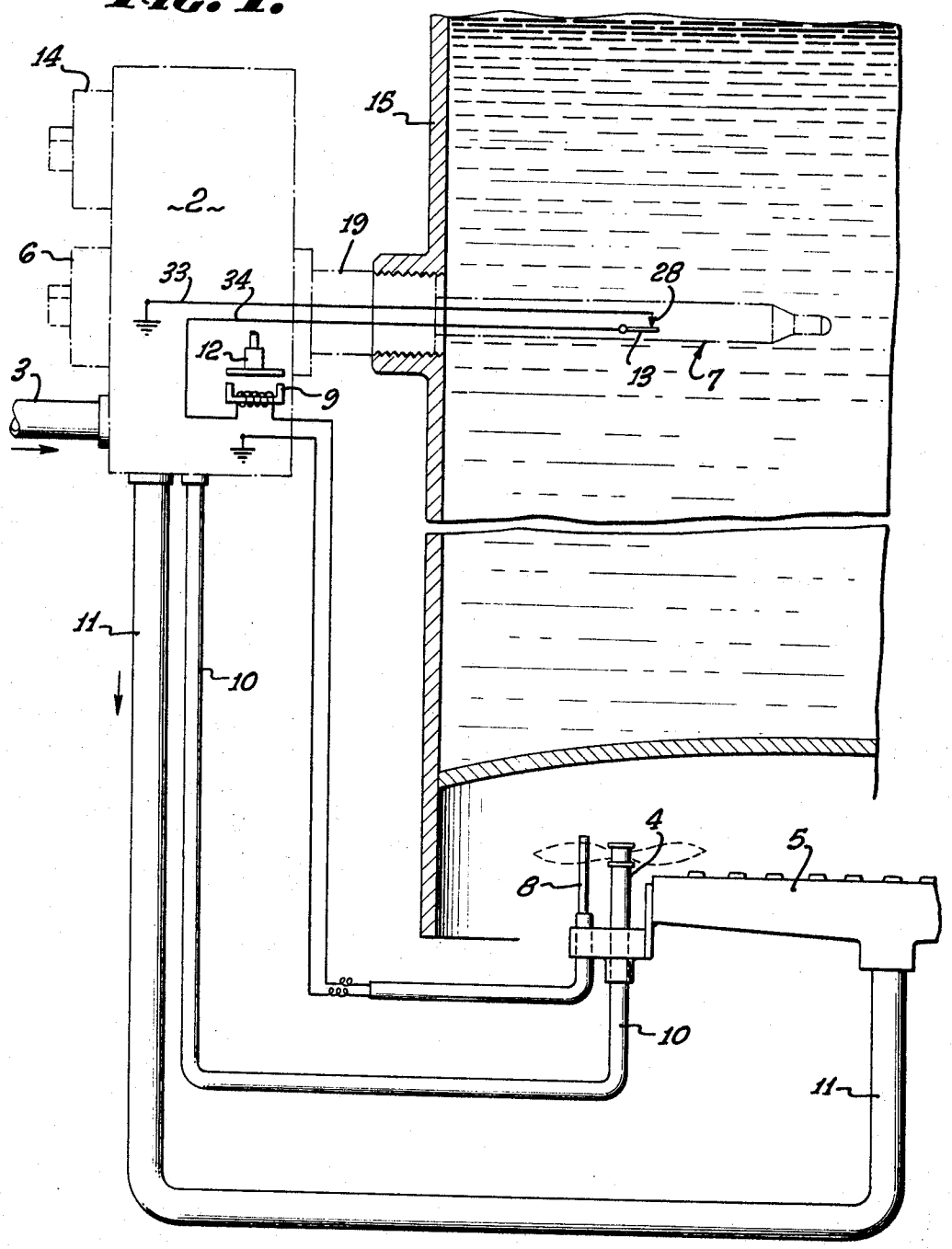
June 4, 1968 R. D. GRAYSON 3,387,246

HELICAL THERMAL SWITCH

Filed Sept. 22, 1965 2 Sheets-Sheet 1

FIG. 1.



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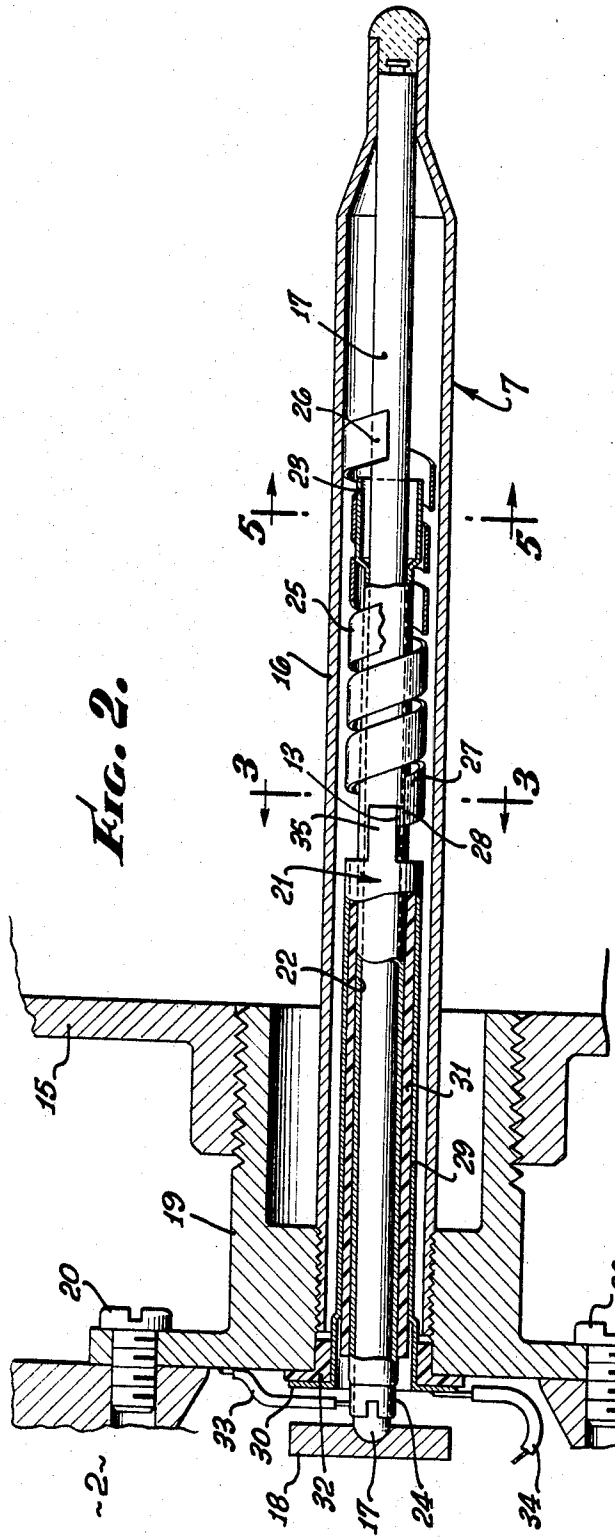

FIG. 2.

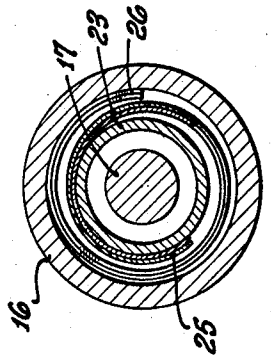

FIG. 5.

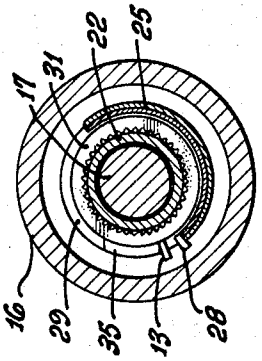

FIG. 4.

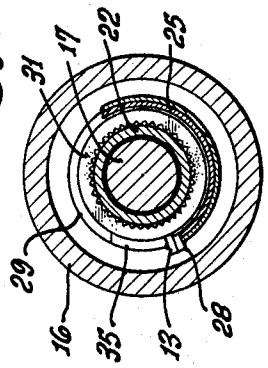

FIG. 3.

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HELICAL THERMAL SWITCH

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5 Claims. (Cl. 337—372)

ABSTRACT OF THE DISCLOSURE

A thermally responsive over-temperature switch includes an elongated helical bimetallic element which surrounds one end of a low thermally responsive rod within a high thermally responsive tube forming a probe unit to be positioned within a water heater. A free end of the element carries a movable contact which cooperates with a fixed contact mounted on a tube which surrounds the other end of the rod and is insulated from the probe tube.

This invention relates in general to thermal switches for use in storage water heaters and in particular to helical thermal switches in which a bimetal element coils and uncoils in response to temperature variations to make and break electrical contacts.

In automatic storage water heaters, it is common practice to provide an over-temperature switch which shuts off the fuel supply to the water heater when the usual thermostatic valve or valve control fails. In the past, these over-temperature switches were usually located in the top zone of the water heater and required special wiring to the main control unit. In addition, these over-temperature switches were usually placed in a blind location, since the water storage tank was usually covered by an outer housing.

A substantial improvement in water heater control systems is disclosed in United States Patent No. 2,409,387, issued Oct. 15, 1946 to Mr. William A. Ray and entitled, "Control Device," wherein the over-temperature switch is positioned outside of the water heater but immediately adjacent the normal control valve unit. Such over-temperature switch consists of a single turn bimetal strip having a large diameter, since precise movement of contacts carried by such a bimetal element cannot be obtained without utilizing a bimetal element of substantial length. Also, such an over-temperature switch was located outside of the water heater and was subject to ambient temperature variations which could affect the precise over-temperature cut-off point. In addition, such over-temperature switches were subject to accidental damage and inadvertent or deliberate changes in adjustment.

According to the present invention, the foregoing disadvantages are overcome by providing a switch unit of the above character which consists of a helical bimetal element which has a plurality of turns to provide an accurate and precise switching point; which is readily adjustable; and which is constructed to fit inside of the normal thermostatic sensing element or probe wherein it is insulated from external ambient temperature and heat losses, in addition to being relatively tamper-proof by virtue of its location.

Features of the present invention relate to the specific construction of the switch which enhances the noted adjustment; which provides reliable electrical connections; and which is relatively free from variations in its switching point.

Other objects and features of the invention will become apparent and the invention will be best understood when the specification and claims are read in conjunction with the accompanying drawings comprising FIGS. 1 through 5 in which:

FIG. 1 shows a diagrammatic view of a conventional storage water heater incorporating the inventive helical thermal switch;

FIG. 2 shows a partly sectionalized view of the helical thermal switch of the system of FIG. 1; and

FIGS. 3 to 5 show various cross-sectional and enlarged views of the thermal switch of FIG. 2.

Referring now to FIG. 1 of the drawings, a conventional storage water heater has a gas control unit **2** mounted thereon for controlling the passage of fuel from inlet pipe **3** to the pilot burner **4** and to the main burner **5** in accordance with demand conditions determined jointly by the setting of a temperature dial **6** and the temperature of the water as sensed by the water heater temperature sensing probe **7**. A pilot generator or thermocouple **8** is positioned immediately adjacent the pilot burner **4** and is subjected to the pilot burner flame. In response to heat from the pilot flame, the thermocouple **8** generates a voltage which is electrically connected to a holding eletcromagnet **9** in the gas control unit **2** over a circuit which includes normally closed contacts **13–28** of probe **7**. Contacts **13–28** form a part of the inventive thermal switch and are adjusted to open at a predetermined temperature above the normal temperature range of the water to release electromagnet **9** and terminate all fuel flow. This arrangement, thus, provides a safety feature in the event of failure of the usual thermostatic control and a consequent over-temperature condition in the water heater.

The control unit **2** is of the well-known manual reset type gas control unit and includes a gas cock having "OFF," "PILOT," and "ON" positions; a thermomagnetic safety valve, a main line automatic valve, and an adjustable water temperature control element.

With the gas cock knob **14** in the "OFF" position, the flow of fuel is prevented between the main line **3** to either the pilot burner line **10** or the main burner line **11**.

With the knob **14** in the "PILOT" position and activated, by depressing the knob, for example, the pilot valve (not shown) operates and fuel flows from the main line **3** to the pilot burner **4** over pilot line **10**. The pilot valve is mechanically coupled to armature **12** of electromagnet **9** and the above described operation of the pilot valve moves armature **12** into mechanical association with the pole pieces of electromagnet **9**. While the knob **14** is depressed and the pilot valve manually operated, the pilot burner **4** may be ignited causing the voltage generated by the thermocouple **8** to energize electromagnet **9** and maintain armature **12** in its attracted position. Thereafter, knob **9** may be released, with armature **12** now holding the pilot valve open as long as the pilot flame remains.

When knob **14** is thereafter advanced to the "ON" position with electromagnet **9** still operated, the main line **3** is connected to the main burner line **11** through a main gas valve (not shown). As is well known the main gas valve is operated by the thermal expansion portion of probe **7** as determined by adjustable linkage associated with the temperature setting knob **6**. When the water temperature is below the temperature setting knob **6**, the main gas valve is open and the main burner **5** is ignited by the pilot flame. When the water temperature exceeds the noted temperature setting, the main valve closes.

If for any reason, the voltage fed to electromagnet **9** fails, as by extinguishment of the pilot burner flame or the over-heating of the water, armature **12** releases and closes the fluid path to both the pilot and main burner.

A system of the above character is disclosed in the noted United States Patent No. 2,409,387 and accordingly, a more detailed description of the control unit **2** is not set forth herein. In the noted patent, the equivalent of contacts **13–28** were located outside of the water heater near the external portion of probe **7**.

The invention herein relates to a helical thermal switch

unit rather than a concentric switch as shown in the above noted patent, and is of a construction suitable for positioning it inside the confines of probe 7 rather than being mounted external thereto.

Referring now to FIGS. 2–5, the inventive helical thermal switch unit will be described.

The probe 7 or sensing element, is inserted into the water heater, is held in position by shank 19 threadedly engaging a threaded opening in the water heater housing 15. The control unit 2 is secured to probe 7, as by bolts 20, for example. The probe 7 consists generally of a copper tube 16 having one end threadedly secured to shank 19 and the other end secured, as by welding, to an "Invar" rod 17 which is encompassed by the copper tube 16 and which extends coaxially therewith. The free end of rod 17 extends within the confines of control unit 2 and engages element 18 of control 2. The copper tube 16 expands and contracts in response to changes in water temperature and the non-expanding rod 17 transmits such movement to element 18 which activates a snap action thermostatic mechanism (not shown) which in turn controls the noted main gas valve of control unit 2. The above described structure is well known in the art and is one variation of the thermal bulb thermostatic element of the noted United States Patent No. 2,409,387. For purposes of clarity, it has been chosen to omit a showing of the normal sealing and insulating material and components for connecting the copper tube 16 to shank 19 and for connecting shank 19 to the housing of control unit 2.

The helical thermal unit shown generally at 21 consists of an inner cylinder or tube 22 having an inner diameter slightly in excess of the diameter of rod 17 to permit free movement of the rod 17 therethrough. The rearward end 24 of the inner cylinder 22 may be formed into hexagonal shape to enhance gripping thereof by an adjusting tool or having a screwdriver slot for adjustment functions as will be described hereinafter. The forward end 23 of cylinder 22 is slightly expanded to match the inner diameter of a helical bimetal element 25 which has a portion near one end suitably secured, as by welding, to the expanded end 23 of inner cylinder 22. As seen most clearly in FIG. 5, the forward free end of the bimetal element 25 is uncurled sufficiently to make electrical and mechanical contact with the inner periphery of the copper tube 16. The remainder of the bimetal element 25 freely passes over the inner cylinder 22 and freely inside of the copper tube 16 to permit frictionless coiling and uncoiling in response to ambient temperature variations. The rearward and free end 27 of the bimetal element 25 includes a contact element 28 suitably secured thereto.

The thermal switch unit 21 also includes an outer cylinder or tube 29 having one end terminating in a flange 30 and the other end terminating in a forward projecting tab 35 which has a contact 13 suitably secured thereto. The outer diameter of the outer cylinder 29 is less than the inner diameter of copper tube 16 in order to preclude electrical contact therebetween.

The outer cylinder 29 is placed over an insulating cylindrical element 31, preferably of "Teflon" which in turn is placed over the inner cylinder 22, the thickness of the insulating element 31 being selected so as to provide a press fit relationship between the outer cylinder 29 and inner cylinder 22. As seen in FIGS. 3 and 4, insulating element 31 includes a plurality of elongated serrations which are deformed slightly to provide the noted press fit. The outer cylinder 29 is positioned longitudinally on inner cylinder 22 so that contact 13 is in alignment with contact 28.

An insulating washer 32 of L-shaped cross-section is provided on outer cylinder 29 to prevent its electrical contact with the copper tube 16 and/or shank 19. Washer 32 also permits easy insertion and removal of helical switch unit while providing an alignment function in maintaining inner cylinder 22 frictionally independent of the rod 17.

With the inner and outer cylinders 22 and 29 positioned with contacts 13 and 28 in alignment, a suitable tool is placed over the hexagonal shaped, or slotted end 24 of inner cylinder 22 and cylinder 22 is rotated so that electrical contact is just established between contacts 13 and 28 at the maximum temperature permissible in the water heater 1. With such an adjustment, electrical contact is maintained between contacts 13 and 28 as long as the noted predetermined over-temperature condition is not reached. FIG. 3 shows the position of contacts 13 and 28 prior to the noted over-temperature condition.

When the ambient temperature exceeds the noted over-temperature limit, the helical bimetal element contracts and opens contacts 13 and 28 to the position shown in FIG. 4.

As seen in FIG. 1, contact 28 is connected to ground potential. This is accomplished by conductor 33 being suitably connected between the hexagonally shaped, or slotted end 24 of inner cylinder 22 and the shank 19. A parallel connection also exists between the copper tube 16 and the free end 26 of bimetal element 25.

The outer cylinder 29, carrying contact 13 is insulated from ground potential and a conductor 34 is suitably secured thereto for series connection with the electromagnet 9 winding as hereinbefore described.

From the foregoing, it can be seen that the helical thermal switch unit 21 is arranged to fit inside of the copper tube 16 and over the "Invar" rod 17 so as not to interfere with the normal thermostatic functions thereof. Also, the switch unit 21 is readily adjustable, yet arranged to preclude misadjustment by normal thermal conditions. Still further, switch unit 21 is readily removable for repairs, cleaning and/or replacement. By virtue of being physically located within the confines of the normal sensing probe 7, an over-temperature condition can be sensed by the control unit 2 without external wiring and the switch is physically located to prevent unauthorized adjustment or tampering.

While I have described my invention in conjunction with specific apparatus and components, it is to be understood that numerous other embodiments are possible without departing from the spirit of the invention.

I claim:

1. In a thermal switch including a tube-like body having a high thermal coefficient of expansion, a support for said body, and a rod having one end fixed to one end of said body, said rod having a cross section smaller than that of said body, said rod extending through said body in spaced relation to the internal surface thereof, the combination comprising: a bimetallic helix in the said space between said rod and said body, said helix having an axis extending along the lengths of said rod and said body inside of said body, said helix being spaced both from said rod and said body from one end of said helix to a portion thereof near the other end thereof, said helix including a first metal layer at its outside diameter and a second metal layer at its inside diameter, said first and second metals having different thermal coefficients of expansion; first means to hold only said portion of said helix near said other end in a fixed position in the space between said rod and said body, said one end of said helix being free to move relative to said rod and said body; a first electrical contact fixed to said one end of said helix and movable therewith; a second electrical contact; second means to support said second contact in a fixed position to be engaged by said first contact; first and second electrical leads, said first means electrically connecting said first lead to said portion of said helix near said other end; and means electrically connecting said second lead to said second contact, said helix serving both as a bimetallic element and as an electrical conductor between said first contact and said portion of said helix near said other end; said helix being a spiral tape having a width along the length of said helix greater than the thickness thereof, said body being a cylindrical tube, said rod also being cylin-

drical, said tube, said rod and said helix all having a common longitudinal axis, said helix having at least a portion of an end turn of an increasing diameter at the said other end thereof, the unstressed outside diameter of said end turn portion being larger than the inside diameter of said body, said end turn thereby lying in pressure contact with said body, said first means including a cylindrical conductive tube having at least a portion contiguous to but rotatable around said rod, said first means tube extending through said helix from said one end to said portion thereof in spaced relation thereto, said helix portion being welded to said tube, said second means including a first cylindrical insulating tube contiguous to and surrounding said first means tube, a conductive tube contiguous to and surrounding said first insulating tube, and an annular insulator contiguous to and surrounding said second means conductive tube, said second means also including means to hold said annular insulator in a fixed position relative to said support, said second means conductive tube having a projection to carry said second contact.

2. In a thermally responsive control device including an elongated main tube of high thermal expansive characteristics adapted to be mounted in a support adjacent the wall of a chamber to be heated, with the forward end of the tube extending into the chamber, and an elongated rod of low thermal expansive characteristics positioned within the tube with its forward end attached to the forward end of the tube, and the remainder of the rod spaced from the surrounding tube, an elongated temperature responsive switch unit positioned within the space between the tube and the rod, the unit comprising: an elongated conductive inner tube surrounding a portion of the rod extending through the wall of the chamber and surrounding a major portion of the rod extending into the chamber, the inner tube having a considerable portion of its length contiguous to but movable with respect to the rod; an elongated bimetallic helical element surrounding a forward portion of the inner tube with a forward portion of the element being attached to a forward portion of the inner tube, and with the portions of the element extending rearwardly from the attachment point loosely surrounding the inner tube, a contact mounted on the rear end of the helical element and the bimetallic element being formed such that the contact is arcuately movable

in response to ambient temperature changes; an elongated outer conductive tube surrounding the rear portion of the inner tube and carrying on its forward end a fixed contact which cooperates with the movable contact on the helical element, the outer tube being insulated from the main tube; and a tubular insulator extending snugly between the inner end outer tubes.

3. The control device of claim 2 wherein the outer tube has its forward end terminating in a forwardly extending projection carrying the fixed contact and the rear end of the tube terminates in an outwardly extending flange; and including an insulator with an L-shaped cross-section surrounding the rear end of the outer tube for insulating the outer tube with respect to the main tube and for properly aligning the inner and outer tubes within the main tube.

4. The control device of claim 2 wherein the forward end of the inner tube has an enlarged diameter with respect to the remaining portion of the inner tube to facilitate attachment to the bimetallic element; and the forward turn of the helical element has an outside diameter which when unstressed is larger than the inside diameter of the main tube such that the forward turn is pressed against the main tube.

5. The control device of claim 2 wherein the frictional fit between the tubular insulator and the inner and outer tubes is such that the angular orientation of the inner and outer tubes may be varied but the inner and outer tubes will remain in the orientation selected due to the frictional engagement with the tubular insulator thereby permitting angular adjustment of the contacts relative to each other.

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