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(51) INT CL:
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(56) Documents Cited:
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GB 2358789 A
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WO 2007/131271 A1
US 20090114637 A1
US 20040149729 A1
GB 2407478 A
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GB 2194107 A
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(58) Field of Search:
INT CL **A47J, G05D, H05B**
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(54) Title of the Invention: **Boiling sensor**
Abstract Title: **Boiling sensor for water-boiling appliances**

(57) A water-boiling sensor usable in electric kettles, or other water-boiling appliances incorporating an electrically powered heating element, is designed to reliably detect when the water boils. It utilises a capacitive detection element comprising electrodes 10, 12, which disposed in contact with water in the appliance and are connected to an oscillator 16 or other circuit, which generates electrical signals that are influenced by the capacitance between the electrodes, and which exhibit a peculiar and repeatable characteristic response when the water boils. Electrical circuitry 18 is provided to recognise electrical signals having the aforementioned characteristic response and to then develop control signals which disconnect the power from the heating element when the water boils. The sensor is wholly electronic and preferably can also be used to detect the water level, and calculate the expected boiling time. A warning device may also be included to alert to an extended boiling time, which may be indicative of an issue with the appliance.

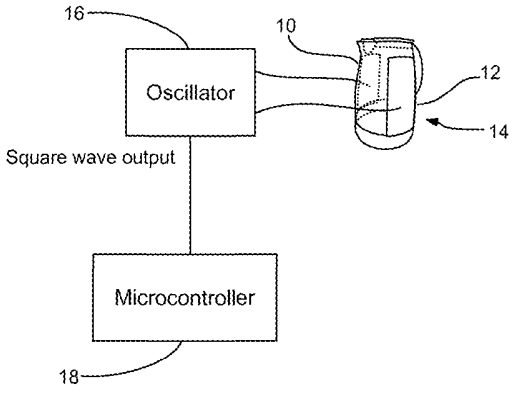
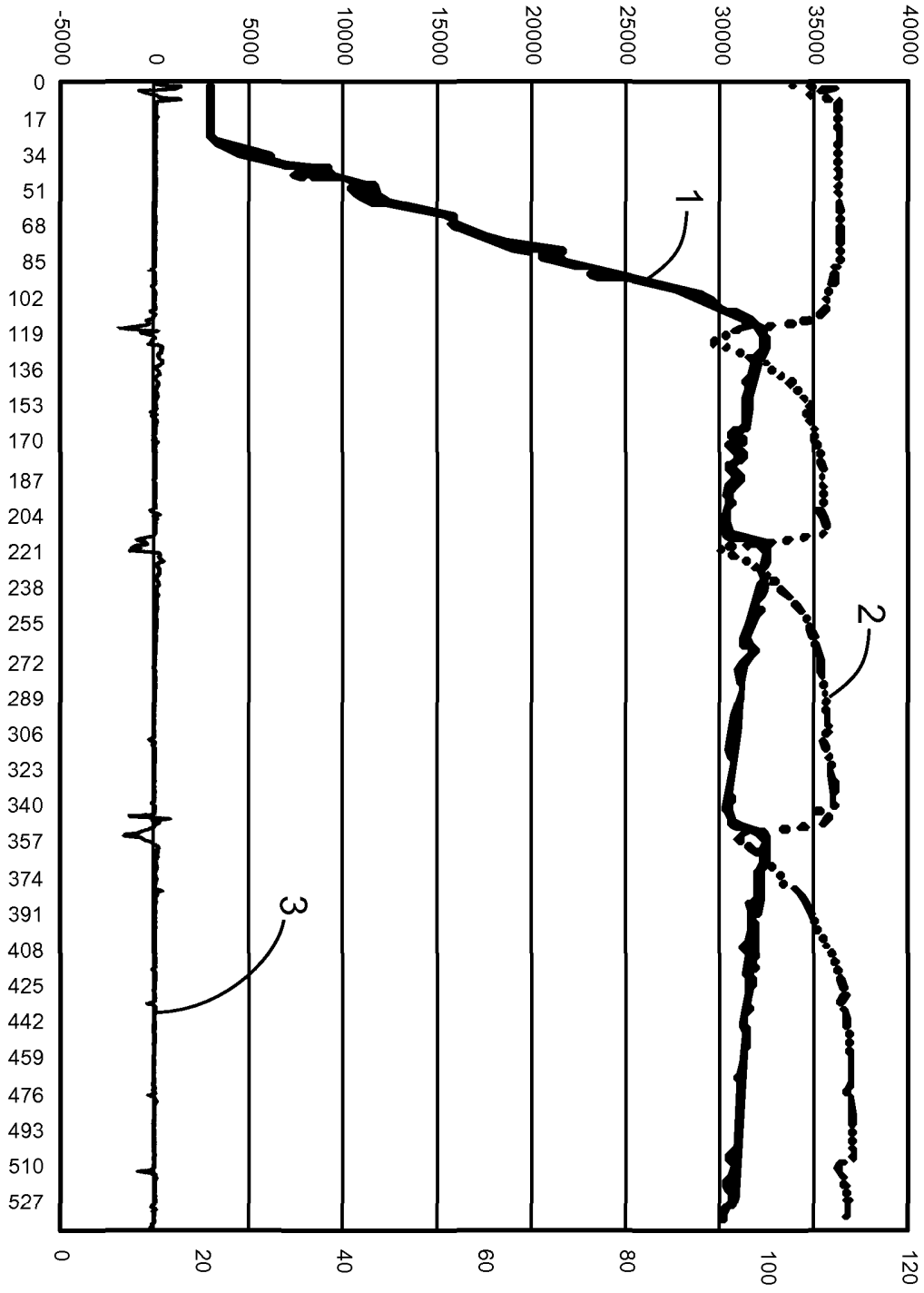


Fig 2

GB 2475324 A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374
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Fig 1

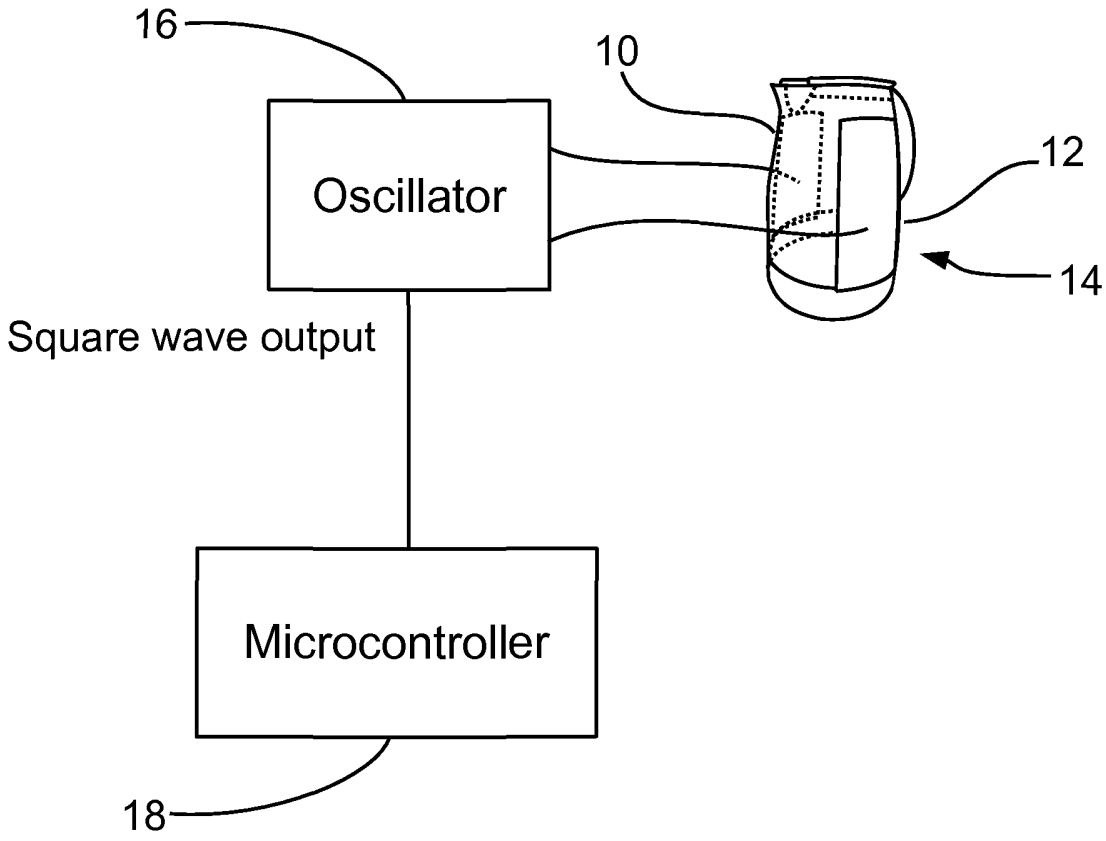
16
10
Oscillator
12
14
Square wave output
Microcontroller
18

Fig 2

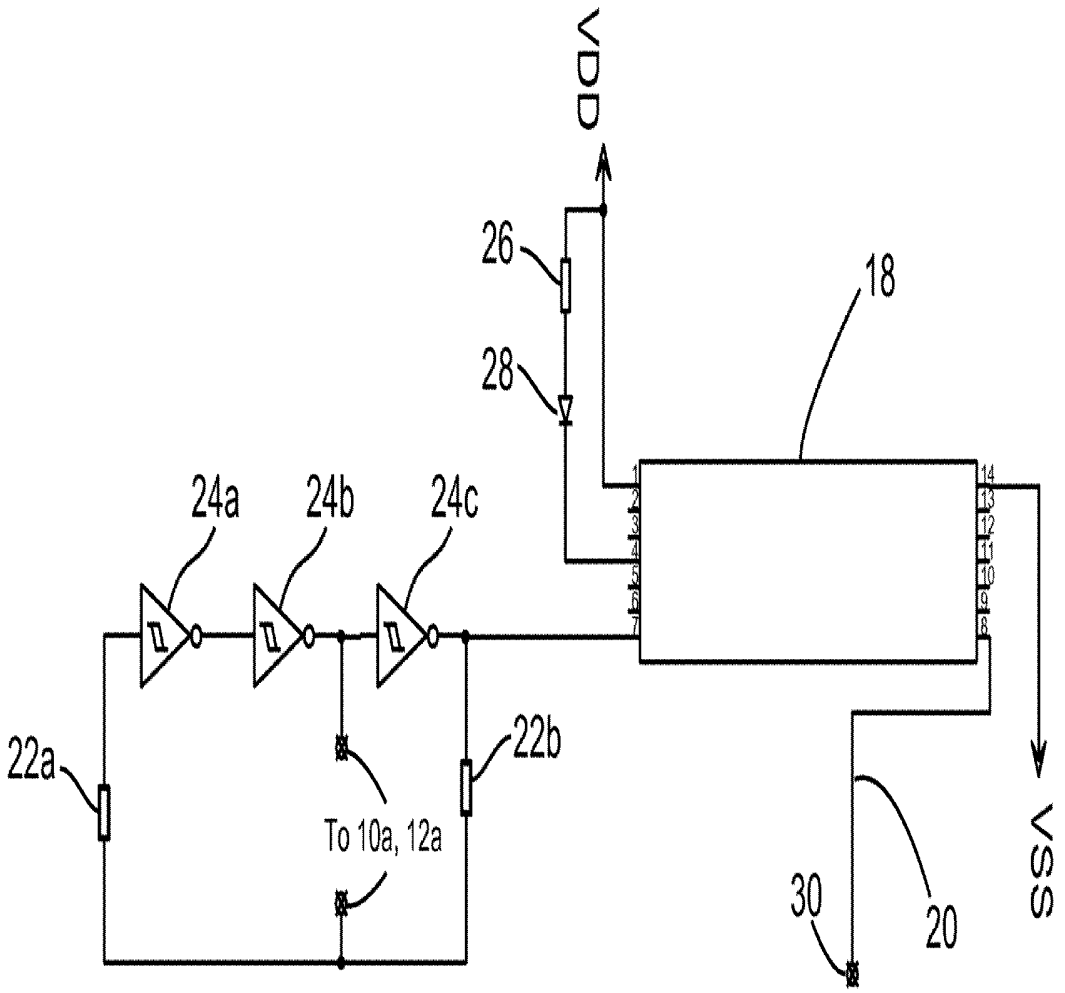

Fig 3

BOILING SENSOR

This invention relates to a boiling sensor, and it relates more particularly to such a sensor usable in electric kettles, or other water-boiling appliances, to reliably detect when the water boils.

Preferably, and in accordance with an aspect of this invention, a detection element of the sensor is also usable to detect the level of water in the kettle or other appliance.

Electric kettles are widely used in domestic kitchens in preference to kettles that require an external source of heat. By and large, such appliances are reliable and speedy in operation, and, being electrically powered, can readily be provided with control circuitry to detect when the water boils and/or to detect the onset of potentially damaging boil-dry situations and to disconnect the supply of electrical power to the heating element when appropriate. Various circuit arrangements are known for effecting such detection and control, and many of these are proven and highly reliable, though most require quite complex electro-mechanical arrangements; boiling detection, for example, typically requiring the provision of a duct to carry steam from the region above the water line down to an electrical circuit in or near the base of the kettle which responds to the ducted steam by throwing a switch that disconnects the kettle's heating element from the mains power supply.

One object of this invention is to provide a boiling sensor, for an electric kettle or other electrically powered water-boiling appliance, that is wholly

electronic, and thus economic to incorporate into a kettle or other appliance. In preferred embodiments of the invention, a detection element of the sensor provides, when the water boils, electrical signals having a particular characteristic and there is provided electronic circuitry capable of recognising signals having said characteristic and to develop a switching signal in response to such recognition; the switching signal being usable, for example, to disconnect electrical power from a heating element of the kettle or other appliance.

A particularly preferred embodiment of the invention utilises capacitive means as said detection element.

Another object of the invention is to utilise, as a detection element of such a sensor, componentry used, or usable, to detect or monitor at least one other criterion or parameter associated with the kettle or other appliance, such as a level of water to which the kettle or other appliance is filled.

A particularly preferred form of the invention utilises capacitive means as such a detection element; the capacitive element providing electrical output signals with one characteristic indicative of water level and with another characteristic indicative of boiling. Electrical circuitry is provided to differentiate between electrical signals having the two characteristics and to provide as outputs appropriate control signals, such as switching signals, and parameter magnitude signals.

According to the invention there is provided an electronic boiling sensor, for an electric kettle or other electrically powered water-boiling appliance,

the sensor comprising a detection element configured to provide, when the water boils, electrical signals having a particular characteristic, and electronic circuitry capable of recognising signals having said characteristic and developing, in response to such recognition, a control signal usable to control an operating function of the kettle or other appliance.

In a preferred embodiment of the invention, the control signal comprises a switching signal usable to disconnect electrical power from a heating element of the kettle or other appliance.

It is further preferred that said detection element is also usable, to detect or monitor at least one other criterion or parameter associated with the kettle or other appliance, such as a level of water to which the kettle or other appliance is filled.

Most preferably, said detection element comprises capacitive means.

In some preferred embodiments of the invention, said capacitive means is configured to provide electrical output signals with one characteristic indicative of boiling and with another characteristic indicative of water level, and electronic circuitry may be provided to differentiate between electrical signals having the two characteristics and to provide as outputs both switching signals, derived from said control signal, and parameter magnitude signals.

Typically, some embodiments of the invention further comprise means for utilising signals indicative of a detected water level and of the known power of a heating element of the kettle or other appliance, to predict the time it should take to boil the water, and for comparing the predicted time with the actual time taken to boil the water, and means for generating a warning if the compared times differ by more than a predetermined amount, indicative of a possible need for descaling the kettle or other appliance.

Said warning may conveniently comprise a visual warning provided by illumination of a light-emitting device.

The invention also encompasses an electric kettle or other water-heating appliance incorporating any of the aforesaid electronic boiling sensors.

In order that the invention may be clearly understood and readily carried into effect, one embodiment thereof will now be described, with reference to the accompanying drawings, of which:

Figure 1 shows a graph indicative of the operation of the detecting element of a sensor in accordance with one example of the invention;

Figure 2 shows, in block diagrammatic form certain elements of the sensor; and

Figure 3 shows in more detail the circuitry utilised in a sensor comprising one embodiment of the invention.

The use of capacitive means for detecting the water level in electric kettles has already been proposed, for example in US-A-5756876 and GB-A-2358789, and the latter publication describes the use of associated circuitry to detect (inter alia) excessive or insufficient water in the kettle, and to prevent the element from receiving power in either case.

The present invention can, of course, perform such functions. Surprisingly, however, it has been found that, if the output signals from a capacitive detection element are monitored during operation of a kettle or other appliance, they exhibit a peculiar and repeatable characteristic response when the water boils. The present invention utilises this surprising effect to develop control signals usable to disconnect the power from the heating element reliably and precisely when the water boils.

Referring now to the drawings, Figure 1 shows a graph indicative of the measured characteristics of electrical signals derived from a capacitive detecting element used in a boiling sensor according to one example of the invention. It will be appreciated in this respect that the kettle element was switched off when boiling was detected, and then repeatedly re-energised once the water temperature had fallen by a predetermined amount.

In this example, as will be described in more detail hereinafter, capacitive detection means, provided on or otherwise incorporated into an internal surface of a kettle in any convenient format, for example as plate-like or linear electrodes, are coupled to an electronic oscillator circuit. The oscillator is set up, in this instance, to generate a square wave, the

frequency of which is influenced by the capacitance between the electrodes of the detection means, and a microprocessor is provided to monitor the frequency, or a derivative of the frequency, such as its rate of change.

Figure 1 shows, as a solid line 1, the actual temperature of the water in the kettle and, as a dashed line 2, the frequency of the oscillator. It will be observed that the frequency drops sharply and recognisably each time the water temperature reaches boiling point and then recovers as the water temperature cools following the disconnection of power from the heating element. The rate of change of the oscillator frequency is also shown on the graph of Figure 1, as a solid line 3. It will be observed that either or both characteristics (i.e. frequency 2 and rate of change of frequency 3) can be detected by the microprocessor and used to develop control signals that can be employed to reliably switch off the heater when boiling occurs.

It will be appreciated that the use of an all-electronic boiling sensor of this kind provides important advantage over, for example conventional boiling cut-outs based on the use of steam tubes to duct steam down to circuitry located in the base of a kettle. Notably, the steam ducts tend to become obstructed with lime deposits over extended use, thus rendering the cut-out (or so-called "steam-stat") less efficient over time and leading to over-long boiling times, which wastes energy and stresses the elements.

The capacitive detection means can, of course, still be used to sense the water level in the kettle, and this example of the invention thus provides useful duality of purpose, functioning as an efficient level sensor and

boiling sensor. Moreover, this duality of purpose leads to further flexibility in operation of the kettle, as it is possible, based upon the detected water level and the known power of the heating element, to predict the time it should take to boil the water. If the predicted time does not correspond (within reasonable tolerance) to the time it actually takes the water to boil, as measured by the capacitive detection means and its associated circuitry, the microprocessor can be caused to generate a signal which illuminates an LED, or stimulates some other form of display (audible and/or visual) to warn the user that the kettle may require descaling.

Referring now to Figures 2 and 3, electrodes 10 and 12 forming the detection elements of a boiling sensor in accordance with one example of the invention are applied to the internal wall of a kettle body 14. The electrodes 10 and 12 may be attached or deposited in any convenient manner upon, or incorporated into, the body 14; the attachment or deposition technique being determined at least to a degree by the materials of which the kettle body is made. For example, where the body 14 is of plastics material, the electrodes 10 and 12 may be provided directly upon the interior surface of the body 14. Where the kettle is metal bodied, it is necessary either to pre-form one or more electrically insulating layers on at least the electrode-bearing regions of the internal surface of the kettle body 14 to support the electrodes 10 and 12, or to provide the electrodes 10 and 12 with respective backings of electrically insulating material prior to attaching them to the metal body.

The electrodes can be of any convenient shape, such as the rectangular plate format shown and, in general, they may be "tuned" in shape and/or dimensions to achieve a desired electrical performance from any given body 14. The electrodes need not be plate-like or widely separated, however, and can be configured, for example, into nested spirals, or elongated, sinuous forms.

The electrodes 10 and 12 are coupled to an oscillator circuit 16 and a microprocessor 18 is connected to monitor the performance of the oscillator 16, for example by monitoring its frequency or a rate of change of its frequency, in order to sense when the water in the kettle boils. When a performance variation, such as the aforementioned drop in frequency, that is indicative of boiling is sensed, microprocessor 18 provides an output signal on line 20 which is usable to disconnect the heating element of the kettle from the electrical power supply.

In this particular embodiment of the invention, the oscillator 16, as shown in Figure 3, comprises a group of three inverted Schmitt trigger circuits 24a, 24b and 24c (each of the type designated 40106N), interconnected in known manner in series with a pair of resistors 22a and 22b, to generate (with the capacitance of the electrodes 10 and 12, the leads from which are connected into the circuit at connection points 10a and 12a respectively as shown in Figure 3) a square wave, the frequency of which is influenced by the capacitance, i.e. the dielectric, between the electrodes 10 and 12. The oscillator 16 is connected to pin 7 of the microprocessor 18 which, in this example, is an integrated circuit of the type designated 16F676DIL, and

the microprocessor 18 measures the period of the square wave, using a timer, or counts the number of rising or falling edges in a predetermined time to determine the oscillator frequency. The frequency may be used as the measured parameter, as aforesaid, or the period of one sample may be compared with that of the previous sample to calculate any gradient of a frequency change.

The level sensing operation uses the same electrodes 10 and 12, and the same microprocessor 18, and can be implemented in any convenient manner, such as those disclosed in the aforementioned GB-A-2358789. Usefully, the level-sensing output can be used to inhibit the application of power to the heating element if the kettle does not contain sufficient water and/or if the kettle contains too much water. In some embodiments, level sensing is carried out only when the kettle is first connected to the power source; i.e. when the water is cold, simply to check that the kettle has not been under- or over-filled at the outset.

In other embodiments, however, the water level is sensed throughout the operation of the kettle, or is switched in to operation again after boiling has been detected by the circuit of Figures 2 and 3, to ensure that the kettle is not allowed to boil dry. This facility can avoid the need for a separate boil-dry protector of the kind usually employed.

The application of the electrodes to the kettle body 14 may be used to provide additional visual features, such as a volume capacity bar.

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Claims:

1. An electronic boiling sensor, for an electric kettle or other electrically powered water-boiling appliance, the sensor comprising a detection element configured to provide, when the water boils, electrical signals having a particular characteristic, and electronic circuitry capable of recognising signals having said characteristic and developing, in response to such recognition, a control signal usable to control an operating function of the kettle or other appliance.

2. A sensor according to claim 1, wherein the control signal comprises a switching signal usable to disconnect electrical power from a heating element of the kettle or other appliance.

3. A sensor according to claim 1 or claim 2, wherein said detection element is also usable, to detect or monitor at least one other criterion or parameter associated with the kettle or other appliance, such as a level of water to which the kettle or other appliance is filled.

4. A sensor according to any preceding claim, wherein said detection element comprises capacitive means.

5. A sensor according to claim 4, wherein said capacitive means is configured to provide electrical output signals with one characteristic indicative of boiling and with another characteristic indicative of water level.

6. A sensor according to claim 5, wherein electronic circuitry is provided to differentiate between electrical signals having the two characteristics and to provide as outputs both switching signals, derived from said control signal, and parameter magnitude signals.

7. A sensor according to claim 5 or claim 6, further comprising means for utilising signals indicative of a detected water level and of the known power of a heating element of the kettle or other appliance, to predict the time it should take to boil the water, and for comparing the predicted time with the actual time taken to boil the water, and means for generating a warning if the compared times differ by more than a predetermined amount, indicative of a possible need for descaling the kettle or other appliance.

8. A sensor according to claim 7, wherein said warning is a visual warning provided by illumination of a light-emitting device.

9. An electronic boiling sensor substantially as herein described with reference to and/or as shown in the accompanying drawings.

10. An electric kettle incorporating an electronic boiling sensor according to any preceding claim.

Application No:	GB0920033.8	**Examiner:**	Mr Michael Warren
Claims searched:	1-10	**Date of search:**	4 March 2010

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-3, 10	US 3784788 A (FOURNY) See column 2, line 61-column 3, line 3; column 3, lines 24-30.
X	1, 2, 4, 10	GB 2358530 A (OTTER) See page 5, line 15-page 6, line 21.
X	1, 2, 10	GB 2432212 A (CRASTAL) See page 1, third paragraph; page 4, first paragraph.
X	1, 2, 10	GB 2407478 A (STEHLE) See page 4.
X	1, 2, 10	GB 2194107 A (PROCTOR) See claim 8.
X	1, 2, 10	WO 2007/131271 A1 (SUNBEAM) See page 6, lines 16-21; page 9, line 27-page 10, line 10.
X	1, 2, 10	US 2009/0114637 A1 (IREMAN et al) See paragraph [0077].
X	1, 2, 10	US 2009/0001070 A1 (SCOTT et al) See paragraphs [0082]-[0084].
X	1, 2, 10	US 2004/0149729 A1 (KRESSMANN) See paragraphs [0067]-[0074], [0089]-[0106].
A	-	GB 2344045 A (BOSCH)
A	-	GB 2358789 A (OTTER)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

A47J; G05D; H05B

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC, TXTE

International Classification:

Subclass	Subgroup	Valid From
A47J	0027/21	01/01/2006