

IMPROVEMENTS RELATING TO THERMALLY RESPONSIVE
CONTROLS FOR WATER BOILING VESSELS

FIELD OF THE INVENTION:

5 This invention concerns improvements relating to
thermally responsive controls for water boiling
vessels, and has particular application to the field
of thermally responsive controls for use in
electrically heated water boiling vessels such as
kettles and jugs for switching off or reducing the
10 supply of power to an electric heating element of the
vessel when water boils in the vessel and the vapour
generated impinges upon a thermally-responsive switch-
actuating element. The present application was
divided out of our British Patent Application No.
15 8827340.4 (GB 2212664). British Patent Application
No. 9123640.6 (GB 2248520) was also divided out of
British Patent Application No. 8827340.4.

BACKGROUND OF THE INVENTION:

20 Electrical switches for use with water boiling
vessels and which are responsive to the generation of
steam when water boils in the vessel are disclosed in
British Patent Specifications Nos. 1,470,365,
1,470,366 and 1,470,367, for example, and additionally
are disclosed for example in British Patent
25 Specifications Nos. 2,117,568 and 2,128,029. In

addition to steam sensing electric switches, element protector switches are also known which are adapted to switch off the supply of power to the heating element of the vessel in response to a sensed element overtemperature condition, caused for example by switching on the vessel with insufficient water in it or by allowing the vessel to boil dry. It has been known to provide element protectors and steam sensors as entirely separate units and it has also been known to provide combined element protector and steam sensing units. Furthermore, it has been known to provide element protector and steam sensing units such that the element protector may be used alone or alternatively may be combined with a steam sensor in which case a mechanical interconnection between the element protector and the steam sensor has enabled the steam sensor to operate the switching contacts within the element protector.

Thus in one known arrangement, an element protector unit has comprised a bimetallic switch actuating element arranged to determine the condition of switch contacts within the unit through the intermediacy of a push-rod arrangement, and a steam sensor unit adapted for use with the element protector unit has comprised a further bimetallic switch actuating element arranged so as in use to be exposed

to steam generated when water boils in an associated vessel and a lever arrangement for coupling the resulting movement of the steam sensor bimetal to the push-rod of the element protector unit for operating the switch contacts therein when the steam sensor unit is appropriately combined with the element protector unit. By manufacturing the element protector and the steam sensor as separate units but arranging that they can readily be combined together, a rationalisation of the need to manufacture a variety of different controls in order to accommodate the requirements of different manufacturers of water boiling vessels can be obtained. However, such arrangements of this type that have previously been known have suffered from the limitation that the same element protector unit is not capable of being operatively combined with a variety of different steam sensor unit designs and furthermore have placed limitations on vessel design.

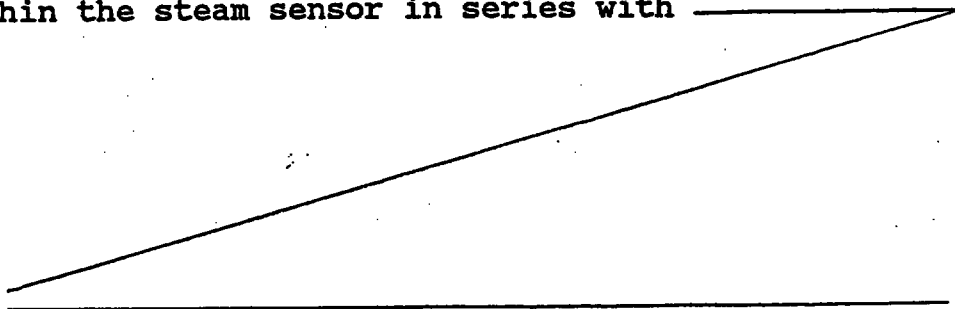
OBJECTS AND SUMMARY OF THE INVENTION:

The object of the present invention is to provide a new and improved steam sensor and element protector combination for an electrically heated water boiling vessel, the steam sensor being flexibly utilizable with the element protector in a variety of different ways providing enhanced freedom for vessel design.

According to the present invention, there is

provided an electrically-heated water boiling vessel incorporating an electrically powered heating element, or an electrically powered heating element for such a vessel, said heating element having associated therewith an element protection unit for switching off the supply of electrical power to the heating element in the event of an element overtemperature condition, and a steam-sensing unit for switching off or reducing the supply of electrical power to the heating element in the event of water boiling in the vessel, the steam-sensing unit comprising a module having an electrical terminal portion adapted to be plugged into a complementary part of the element protection unit and the steam-sensing unit and element protection unit being arranged such that the action of plugging the electrical terminal portion of the steam-sensing module into the complementary part of the element protection unit places an electrical switch within the steam sensing module in series with an electrical switch in the element protection unit in the current supply path of the heating element.

Described hereinafter is an improved form of steam sensor according to the invention of our abovementioned British Patent Application No. 8827340.4 (GB 2212664) which is designed to be capable of being plugged into an element protector as described in our British Patent Specification No. 2194099, the action of plugging the steam sensor into the element protector placing an electric switch within the steam sensor in series with



an electrical switch in the element protector in the current supply path to the heating element. The arrangement of this particular steam sensor and element protector enables either device to be used alone and enables the two devices to be used together either with the steam sensor directly plugged into the element protector or with the two connected together by means of a connecting lead.

The steam sensor in question, in one embodiment, is based upon a thermally responsive switch actuator which comprises a bimetal blade, a trip lever, and a chassis which supports the bimetal and the trip lever, the chassis providing spaced-apart mountings which are bridged by the bimetal blade and the trip-lever mounted in series with each other and defining a snap-acting overcentre bridge the range of movement whereof is limited by abutment with the chassis at least in the cold condition of the bimetal and preferably also in the hot condition of the bimetal.

The overcentre bridge extending between the spaced-apart mountings in the chassis is constituted by one end of the bimetal being pivotally received in one of the chassis mountings and defining one end of the bridge, one end of the trip-lever being received in the other of the chassis mountings and defining the other end of the bridge, and the other ends of the

bimetal and the trip-lever abutting each other generally intermediate the ends of the bridge. The chassis further defines stops or abutments limiting the range of movement of the overcentre bridge in both directions, that is to say both the cold condition position and the hot condition position of the overcentre bridge are defined by the chassis, and also provides an abutment against which the bimetal may act to provide the actuating force for movement of the bridge between its two stable states, namely its cold state and its hot state. The chassis also provides compliance to accommodate the change in the dimensions of the overcentre bridge between the spaced-apart bimetal and trip-lever mountings as the bridge moves between its two stable states, though this compliance could alternatively or additionally be provided by the trip-lever. The compliant abilities of the chassis can be augmented or supplemented by use of a spring metal component supported in the chassis and in turn supporting one end of the bimetal, such an arrangement being particularly useful where the chassis is a moulded plastics component.

The trip-lever could be formed integrally with the chassis moulding, with the result that a two-part switch actuator is obtained. In such a construction, the trip lever might be pivotally mounted to the

chassis moulding by means of an integral moulded hinge. Plastics materials are well known which are suitable for the formation of such integrally moulded hinges, though it may be preferred, given that the moulding may be subjected to relatively high temperatures by virtue of the impingement of hot vapour thereon, to utilize a non-integral mounting arrangement which is not prejudiced by any reduction in the strength of the plastics material at elevated temperatures and enables stronger materials to be used which are not as well suited to the formation of integrally moulded hinges. Polypropylene, as is well known, is a material which can be formed into effective integral hinges but is weakened by exposure to high temperatures, and rather than using polypropylene it might accordingly be preferable instead to use a stronger material, such as glass filled nylon for example, and form the pivotal bimetal and trip-lever mountings as knife edge type mountings.

The switch actuator as above described thus has three functional parts, namely the bimetal, the trip-lever and the chassis, and can be formed in only two parts or as three. The bimetal serves two functions, firstly it acts as a thermally active component providing the force which generates the action of the device in response to a change in temperature, and

secondly it provides the spring force which operates the overcentre bridge and provides a bistable latch mechanism which, for example, could open and hold open switch contacts. The trip-lever is moved by the action of the bimetal and may be used to transmit this movement to switch contacts provided in the steam sensor. The chassis provides support for the bimetal and the trip-lever, providing a pivotal mounting for both components and allowing them to rotate through an angle limited by stops or abutments on the chassis, and also providing the compliance necessary to accommodate the movement of the overcentre bridge. By manufacture of the chassis of a suitable material, such as a flame retardant plastics material, it could also be used to support the electrical components of a switch.

The bimetal blade need not be of any special configuration and does not itself have to be snap acting. Preferably and advantageously the bimetal is a flat rectangular blade of a grade suitable for the intended steam sensing application of the actuator, that is to say the bimetal should preferably be corrosion (rust) resistant and generally of high-flexivity, high yield strength, and spring-grade. Such a bimetal requires no special forming or tooling and no subsequent stress relief or selection. The

dimensions of the bimetal also are not critical, enabling manufacturing tolerances to be readily accommodated without prejudicing the operational characteristics of the actuator.

5 The steam sensor as generally described in the foregoing can be utilized with the chassis fixedly mounted as a switch component and switch-operating movement developed by the trip-lever, and can alternatively be utilized with the trip-lever fixedly
10 mounted and the chassis moving to develop the requisite switch operation. The latter arrangement is particularly well suited to utilization in electric kettles and the like where the chassis moulding or a part mounted thereon can conveniently be used as a
15 reset knob.

Further features of the invention are set forth with particularity in the appended claims and they, together with other aspects features and advantages of the invention will become well understood by those
20 possessed of the relevant skills from consideration of the following descriptions of exemplary embodiments which are illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS:

2 Figures 1A to 1M show various perspective, elevation and plan views of the component parts and their assembly into a steam sensor constructed in

accordance with the teachings of the invention;

Figures 2A and 2B show exploded perspective views of an element protector generally as described in our British Patent Specification No. 2194099 with reference to Figures 3A, 3B and 3C thereof, Figure 2A showing the element protector as viewed from the rear and Figure 2B showing it as viewed from the front;

Figures 3A to 3E are perspective views showing how a steam sensor substantially as shown in Figures 1A to 1M may be plugged into the element protector of Figures 2A and 2B hereof;

Figures 4A to 4C illustrate different ways in which an element protector in accordance with Figures 2A and 2B hereof may be utilized with a steam sensor according to Figures 1A to 1M;

Figures 5A and 5B show exploded perspective views from different positions of a modified form of the steam sensor of Figures 1A to 1M; and

Figure 6 is a view, similar to Figure 3J, illustrating the operation of the steam sensor of Figures 5A and 5B.

DESCRIPTION OF THE EMBODIMENTS:

Referring first to Figures 1A to 1M, there is shown a steam sensor module suitable for use with an electrically heated water boiling vessel for switching off the supply of electricity to the heating element

of the vessel when water boils in the vessel and steam impinges upon a thermally sensitive element of the module. The illustrated steam sensing module is designed to be plugged into an element protector unit, that is to say a unit for protecting the electrically powered heating element of a water boiling vessel from overheating, so as to convert the unit additionally into a steam sensing unit for automatically switching off the heating element when water boils within the vessel. The manner in which the steam sensing module attaches to the element protector unit will be described hereinafter with reference to Figures 2A and 2B and Figures 3A to 3E.

The steam sensing module of Figures 1A to 1M comprises a switch sub-assembly 40 shown in assembled condition in Figure 1B and consisting of two identical contact-carrying leaf springs 41 and 42 staked to an insulator 43 shown in Figure 1A, a main moulding 44 shown in perspective in Figure 1C, a trip-lever 45 shown in various stages of assembly with the main moulding 44 in the perspective views of Figures 1F, 1G and 1H, and a bimetal blade 46 shown in Figure 1H.

The main moulding 44 is formed with a chamber 47 which accommodates the assembled switch sub-assembly 40, the grooved parts 48 of the insulator 43 engaging with a slot 49 formed in the wall of the chamber (see

Figure 1H) and a catch portion 50 of the insulator engaging with an aperture 51 formed in the main moulding 44 so as to lock the switch sub-assembly in position (see Figure 1E). When the switch sub-assembly 40 is fully engaged in the chamber 47, a wall portion 52 of the insulator 43 closes off the entrance to the chamber 47 and access to the interior of the chamber 47 is then provided only via the opening 53 defined in the chamber wall (see Figures 1C, 1D and 1F). As will be explained more fully hereinafter, the opening 53 provides access to the chamber 47 for a projection formed on the trip-lever 45, such projection serving for applying switch-actuating movement from the trip-lever 45 to the switch sub-assembly 40.

A limb 54 extends from the main moulding 44 as shown in Figures 1C and 1D and is shaped to provide a knife edge pivotal mounting for the trip-lever 45 which, as can be seen in Figures 1F, 1G and 1H, has a part 55 adapted to be fitted over the limb 54 and to co-operate with the knife edge on the limb for pivotally mounting the trip-lever 45. As can be seen from comparison of Figures 1F to 1G, the trip-lever is adapted to be fitted onto the limb 54 of the main moulding 44 in the relative orientation of the two parts that is shown in Figure 1F and thereafter is

rotating into the position shown in Figure 1G. This rotation of the trip-lever 45 brings a peg 56 on the main moulding 44 into engagement with a groove 57 formed in the trip-lever so as to prevent the trip-lever from sliding off of the limb 54, and also causes the end of a projection 58 formed on the trip-lever (see Figure 1F) to enter the opening 53 providing access to the switch sub-assembly 40 housed within chamber 47 of the main moulding 44.

The trip-lever 45 has a V-notch mounting 59 formed therein for receiving one end of the bimetal blade 46 and an opposed V-notch mounting 60 for the other end of the bimetal blade 46 is provided on a part of the main moulding 44 and, with the trip-lever 45 rotated into the orientation relative to the main moulding 44 that is shown in Figure 1G, the bimetal 46 can be inserted into the two opposed V-notch mountings 59 and 60 as shown in Figure 1H. The assembly of the steam sensing module is then complete.

In operation of the steam sensing module as thus described, in the cold condition of the bimetal 46, the contacts of the switch sub-assembly 40 are closed and the trip-lever 45 takes up a position such that the projection 58 does not interfere with the closed condition of the switch contacts (see the trip-lever position shown in phantom in Figure 1J). When the

bimetal 46 is heated by the impingement of steam thereupon, the overcentre bridge defined by the trip lever 45 and the bimetal 46 snaps over and causes the trip-lever 45 to take up the position that is shown in full lines in Figure 1J and causes the projection 58 to enter into the chamber 47 housing the switch sub-assembly 40 and to move the leaf spring 41 in a direction such as to open the switch contacts.

An upstand 61 on the trip-lever 45 merely comprises an attachment for a reset knob and has no other operational significance. A post 62 (shown in Figure 1J) defines an abutment for the bimetal to work against when switching the overcentre bridge from its cold to its hot condition.

The steam sensing module as thus described with reference to Figures 1A to 1M is designed to be capable of being connected to an element protection unit either by being plugged directly into the element protection unit, or by being remotely coupled therewith by means of a connecting lead provided with appropriate plug and socket connectors at its ends. As is well known, an element protection unit comprises a thermally-responsive switch arrangement which is adapted to be connected in series with the power supply line of an electrically powered heating element and serves to disconnect the heating element from the

power supply line in the event of an overtemperature condition arising at the heating element, for example on account of the heating element being switched on when there is insufficient liquid in an associated vessel to absorb the heat output of the element or on account of the vessel being permitted to boil dry. Exemplary element protection units are described in British Patent Specifications Nos. 1,264,464, 1,316,436, 1,439,229, 2,045,588 and others, to which reference may be made for a fuller understanding, but for the purposes of the present specification it is sufficient only that it be appreciated that an element protection unit commonly comprises live and neutral conductor leaf springs which contact the cold tails of a heating element when the protector unit is fitted to the head of the heating element and serve for conveying electrical power from power supply terminal pins of the element protection unit to the heating element, a switch arrangement in the neutral side at least of the power supply line to the heating element and comprising a leaf spring carrying a contact normally biased into electrical engagement with a contact provided on a portion of the neutral conductor leaf spring and movable out of contact therewith for opening the switch, a push rod for applying switch-operating movement to such movable contact, and a

bimetallic switch-actuating element which is arranged to be in close thermal contact with the heating element head plate when the element protection unit is coupled thereto and which, in response to the heating element temperature increasing above a predetermined normal level, develops a movement which is transferred by way of the push rod to the movable contact of the switch so as to open the switch. Element protection units are known which provide only a single level of protection, and other element protection units are known which provide a primary protection and an additional back-up or secondary protection operative in the event of failure of the primary protection. The steam sensing device hereinbefore described can in principle be used with any kind of element protection unit, and the embodiment hereinafter described is particularly (though not exclusively) adapted for use with an element protection unit as described in our British Patent Specification No. 2194099 with reference to Figures 3A, 3B and 3C thereof so as to extend the element overtemperature sensing facility of the element protection unit to the provision also of steam sensing facilities. The same element protection unit can therefore be associated with the heating elements of simple electric kettles, for example, and can also be used with fully automatic _____

kettles which switch off when they boil.

Referring to Figures 2A and 2B, the construction and operation of the element protector will now be briefly described, it being appreciated that reference may be made to our British Patent Specification No. 2194099 for a more complete description. The element protector as shown comprises a sub-assembly 20 (the same reference numerals will be used herein as are used in our British Patent Specification No. 2194099 to denote like parts) comprising a collapsible carrier 21, a bimetal blade 22 and a push rod 23, the sub-assembly 20 being adapted to locate in use of the element protector between the rear face of the heating element head 24 and the outer side of an inner moulding 25 of the element protector. The inner moulding 25 is adapted to co-operate with a main moulding 26 defining a socket inlet 27 for a kettle connector plug so as to define within the assembled control a chamber for accommodating the L,N and E terminal pins 28, 29 and 30 of the control and for accommodating a contact carrying live (L) connecting spring 31, a contact carrying live leaf spring 32, a neutral (N) connecting spring 33 and an earth (E) connecting spring 34.

The inner moulding 25 is adapted to be clipped to the main moulding 26 and has a pair of integrally-

formed moulded spring clips 36 which co-operate with a pair of apertures 37 in the main moulding so that the inner moulding 25 makes a positive fit into the mouth of the main moulding 26 and is positively retained therein by the clips 36. Upstands are formed on the inner face of inner moulding 25 (that is the face that can be seen in Figure 2A) and co-operate with formations provided on the opposed face of the main moulding 26 (that is the face that can be seen in Figure 2B) for retaining the L,N and E terminal pins 28, 29 and 30 securely in the assembled control, the terminal pins extending through respective apertures provided within the socket inlet part 27 of the main moulding 26, and in similar fashion the live connecting spring 31, the live leaf spring 32 and the neutral connecting spring 33 are trapped between the inner moulding 25 and the main moulding 26 when the two are assembled together. The earth connecting spring 34 is adapted to affix to the upstand 41 provided on the element head 24 when the element protector is fully assembled and is attached to the element head and, within the element protector, makes contact with the earth terminal pin 30.

Referring now more particularly to the sub-assembly 20, the bimetallic blade 22 is generally rectangular with a central cut-out 42 of generally X-

shaped configuration and is dished so as to be capable of moving with a snap action between two oppositely dished configurations, the X-shaped cut-out 42 ensuring a substantially greater operating movement at the centre of the bimetal than would be provided by a plain dished blade. The bimetallic blade 22 is retained in the sub-assembly 20 by means of the engagement of the push rod 23 both with the central cut-out 42 of the blade 22 and with the collapsible carrier 21, the push rod 23 being adapted to be inserted into a guide passage 45 formed in the carrier 21 from the side thereof which can be seen in Figure 2A, but being incapable of passing completely through the guide passage 45, and having a nose portion adapted to be engaged in the centre of the cut-out 42 in the bimetal blade 22. As will be appreciated, the position of the opposite, pusher end of the push rod 23 relative to the carrier 21 will be dependent upon whether the bimetal 22 is in its hot or its cold state.

The carrier 21 is generally in the form of a four-legged table and has relatively large feet 46 for ensuring good thermal contact with the rear face of the heating element head 24 when the assembled element protector is affixed to the element head. The bimetallic blade 22 seats at its corners on the ends of the four legs 47 of the carrier, flush with the

soles of the feet 46. A pair of locating grooves 48 are provided in the carrier 21 and the inner moulding 25 is provided on its outer face with a pair of upstanding rails 49 adapted to slidingly engage in the grooves 48. On its upper surface, as shown in Figure 1A, the carrier 21 has four upstanding posts designed to project through an aperture 50 provided in the inner moulding 25, there being two small posts 51 and two larger posts 52 and 53.

When the element protector as thus described is assembled together and to the element head 24 of an electrically heated water boiling vessel for example, the heating element cold tails 54 and 55 (that is the terminal ends of the heating element proper) extend through apertures 56 and 57 provided in the inner moulding and contact the upper ends of the live connecting spring 31 and the neutral connecting spring 33 respectively, the upper end portions of the springs 31 and 33 being curved as shown for accommodating such contacts. The heating element cold tails may be tipped with silver solder or may be provided with crimped ferrule terminations to enhance their connections with the leaf springs. The lower end of the live connecting spring 31 extends across the aperture 50 of the inner moulding 25 and carries a contact which constitutes the "moving" contact of the

switching contacts set of the element protector. This lower limb of the live connecting spring 31 is arranged to be abutted by the pusher end of the push rod 23 for moving the moving contact in response to switching of the bimetallic blade 22 into its "hot" condition from its normal "cold" condition.

The live leaf spring 32 is trapped between the inner and main mouldings 25 and 26 when the two are assembled together, and has a first, relatively-substantial limb 58 which extends across the aperture 50 formed in the inner moulding 25 and is contacted and urged away from the inner moulding 25 and towards the main moulding 26 by the large post 52 upstanding from the carrier 21, which causes the limb 58 of the live leaf spring 32 to be biased into contact with the live terminal pin 28. The live leaf spring 32 also has a second, less-substantial limb 59 which extends across the aperture 50 in the inner moulding 25 and carries at its free end a contact which cooperates with the "moving" contact provided on the live connecting spring 31 and constitutes the "fixed" contact of the switching contacts set. The second limb 59 of the live leaf spring 32 is arranged to be contacted by the lowermost of the two small posts 51 provided on the carrier 21, such posts projecting through the aperture 50. This contact between the

lower post 51 and the limb 59 of the live leaf spring 32 establishes the position of the contact carried by the live leaf spring 31 (the "fixed" contact of the switching contacts set) relative to the carrier and thus relative to the push-rod, the bimetallic blade and the element head and establishes the position of the "fixed" contact relative to the element head irrespective of variations in the dimensions of the element head.

10 In similar manner, the neutral connecting spring 33 is trapped between the assembled mouldings 25 and 26 and has a relatively substantial limb 60 which extends across the aperture 50 and is butted by the post 53 on the carrier 21 into contact with the neutral terminal pin 29.

In operation of the element protector as thus described, an element head overtemperature condition will normally cause bimetal 22 to snap to its hot configuration thereby causing the moving contact carried by live connecting spring 31 to be pushed away from the fixed contact carried by live leaf spring 32 by the push rod 23. In the event of an abnormal over-temperature condition, such as might arise if the switching contacts were to weld themselves together for example, then a secondary protection mode comes into operation when the temperature of the element

head reaches such a high level as to cause the carrier 21 to collapse towards the element head by virtue of heat distortion of its legs under pressure from the spring parts 58 and 60 of the live and neutral leaf springs 32 and 33 respectively. As is more completely explained in British Patent Specification No. 2194099, the collapse of the carrier 21 towards the element head 24 causes the leaf spring parts 58 and 60 to move out of contact with the live and neutral terminal pins 28 and 29 thereby disconnecting the heating element from its power supply.

Referring now to Figures 3A to 3E of the accompanying drawings, Figure 3A shows a perspective view of a slightly modified form of the steam sensor main moulding 44 described hereinbefore with reference particularly to Figure 1C of the accompanying drawings, the principal modifications being the provision of a portion 100 for shielding the chamber 47 of the main moulding against the entry therein of steam condensate and the provision of an engaging portion 200 for positive engagement with an element protector. As shown in Figure 3B hereof the chamber 47 of the main moulding 44 is adapted to accommodate a switch sub-assembly 40 comprising contact-carrying leaf springs staked to an insulating body having a side wall portion 52 shaped to close off the entrance

to the chamber 47 when the switch sub-assembly is fully engaged therein. The same reference numerals are employed in Figures 3A to 3E hereof as are used to designate like parts in Figures 1A to 1M. When the switch sub-assembly 40 is fitted into the chamber 47 of the steam sensor main moulding 44, a lower part of the switch sub-assembly 40 projects outwardly from the chamber 47, such lower part comprising a flat portion of the insulating body of the switch sub-assembly flanked on either side by parts of the contact-carrying leaf springs thereof. As shown in Figures 3C, 3D and 3E of the accompanying drawings, this lower part of the switch sub-assembly of the steam sensor is adapted to be plugged into a socket portion defined in an element protector as described with reference to Figures 2A and 2B hereof.

To enable the steam sensor to be plugged into the element protector, the main moulding 26 of the element protector is provided with an aperture 125 in its upper surface (see Figure 2A hereof) which provides access to the location within the element protector whereat, in use of the element protector on its own, that is to say without a steam sensor, the cold tail 55 of the heating element would contact the upper part of the neutral connecting spring 33. As shown in —

Figure 3C hereof which shows a modified form of the main moulding of the element protector, there is provided externally of the aperture 125 a structure 250 which is complementary to the engaging portion 200 of the steam sensor as shown in Figure 3B so that when the depending lower part of the switch sub-assembly 40 of the steam sensor is plugged into the aperture 125 in the top of the element protector the steam sensor will engage positively with the element protector as is shown in Figures 3D and 3E hereof. With the steam sensor thus assembled with the element protector and the element protector assembled to a heating element, the switch sub-assembly of the steam sensor is introduced between the cold tail 55 of the element head and the upper end of the neutral connecting spring 33 of the element protector whereby the steam sensor is placed electrically in series with the switching contacts set of the element protector.

Referring now to Figures 4A, 4B and 4C of the accompanying drawings, these illustrate a variety of applications options for the element protector and steam sensor as hereinbefore described. As shown schematically in Figure 4A, the element protector may be used on its own in a variety of water boiling vessels exemplified in the drawing as a conventional kettle 301 and a jug type of vessel 302. In Figure

4B, a steam sensor is shown plugged into the top of an element protector and the drawing schematically shows the combination assembled with the heating element of a conventional kettle 301 provided with an aperture for venting steam onto the steam sensor bimetal and alternatively assembled with the heating element of a jug type vessel 302 incorporating a steam duct for directing steam from the interior of the vessel to the location of the steam sensor where it is plugged into the element protector. Figure 4C shows an alternative option whereby the steam sensor can be located spaced apart from the element protector and coupled thereto by means of an appropriate connecting lead having at one end thereof a plug type connector adapted to be plugged into the top of the element protector and at the other end thereof a socket type connector adapted to receive the plug type end portion of the steam sensor switch sub-assembly.

Referring now to Figures 5A and 5B and Figure 6, one end of the bimetal blade 46 is shown to be received in a V-notch formed in a spring metal reinforcing part 320 captured in the moulding 44 behind the post 321. It would be preferable to avoid use of the spring metal reinforcing part 320 but, on account of difficulties that we have encountered in finding a plastics material for the moulding 44 which

will provide a compliant mounting for the bimetal without also being subject to mechanical creepage as it ages, the provision of the spring metal part 320 has provided an elegant solution to the problem of providing a compliant mounting for the bimetal. Many other variations will be seen in Figures 5A, 5B and 6 as regards the detailed form of the various component parts of the illustrated steam sensor, but its overall function and operation remains as described hereinbefore and accordingly no further discussion of Figures 5A, 5B and 6 is considered to be necessary.

The steam sensing devices described herein have various advantages. When used in an electric automatic kettle or hot water jug, the form of the device allows for free access of steam to the bimetal before operation which permits rapid response of the device, and, in some of the described arrangements, will allow obstruction to the passage of steam after operation which permits the device to be reset more readily than with existing devices. The fact that only a plain bimetal need be used and that the bimetal does not need to change the sense of its curvature in moving from a cold to a hot condition is further advantageous in this respect in that whereas a conventional Otter type of snap-acting bimetal displays a temperature differential between its set

and reset conditions and therefore cannot be reset until it has cooled, no such differential exists with a plain bimetal. The described steam sensors utilize a low number of component parts, as compared to conventional devices, and, even in the arrangement of Figures 1A to 1M for example which employs relatively complex mouldings, are of simple construction leading to the promise of more readily achieved automatic assembly, and furthermore promise to be effective and efficient in long term operation by virtue inter alia of the elimination of the high stress levels that are normally present in conventional bistable bimetallic actuators and can lead to fatigue failure.

The embodiments and arrangements hereinbefore described are in all respects exemplary only and many modifications and variations will occur to those possessed of relevant skills without departure from the scope of the invention as set forth in the appended claims.

It is considered that calibration of the arrangements hereinbefore described to suit specific applications might readily be achieved by corresponding selection and/or adjustment of the bimetal characteristics, but it would be possible, additionally or alternatively, to achieve calibration by provision of adjustable abutments defining the

working conditions of the bimetal. Thus, for example, the abutment against which the bimetal works could be adjustable, for example by use of set screws in appropriate positions or by use of separately moulded and adjustably positionable click-fit moulding parts. A one piece moulding is advantageous from the viewpoint of simplicity and calibration by bimetal characteristics selection is perfectly feasible, but it is to be well understood that the invention extends to alternative means of achieving calibration.

The invention as described provides steam sensor and element protection units which can be used individually if required, and also can be combined together with the steam sensor plugging into the element protector or with an electrical lead operatively interconnecting the two. Whereas in the embodiments described herein the steam sensor and the element protector each takes a specific form, the invention is capable of wider application and not only could various modifications be made to the embodiments described without departing from the scope of the invention, but also different forms of steam sensor and element protector units could be adapted to couple together in accordance with the teachings hereof. It is particularly to be noted that whilst it is convenient in the embodiments described herein that

the steam sensor should connect into the element protector between an element cold tail and a leaf spring of the element protector, various alternative arrangements within the scope of the present invention could be adopted for connecting the switch in the steam sensor in series with the switch in the element protector.

As mentioned hereinbefore, the present application was divided out of British Patent Application No. 8827340.4 (GB 2212664) which discloses and claims a thermally responsive snap-acting bimetallic actuator mechanism for developing an operational movement in response to a temperature change, said actuator mechanism comprising a moulded plastics material chassis, a bimetal blade, and a moulded plastics trip lever, the bimetal blade and the trip lever being pivotally mounted in series with each other between two spaced-apart opposed mountings defined in said chassis so as to define a sprung overcentre bridge which is movable with a snap-action between two stable positions on opposite sides of an intermediate unstable position, the trip lever having one end portion which defines one end of the overcentre bridge and is pivotally mounted with respect to said chassis at one of said mountings, the bimetal blade having one end portion which defines the

other end of the overcentre bridge and is pivotally mounted with respect to said chassis at the other of said mountings, the bimetal blade and the trip lever each having another end portion whereat the trip lever and the bimetal blade pivotally engage each other at an intermediate location in the overcentre bridge, and an abutment being provided in the chassis against which the bimetal blade acts in its development of the force necessary for causing the overcentre bridge to move between its two stable positions, the arrangement of said overcentre bridge thereby being such that in response to a predetermined temperature change the bimetal blade will itself develop the spring force necessary to cause the overcentre bridge to move overcentre with a snap-action, and such overcentre movement of the bridge involving relative pivotal movement between the trip lever and the chassis which constitutes the operational movement of the actuator.

CLAIMS:

1. An electrically-heated water boiling vessel incorporating an electrically powered heating element, or an electrically powered heating element for such a vessel, said heating element having associated therewith an element protection unit for switching off the supply of electrical power to the heating element in the event of an element overtemperature condition, and a steam-sensing unit for switching off or reducing the supply of electrical power to the heating element in the event of water boiling in the vessel, the steam-sensing unit comprising a module having an electrical terminal portion adapted to be plugged into a complementary part of the element protection unit and the steam-sensing unit and element protection unit being arranged such that the action of plugging the electrical terminal portion of the the steam-sensing module into the complementary part of the element protection unit places an electrical switch within the steam sensing module in series with an electrical switch in the element protection unit in the current supply path of the heating element.
2. And apparatus as claimed in claim 1 and including a connecting lead for coupling said steam sensing unit to said element protection unit, said connecting lead



providing for operative interconnection of said steam sensing unit and said element protection unit when the two units are spaced apart from each other.

5 3. An apparatus as claimed in claim 2 wherein said connecting lead includes at one end thereof a socket adapted to receive said electrical terminal portion of said steam sensing unit, and at the other end thereof an electrical terminal portion adapted to be plugged into said complementary part of said element protection unit.

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4. An apparatus as claimed in any of the preceding claims wherein said steam sensing unit comprises a snap-acting bimetallic actuator comprising an overcentre bridge arranged between two spaced-apart positions and incorporating a bimetallic element arranged as part of the length of the bridge for generating snap-action overcentre movement in said bridge in response to a change in the temperature of said bimetallic element.

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20 5. An apparatus as claimed in claim 4 wherein the mounting arrangement of the overcentre bridge defines predetermined, stable, cold-condition and hot-condition positions, the actuator thereby being predeterminedly bistable.



6. An apparatus as claimed in claim 5 wherein said mounting arrangement includes abutments against which the bimetallic element acts in its development of a force to change the overcentre bridge from its cold condition to its hot condition and defining one or more stops limiting the movement of the overcentre bridge.
7. An apparatus as claimed in claim 6 wherein an abutment defining the working conditions of the bimetallic element is arranged to be adjustable.
8. An apparatus as claimed in any of claims 4 to 7 wherein the bridge comprises a jointed structure the opposed ends of which are pivotally mounted at said two spaced-apart positions and wherein the bimetallic element extends from one end of the bridge to a joint therein part-way to the other end thereof.
9. An apparatus as claimed in claim 8 wherein the bridge comprises two parts, one being the bimetallic element and the other being a switch-actuating trip-lever which is journalled with the bimetallic element at said joint in the bridge.
10. An apparatus as claimed in any of claims 4 to 9



and wherein said steam sensing unit further comprises
a moulded plastics mounting for said overcentre
bridge, a part of the bridge being formed integrally
with said moulded plastics mounting and being coupled
thereto by an integral flexible plastics hinge
portion.

11. An apparatus as claimed in any of claims 4 to 9
wherein said two spaced-apart positions are defined by
a mounting forming part of said steam sensing unit,
said mounting being formed so as to be compliant for
accommodating dimensional changes that occur in said
bridge during overcentre movement thereof.

12. An apparatus as claimed in claim 11 wherein said
mounting is formed of a moulded plastics material and
the required compliance is provided, at least in part,
by the inherent flexibility of the plastics material.

13. An apparatus as claimed in claim 11 wherein said
mounting incorporates a compliant spring metal
element.

14. An apparatus as claimed in any of claims 4 to 13
wherein the bimetallic element of the overcentre
bridge is not in itself snap-acting.



15. An apparatus as claimed in any of claims 4 to 14 wherein said steam sensing unit comprises a body moulding defining a first compartment for said overcentre bridge and a second compartment for a switch sub-assembly, the arrangement being such that when said bridge and said switch sub-assembly are installed in said compartments they co-operate with each other for switch operation.

16. An apparatus as claimed in any of the preceding claims wherein the steam sensing unit has a plug-in electrical terminal portion adapted to be received in a complementary socket of said element protection unit, and switch terminals adapted to make contact with complementary terminals within the socket are provided in said terminal portion, and wherein the element protection unit has spring terminals arranged to make electrical contact with element cold tails of said heating element, and said socket provides access to the location whereat a spring terminal of the element protection unit makes spring contact with an element cold tail so that, when the plug-in electrical terminal portion of the steam sensing unit is plugged into said socket, the switch terminals of the steam sensing unit are interposed between the spring terminal and the element cold tail.



17. An apparatus as claimed in any of the preceding claims wherein the element protection unit includes a bimetallic element in close thermal contact with said heating element, said bimetallic element being
5 arranged to open said electrical switch in the element protection unit in response to an element overtemperature condition.

18. An apparatus as claimed in claim 17 wherein the element protection unit includes means providing a
10 secondary level of element protection operable in the event of failure of the primary level of element protection afforded by said bimetallic element.

19. An apparatus as claimed in claim 18 wherein the secondary level of element protection is provided by
15 the inclusion in the element protection unit of a thermally deformable element exposed to the element temperature, and means responsive to deformation of said element in response to an extended element overtemperature condition for disconnecting the
20 heating element from its power supply.

20. An apparatus as claimed in claim 19 wherein said thermally deformable element comprises a thermally deformable carrier for the bimetallic element that is



provided in the element protection unit for providing a primary level of protection, the condition of said thermally deformable carrier determining the status of a secondary switch that is provided in the element protection unit.

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21. An apparatus as claimed in claim 1 and wherein said element protection unit is substantially as herein described with reference to Figs. 2A, 2B and 3C of the accompanying drawings, and the steam sensing unit is substantially as herein described with reference to Figs. 1A to 1M-1 and 1M-2, or Figs. 3A and 3B, or Figs 5A, 5B and 6 of the accompanying drawings.

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