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L. J. GEE ET AL
ELECTRIC THERMAL DEVICE

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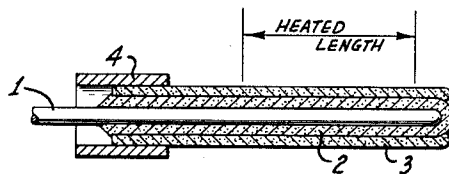


FIG. 1

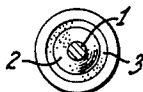


FIG. 2

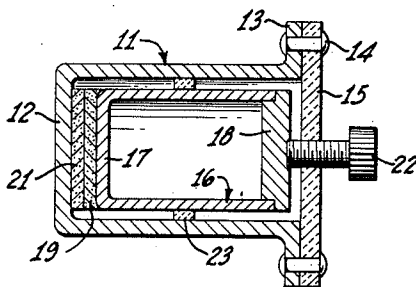


FIG. 3

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ELECTRIC THERMAL DEVICE

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This invention relates to thermal switches associated for example, with the pilot flame of gas or oil burners, and which are used to control the fuel valve associated with the burner.

Fuel valves used for this purpose are generally solenoid-operated. Normal operating voltage in connection with furnace controls in this country is 24 volts A.C. While the solenoids are nominally rated at 24 volts, they will generally have a pull-in voltage of the order of 20 volts and a drop-out voltage of the order of 16 to 18 volts. It is desired that the solenoid be operated at a voltage as close as possible to its normal rated voltage. Therefore, the operating resistance of any thermal switch used to control it should be as low as possible to allow the full circuit voltage to be applied to the solenoid.

In general, the object of this invention is the provision of a thermal switch of the character above described and the active component of which consists of a coating or film of zirconia of such a gauge and geometry that when at a temperature in the order of from 1200° to 1400° F. it will have a resistance in the order of 10 ohms.

Although it is well-known that zirconia has a negative temperature coefficient of resistance, is a nonconductor at low temperature, and becomes a much better conductor at high temperatures, this characteristic in and of itself does not make zirconia suitable as the active component of a thermal switch, for its resistivity may still be too high even at elevated temperatures to operate at the relatively low voltages normally used in connection with furnace control circuits, etc.

To this end, one of the objects of this invention is the provision of a zirconia thermal switch the geometry of which is such that the resistance of the switch is sufficiently low to operate at relatively low voltages.

More specifically, one of the objects of this invention is the provision of a low-voltage thermal switch of the character described, comprising a pair of electrodes of extended area bonded to an intermediate film of zirconia.

Still another object of this invention is the provision of a thermal switch of the character above described in the form of a composite cylinder including a central metal rod coated with a film of zirconia and which in turn is surrounded by and bonded to an outer metal cylinder which, together with the central rod, forms the two electrodes of the switch.

A still further object of this invention is the provision of a thermal switch of the character above described in the form of a pair of nested thimbles separated at their closed ends by a film of zirconia and insulated along their peripheral walls by an insulating ring.

The invention possesses other advantageous features, some of which, with the foregoing, will be set forth at length in the following description where those forms of the invention which have been selected for illustration in the drawings accompanying and forming a part of the present specification are outlined in full. In said drawings, several forms of the invention are shown, but it is to be understood that it is not limited to such forms, since the invention as set forth in the claims may be embodied in other forms.

Referring to the drawings:

FIG. 1 is a longitudinal midsection taken through a

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composite cylinder embodying the objects of our invention.

FIG. 2 is a left-hand end view of the composite cylinder illustrated in FIG. 1.

FIG. 3 is a midsection taken through a pair of thimbles embodying the objects of our invention.

As illustrated in FIGS. 1 and 2, the object of our invention has been embodied in a thermal switch including a central metal electrode rod 1, flame-sprayed with a zirconia coating or film 2. The film 2 surrounds the right-hand end of the rod 1 but terminates short of its left-hand end. Flame-sprayed over the zirconia film 2 is an outer metal film or coating 3. Drawn over the left-hand end of the coating 3 is a cylindrical metal collar 4 serving as one of the switch terminals, the exposed end of the electrode rod 1 serving as its other electrode.

Preferably, all of the metal elements of the switch so described are made of oxidation-resistant alloys such as Inconel and Nichrome.

The gauge of the zirconia film or coating 2 should preferably be in the order of from 0.010 to 0.015 inch so as to keep the electrical resistance radially through this film at a very low value. It is for the purpose of attaining a film having a gauge of this order that flame-spraying is resorted to, in addition to the fact that by the use of this technique an excellent bond between the rod 1 and the zirconia film or coating 2 is obtained. On the other hand, flame-spraying of the metal coating 3 is resorted to only for the reason that this produces an excellent bond and electrical contact between this coating and the zirconia coating 2. The thickness or gauge of the coating 3 is here unimportant, and the coating 3 may be considered as a metal electrode cylinder.

In operation, a thermal switch of this character can be connected in series by its thermal sleeve 4 and the left-hand end of the electrode rod 1 with a source of power and the coil of a solenoid used in controlling the fuel valve of a burner. When so used, the right-hand portion of the switch is located in heat transfer relation with the pilot flame of the burner. So long as the pilot flame persists, the zirconia film 2 remains at a temperature in the order of from 1200° F. to 1400° F. and at this temperature it remains a good electrical conductor. Current here passes from the rod 1 radially through the zirconia film 2 to the cylindrical metal coating 3. Since the zirconia film 2 is very thin, its radial resistance is low, and since the switch is relatively long, its conductivity is such as to enable sufficient current to pass through it to maintain the solenoid coil energized to a point above its drop-out voltage. Actually the resistance of zirconia film 2 is a function of its area as well as its gauge, and consequently these two parameters must of necessity be correlated in designing a switch to function against a solenoid having a rated voltage and operating on a predetermined power line voltage. Upon flame failure and a resultant depression of the temperature of zirconia coating 2, the latter becomes virtually a nonconductor, the circuit is broken and the fuel valve closes.

The modification illustrated in FIG. 3 comprises an outer metal (Inconel, for example) thimble 11 having a closed end 12 and provided at its open end with an annular peripheral flange 13. Secured to the flange 13 by rivets 14 is an insulating plate 15.

Nested within the thimble 11 coaxially therewith is an inner thimble 16 having a closed end 17 contiguous to the closed end 12 of the outer thimble 11. Closing the open end of the inner thimble 16 is a stepped metal cap 18 which, with the inner thimble, forms a closed-ended cylinder.

Flame-sprayed on the outer surface of the thimble end 17 is a film or coating 19 of zirconia, and likewise flame-

sprayed on the coating 19 is a metal coating 21 of an alloy such as, for example, Nichrome.

Screwed through the insulating plate 15 into engagement with the cap 18 is a headed screw 22 serving as a means for lightly clamping the left end of the inner thimble 5 and its associated elements into good electrical contact with the inner surface of the thimble end 12.

Disposed between the cylindrical walls of the outer and inner thimbles 5 and 16 is an insulating ring 23 serving to hold the two thimbles out of electrical contact with each other except through the intervening films or coatings 19 and 21.

Here the screw 22 serves as one terminal of the switch and one of the rivets 14 can be made to serve as the other for connecting the switch in series with a source of line voltage and with a solenoid coil. In this case the thimble end 12 serves as the hot sensing end of the switch and is located in heat transfer relationship with the furnace pilot flame so that so long as the flame persists, the temperature of the zirconia coating or film 19 will be in the order of from 1200° to 1400° F. As in the case of the first modification, the zirconia coating 19 at this temperature range is a good electrical conductor permitting current to pass from the end 12 of the outer thimble 5, through the metal disc or film 2 and the zirconia film 19, to the end 17 of the inner thimble 16 and thence to the screw 22. Upon flame failure, and a resultant depression of the temperature of the zirconia film, the latter becomes virtually a nonconductor and so breaks the circuit. The solenoid drops out, the fuel valve closes and remains closed until the thermal switch is again brought up to the temperature at which its zirconia element becomes a conductor. In this modification the area of the zirconia film 19 and its gauge are so correlated that when the film 19 is up to temperature its resistance is sufficiently low to permit the circuit to operate the solenoid at the line voltage.

We claim:

1. A low resistance thermal switch comprising: a first electrode having an extended surface, a thin film consisting of zirconia deposited on said extended surface of said first electrode in intimate bonded relation thereto, and a second electrode deposited on said film of zirconia in intimate bonded relation thereto.

2. A low-resistance thermal switch as set forth in claim 1 wherein said film of zirconia has a thickness in the order of .010 to 0.015 inch.

3. A low-resistance thermal switch as set forth in claim 1 wherein said first and second electrodes are made of an oxidation-resistant alloy.

4. A low-resistance thermal switch comprising: a first electrode shaped as a rod and having an extended surface, a thin film consisting of zirconia deposited on and surrounding said extended surface of said first electrode in intimate bonded relation thereto, a second electrode deposited on and surrounding said film of zirconia in intimate bonded relation thereto, and a cylindrical metal terminal surrounding and clamped to one end of said second electrode.

5. A thermal switch comprising: a first metal thimble having a closed end, a thin film consisting of zirconia deposited on said closed end of said first thimble in intimate bonded relation thereto, a metal cap deposited on said film of zirconia in intimate bonded relation thereto; a second metal thimble nested over the closed end of said first thimble; means electrically insulating between the walls of said thimble; and means for maintaining the closed end of said second thimble in light engagement with said metal cap.

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