(12) UK Patent Application (19) GB (11) 2 363 908 (13) A

(43) Date of A Publication 09.01.2002

(21) Application No 0121868.4

(22) Date of Filing 27.05.1998

Date Lodged 10.09.2001

(30) Priority Data
(31) 9725401 (32) 28.11.1997 (33) GB

(62) Divided from Application No 9811400.2 under Section 15(4) of the Patents Act 1977

(51) INT CL[7]
H01H 37/54

(52) UK CL (Edition T)
H1N NBG N54X N543 N623 N631 N637 N704 N838
U1S S1788 S1976

(56) Documents Cited
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EP 0014102 A1

(58) Field of Search
UK CL (Edition S) H1N NBG
INT CL[7] H01H

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(54) Abstract Title
Thermally-responsive actuator

(57) A steam sensor switch for an automatic kettle employs a snap-acting bimetallic actuator 12 to operate an overcentre arrangement by means of a push rod 13, the overcentre arrangement comprising a C-spring 1 and a trip lever 8 sprung between spaced-apart abutments. Spring contact elements are integrally formed with the C-spring 1 so that they pivot about a fulcrum when the overcentre arrangement switches between its two stable conditions and are not subject to mechanical deformation. This contact arrangement enables a large contact separation to be achieved in a small size switch and thereby enhances electrical safety. A second bimetallic actuator ensures operation of the switch if it fails to be operated by the first bimetallic actuator, the second actuator being shielded from steam generated when water boils in a vessel to which the steam control is fitted so that it will operate only after such a time delay as to give the first bimetallic actuator a chance to operate.

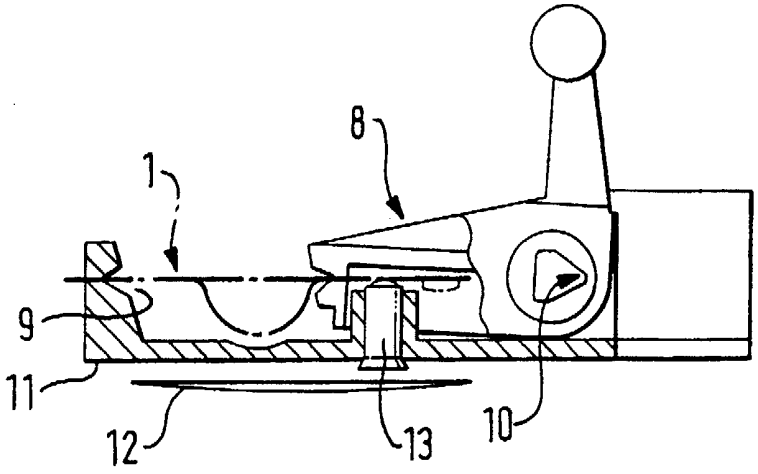

FIG. 4

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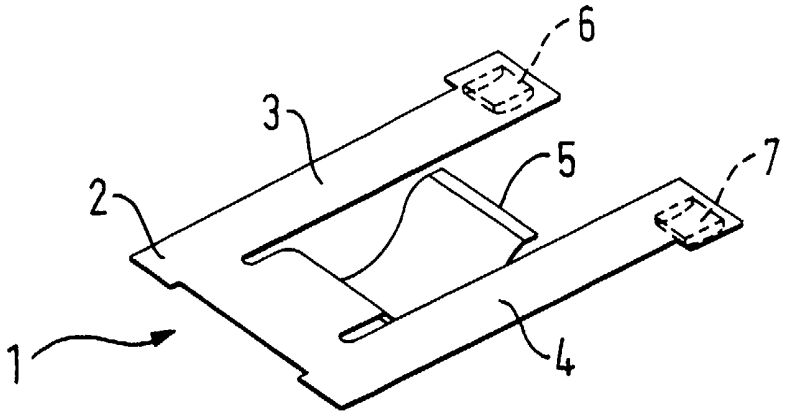


FIG. 1

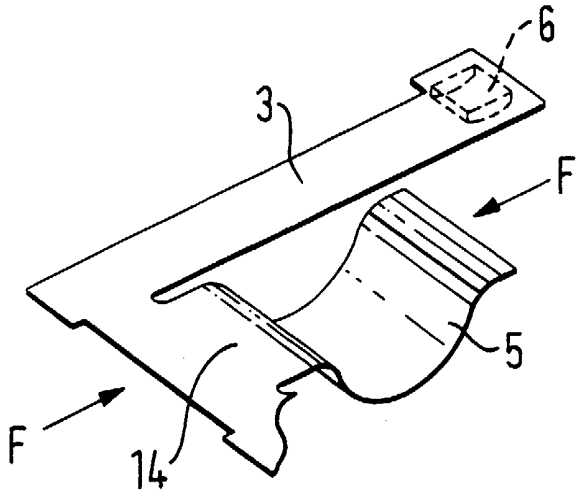


FIG. 2A

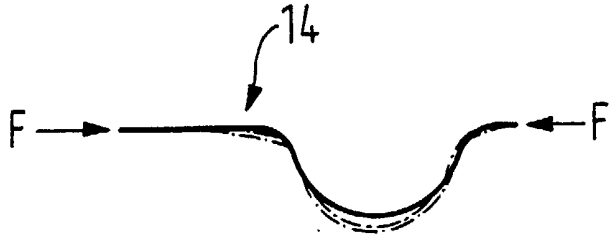


FIG. 2B

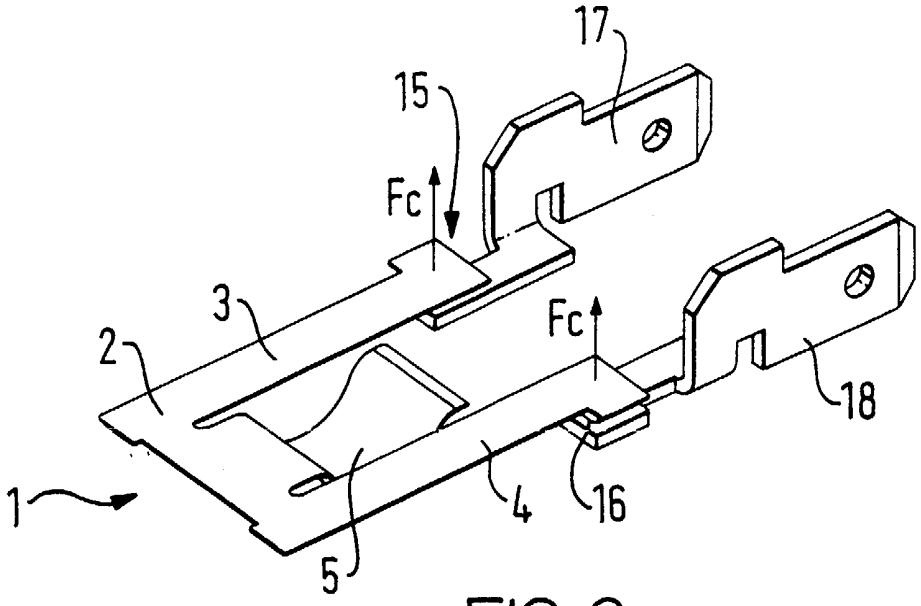


FIG. 3

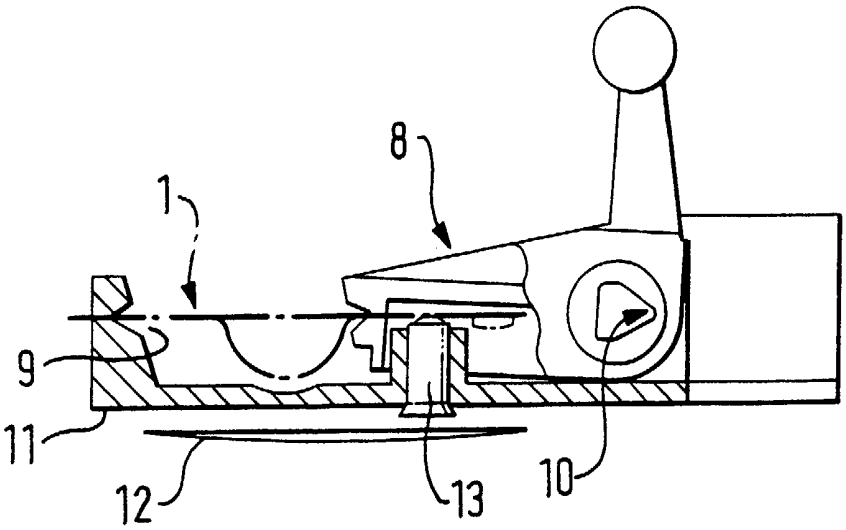


FIG. 4

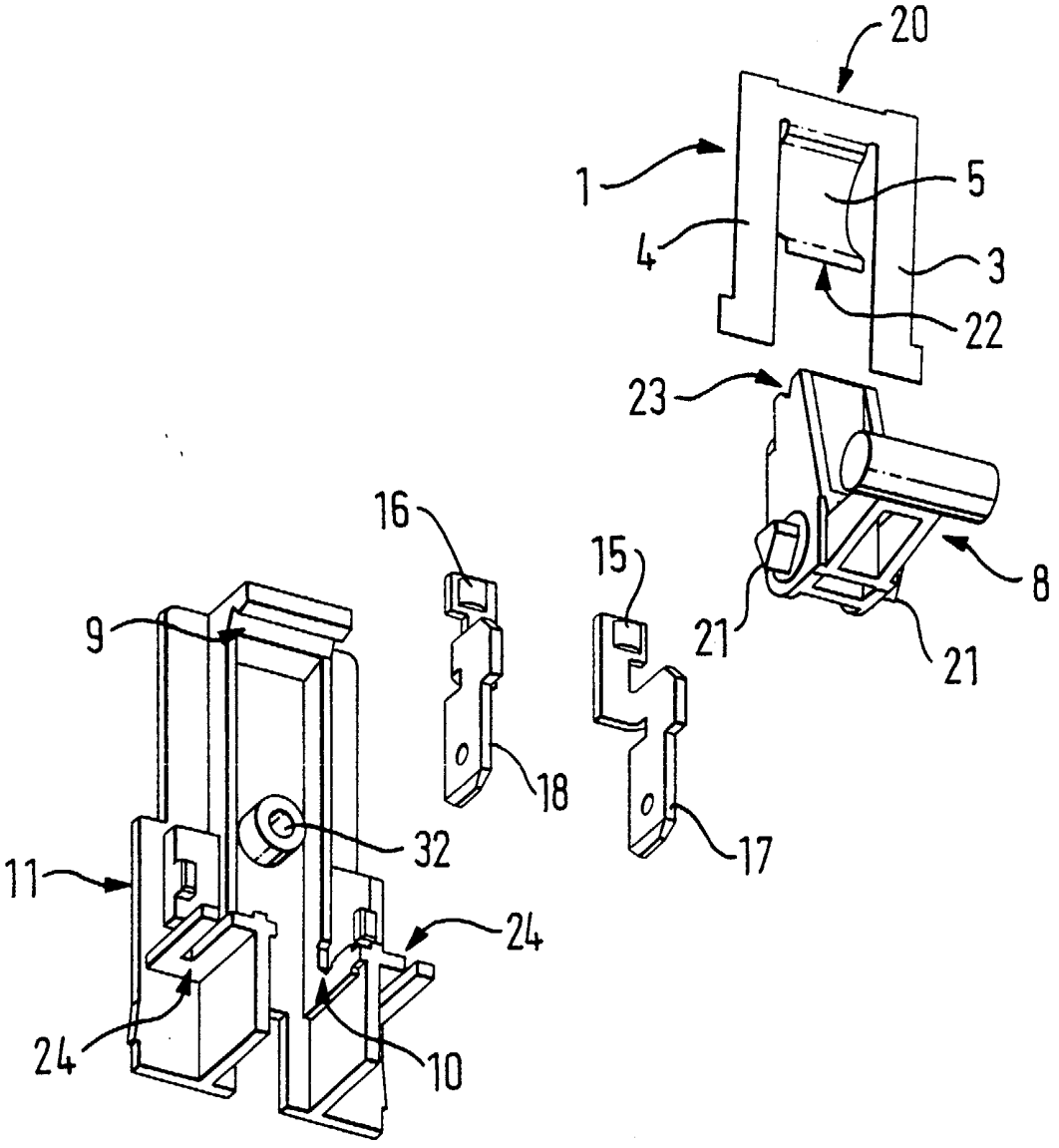
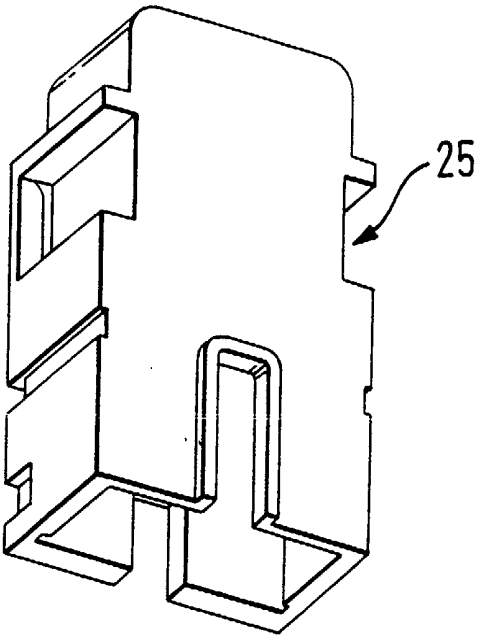


FIG. 5A



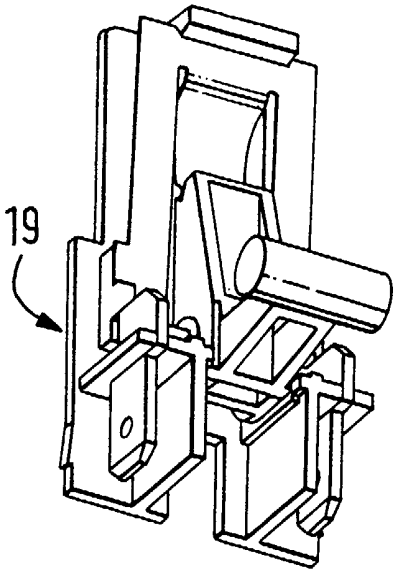
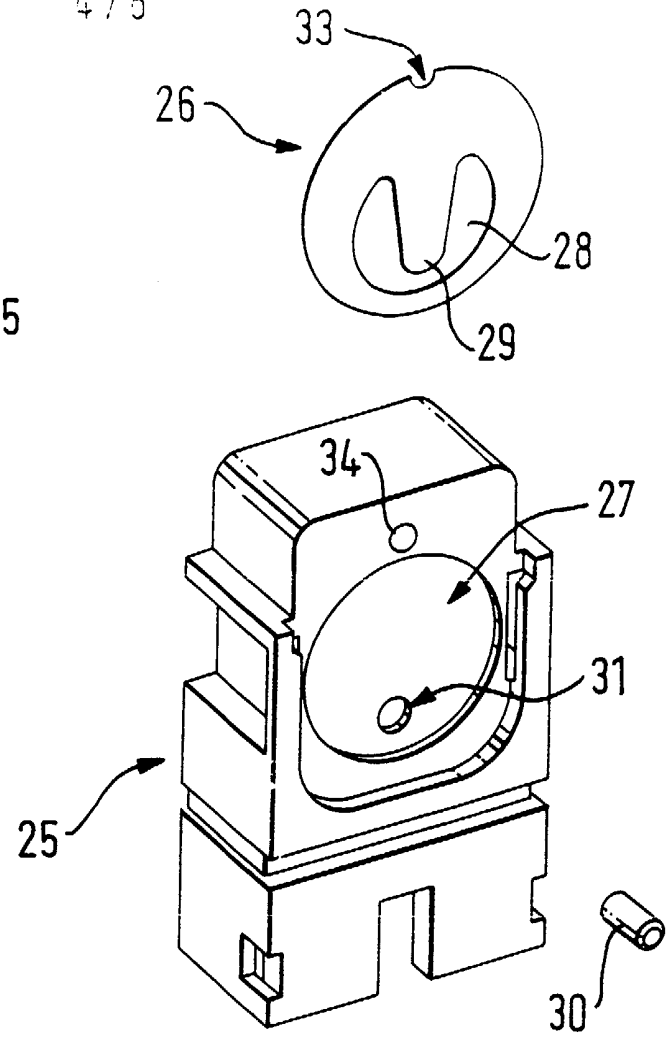


FIG. 5B



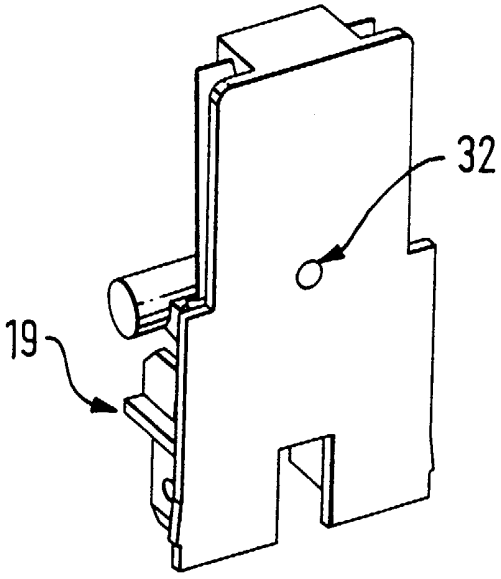


FIG. 5C

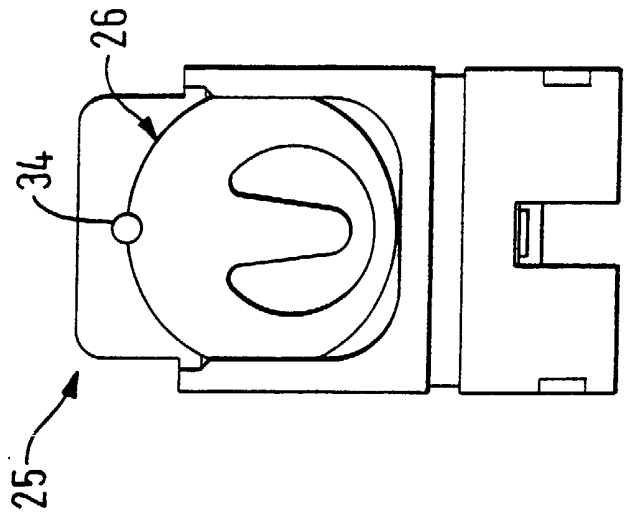


FIG. 6C

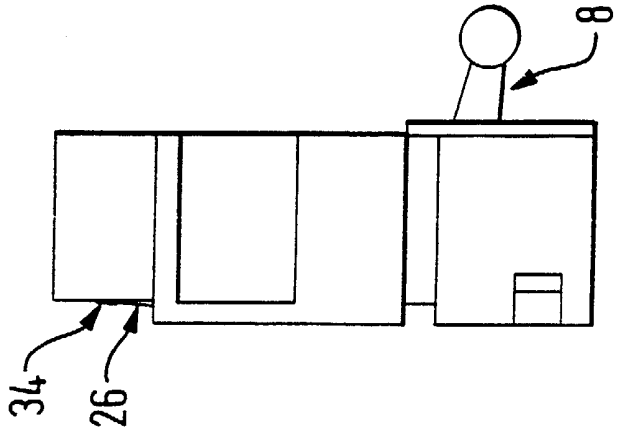


FIG. 6B

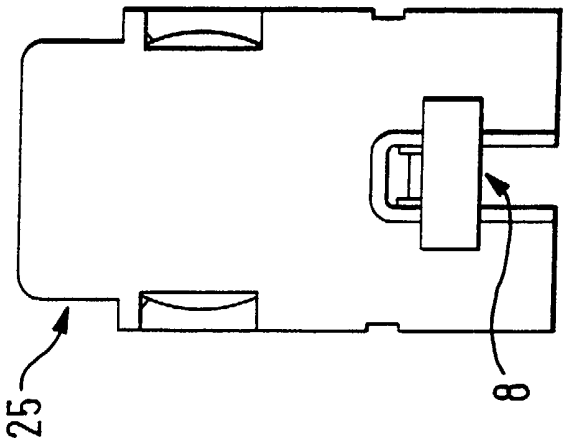


FIG. 6A

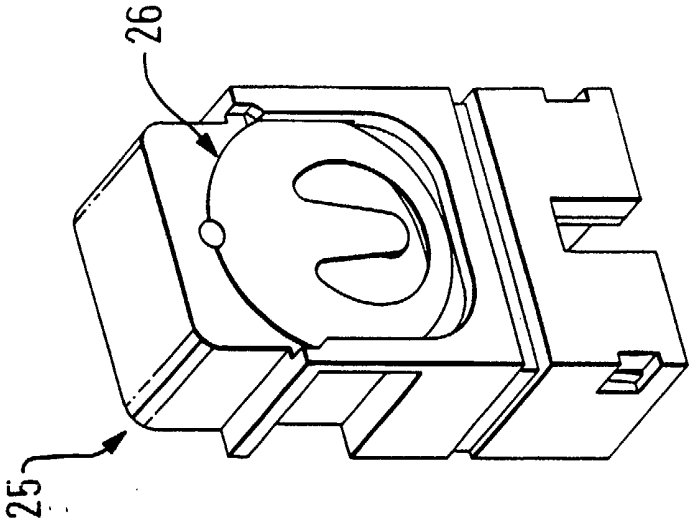


FIG. 6F

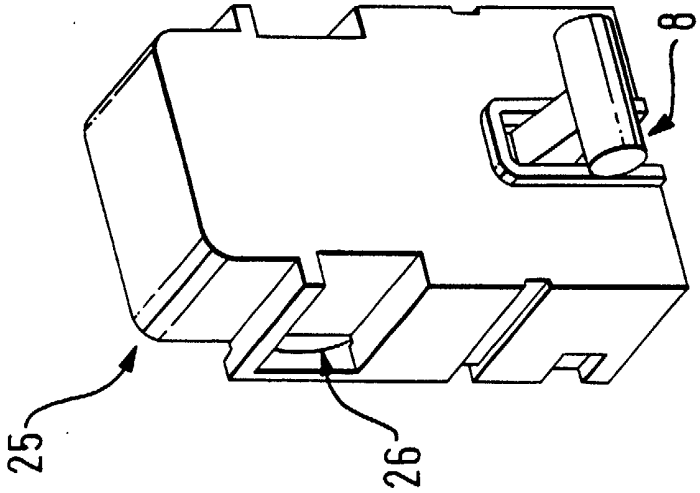


FIG. 6E

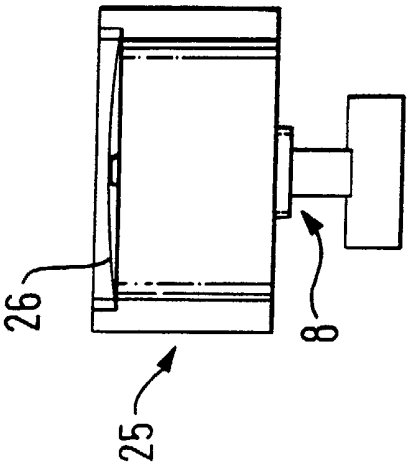


FIG. 6D

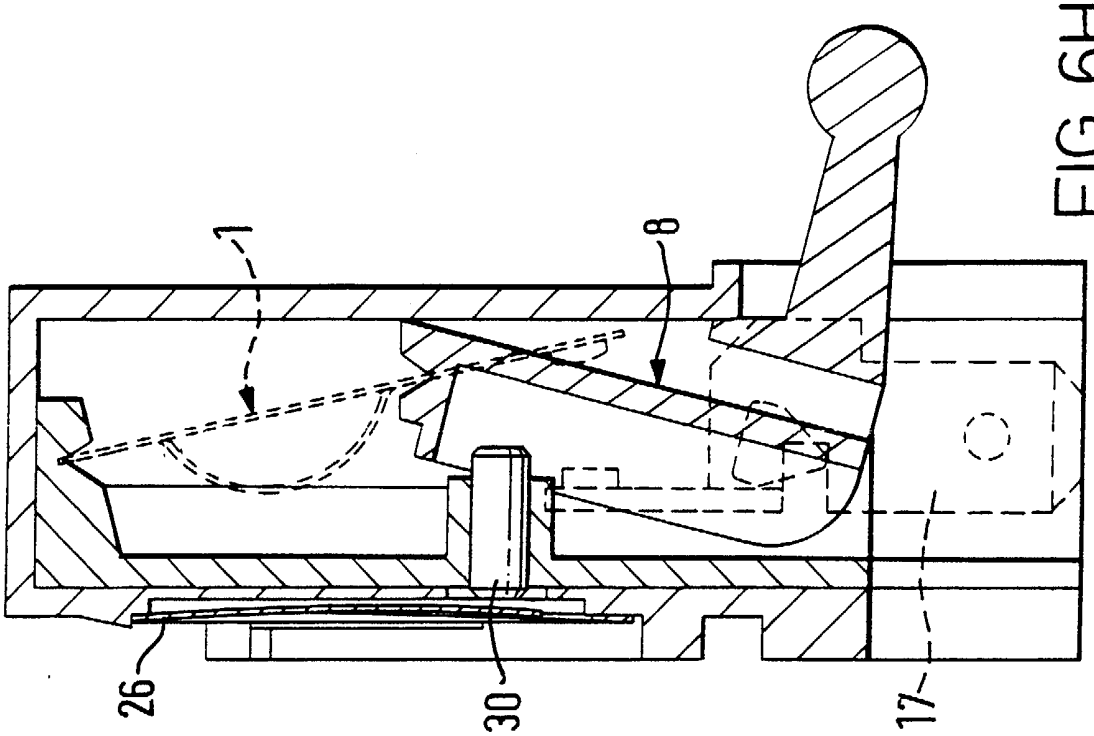


FIG. 6H

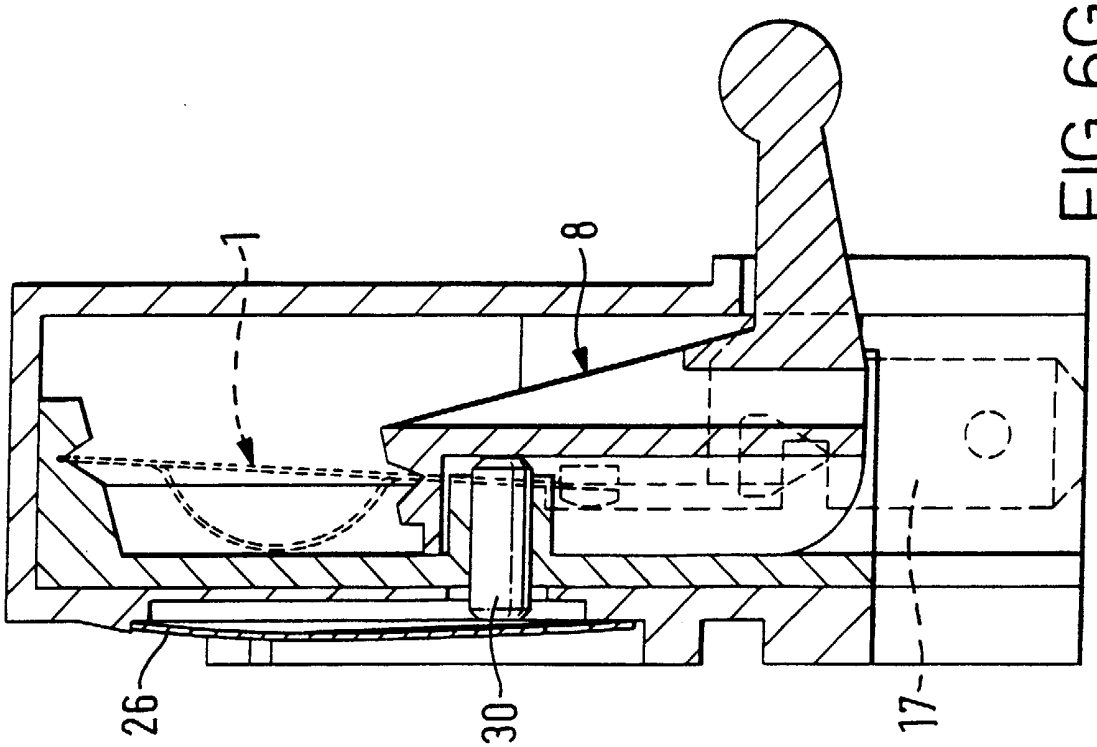


FIG. 6G

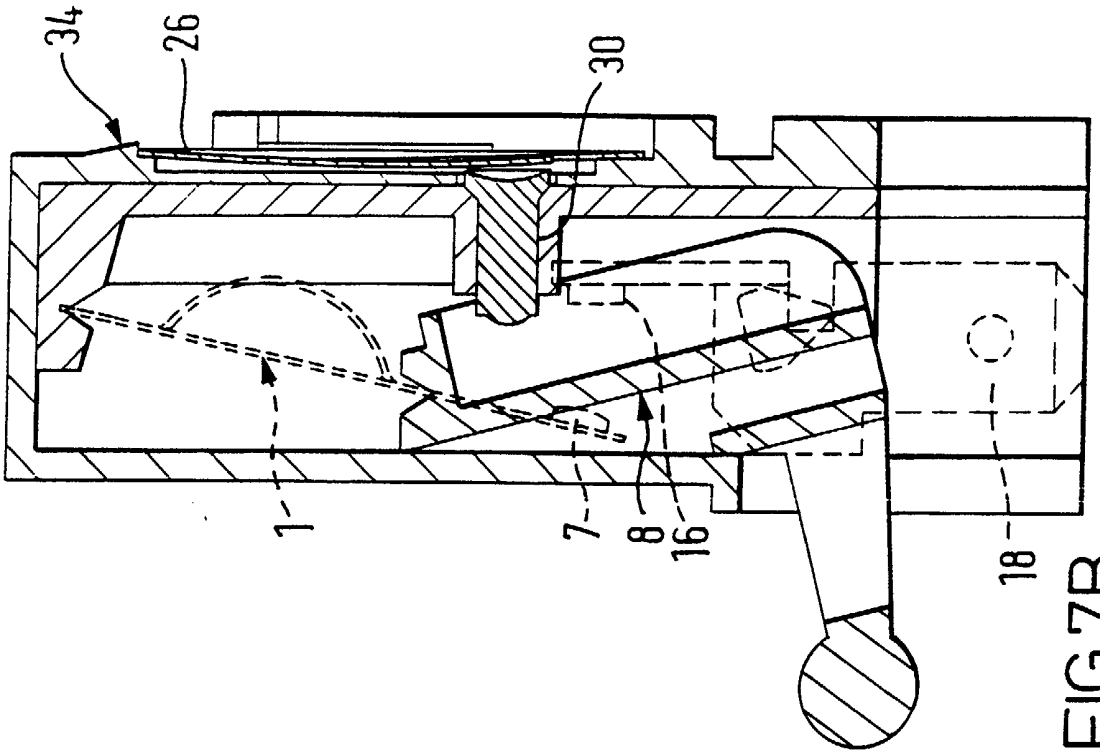


FIG.7B

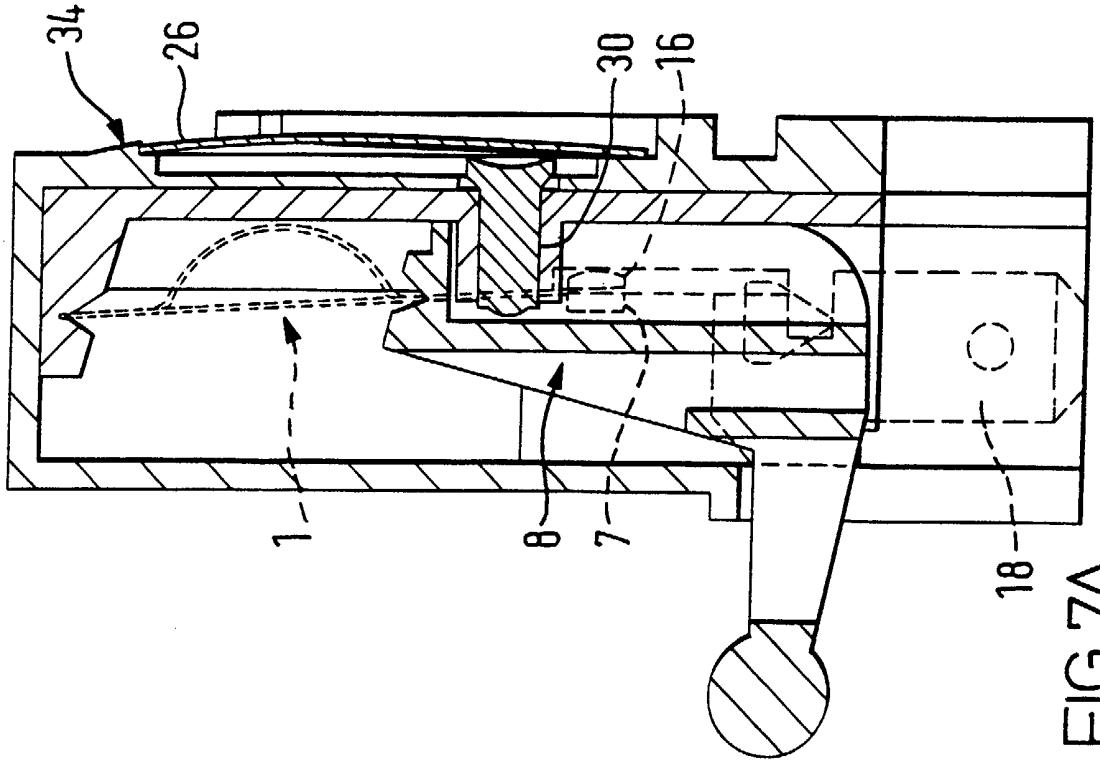


FIG.7A

IMPROVEMENTS RELATING TO THERMALLY-RESPONSIVE ACTUATORS

Field of the Invention:

This invention concerns improvements relating to thermally-responsive actuators, particularly though not exclusively actuators comprising bimetallic elements, and to control devices, electrical switches for example, incorporating the same. Whilst the invention will be particularly described in the following by reference to electrical switches incorporating thermally-responsive actuators and designed to switch off kettles and other water boiling appliances in response to the generation of steam when water boils in the appliance, the invention is not limited to such an application.

Background of the Invention:

A fundamental problem with electrical controls which have to operate in the humid atmosphere of an automatic electric kettle for example, is that condensation from the steam which is responsible for operating the control can form on surfaces providing electrical insulation and cause tracking and catastrophic failure of the control. The size restraint to which controls for automatic kettles are subject means that the achievement of large creepages and clearances is difficult, since long cantilever contact springs would normally be required to ensure that the mechanical properties of the spring material were not exceeded as a result of the relatively large deflections required to obtain acceptably large contact separation. If the target contact separation

was 3mm for example, the length of cantilever spring that would be required would be too long to fit within a reasonably sized control.

Examples of steam controls as aforementioned which employ cantilevered spring contact arrangements are described in GB-A-2 213 646 and GB-A-2 221 795. A further example is the J-type steam control which we manufacture and which is described in GB-A-2 212 664 with reference particularly to Figs 9A, 9B and 10 of the drawings thereof. In all of these controls, measures are taken to seek to isolate the switch contacts in a separate compartment from the parts of the control that are exposed to steam, but even with such measures the possibility nonetheless exists that the switch compartment might be contaminated with moisture and larger switching clearances would be desirable.

Objects and Summary of the Invention:

It is therefore the principal object of the present invention to overcome or at least substantially reduce the abovementioned problems.

According to the present invention the requisite increased contact separation can be obtained by use of a contact spring which moves by rotation about a fulcrum rather than by elastic deformation as in the case of the prior art cantilevered springs. By rotation of the contact spring, rather than bending it as in the prior art arrangements, the spring is subjected to substantially no stress and increased contact separation can readily be achieved without prejudicing the mechanical properties of the spring material.

In accordance with a steam sensor embodiment of the present invention which will be described in detail hereinafter, a generally E-shaped spring is employed in which the central element of the E is formed as a C-spring. The C-spring element of the spring is assembled with the free end of a pivotally mounted lever between spaced apart abutments to form an overcentre arrangement, known per se from the J-type steam control aforementioned for example, and the outer (top and bottom) elements of the E extend on opposite sides of this overcentre arrangement. In operation of this embodiment, as the overcentre arrangement moves with a snap action between its two opposite of centre stable positions, so the outer limbs of the E-shaped spring move in pivotal fashion as the whole E pivots on its upright (the E-shaped spring consisting of an upright from which its three horizontal elements extend) and the free ends of the top and bottom elements of the E make substantial displacements. By providing electrical contacts on the free ends of the top and bottom elements of the E-spring and employing such contacts as moving contacts of a switch arrangement, substantial contact separation can readily be achieved.

The overcentre arrangement abovementioned can readily be associated with a thermally-responsive actuator such as a bimetal or shape memory effect (SME) device for example so as to constitute a thermally-responsive switch. Furthermore, the E-shaped spring could itself be formed of bimetallic material, and/or a second thermally-responsive actuator might be provided, for the

purpose of ensuring operability of the device in the event, however unlikely, of failure to operate of the primary thermally-responsive actuator, and such secondary operation might be arranged to be operable only after a time delay such as to accommodate normal operation without operation of the secondary protection

The above and other features of the present invention are set forth in the appended claims and, together with advantages thereof, will become clear from consideration of the following detailed description given with reference to the accompanying drawings.

Description of the Drawings:

Figure 1 is a perspective view of an exemplary E-spring according to one aspect of the present invention;

Figures 2A and 2B are enlarged part-perspective and side elevation views of the spring of Figure 1 useful for explaining its operation;

Figure 3 is a perspective view showing how the E-spring of Figure 1 might be used in a switch environment;

Figure 4 is a part-sectional side elevation of an exemplary steam sensor incorporating an E-spring as shown in Figure 1;

Figures 5A, 5B and 5C are exploded perspective views of the steam sensor of Figure 4, Figure 5A showing internal components of the sensor in exploded view, Figure 5B showing the internal components of Figure 5A

assembled together for insertion into an outer cover, and Figure 5C being an exploded view similar to Figure 5B but showing the opposite side thereof;

Figures 6A, 6B, 6C and 6D show top plan, side elevation bottom plan and end elevation views respectively of the sensor of Figures 5A, 5B and 5C, Figures 6E and 6F are perspective views from opposite sides and Figures 6G and 6H are part sectional views showing the different conditions of the sensor; and

Figures 7A and 7B are enlarged views similar to Figures 6G and 6H.

Detailed Description of the Embodiments:

Referring to Figure 1, shown therein is a generally E-shaped spring 1 formed of beryllium copper for example and comprising an upright or rear cross-member portion 2 from which extend upper and lower elements 3 and 4 and a central element 5 which, as shown, is formed as a C-spring. The free (front) ends of the spring elements 3 and 4 are enlarged as shown and electrical contacts 6 and 7 formed of silver or a silver alloy for example are welded or otherwise affixed thereto.

Figure 4 shows an exemplary steam sensor device in which the E-spring 1 is assembled with a pivotally-mounted trip lever 8 between spaced apart abutments 9 and 10 so as to define an overcentre arrangement which is movable with a snap action between stable positions on opposite sides of an unstable central position. The abutments 9 and 10 are formed in a body part 11 of the device and the action of the overcentre arrangement is made

temperature responsive by mounting a bimetal 12 on the body part 11 and providing a push rod 13 which couples the bimetal movement to the overcentre arrangement. The steam sensor of Figure 4 is described more fully in the following.

As shown in Figures 2A and 2B, the E-spring 1 has a region 14 which rotates in the fulcrum defined by the abutment 9 as the trip lever 8 moves between its stable positions, the movement of this region 14 following the movement of the central C-spring element 5 of the E-spring 1. The two outer (upper and lower) elements 3 and 4 of the E-spring 1 therefore also rotate and the movement at their free ends depends only on the angle of rotation and the lengths of the elements 3 and 4. For rotation angles of such size as are readily achieved with overcentre arrangements such as the one shown in Figure 4 and with the lengths of the elements 3 and 4 being such as will comfortably fit within a small size control, it is a simple matter to achieve an amount of movement at the free ends of the E-spring elements 3 and 4 considerably in excess of 3mm. It is noteworthy that in counterclockwise rotation of the E-spring 1, corresponding to clockwise rotation of the trip lever 8 about its abutment 10 and operation of the switch in the steam sensor of Figure 4 from its ON to its OFF condition, the elements 3 and 4 of the E-spring 1 do not suffer any deformation (so long as the arrangement of the steam sensor provides sufficient clearance for their movement) and are not subjected to any stress. The only stress in the system is in the C-spring part 5 of the E-spring 1

and conventional spring design practices may be employed to avoid overstressing of this part.

Figure 3 shows an exemplary arrangement wherein the contacts 6 and 7 that are provided on the undersides of the free ends of the elements 3 and 4 of the E-spring 1 co-operate with fixed contacts 15 and 16 that are provided on supply terminals 17 and 18 of the Figure 4 control. The interaction between these two sets of contacts is advantageously such that the fixed contacts 15 and 16 limit to clockwise movement of the ends of the outer elements 3 and 4 of the E-spring so that they generate a contact force such as to ensure good current carrying capability. This is accompanied by deformation of the elements 3 and 4 by much less than the total movements of the elements 3 and 4 as the E-spring 1 rotates. Since the outer elements 3 and 4 perform no other function than providing this contact force, their design can be optimised for this task.

It can be seen from Figure 3 that the E-spring 1 operates as a movable contact bridge between the fixed contacts 15 and 16 that are provided on the supply terminals 17 and 18. In the OFF condition, with the outer elements 3 and 4 of E-spring 1 pivoted anti-clockwise, there is a large contact gap between the contacts 6 and 15 and between the contacts 7 and 16. If each of these gaps is 3mm or more, the combined gap of both sets of contacts is 6mm or more which is well in excess of design requirements for electrical safety.

A further effect of the described E-spring 1 as incorporated into the arrangement of Figure 4 is that as the trip lever 8 is moved from its stable ON position towards the unstable central position of the overcentre arrangement, so the C-spring central element 5 of the E-spring is subjected to compressive end loading which, as shown in Figures 2A and 2B where the arrows F represent the compressive force, causes the portion 14 to rotate in a clockwise direction which increases the contact forces between moving contacts 6 and 7 and fixed contacts 15 and 16. This ensures that good contact force is maintained until the trip lever 8 passes through its unstable position whereupon the contacts snap open. To achieve this effect, the C-spring element 5 of the E-spring 1 must be formed in the direction shown in the drawings, namely with its concavity towards the side of the E-spring 1 on which the contacts 6 and 7 are provided, and the contacts must be arranged such that they remain closed until the trip lever 8 has passed through its central unstable position. In Figure 2A, the region 14 of the E-spring 1 is shown as extending from the rear cross-member 2 of the spring for a short distance before the C-spring part 5 begins, and it is the effect of the forces within the C-spring 5 on this region 14 which generates the torque leading to the increased contact force as the trip lever begins to switch OFF.

The contact force generated between the movable contacts 6 and 7 and the fixed contacts 15 and 16 has an additional effect in that it acts in a direction such as to assist the bimetal 12 in moving the trip lever 8 from its ON to its

OFF position. This reduces the demands on the bimetal actuator so that, for example, a smaller and/or cheaper bimetal design can be used. Alternatively it allows the use of a stiffer C-spring which would give rise to higher forces in the OFF condition and a more positive action which is less subject to being affected by external influences such as physical shock or the weight of heavy appliance on/off rocker mechanisms attached to the trip lever 8.

Further details of the steam sensor device that is shown in Figure 4 will be described in the following with reference first to the exploded views of Figures 5A, 5B and 5C. As shown in Figure 5A, the E-spring 1, the trip lever 8 and the terminals 17 and 18 are adapted to be assembled with the moulding 11 to form an inner moulding sub-assembly 19 as shown in Figure 5B. The moulding 11 has spaced apart abutments 9 and 10, the former of which serves to receive the rectangular notch 20 that is provided in the rear edge of E-spring 1 and the latter of which serves to receive pivotal V-bearings 21 provided on the trip lever 8. The forward edge 22 of the C-spring portion 5 of E-spring 1 is received in a V-notch 23 formed in the front edge of the trip lever 8. The abutments 9 and 10 of the moulding 11 are spaced apart by a distance less than the sum of the length of the E-spring between its edges 20 and 22 in its relaxed condition and the length between the V-notch 23 and the V-bearings 21 of the trip lever so that the combination of E-spring 1 and trip lever 8 have to be sprung into the abutments 9 and 10 and thereby form an overcentre arrangement as hereinbefore described. Accommodating

formations 24 are provided in the moulding 11 for receiving the terminals 17 and 18.

Figure 5B shows the inner moulding sub-assembly 19 formed by assembly of the components shown in Figure 5A and further shows a cover moulding 25 into which the sub-assembly 19 is adapted to be fitted. Figure 5C shows the sub-assembly 19 and the cover moulding 25 from the opposite side and it can be seen that the cover moulding 25 has provision for mounting a bimetallic blade 26 thereon, the blade 26 being adapted to be push fitted into an accommodating recess 27 on the back of the cover 25. The bimetal blade 26 is shown as a circular disc-shaped blade having a central cut-out 28 which defines a tongue 29. The blade 26 is dished so as to be movable between oppositely curved configurations with a snap action and the cut-out 28 and tongue 29 provide for greater movement at the free end of the tongue than would be obtained from a plain disc, as is well known.

A push rod 30 passes through an opening 31 in the cover 25 and through a registering opening 32 in the moulding 11. One end of the push rod 30 underlies the free end of the tongue 29 of bimetal 26 and the other end underlies the trip lever 8. A small notch 33 is formed in the periphery of bimetal 26 and registered with a wedge-shaped (in side elevation view) projection 34 formed on cover 25 so as properly to locate the bimetal. The wedge shape of the projection 34 permits the bimetal to be inserted into its

accommodating recess and prohibits its return. A better showing of the wedge shaped projection 34 is to be seen in Figures 7A and 7B.

Figures 6A through 6H are various elevation, perspective and sectional views of the aforedescribed steam sensor device which are included herein for the sake of completeness but will not be further described. Figures 7A and 7B are enlarged views similar to Figures 6G and 6H and these enlarged views clearly show the ON and OFF conditions of the device, Figure 7A showing the contacts-closed ON condition of the device and Figure 7B showing the OFF condition of the device wherein the contacts are widely open.

It is a further advantage of the use of an E-shaped spring that the two poles of the switch, namely the two contact sets 6, 15 and 7, 16, are well separated from each other. This separation is enchanced in the described steam sensor device by virtue of the fact that the provision of ribs on the inner moulding 11 is such as in effect partially to compartmentalize each of the upper and lower elements 3 and 4 of the E-spring 1 in its own chamber so that electrical creepage distances are much increased and the likelihood of the electrical safety of the control being compromised by condensation is much reduced.

Although both limbs 3 and 4 of the E-spring 1 contribute to the large contact gap, it is only necessary for one of the limbs to carry out the current make and break. This allows smaller cheaper contacts (or simply silver plating) on the other limb, reducing contact cost. The limb which makes and

breaks the current may be arranged to make last and break first, by adjusting the relative heights of the fixed contacts and/or by adjusting the shape of the spring.

Yet another advantage of the E-shaped spring of the described embodiment results from the fact that breaking of the circuit in response to steam generation is accomplished by the opening of two sets of switches, namely the contact sets 6,15 and 7,16. In the event of one of these contact sets failing to operate on account of their contacts welding together, there will be no ill effect upon the function of the other contact set so long as the characteristics of the spring material of the E-spring are suitably selected, which would normally be the case given the relative dimensions of the limbs 3 and 4 in comparison to the C-spring portion 5, to ensure that the limbs 3 and 4 are not stiff enough to prevent the portion 5 from rotating. Thus, regardless of the state of one of the limbs 3 and 4, the portion 5 will rotate as the device operates and the other limb will rotate with it as if nothing were amiss.

Other features of the control which are designed to limit the effects of condensation are shown in the drawings. In Figure 1 and the two sectioned views of Figures 7A and 7B (not on any of the other views), the push rod 30 is shown with an enlarged head, the underside of which is conical. This engages with a similar conical surface in the hole 32 of the inner moulding 11 through which it passes, and forms a seal when the bimetal 26 is in its operated state, which is when most steam is present. The narrow clearance of the hole

ensures that the lower volumes of steam, present at other times, have only restricted access to the control interior. The internal ribs of the control baffle the steam further, and are arranged to encourage the steam to leave the control via the gap under the trip lever 8. The lower side of the trip lever, best seen in the two sectional views, is arranged to enclose the push rod hole 32 when the switch is in the "ON" position, thus complementing the tapered head of the push rod which functions when the switch is in the "OFF" position. The top surface of the control, where the top of the trip lever 8 projects, is arranged to ensure that water spilt over the control is safely directed away from any electrical components, and rib features are included on the outside of the cover to engage mating appliance features to enhance this effect.

Having thus described the present invention by reference to several embodiments, it is to be appreciated that the embodiments are exemplary only and the modifications and variations thereto will occur to those possessed of the appropriate skills without departure from the spirit and scope of the invention as set forth in the appended claims. For example, if a changeover switch configuration were required, the outer elements 3 and 4 of the E-spring 1 could additionally extend on the opposite side of the cross-member 2 so as to form a generally H-shaped spring having the C-spring 5 extending from the cross piece of the H-shape. Yet another possibility, if space was not a constraint, would be to have the C-spring 5 extending on the opposite side of cross-member 2 to the arrangement shown in Figure 1.

Other modifications, described hereinafter, might be incorporated in order to overcome or at least substantially reduce the possibility that the steam control fails to operate, for example if the lid of a vessel into which the device was fitted were left open or if the switch rocker was prevented from moving. It might take about 15 minutes for a kettle to boil dry under these conditions, giving rise to excessive condensation and the possibility of damage to the appliance. To resolve or reduce this problem, an additional thermal action might advantageously be incorporated which either opens the contacts independently of the trip lever or the steam-responsive thermal actuator and/or causes the trip lever to operate after a time delay. Two means of achieving this will be described hereinafter.

One possible means comprises the formation of the E-spring 1 from bimetallic material. An abutment might be provided close to one of the limbs 3,4 or to both of them such that as the limb deflects as its temperature rises, so it contacts the abutment and causes the E-spring to move over-centre. Alternatively, no abutment may be provided and the limbs 3,4 may simply bend as their temperature rises until the contact sets 6,15 and 7,16 are opened so as to break the circuit, albeit with some arcing. The E-spring may be arranged to be heated by the passage of electric current through the spring and/or by the general rise in the temperature of the steam sensor device overall as it is heated by steam. Preferably such a mechanism for opening the switch contacts would be arranged to be operative only after a delay of about 5 minutes, to avoid the

possibility of nuisance operation before the vessel contents have had time to be boiled under normal conditions. The heating of the E-spring can be adjusted to achieve this, if necessary, by the inclusion of suitable heat conductors (or insulators) from the hot areas of the steam sensor control, most notably the area of the bimetal 26.

A less preferred option is to provide a separate thermal actuator, such as a bimetal or SME (shape memory effect) actuator, and arrange for this actuator to act on the trip lever. By suitably shielding this second actuator from the heat of steam generated when water boils in the appliance the desired delay in operation can be achieved. It would further be possible to heat the second thermal actuator electrically, but the necessary electrical connections would have undesirable cost implications.

Those skilled in the art will appreciate that the above described modifications provide secondary protection for steam controls, thereby offering the user an enhanced level of safety.

CLAIMS:

1. An electrically heated water boiling vessel including a steam sensor adapted to switch off the supply of electricity to a heating element of the vessel in response to the generation of steam when water boils in the vessel, and wherein an additional thermal action is provided to cause switching off of the supply of electricity to the heating element within a time period greater than that normally required for operation of the steam sensor but less than that normally required for boiling dry of the vessel absent operation of the steam sensor.

2. An electrically heated water boiling vessel including a steam sensor adapted to switch off the supply of electricity to a heating element of the vessel in response to the generation of steam when water boils in the vessel, and wherein an additional thermal action is provided to cause switching off of the supply of electricity to the heating element even if said steam sensor fails to operate, said additional thermal action being operative within a time period less than that normally required for boiling dry of the vessel absent operation of the steam sensor but greater than that normally required for boiling of the vessel contents.

3. An electrically heated water boiling vessel as claimed in claim 2 wherein said steam sensor comprises first and second thermally-responsive switch actuators which are each arranged to switch off the supply of

electricity to the heating element independently of the condition of the other, one of said switch actuators being adapted for performing a normal steam sensing operation responsive to the generation of steam when water boils in the vessel and the other being adapted to perform said additional thermal action.

4. An electrically heated water boiling vessel as claimed in claim 3 wherein said steam sensor comprises a contact spring in an overcentre arrangement the condition whereof can be determined by said first and second thermally-responsive switch actuators, said one switch actuator being arranged in the vessel to be subject to the temperature of steam generated when water boils in the vessel to determine the condition of said overcentre arrangement in normal operation, and said other switch actuator being shielded from the temperature of steam generated when water boils in the vessel so as to have a delayed action as compared to said one switch actuator.

5. An electrically heated water boiling vessel as claimed in claim 3 wherein said steam sensor comprises a contact spring in an overcentre arrangement, said one switch actuator comprises a bimetallic or other thermally-responsive member arranged in the vessel to be subject to the temperature of steam generated when water boils in the vessel for determining the condition of said overcentre arrangement, and said other switch actuator

being constituted by the formation of said contact spring of bimetallic or other thermally-responsive material.

6. An electrically heated water boiling vessel as claimed in claim 5 wherein said contact spring is arranged to be heated by the flow of electricity through the steam sensor during operation of the vessel, such heating contributing to said additional thermal action.

7. An electrically heated water boiling vessel as claimed in any of the preceding claims wherein the means enabling said additional thermal action is integrated into said steam sensor.

8. A steam sensor for an electrically heated water boiling vessel as claimed in claim 7.

9. A steam sensor for an electrically heated water boiling vessel, said steam sensor being adapted to switch off the supply of electricity to the heating element of the vessel in response to the generation of steam when water boils in the vessel, said steam sensor comprising a first thermally-responsive switch actuator and a second thermally-responsive switch actuator, each of said switch actuators being arranged to switch off the supply of electricity independently of the condition of the other.

10. An electrically heated water boiling vessel including first and second means operative in response to the generation of steam when water is heated in the vessel for terminating heating, said first and second means being operative at different times in operation of the vessel.

Application No: GB 0121868.4
Claims searched: 1-7, 9, 10

Examiner: Vaughan Phillips
Date of search: 17 October 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): H1N (NBG)

Int Cl (Ed.7): H01H

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X, E	GB 2329523 A	(STRIX) see abstract	1, 2, 9, 10
X	GB 2308743 A	(STRIX) see abstract	1, 2, 9, 10
X	GB 2301226 A	(STRIX) see abstract	1, 2, 9, 10
X	GB 2217160 A	(STRIX) see abstract	1, 2, 9, 10
X	GB 2212664 A	(OTTER) see abstract	1, 2, 9, 10
X	EP 0014102 A1	(EATON) see abstract	1, 2, 9, 10

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.
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