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HEAT RESPONSIVE ACTUATING DEVICE

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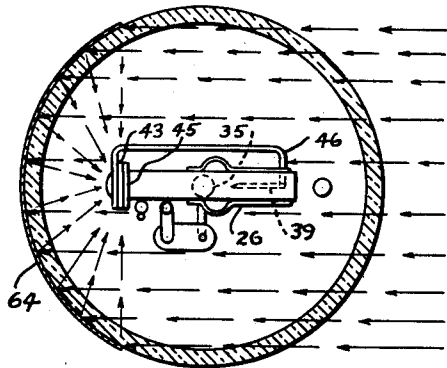


FIG. 4

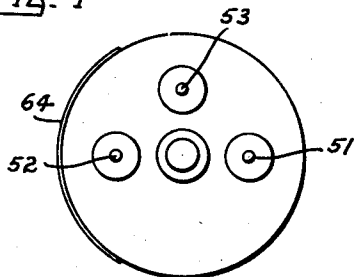


FIG. 3

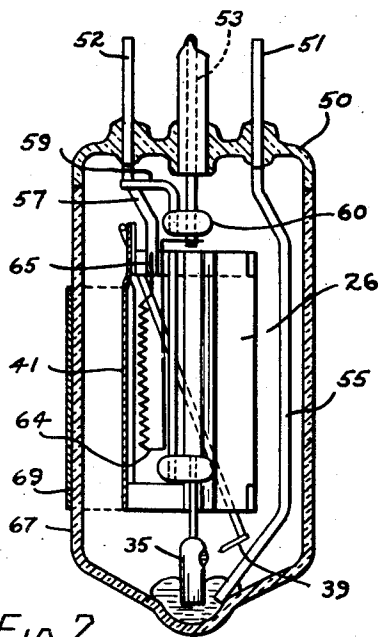


FIG. 2

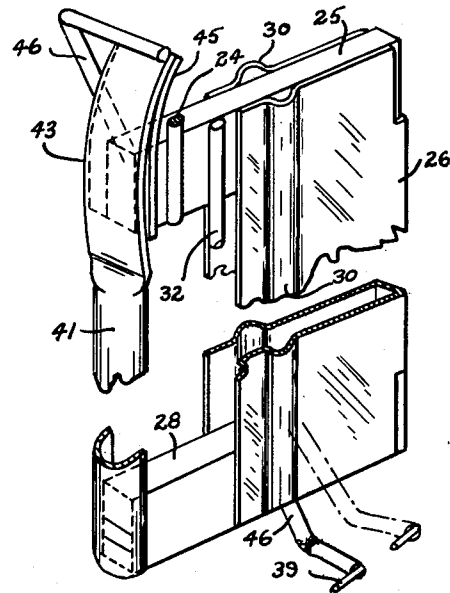


FIG. 5

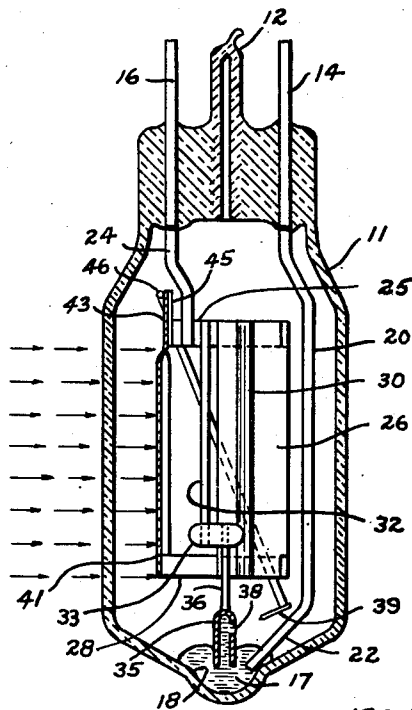


FIG. 1

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HEAT RESPONSIVE ACTUATING DEVICE

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8 Claims. (Cl. 297—11)

1

This invention relates to a new and improved heat responsive actuating device and more particularly to an electric switch in which said actuating device is incorporated for the purpose of opening and closing said switch under the influence of varying conditions of applied heat.

The actuating device is designed to impart substantial amounts of movement upon heat variation with the movement following promptly upon such heat variation. The source of heat to which the device may be responsive for operation may be that emanating from light rays which are absorbed by a portion of the device to transmute the energy carried by the rays into heat, or from local heating coils or the like or by a combination of these or other means.

The structure of my present invention constitutes an improvement over the operating structures shown in my prior Patents Numbers 2,149,853 of March 7, 1939; 2,159,392 of May 23, 1939; 2,162,098 of June 13, 1939, and 2,325,785 of August 3, 1943.

Heretofore, as disclosed in the above mentioned patents, bi-metallic coils or strips have served as the heat responsive actuating elements of generally similar devices and, with such means, it was necessary to provide means to compensate for ambient temperature changes. This is particularly true in view of certain of the specific uses for which the devices are designed and intended. For example, in certain uses, the devices may be associated with oil burners and with fire boxes heated by such burners where the ambient temperature may be much higher with the burner operating than after sustained periods with the burner out of operation. The device is not designed to operate upon such gradual changes in ambient temperature but to operate rapidly upon quick changes such, for example, as the change in heat energy derived from the light rays of a burner flame, which heat energy changes instantly when the flame is ignited or goes out. Another application, for example, is where the device is used to operate a signal or various combustion control means upon indications of smoke density. Here, light may be directed from a light source across a flue through which the products of combustion pass and rapid control is desired upon changes in smoke densities independently of stack temperatures. Such stack temperatures may modify widely the ambient temperatures at the location of the device of the present invention. Further, it has been found as a practical matter in striving for sensitivity of response, which involves substantial

2

travel of a moving member upon relatively small temperature changes, that bi-metallic members assumed proportions detrimental to stability and permanence of operating adjustments. While successful devices of the bi-metallic type, following the teachings of the above mentioned patents, have been produced and used, the need for more rugged structures and the desire for the elimination of ambient temperature compensation, both from the standpoint of simplifying the structures as well as eliminating the effect of such means during the process of manufacture and adjustment of the device for service, has been evident. Also, greater sensitivity in the time of response of the heat responsive element to the presence and absence of heat has been desired than has been attainable in structures employing bi-metal, such speed of operation being desirable in mechanical devices to enable their use for certain control purposes now precluding the use of the slow acting mechanical type of devices at present available.

In its preferred form, the operating structure will be formed of metal characterized by a high temperature coefficient of expansion and low thermal conductivity, both of which properties contribute towards meeting the desired objectives. One commercial alloy having these characteristics is Chace No. 772 manganese base alloy, but it will be understood that the present invention does not reside in the specific metal and that any suitable material may be used.

In utilizing light to actuate the present mechanism, the device operates on the basic principle that light waves can be transmuted into heat and this heat is utilized in the present invention to cause movement of the actuated member, which may take the form of a movable switch contact. The switch contact will be opened or closed in response to the presence or absence of light which may be focused on the heat responsive element of the mechanism. An electric switch so actuated has utility, for example, in serving to indicate smoke conditions arising from improper combustion within a furnace. Another example of its use is an element in the safety controls employed in systems for control of fluid fuel burners. In the latter use, this switch construction may provide both a starting circuit and a maintaining circuit, the latter being held closed by the presence of light resulting from apparatus such, for example, as a fuel burner, which is capable of producing a source of light rays upon closure of the switch contact for the starting circuit. A switch of this type finds its specific use

3

in conjunction with control apparatus for control of fluid burners as disclosed in my copending application Serial No. 130, 896 filed December 3, 1949, entitled Fuel Burner Control.

As previously stated, this switch may also find use in connection with the control of combustion based on variations in smoke density, the switch being actuated by abnormal smoke conditions. To render the device useful in some applications of smoke control, it may be desirable that the switch be sensitive to quite small changes in the amount of light so that the presence of small amounts of smoke or of small variations in smoke density may be sufficient to interrupt or decrease the light rays enough to effect an opening of the switch circuit. Since the amount of heat energy needed to maintain the switch closed after it has once been closed may be much less than that needed to close it initially, the adjustment of the light to effect sensitivity in response to its absence when cut-off by smoke may be such that transmuted light will be insufficient in the absence of smoke to cause a closure of an open circuit switch. With a separate heater forming a part of the switch structure, this heater may be energized by closure of a circuit therethrough from some remote point after which the light, as adjusted for sensitivity, will be sufficient to hold it closed. It is to be appreciated that where the device includes mercury as a contact element, the mercury tends to cling to the contact as that is moved away so that, having closed the circuit, the actuating element need not be heated as much to maintain the circuit closed.

It is an object of the present invention to provide a new and improved highly sensitive heat responsive device requiring no operating or moving elements for the purpose of compensation for ambient temperature variation.

It is a further object to provide a device of this character sufficiently rugged to withstand abnormal handling and to retain adjustments made at the time of assembly.

It is an additional object to provide a novel operating structure serving to multiply to a high degree the movement of an end of an expandable member for effecting the movement of an operating member whereby the structure may be relatively small in size and yet provide the necessary amplitude of operating movement for its contemplated use.

It is also an object to provide a device adapted to serve as the operating mechanism of an enclosed electric switch which may be responsive to heat energy emanating from light rays to open or close an electric circuit.

It is another object of the present invention to provide, in a light actuated switch structure of this character, a second and local source of heat for the heat responsive member, such source comprising an electrical resistance heater which, when energized, will effect an operating movement of the switch contact. Such secondary heat source may be de-energized by means external to the present device upon predetermined conditions and the switch thereafter retained in the position to which the heat has moved it, by means of heat derived from light directed upon the switch actuating means.

It is also an object to provide a device which is comparatively simple in design and construction and adapted for commercial production and use.

4

Other and further objects will appear as the description proceeds.

I have shown certain preferred embodiments of my invention in the accompanying drawings, in which—

Figure 1 is a vertical view, partly in section, showing one form of construction of a two wire switch;

Figure 2 is a view similar to Figure 1 but showing a modified form of construction including a three wire switch having an externally energized heating element;

Figure 3 is a plan view of the construction of Figure 2;

Figure 4 is a horizontal section showing the construction of Figure 2 on an enlarged scale; and

Figure 5 is an enlarged perspective view, partly broken away, showing the actuating members used in both forms of the switch construction.

Referring first to the form of construction shown in Figure 1, the switch is enclosed in an evacuated bulb 11 having the usual exhausting and filling tube 12. The switch elements are supported on a pair of lead-in wires 14 and 16. In the manufacture of the device, after closing the bulb, it is exhausted and an inert gas and mercury are inserted after which the filling tube 12 is closed off. The mercury, as shown at 17, is normally trapped as a globule in a depression 18 formed in the lower end of the bulb 11. The stationary contact member 20 is secured, as by welding, to the lead-in wire 14, this contact 20 being offset laterally to provide room for the remaining switch elements while having its lower end 22 extend into the globule of mercury 17. The lead-in wire 16 has secured thereto the supporting wire 24 which is welded to a transverse end member 25, this member forming a part of an elongated, rigid supporting structure which includes side wall members 26 and an opposite end member 28.

As best shown in Figure 5, the side wall member 26 is U-shaped, extending around on both sides of the end supporting members 25 and 28 and being provided with stiffening corrugations 30. The support wire 32 is welded to the member 25 and carries the insulating bead 33 at its lower end. The capillary tube 35 is supported by wire 36 from the insulating bead 33 and is insulated by that bead from the remaining structure. The capillary tube 35 extends into the globule of mercury 17, and the tube is provided with a lateral opening 38 through which the movable contact 39 may engage the mercury.

The heat expandable member 41 has its lower end positively secured to the lower end member 28 of the supporting structure. The main body of this expandable member 41 is curved in cross-section, as clearly shown in Figure 5, this curvature serving not only to stiffen the member but, also, to provide increased area for heat absorption. The upper end 43 of the expandable member 41 is flat and is located closely adjacent the flexible blade 45. This blade 45 has its lower end positively secured, as by welding, to the upper end member 25 of the supporting structure. The upper free ends of the flat upper portion 43 of the expandable member 41 and of the blade 45 are welded together. The actuated member 46 is also welded to the upper end of portion 43 of the expandable member 41. In the form shown, this member 46 extends downwardly and its lower end carries the movable contact 39. It is to be noted that the upper end 43 of the ex-

5

pandable member 41 and the blade 45 are shown in Figure 5 with the member 41 in an expanded state. The position taken by the movable contact 39 when member 41 is not expanded is shown in broken lines.

The form of construction shown in Figures 2, 3 and 4 contains all of the elements which have been described as present in Figure 1 and, in addition, contains a separate circuit connected to a third lead-in wire. The specific construction shown includes a button type base 50 having the lead-in wires 51, 52 and 53 passing through thickened portions of the base. The lead-in wire 51 supports the fixed contact member 55 which is similar to the member 20 of Figure 1. The lead-in wire 52 supports an interior wire 57 similar to the wire 24 of Figure 1, but the wire 57 has a secondary support wire 59 welded thereto, this wire 59 supporting an insulating bead 60. The insulating bead 60 is also secured to the third lead-in wire 53 which protrudes below it. From this end of wire 53, a resistance heating element 64 is connected in series with the wire 57 by being welded to the latter wire at 65.

The tubular glass envelope 67 of the form of construction of Figures 2, 3 and 4 is provided with an external mirrored surface 69 which, as best shown in Figure 4, is designed to reflect rays of light against the arcuate or rounded surface of the expandable member 41 at the focal point. In the form of construction shown in Figure 1, the mirror is not used, the light impinging directly on the member 41, as indicated by the arrows in Figure 1. If desired in this form, a cylindrical or spherical lens may be interposed between the source of light and the glass envelope to focus the light rays upon the expandable member. While the particular form of construction of the base and enclosing bulb forms no part of the present invention, it has been found that the button type base shown in Figure 2 affords a finished switch shorter in length and more adaptable to compact installation than that type of construction shown in Figure 1.

The various elements of the supporting structure, including the end members 25 and 28 and the intermediate connecting U-shaped member 26, are formed of a metal or alloy having a high temperature coefficient of expansion and preferably a low degree of heat transfer. The use of a metal having a high coefficient of expansion makes it possible to produce an operative device with very small dimensions. The present structure multiplies greatly the movement imparted by the expansion of the member 41. The alloy used is also quite rigid and, as specific examples, the supporting member 25 may be formed of metal .003 inch in thickness, while the upper and lower members 25 and 28 may have cross-sectional dimensions on the order of .065 inch by .125 inch. The embossed ribs 30 serve to add to the rigidity of the structure.

It is to be noted that the open end of the U-shaped member 26 is toward the expandable member 41 and that that member is spaced somewhat away from the support. This reduces heat transfer and, in the form of construction shown in Figure 2 where the resistance heater element 64 is used, it keeps the supporting structure away from the heater.

The current carrying wires and the supporting members for the capillary tube 35 may be formed of iron, and the contact point 39 carried by the actuated member 46 may be formed of platinum,

6

which is readily wetted by mercury, thus insuring a uniform separation from the mercury throughout repeated operations. The electrical resistivity is substantially that of the iron wire to which it is secured.

The length of the upper flat portion 43 of the expandable member 41 and the length of the movable portion of the flexible blade 45 are kept to a minimum commensurate with their ability to be flexed within the elastic limits of the metal from which they are formed throughout the expandable limits of the expandable member 41. It has been found in actual practice that, by tensioning the expandable member 41 and the flexible blade 45 the proper amount, they can be caused to lie substantially against each other at normal ambient temperatures so that, upon expansion of the expandable member, movement of the joined upper ends of the two members takes place with little or no lost motion. The flexing action takes place about the upper frame end support 25, the upper corner thereof serving as a fulcrum.

By making the flexible blade 45 and flat portion 43 of the expandable member as short as possible without either member taking a set throughout the intended range of temperature changes and yet not so short that the blade tends to act as a restraining influence on the movement of the free end of the expandable member, a maximum of angular travel can be obtained at the line where the free ends of these two members are joined. By having the two flat surfaces in contact with each other, or substantially so, a slight curling action results at their free ends upon expansion of the expandable member to augment the angular travel obtained so that a very high degree of movement is imparted to the contact arm or actuated member secured thereto. With the expandable member 41 and the blade 45 under very little tension any expansion taking place in the expandable member results in an immediate pushing action to the right, as clearly shown in Figure 5. A metal is preferably used which is a poor heat conductor so that the heat from the expandable member 41 is not lost to the blade 45 and expansion is mainly confined to the member 41. It is to be noted that only the small upper portion 43 of the member 41 is in contact with the blade 45.

In the form of construction shown in Figures 2, 3 and 4, the heater element 64 is connected between lead-in wires 52 and 53, while the switch closes the normally open circuit between lead-in wires 51 and 52. In one specific form of construction, a heater 64 drawing about one-sixth of an ampere effected a switch closure in fifteen seconds and an opening of the switch circuit thirty seconds after the heater circuit had been opened. In this specific embodiment, when the device was exposed to the light from a fluid fuel burner flame, applied as indicated by the arrows of Figure 4, the switch contact was closed in five seconds and the switch opened in the same length of time after the burner flame was out. With a metal of low heat conductivity used as specified herein, the device was tested under ambient temperature conditions varying from 35° F. to 200° F., and the variation in time response to closure and opening of the circuit by action of the electric heater was no greater than two seconds.

It is to be noted that the actuating device is constructed to insure transmission of a minimum of light and heat to the supporting structure. In the form of construction shown in Figure 1,

the supporting structure is entirely shielded from the direct light rays by the member 41 when the device is properly oriented towards the light source. In the form of construction of Figures 2 to 4 with the mirror, the light is concentrated on member 41 so that the light reaching that element is very substantially greater than light or heat rays impinging upon the supporting structure which presents a narrow face toward the light source.

While I have shown certain preferred embodiments of my invention, these are to be understood to be illustrative only as it is capable of change and variation to meet differing conditions and requirements, and I contemplate such modifications as come within the spirit and scope of the appended claims. As one example of modification, the movable switch contact may be so related to a fixed contact including a meniscus of mercury that the movable contact may be normally engaged with the mercury and separated therefrom upon operation of the expandable member when heated.

I claim:

1. A heat responsive actuating device comprising a transparent, impervious bulb enclosing the operating parts, a supporting structure, a heat expandable member having one end secured to the supporting structure, said member extending substantially parallel to a face of the supporting structure and beyond the supporting structure, a flexible blade secured to the structure at a point spaced from the point at which the expandable member is secured, said blade being substantially shorter than the expandable member and extending parallel to said member, the free ends of said member and blade being connected together, and an actuated member secured to said point of connection, the major portion of the expandable member being relatively rigid with that portion of said member adjacent and parallel to the flexible blade being relatively flexible.

2. A heat responsive actuating device comprising a transparent, impervious bulb enclosing the operating parts, a supporting structure, a heat expandable member having one end secured to the supporting structure, said member being of an area sufficient to cover the adjacent face of the supporting structure and extending beyond the supporting structure, a flexible blade secured to the structure at a point spaced from the point at which the expandable member is secured, said blade being substantially shorter than the expandable member and extending parallel to said member, the free ends of said member and blade being connected together, said supporting structure and expandable member being both formed of the same metal, said metal having a high coefficient of expansion and low thermal conductivity, and an actuated member secured to said point of connection.

3. A heat responsive device comprising a transparent, impervious bulb enclosing the operating parts, a rigid frame having top and bottom supporting means, a flexible blade having one end secured to the top support with its free end extending thereabove, an expandable and contractible member having one end secured to the bottom support and a free end extending beyond the top supporting member, the free ends of the flexible blade and expandable and contractible member being secured together, the portion of the expandable and contractible member adjacent its free end providing a flat and flexible

section comparable in size to the flexible blade, the lengths of the flat section and flexible blade being no greater than that required to prevent movement thereto beyond their respective elastic limits throughout the normal expandable range of the expandable member, and means secured to the secured together free ends to transmit movement imparted thereto to a part to be actuated.

4. A heat responsive device comprising a transparent, impervious bulb enclosing the operating parts, a rigid frame having top and bottom supporting means, a flexible blade having one end secured to the top support with its free end extending thereabove, an expandable and contractible member having one end secured to the bottom support and a free end extending beyond the top supporting member, the free ends of the flexible blade and expandable and contractible member being secured together, the portion of the expandable and contractible member adjacent its free end providing a flat and flexible section comparable in size to the flexible blade, the remainder of the length of the expandable member being stiffened by an arcuate cross-section, the lengths of the flat section and flexible blade being no greater than that required to prevent movement thereto beyond their respective elastic limits throughout the normal expandable range of the expandable member, and means secured to the secured together free ends to transmit movement imparted thereto to a part to be actuated.

5. A heat responsive device comprising a transparent, impervious bulb enclosing the operating parts, a rigid frame having top and bottom supporting means, a flexible blade having one end secured to the top support with its free end extending thereabove, an expandable and contractible member having one end secured to the bottom support and a free end extending beyond the top supporting member, the free ends of the flexible blade and expandable and contractible member being secured together, the portion of the expandable and contractible member adjacent its free end providing a flat and flexible section comparable in size to the flexible blade, the lengths of the flat section and flexible blade being no greater than that required to prevent movement thereto beyond their respective elastic limits throughout the normal expandable range of the expandable member, and means secured to the secured together free ends to transmit movement imparted thereto to a part to be actuated, the area of the expandable member as viewed from the side of said member opposite the rigid frame being substantially the same as that of the frame when viewed from the same direction.

6. A heat responsive device comprising a transparent, impervious bulb enclosing the operating parts, an elongated rigid supporting structure, a heat expandable member having one end secured adjacent one end of the supporting structure, said member extending beyond the other end of the supporting structure, a flexible blade secured adjacent the second end of the supporting structure and extending away from said structure parallel to that portion of the heat expandable member extending beyond said structure, adjacent free ends of the expandable member and the flexible member being secured together, an actuated member secured adjacent said last named point of connection, the major portion of the expandable member being arcuate in cross-section to stiffen that portion of the member and to pro-

vide increased surface area, and means for concentrating a beam of radiant energy on said expandable member.

7. A heat responsive actuating device comprising a transparent, impervious bulb enclosing the operating parts, a supporting structure, operating member and an actuated member all made of the same material, said supporting structure being rectangular with projecting arms extending from opposite extremities thereof contiguous with the short dimensioned ends of the support for mounting the operating member in spaced parallel relationship with one of the longest sides of the supporting structure, said operating member consisting of a thin blade secured at one end to one of the support arms with its free end extending beyond the other of said support arms, said actuated member consisting of a thin flexible blade having one end secured to the other arm and extending therefrom parallel and adjacent to the extended free end of the operating member, the free end of both being connected together to cause a flexing of the actuated member upon the longitudinal expansion of the operating member as a result of a differential in temperature being established between the operating member and that of the rest of the device.

8. A heat responsive actuating device comprising a transparent, impervious bulb enclosing the operating parts, an elongated, U-shaped, rigid supporting structure, a heat expandable member, the supporting structure and the heat expandable member both being formed of metal having a high coefficient of expansion and low

thermal conductivity, said expandable member having one end secured adjacent one end of the supporting structure, said member extending substantially parallel to and spaced apart from the lateral open end of the supporting structure and beyond the other end of the supporting structure, said member having an area sufficient to cover said open end of the supporting structure, a flexible blade secured adjacent the second end of the supporting structure and extending parallel to the expandable member, adjacent free ends of the expandable member and the flexible blade being connected together, and an actuated member secured adjacent said last named point of connection.

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