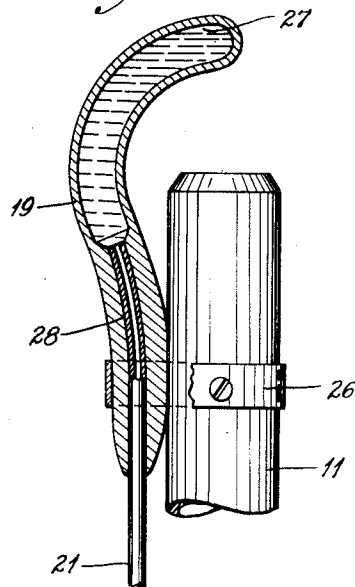


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TEMPERATURE RESPONSIVE CONTROL

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This invention relates to temperature responsive controls and particularly to those suitable for high temperature use such as in the detection of flame at a burner.

It is an object of the present invention to provide a novel and reliable temperature responsive device suitable for flame detection use, employing a fluid having liquid form at normal temperatures, and in which the control is actuated by the pressure-volume change due to the vaporization of a portion of the fluid at certain temperatures. A further object is to provide in a device of this character, means whereby the pressure-volume change required to operate the control and therefore the temperature at which it will operate, may be predetermined and varied within a range above the normal atmospheric boiling point of the fluid.

It is a further object to provide a temperature responsive control having a temperature sensitive bulb and a remote expansible chamber connected thereto by a conduit to form a closed system, which system contains a liquid in sufficient quantity so that there is an amount of liquid forced into the bulb when the expansible chamber is in its contracted position, and in which the liquid is displaced from the bulb by vaporization of a relatively small portion thereof at a predetermined temperature to expand the remote expansible chamber and thereby actuate a control means.

It is a further object to provide a device of this character in which the communicating passage between the bulb and the expansible chamber is highly restricted, and in which the expansible chamber is expansible from its contracted position sufficiently to receive all of said amount of liquid in the bulb so that the liquid may be completely expelled from the bulb when it is sufficiently heated, whereby the liquid vapor phase occurs in the highly restricted passage, thereby to minimize its surging effect upon the expansible chamber.

It is a further object to provide a device of this character in which the liquid filled bulb having a single opening for communication with the expansible chamber is so constructed and arranged that the opening is covered by liquid until all liquid is displaced therefrom by the pressure of a vaporized portion thereof.

Further objects and advantages will appear upon reference to the following description and accompanying drawing.

In the drawing,

Fig. 1 diagrammatically illustrates one form of

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the present invention in use as a safety fuel cut-off device sensitive to flame at a pilot burner;

Fig. 2 is an enlarged cross-sectional view of the combined switching mechanism and expansible chamber shown in Figure 1;

Fig. 3 is an enlarged cross-sectional view of the temperature sensitive bulb shown associated with the pilot burner in Fig. 1.

In Figure 1 a main burner is indicated in part at 10 and a pilot burner is indicated at 11. Fuel is supplied to the main and pilot burners thru the conduit 12 and the branch 13. The fuel supply to both burners is controlled by an electromagnetic valve 14 which when energized moves to an open position to permit fuel to flow to the burners and upon deenergization closes by gravity or by spring to cut off all fuel to the burners. A manual means for opening valve 14 is provided and is indicated at 14a. The fuel supply to the main burner for intermittent operation as required is controlled by a suitable valve 15. The valve 14 is energized by a circuit consisting of the leads 16 and 17, which are connected to a suitable source of electrical energy (not shown), and the circuit is controlled by a switch generally indicated at 18. The switch 18 is actuated by a temperature responsive device constructed in accordance with the present invention. The device comprises a bulb 19 which is arranged to be heated by the pilot burner flame, an expansible chamber generally indicated at 20, and a connecting capillary tube 21.

The expansible chamber consists of an outer heavy walled cup member 22 and an inner thin walled flexible cup member 23. The side walls of the inner and outer cups are joined by continuous welding as indicated at 24 to form a high pressure fluid tight seal. There is an opening 25 in the outer cup which receives one end of the capillary tube 21. The tube is therefore in communication with the space between the bottom walls of the cups. The tube is suitably attached to cup 22 by welding. At its other end the capillary tube is connected to the temperature sensitive bulb 19 which bulb is attached in an upright position, as indicated, to the pilot burner by any suitable means, as by the clamp 26.

The bulb has a chamber 27 formed in its upper portion and a concentric longitudinal bore 28 extending thru its lower portion which is sized to receive the capillary tube in close fit relationship. The capillary is inserted to the point of junction of the chamber 27 and bore 28 and the lower end of the chamber 27 is tapered so as to avoid any corners which may entrap liquid. The

capillary is attached within the bulb by welding the tube to the walls of the bore 28 thereby to form a high pressure fluid seal.

The expansible chamber 20 is attached to a plate member 29 by screws 30. Plate 29 has a central bore 31 which receives in sliding fit relationship an actuating pin 32. One end of pin 32 is held against inner cup 23 by a spring 33. The other end of the pin 32 bears against a switch arm 34. The pin is provided with an insulating tip 35 and the switch arm 34 is provided with a leaf spring 36 to provide for overtravel after the contacts are closed. The spring 33 may be adjustably tensioned by rotating the threadedly adjustable collar 33a on the pin 32. The switch arm is pivoted at 37 in a casing 39 and carries a movable contact 38 adjustably mounted at its free end. A fixed contact 40 is mounted in the wall of the casing 39. Terminal connections 41 and 42 are mounted in the casing wall for attachment of leads 16 and 17, and a pig-tail connection 43 is provided between terminal 42 and the switch arm. The switch arm is urged in a clockwise direction by a spring 44 and therefore the switch is biased in a circuit breaking position. It will be understood that the leaf spring 36 is much stronger than the spring 44.

The expansible chamber is shown, in Figure 2, in its fully expanded position in which the volume between the walls of the cups is substantially equal to the volume of the bulb chamber 27. In its contracted position, to which it is urged by the spring 33, the walls of the cups come into contact and the volume is substantially zero. With the expansible element in a contracted position the system is exhausted of air and filled with a high boiling point liquid.

Experiments indicate mercury to be the preferred liquid, because it is stable at high temperatures, it is heavy and gravitates well to the opening in the lower end of the bulb chamber, and because its boiling point is high enough so that heavy loading of the spring 33 is not required to maintain the operating temperature of the device safely above temperatures which may occur ambient to a burner in a furnace.

It will be seen that the bulb 27 is so constructed and positioned that, upon boiling of the liquid, vapors will rise to the upper end, and as vaporizing progresses, the liquid will continue to cover the opening at the lower end of the chamber until all liquid is forced from the bulb. It is imperative that the opening is at the lowest point of the bulb chamber, otherwise liquid will continue to gravitate into the chamber wherein it will be vaporized causing unduly high pressures and erratic operation. The expanded volume of the expansible chamber being at least equal to the bulb chamber 27, the chamber may therefore receive all of the liquid in the bulb and the liquid-vapor phase or the point at which the liquid is boiling will therefore occur in the capillary tube when the bulb is sufficiently heated. The internal diameter of the capillary tube is exceedingly small relative to the diameter of the bulb chamber and therefore the effect of this agitation on the expansible element is reduced to a minimum. It is obviously necessary to arrange the bulb so that all of chamber 27 is sufficiently heated, at least as far as the junction with the capillary tube, in order to completely displace liquid from the chamber 27 and to insure that the point of boiling occurs in the capillary tube. In the present use of the device, wherein the bulb is directly impinged by flame, the design

of the burner port and the disposition of the bulb relative thereto should be such that the flame plays on a sufficient portion of the bulb, to insure this, as is indicated in Fig. 1.

The strength of spring 33, which urges the pin 31 toward the right and thereby urges the expansible element toward its contracted position, determines the temperature at which the contacts 38 and 40 are closed. As the strength of the spring is increased, the pressure in the sealed system is increased and the boiling point of the liquid is thereby raised. By increasing the tension of spring 33 the temperature at which the contacts are closed can be raised above any anticipated temperature likely to occur ambient to the burner. By constructing the expansible element so that it will operatively expand sufficiently to receive all of the mercury in liquid form from the bulb chamber, excessive pressures, which would otherwise occur upon further heating and which would require massive structure to withstand, are avoided.

In operation

When in a cold or no-flame position, the positions of the elements of the device will be as follows: the inner and outer walls of the expansible element will be contiguous due to the pressure of spring 33 and the liquid will fill the bulb and the capillary tube. The switch arm 34 will be rotated clockwise by the spring 44 and the contacts 38 and 40 will be open and the energizing circuit for the electromagnetic valve 14 will be open causing all fuel to the burner to be cut off.

In order to light the pilot burner under these conditions the valve 14 is opened manually by the manual means 14a and is held open as the pilot burner is ignited and thereafter until the contacts 38 and 40 are closed to complete an energizing circuit for holding the valve open. As the burner is ignited the temperature of the liquid in bulb 27 will rise rapidly until a portion thereof vaporizes. Prior to reaching the boiling point, there will of course be a slight expansion of the liquid, but this increase in volume is negligible in its effect upon movement of the switch arm because of the proportioning of the instrument. In the case of mercury for instance, the volume increase from 32° F. to 676° F. (the atmospheric pressure boiling point) is less than 7 per cent, while the volume increase from liquid to saturated vapor at 850° F. (which is in the order of the temperature at which the control would be operated in flame detection use) is approximately 850 times. After the boiling point is reached expulsion of the liquid from the bulb progresses rapidly with relatively slight temperature increase and at some point before the liquid is completely expelled from the bulb the switch arm will be moved counterclockwise sufficiently to close the contacts. Expansion of the chamber beyond this point so as to permit complete expulsion of the liquid from the bulb is provided for by the overtravel spring 36 carried by the switch arm. The device will thereafter remain at a circuit closing position as long as the flame at the burner is maintained.

If for any reason the flame at the pilot burner is extinguished, the temperature of the bulb drops rapidly to a point below the boiling point of the mercury at the instant pressure and the liquid is expelled from the expansible chamber under the pressure of spring 33, and switch arm 34 moves clockwise to break the circuit under the urging of spring 44. It will be seen that dur-

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ing the initial contracting movement of the expandible element following flame failure the spring 36 will retain the contacts at a closed position. The provision of the overtravel spring 36 and the adjustable mounting of contact 38 permits varying the time required to make or break the contacts after ignition or extinguishing of the flame.

The foregoing description is intended to be illustrative and not limiting and the exclusive use of all modifications within the scope of appended claims is contemplated.

I claim:

1. A burner safety device adapted to use in high ambient temperatures for detecting the presence or absence of flame at a burner: comprising an expandible chamber, a bulb portion spaced from said expandible chamber for disposition at the flame, a tube connecting the bulb portion and expandible chamber so as to complete a closed system, the system being filled with a high boiling point liquid charge when said expandible chamber is in a contracted position, said liquid charge having a boiling point of at least 600° Fahrenheit, and said expandible chamber being expandible from its contracted position to receive the amount of liquid contained in the bulb portion of the system when the bulb portion is heated sufficiently by flame to complete the expulsion of all liquid therefrom, whereby a large rapid expansion or contraction of the expansion chamber occurs as the bulb temperature rises slightly above or falls slightly below the boiling point of the fluid therein, control means having first and second operating positions, and being connected to said expansion chamber to be moved by expansion and contraction thereof, the said positions being separated sufficiently to require the large volumetric change caused by a change of state of the fluid in said bulb portion for producing the operational shift of the operating means.

2. The device of claim 1, as a pilot burner safety device: there being a pilot burner adjacent the bulb portion, means holding the burner of the bulb portion in position to cause the flame from the pilot burner to impinge upon the bulb portion; the bulb portion and the connecting tube being relatively disposed so as to result in the expulsion of all of the liquid from said bulb portion and to maintain the same out of said bulb portion when the flame is impinging thereon.

3. The device of claim 1, wherein the tube connecting the expansion chamber of the bulb portion connects into the latter at the lowest point to which liquid within the zone of heating by the burner will gravitate, to provide for a smooth expulsion of liquid from the bulb portion and to prevent the gravitating of liquid back into the heated zone.

4. The combination of claim 1, wherein a heater is supported adjacent the bulb portion, the heater having the capacity to supply sufficient heat thereto to vaporize the liquid in the bulb portion and cause expulsion of all liquid from the bulb to effect expansion of the expansion cham-

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ber, the heater having a limited area of heating upon the bulb portion so that, after vaporization and expulsion of liquid therefrom, heat will be applied substantially only to the vapor phase in the bulb portion, resulting in only relatively small volumetric changes in the system.

5. The combination of claim 1, wherein the closed system is entirely filled with mercury when the expansion chamber is in a contracted position.

6. A burner safety device adapted to respond to the existence or absence of flame under conditions of high ambient temperature: comprising an expansion chamber, a bulb portion spaced from said expansion chamber, a capillary-type tube connecting the bulb and expansion chamber to form a closed system, the system being filled with liquid mercury when the expansion chamber is in a contracted position, a pilot burner connected to the bulb portion of the device for projecting a flame onto the latter, and said expansion chamber being sufficiently expandible from its contracted position to receive the liquid expelled from the bulb portion upon complete vaporization therein, whereby a large rapid expansion or contraction of the expansion chamber occurs as the bulb temperature varies slightly above or below the boiling point, said capillary tube connecting into the bulb substantially at the bottom thereof, and said bulb being positioned relative to said burner so that the flame projecting therefrom heats the entire bulb portion sufficiently to cause the liquid-vapor interface to be maintained within the capillary tube immediately adjacent the outlet of said bulb portion, and operating means having first and second operating positions, and being connected to said expansion chamber to be moved by expansion and contraction thereof, the said operating positions being separated sufficiently to require the large volumetric change resulting from a change of state within the bulb portion for producing the operational shift of the operating means.

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