - generating, by the gas sensor, a signal indicative of the level of gas;
    - transmitting, by the gas sensor, the signal to the controller;
    - determining, by the controller, based on the signal, that the gas level is above threshold;
    - generating, by the controller, an alert message; and
    - stopping, by the controller, the fuel combustion in the water heater.

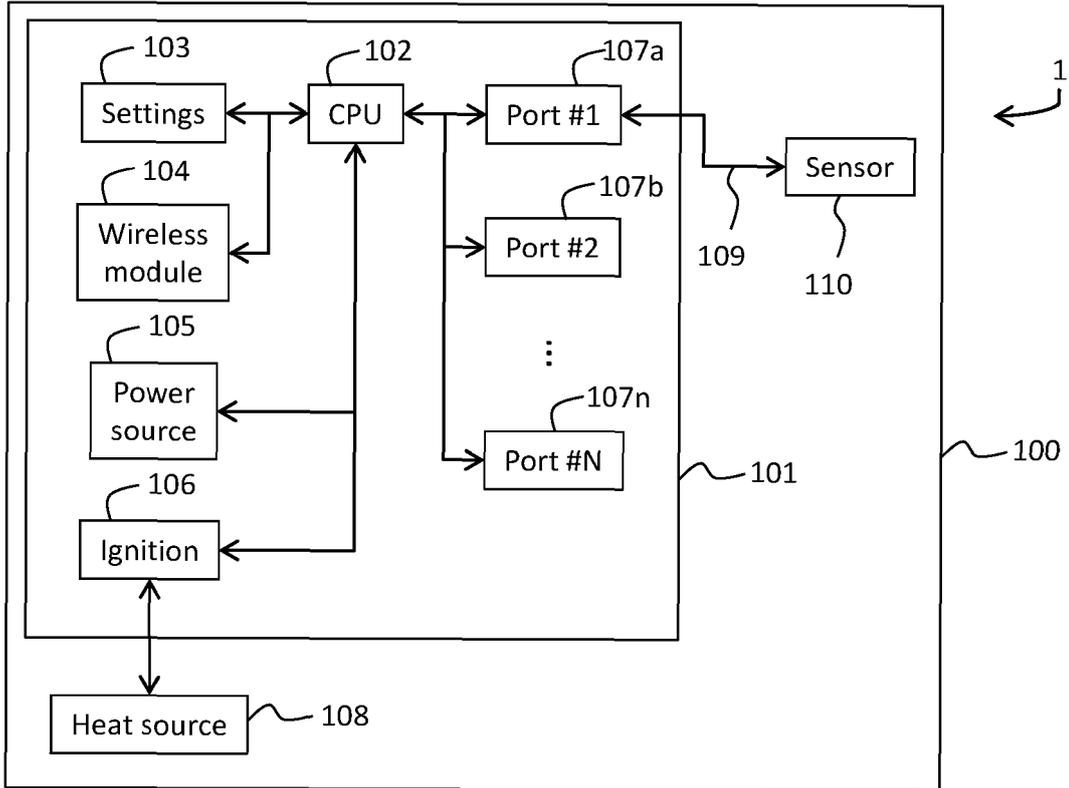


Fig 1

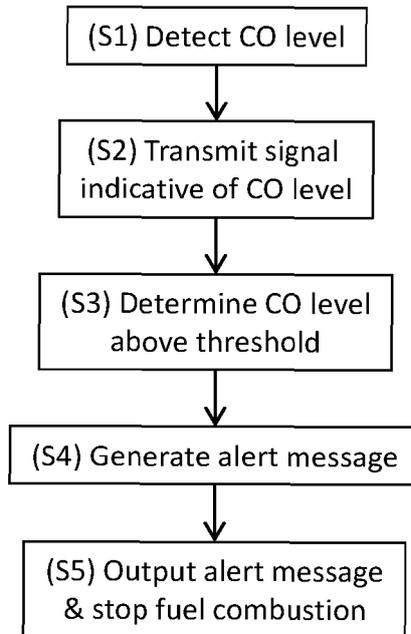


Fig 2



EUROPEAN SEARCH REPORT

Application Number

EP 22 16 4737

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DOCUMENTS CONSIDERED TO BE RELEVANT			
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			TECHNICAL FIELDS SEARCHED (IPC)
			F24D F24H
The present search report has been drawn up for all claims			
Place of search <b>Munich</b>		Date of completion of the search <b>9 September 2022</b>	Examiner <b>von Mittelstaedt, A</b>
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	

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**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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