# United States Patent

**Katchka et al.**

[15] **3,691,501**

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[54] **THERMOSTAT ASSEMBLIES UTILIZING A HEAT EXPANSIVE AND CONTRACTIVE ELASTOMERIC MATERIAL**


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[22] Filed: **April 30, 1971**

[21] Appl. No.: **139,105**

**Related U.S. Application Data**

[63] Continuation-in-part of Ser. No. 25,194, April 2, 1970, abandoned.

[52] **U.S. Cl.**.....**337/393,** 73/363, 236/21 R, 337/398

[51] **Int. Cl.**.....**H01h 37/06,** H01h 37/46

[58] **Field of Search**.....73/363; 236/21 B, 100; 337/317, 388, 393, 394, 398, 403, 407, 408, 409, 416



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 3,402,886 | 9/1968 | Jackson | 337/394 X |
| 3,128,043 | 4/1964 | Feinberg | 236/100 X |
| 2,990,716 | 7/1961 | Butts | 337/393 U X |



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[57] **ABSTRACT**

A thermostat assembly including a tubular housing, a thermal element including a heat expansive and contractive, elastomeric material, an actuator adapted to operate a control device through an open end of the housing, and a retainer slidably disposed within the housing and engaging the thermal element and the actuator to move the actuator in response to expansion and contraction of the material. Various embodiments of the thermostat assembly utilize a removable retainer capsule enclosing the material and an operator member, a thermal element having a central bore to permit withdrawing of the actuator into the housing with heat increase, and a hollow cylindrical retainer to accommodate a temperature responsive switch.


**58 Claims, 7 Drawing Figures**

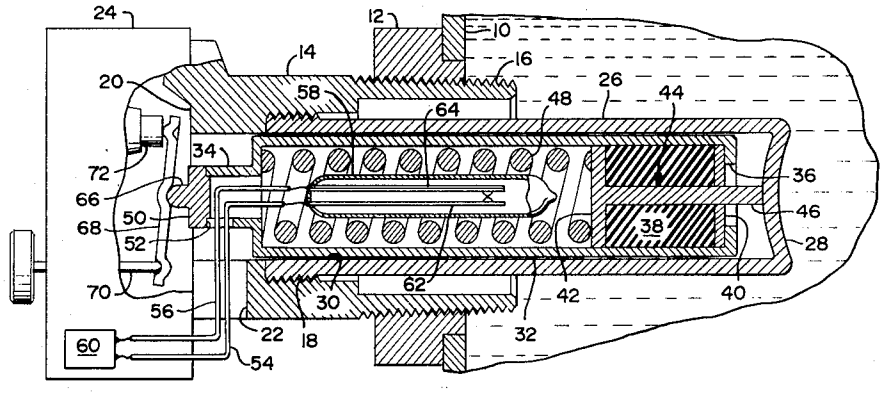
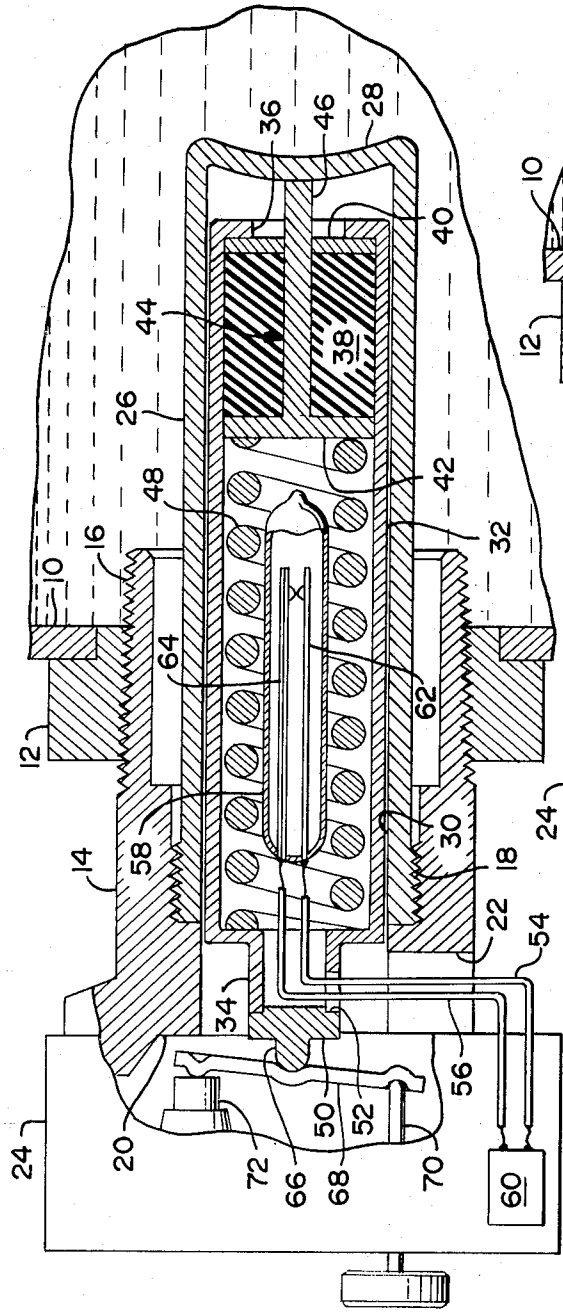


FIG. 1



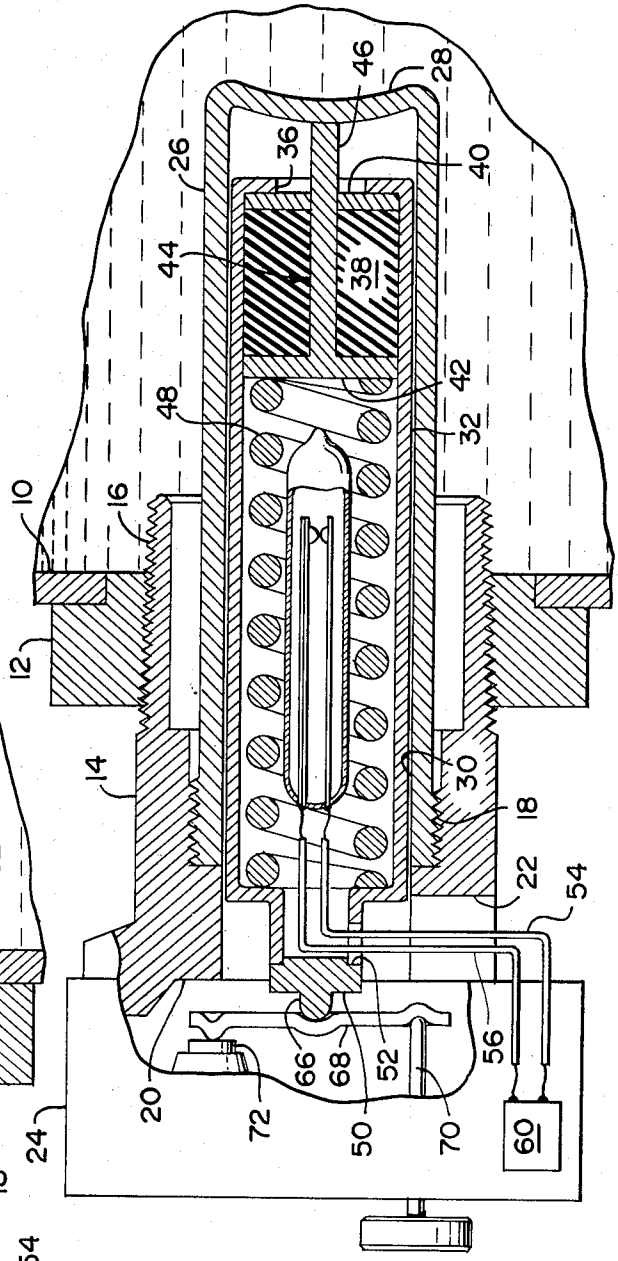




FIG. 2

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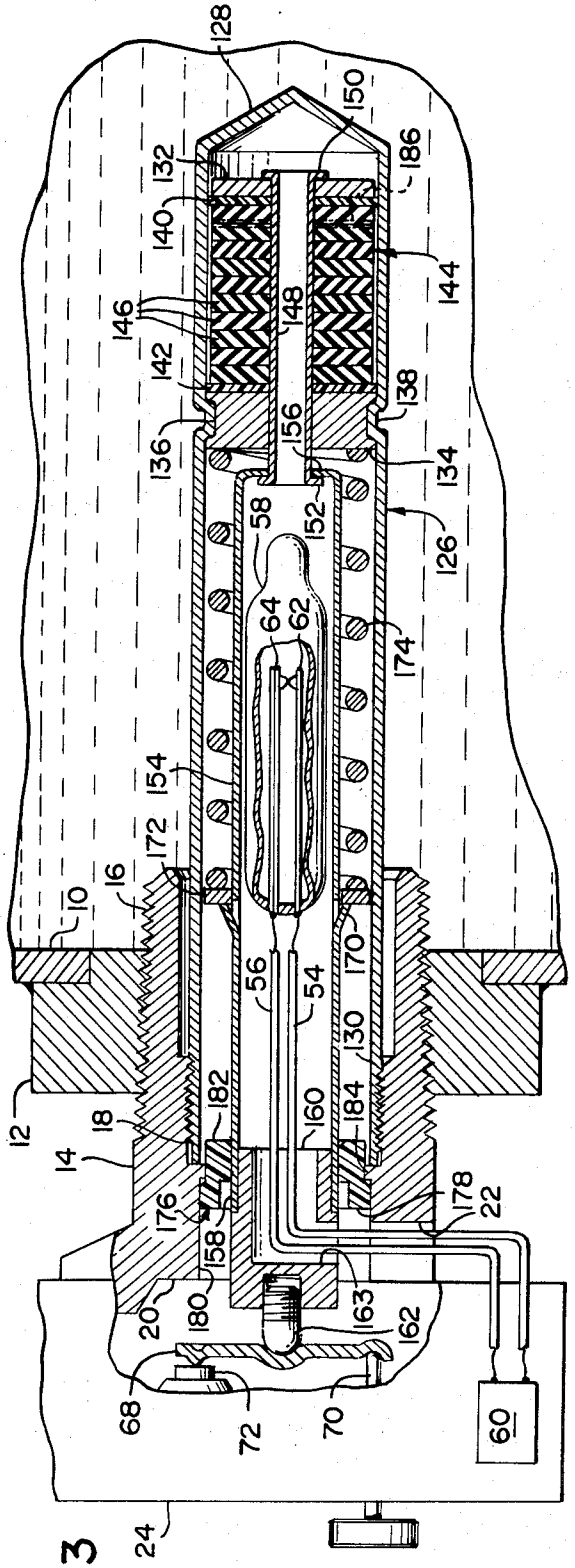



FIG. 3

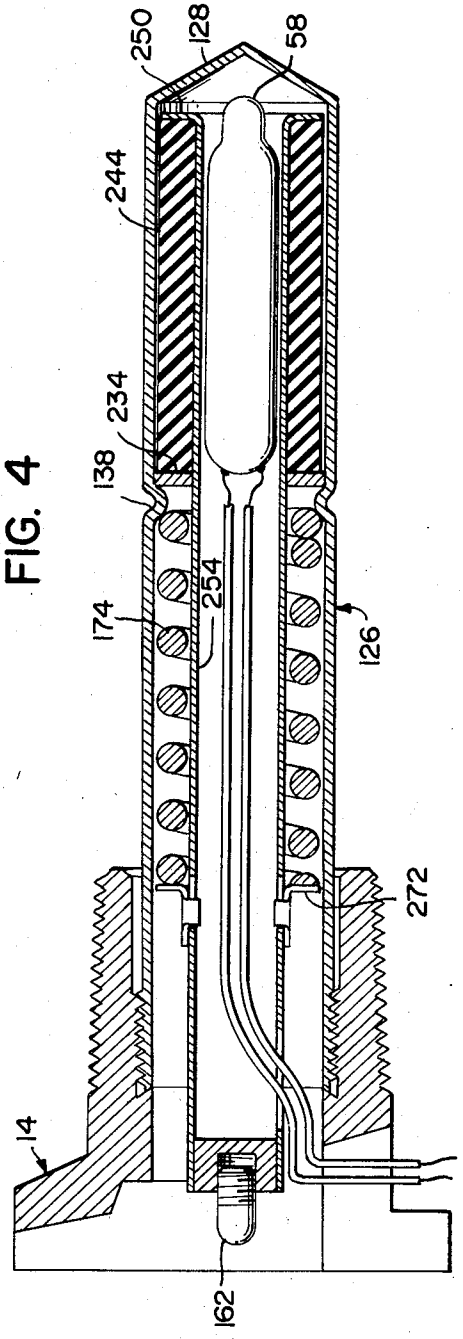



FIG. 4

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FIG. 5

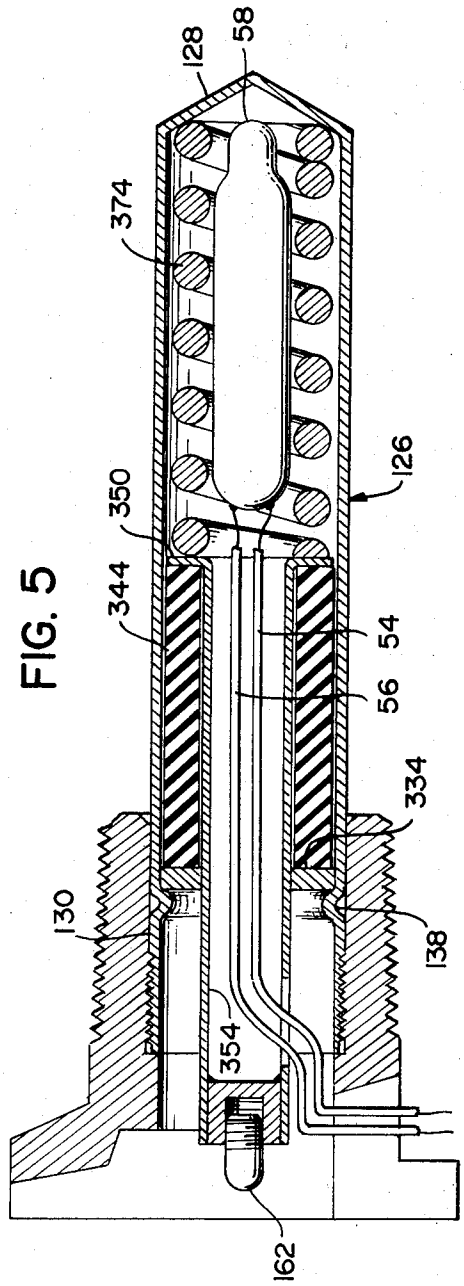
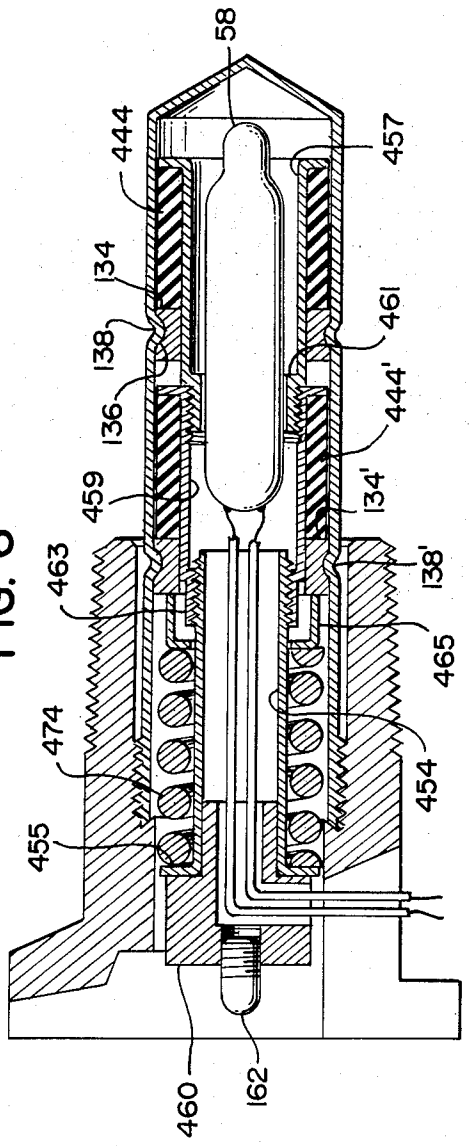



FIG. 6




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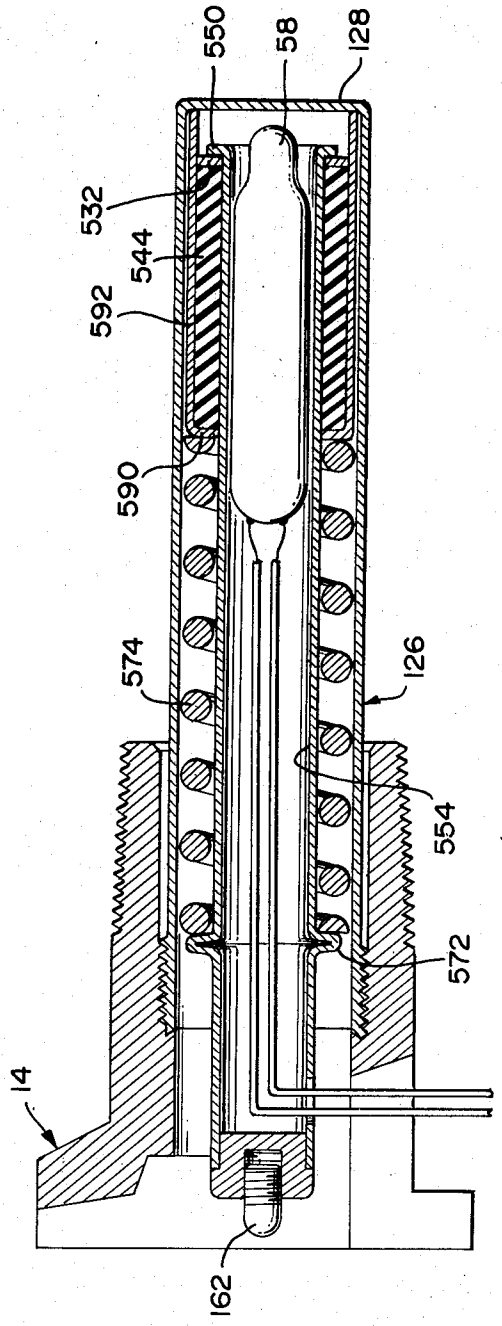



FIG. 7

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# THERMOSTAT ASSEMBLIES UTILIZING A HEAT EXPANSIVE AND CONTRACTIVE ELASTOMERIC MATERIAL

## CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of application, Ser. No. 25,194, filed Apr. 2, 1970 and now abandoned. BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention pertains to thermostat assemblies and, more particularly, to thermostat assemblies utilizing a thermal element including a heat expansive and contractive, elastomeric material.

2. Description of the Prior Art

In the past the most common type of thermostat utilized with appliances to sense the heat of a medium and actuate a control device in response thereto has been the rod and tube. Conventional rod and tube thermostats utilize a tube made of a material having a high coefficient of thermal expansion and a rod made of a material having a low coefficient of thermal expansion. The rod is normally fixed at a closed end of the tube such that with an increase in heat the tube expands and the rod is withdrawn or pulled into the tube. With a decrease in heat, the tube contracts, and the rod is advanced or moved out of the tube.

While conventional rod and tube thermostats are widely used they have the disadvantages of being expensive, having high temperature differentials and requiring substantial length to provide sufficient movement in response to heat. Many attempts have been made to find a suitable replacement for the rod and tube thermostat; however, none of the replacements have overcome the obstacles of the accuracy required, cost limitations and the requirement that the replacement be suitable for use with existing control devices.

Thermostats utilizing a heat expansive and contractive, elastomeric material as a thermal element have been suggested in the past; however, none of these thermostats have been acceptable in that their use requires redesign of existing systems due to the movement of the actuator away from the thermostat assembly and toward the control device with an increase in heat. Most control devices for use with appliances for which such thermostats would be utilized, require the withdrawing or inward movement of the actuator toward the thermostat assembly and away from the control device with an increase in heat. Furthermore, such thermostats have utilized solid cylindrical masses of the material, and the material acts to insulate itself thereby preventing uniform heat sensing by the entire cylinder of material. Along with the disadvantages of not being adaptable to provide movement in the opposite direction and non-uniform heat sensing, such thermostats have not been adaptable to permit the construction of dual thermostat assemblies having a second temperature responsive means such as a bimetal switch. Another disadvantage of such thermostats is that the housing for the material must be constructed of a material having a low coefficient of expansion in order to obtain as much movement of an actuator with expansion and contraction of the material as is possible.



## SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to construct a replacement for rod and tube thermostats by using a heat expansive and contractive, elastomeric material as a thermal element.

The present invention is generally summarized in a thermostat assembly including a tubular housing, a thermal element including a heat expansive and contractive, elastomeric material, and a retainer movably disposed in the housing and including an actuator adapted to operate a control device through an open end of the housing, the retainer engaging the thermal element to move the actuator into the housing with expansion of the elastomeric material in response to increased heat.

Another object of the present invention is to reduce the length of a thermostat assembly without adversely affecting actuator movement by constructing a housing of a material having a high coefficient of thermal expansion and positioning an elastomeric material having a high coefficient of thermal expansion in the housing such that thermal expansion of both the housing and the elastomeric material tend to move the actuator in the same direction.

A further object of the present invention is to construct a relatively short thermostat assembly with a low temperature differential.

The present invention has another object in that a thermostat assembly utilizes a thermal element constructed of an elastomeric material having a high coefficient of thermal expansion and having a central bore to permit uniform response of the elastomeric material to heat.

Another object of the present invention is to utilize a removable, thermally responsive subassembly in a tubular housing of a thermostat assembly to permit interchanging of subassemblies without discarding the tubular housing.

A further object of the present invention is to reduce assembly and component costs by utilizing a removable, thermally responsive subassembly in a thermostat assembly.

Another object of the present invention is to utilize a plurality of wafers of a heat expansive and contractive, elastomeric material as a thermal element in a thermostat assembly.

A further object of the present invention is to arrange a heat expansive and contractive, elastomeric material in a thermostat assembly such that an actuator is withdrawn into a housing when the elastomeric material expands in response to increased heat.

The present invention has another object in that a dual thermostat assembly includes a temperature responsive switch and a thermal element made of a heat expansive and contractive, elastomeric material.

Some of the advantages of the thermostat assemblies of the present invention are that very low temperature differentials are obtained, the thermostat assemblies are shorter than rod and tube thermostats, low cost, the thermostat assemblies can house temperature responsive switches without undue increase in dimensions, and the thermostat assemblies are readily adaptable for use with existing control devices.

Further objects and advantages of the present invention will become apparent from the following descrip-

tion of the preferred embodiments taken in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation in section of a thermostat assembly according to the present invention.

FIG. 2 is a side elevation of the thermostat assembly of FIG. 1 in a heat demand condition.

FIG. 3 is a side elevation in section of another embodiment of a thermostat assembly according to the present invention.

FIG. 4 is a side elevation in section of a modification of the thermostat assembly of FIG. 3.

FIG. 5 is a side elevation in section of another modification of the thermostat assembly of FIG. 3.

FIG. 6 is a side elevation in section of a further modification of the thermostat assembly of FIG. 3.

FIG. 7 is a side elevation in section of another modification of the thermostat assembly of FIG. 3.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

The thermostat assembly of the present invention is shown and described as used with a hot water heater; however, it is clear that the thermostat assembly may be utilized to sense temperatures in any appliance or environment in which its small size and accurate operation is advantageous.

A first embodiment of the present invention is illustrated in FIG. 1 for use with a hot water heater, only partially illustrated. A wall **10** of the hot water heater has an aperture therein for accommodating an internally threaded nut **12** that is secured to wall **10** by welding or brazing. A shank **14** has an externally threaded, cylindrical, outer wall **16**, which threadedly engages nut **12**, and an internally threaded, cylindrical, inner wall **18**. Shank **14** has a flange **20** having a slot **22** therein, and flange **20** supports a suitable control device **24**. Control device **24** conventionally includes valve means adapted to be opened and closed with snap action provided in any suitable manner, such as by utilizing a clicker assembly, as is well known in the art.

The thermostat assembly includes a tubular housing **26**, circular in cross section and constructed of a heat conductive material, preferably having a high coefficient of thermal expansion, such as copper. Housing **26** has a slightly concave closed end **28** and an open end **30** which is externally threaded to engage internally threaded wall **18** of shank **14**.

A thermally responsive subassembly is inserted in housing **26** and includes a cylindrical retainer capsule or casing **32** which is formed to have a small diameter neck **34** at an actuating end thereof and an aperture **36** in an operating end thereof. A thermal element **38** is captured between a washer **40** abutting the operating end of retainer casing **32** and a piston-like head **42** of an operating member, generally indicated at **44**, which has a stem **46** extending from head **42** through a central bore in thermal element **38**, washer **40** and aperture **36** in the operating end of retainer casing **32** to engage the inner surface of closed end **28** of housing **26**. A coiled bias spring **48** is mounted in compression between a shoulder formed at neck **34** and head **42** of operating member **44**, and an actuator plug **50** is retained at the end of neck **34** by a friction fit.

Neck **34** has an aperture **52** therein to accommodate leads **54** and **56** which connect an electrical switch **58** with a control element **60** included in control device **24**. Switch **58** is disposed inside bias spring **48** in retainer casing **32**, and is enclosed in any suitable dielectric material, such as ceramic or glass. Switch **58** includes a fixed contact arm **62** and a movable bimetal contact arm **64** disposed in cooperative relationship therewith, and contact arms **62** and **64** are electrically connected to leads **54** and **56**, respectively.

Actuator plug **50** carries a rounded knob **66** at the end thereof, and knob **66** abuts a lever **68** which receives an adjusting shaft **70** and an operating rod **72** for the clicker assembly. Actuator plug **50** may operate rod **72** directly or through any suitable connecting mechanism and may operate any other control device. Accordingly, the lever apparatus shown is for illustrative purposes only.

Retainer casing **32** and operating member **44** are preferably made of a heat conductive material. Thermal element **38** is made of a heat expansive and contractive, elastomeric material having a high coefficient of thermal expansion. One such elastomeric material which is particularly advantageous for use with the present invention is silicone rubber due to its wear resistance and its retention of resilience, flexibility and tensile strength over wide temperature ranges.

The thermostat assembly is illustrated in a heat satisfied condition in FIG. 1 with the valve controlled by the clicker assembly in control device **24** closed. The thermostat assembly is illustrated in a heat demand condition in FIG. 2 such that the valve controlled by the clicker assembly in control device **24** is open to permit fuel flow to a burner, not shown, to heat the water in the hot water heater.

In operation, when the temperature of the water rises above the set temperature, which may be selected by movement of a knob controlling adjusting shaft **70**, thermal element **38** will expand to move operating member **44** against the force of bias spring **48** which causes stem **46** to be withdrawn into retainer casing **32**. The end of stem **46** is maintained in engagement with closed end **28** of housing **26** by a bias force on operating rod **72** which maintains the valve in control device **24** in a normally closed position. Thus, it may be seen that with increasing heat retainer casing **32** and actuator plug **50** are withdrawn into housing **26** to move rod **72** to its close position, as illustrated in FIG. **1**, to close the valve in control device **24**.

Movement of actuator plug **50** into housing **26** is further enhanced by expansion of housing **26** with increased heat in the water. That is, with increasing heat the high coefficient of thermal expansion of housing **26** causes the closed end **28** of the housing to move away from the open end **30** thereof to increase the total movement of retainer casing **32**. Accordingly, the temperature differential of the thermostat assembly is substantially reduced since thermal expansion is provided by both the tubular housing and the thermal element to increase movement of the actuator per degree of temperature change.

Once the water in the hot water heater cools below the set temperature, thermal element **38** will contract thereby permitting bias spring **48** to force stem **46** of operating member **44** out of retainer casing **32** to cause

the retainer casing to move or advance out of the housing **26**. In the same manner as above described, housing **26** will contract with decreasing heat of the water to force retainer casing **32** and actuator plug **50** further towards control device **24**.

Switch **58** is utilized to sense abnormal temperatures above the range of the thermostat assembly and is calibrated to open at a temperature below the high limit temperature of the appliance. Normally, the opening of switch **58** will cause control element **60** to close a safety valve to shut down the system and prevent danger or damage that might result from excessive temperatures. Switch **58** and thermal element **38** are both responsive to the temperature conditions of the same medium, in this case the water in the hot water heater; and, accordingly, the heat conductive characteristics of retainer casing **32** and operating member **44**, as well as housing **26**, serve to render switch **58** responsive to the temperature of the medium.

The central bore through thermal element **38** permits the elastomeric material to respond uniformly to temperature variations of the medium, and the thermal response of thermal element **38** is further enhanced due to the good heat conductive characteristics of retainer casing **32** and operating member **44**, as well as housing **26**.

In order to assemble the thermostat assembly, neck **34** is formed on retainer casing **32** and bias spring **48**, operating member **44**, thermal element **38**, and washer **40** are inserted therein in that order. A predetermined compressive load is then applied to washer **40** to compress the subassembly against the force of bias spring **48** to a predetermined height at which time the operating end of retainer casing **32** is rolled over to retain the subassembly. Switch **58** is then inserted through neck **34** and actuator plug **50** is forced into neck **34**. The thermally responsive subassembly is thus provided in capsule form and may be inserted in housing **26** with the end of stem **46** abutting the closed end **28** of the housing. It may be seen that the encapsulation of the thermally responsive subassembly facilitates replacement of switch **58** or the entire subassembly by merely removing same and substituting identical components. Thus, any components of the thermostat assembly may be replaced without discarding tubular housing **26**.

Another embodiment of the present invention is illustrated in FIG. **3**, and parts identical to parts in the embodiment of FIG. **1** are given identical reference numbers and are not described again.

The thermostat assembly of FIG. **3** includes a tubular housing **126**, which is constructed of a heat conductive material, preferably having a high coefficient of thermal expansion, such as copper. A closed end **128** of housing **126** is sealed, such as by welding, and an open end **130** is externally threaded to engage internally threaded wall **18** of shank **14**. Adjacent end **128** of housing **126** is a washer **132** made of a material such as brass and having a diameter slightly less than the inside diameter of housing **126** to permit movement therein. A washer **134**, which is made of a material such as brass, has a circumferential groove **136** therein and is captured by crimping housing **126** to provide a plurality of dimples **138** around the housing coinciding with groove **136**. A pair of annular seals **140** and **142**, preferably made of a material such as Teflon, are disposed adjacent washers **132** and **134**, respectively, and have a diameter approximately the same as the inside diameter of housing **126**.

A thermal element **144** is disposed between seals **140** and **142** and includes a plurality of wafers or discs **146** made of an elastomeric material having a high coefficient of thermal expansion, such as silicone rubber.

Washers **132** and **134**, seals **140** and **142**, and wafers **146** have a central bore therethrough and are coaxially aligned to accommodate a retained cylinder **148** having an annular flared end **150** abutting washer **132** to hold thermal element **144**. Retainer cylinder **148** has an annular flared end **152** which engages an annular aperture in an end **156** of a hollow cylindrical retainer member **154**; retainer cylinder **148** and retainer member **154** are preferably made of a heat conductive material. An open end **158** of member **154** engages a cup-shaped plug **160** having an internally threaded aperture in its bottom for receiving an actuating knob **162**. An aperture **163** is provided in the cylindrical wall of plug **160** and coincides with slot **22** in shank **14**. The rounded end of knob **162** abuts lever **68** of the clicker assembly in control device **24**.

Member **154** is circumferentially lanced near end **158**, and a plurality of holding legs **170** are bent therefrom to engage a spring retaining washer **172**. A coiled bias spring **174** is mounted in compression between washers **134** and **172**. Member **154** is movable within tubular housing **126** with end **158** moving in a guide washer **176** which has a large diameter portion **178** engaging an inner wall **180** of shank **14** and an offset, smaller diameter portion **182** which acts as a guide for member **154**. An annular burr or shoulder **184** along inner wall **180** is formed when tubular housing **126** is screwed into shank **14** and serves to prevent guide washer **176** from slipping into housing **126**. Guide washer **176** is constructed of a plastic material, such as nylon.

In operation, the thermostat assembly of FIG. **3** responds to temperature to control the clicker assembly of device **24** in the same general manner as previously described with respect to the embodiment of FIG. **1**. That is, actuating knob **162** is withdrawn into housing **126** with increased temperature and is advanced or moved out of housing **126** with decreased temperature.

The thermostat assembly is illustrated in a relatively cool state in FIG. **3** such that the valve controlled by the clicker assembly in control device **24** is open to permit fuel flow to the burner to heat the water in the hot water heater. When the temperature of the water as sensed by the thermostat assembly rises above the set temperature the expansion of wafers **146** will move washer **132** against the force of bias spring **174** towards end **128** of housing **126** since washer **134** is captured. It can be seen that cylinder **148** and member **154** act in concert as retainer means for thermal element **144** and to transfer movement of washer **132** to actuating knob **162**. The force applied to member **154** by bias spring **174** through washer **172** and legs **170** provides continuous abutment of flared end **152** of cylinder **148** and end **156** of member **154**. Thus, the force of expansion of thermal element **144** must overcome the bias force from spring **174** before actuating knob **162** is moved. Movement of washer **132** towards the closed end **128**

of housing **126** accordingly moves cylinder **148**, member **154** and plug **160** into the housing to withdraw actuating knob **162** and permit lever **68** to operate the clicker assembly to close the valve in control device **24** once the set temperature has been exceeded.

When the temperature decreases below the set temperature, wafers **146** will contract thereby permitting the force from bias spring **174** to move actuating knob **162** out of housing **126** and cause lever **68** to operate the clicker assembly and open the valve.

By constructing housing **126** of a heat conductive material, the heat being sensed, such as the heat of the water in the hot water heater, is communicated to thermal element **144**; and, by constructing housing **126** of a material having a high coefficient of thermal expansion, a low temperature differential is obtained in the same manner as described with respect to the embodiment of FIG. **1**. That is, the expansion of housing **126** between open end **130**, which is secured to shank **14**, and captured washer **134** increases the movement of the retainer means per degree of temperature change. Thus, thermal expansion of both thermal element **144** and housing **126** tend to move actuating knob **162** into the housing. Accordingly, due to the increased movement with respect to degree of temperature change, the overall length of housing **126** is reduced.

The thermostat assembly may be calibrated by selecting a set temperature and adjusting knob **162** in the aperture in plug **160** such that the control device will be operated by movement of knob **162** at the set temperature.

Switch **58** operates in the same manner as described with respect to the embodiment of FIG. **1** to sense abnormal temperatures above the range of the thermostat assembly and cause control element **60** to close a safety valve to shut down the system. Switch **58** and thermal element **144** are both responsive to the temperature conditions of the same medium, in this case the water in the hot water heater; and, accordingly, the heat conductive characteristics of cylinder **148** and member **154**, as well as housing **126**, serve to render switch **58** responsive to the temperature of the medium.

In order to further decrease the response time of the thermostat assembly, thin metal discs, such as that indicated by dashed lines at **186**, may be inserted between wafers **146**. The metal discs act as heat conductors to more uniformly heat the central portion of the thermal element **144**.

A modification of the embodiment of FIG. **3** is illustrated in FIG. **4**. Parts in FIG. **4** identical to parts in FIG. **3** are given identical reference numbers and are not described again, and parts similar to parts in FIG. **3** are given the same reference numbers with 100 added.

The basic difference between the embodiments of FIGS. **3** and **4** is that in the embodiment of FIG. **3** the thermal element is located at the tip of the housing and the switch is located towards the center of the housing whereas in the embodiment of FIG. **4** both the thermal element and the switch are located in the tip of the housing.

The thermal element **244** in FIG. **4** is a hollow cylinder of elastomeric material having a high coefficient of thermal expansion and is held in place at one end by a washer **234** abutting a dimple **138** in housing **126** and at the other end by a flared end **250** of a cylindrical retainer member **254**. Bias spring **174** is mounted in compression between dimple **138** and a washer **272** which is secured to member **254** and is L-shaped in cross section.

The operation of the embodiment of FIG. **4** is the same as that described with respect to FIG. **3** with the realization that movement of the end of thermal element **244** by expansion or contraction is transmitted to actuating knob **162** through the single retainer member **254**. The embodiment of FIG. **4** has the advantage that, since both switch **58** and thermal element **244** are disposed at the closed end **128** of housing **126**, the assembly senses the temperature of the water more accurately due to the further extension into the tank of the hot water heater.

Another modification of the embodiment of FIG. **3** is illustrated in FIG. **5**. Parts in FIG. **5** identical to parts in FIG. **3** are given identical reference numbers and are not described again. Parts similar to parts in FIG. **3** are given the same reference numbers with 200 added.

The basic difference in the embodiments of FIGS. **3** and **5** is that the thermal element and the switch are transposed in the embodiment of FIG. **5**. That is, the switch is located in the tip of the housing and the thermal element is located towards the center thereof.

The thermal element **344** in FIG. **5** is a hollow cylinder of elastomeric material having a high coefficient of thermal expansion and is held in place at one end by a washer **334** abutting a dimple **138** crimped in housing **126** near the open end **130** thereof. At its other end thermal element **344** is held by a flared end **350** of a hollow, cylindrical retainer member **354** which accommodates leads **54** and **56** for switch **58**. A coiled bias spring **374** is mounted in compression between the flared end **350** of retainer member **354** and the closed end **128** of housing **126**.

The resultant forces on retainer member **354** from thermal element **344** and bias spring **374** are the same as those previously discussed with respect to the embodiment of FIG. **3**. The strain on flared end **350** of retainer member **354**, however, is reduced because thermal element **344** and bias spring **374** supply opposing forces to the flared end whereas in the embodiment of FIG. **3** flared ends **150** and **152** of retainer cylinder **148** and end **156** of retainer member **154** must withstand the entire force from bias spring **174**. The operation of the embodiment of FIG. **5** is the same as that described with respect to FIG. **3**.

The thermal element **344** may have a large bore if removal of switch **58** is desired; however, if it is acceptable to have switch **58** captured after assembly of the embodiment of FIG. **5**, the bore of thermal element **344** and the diameter of retainer member **354** may be reduced to that required to accommodate leads **54** and **56** for switch **58**.

A further modification of the embodiment of FIG. **3** is illustrated in FIG. **6** and parts in FIG. **6** identical to parts in FIG. **3** are given identical reference numbers and are not described again. Parts in FIG. **6** similar to parts in FIG. **3** are given the same reference numbers with 300 added.

The embodiment of FIG. **6** differs from the embodiment of FIG. **3** basically in that the thermal element is disposed so as to apply parallel forces to the retainer means with both the thermal element and the switch located in the tip of the housing.

A first thermal element **444** is a hollow cylinder of elastomeric material having a high coefficient of thermal expansion and is held in place by a washer **134** having a circumferential groove **136** and captured by a dimple **138** in housing **126** coinciding with the groove in washer **134**. A second thermal element **444'** is identical to thermal element **444** and is held in place at one end by a washer **134'** captured by a dimple **138'** in housing **126** in the same manner as previously described with respect to washer **134**. The retainer means for the embodiment of FIG. **6** includes a cylinder **454** having a flared end **455** secured to a plug **460** which carries actuating knob **162**. Thermal elements **444** and **444'** are surrounded by retainer cylinders **457** and **459**, respectively, with each of the cylinders having flared ends to hold the thermal elements in place. Opposite the flared end of cylinder **457** is an offset threaded portion **461** which is threadedly secured to the flared end portion of cylinder **459**. In a similar fashion cylinder **459** has an offset threaded portion **463** which is threadedly secured to cylinder **454**. A coiled bias spring **474** is mounted in compression between flared end **455** of cylinder **454** and a stop **465** which abuts captured washer **134'**.

The operation of the embodiment of FIG. **6** is similar to that described with respect to the embodiment of FIG. **3**; however, expansion of thermal elements **444** and **444'** applies separate forces to the retainer means which includes cylinders **454**, **457** and **459**. The embodiment of FIG. **6** has the advantage of reduced loading on thermal elements **444** and **444'** and the flared ends of retainer cylinders **457** and **459**. Thus, any tendency to extrude the thermal elements is minimized, and deflection of the flared ends of the retainer cylinders is reduced.

Another modification of the embodiment of FIG. **3** is illustrated in FIG. **7**. Parts in FIG. **7** identical to parts in FIG. **3** are given identical reference numbers and are not described again. Parts similar to parts in FIG. **3** are given the same reference numbers with 400 added.

The embodiment of FIG. **7** differs from that of FIG. **3** in that both the thermal element and the switch are located in the tip of the housing and are part of a removable subassembly which facilitates replacement of the various elements upon the occurrence of component failure.

The thermal element **544** in FIG. **7** is a hollow cylinder of elastomeric material having a high coefficient of thermal expansion and is held in place at one end by an inwardly formed flange **590** formed on one end of a hollow cylindrical stop **592** which abuts the closed end **128** of housing **126**. Thermal element **544** is secured in place at its other end by a washer **532** on cylindrical retainer member **554** adjacent flared end **550**. Bias spring **574** is mounted in compression between flange **590** and an annular shoulder **572** formed by pinching cylindrical retainer member **554** adjacent the open end of housing **126**.

The operation of the embodiment of FIG. **7** is the same as that described above with respect to FIG. **3** with the exception that movement of the end of thermal element **544** by expansion or contraction is transmitted to actuating knob **162** through the single retainer member **554**. The embodiment of FIG. **7** has the advantage that since both switch **58** and thermal element **544** are disposed at the closed end **128** of housing **126** and, thus, are further extended into the tank of the hot water heater, the assembly more accurately senses the temperature of the water.

In assembling the thermostat assembly of FIG. **7**, annular shoulder **572** is formed on retainer member **554** and bias spring **574**, cylindrical stop **592**, thermal element **544**, and washer **532** are inserted thereon in that order. A predetermined compressive load is then applied to washer **532** to compress the subassembly against the force of bias spring **574** at which time the retainer member **554** is flared at end **550** to retain the subassembly. Switch **58** is then inserted into the hollow retainer member **554**, and actuator plug **162** is forced into the outer end of the retainer member. The thermally responsive subassembly is thus provided in capsule form and may be inserted in housing **126** with the end of cylindrical stop **592** abutting the closed end **128** of the housing. It may be seen that fabrication of the thermally responsive subassembly in the above manner facilitates replacement of switch **58** or the entire assembly by enabling rapid and convenient removal of the same for substitution with identical replacement components. Thus, any components of the thermostat assembly may be replaced without discarding or disturbing tubular housing **126**.

The embodiment of FIG. **7** has a number of advantages in that the possibility of the assembly "-freezing" in an unsafe condition by corrosion between the housing **126** and the movable retainer member **554** is all but eliminated since only washer **532** makes sliding contact with cylindrical stop **592**, the switch **58** is disposed in the tip of housing **126** in intimate contact with retainer member **554** and thermal element **544** for improved thermal response, the removable subassembly design facilitates element replacement, the actuator plug **162** is free to center itself on the valve actuating lever for more accurate operation, and less elastomeric material is required in the construction of thermal element **544**.

The elastomeric, non-metallic thermal elements for use with the present invention may include unitary hollow cylinders or a plurality of wafers, as well as various other shapes, and any of the elements may be used with the various embodiments. In any case, by using an elastomeric thermal element having a central bore, the element uniformly senses temperature without the insulation of the central core normally concomitant with solid cylinders of elastomeric material. Accordingly, if it is desired to provide a thermostat assembly wherein actuator means moves or advances away from the housing, an elastomeric thermal element having a central bore is still advantageously utilized due to its uniform, fast and accurate response.

Inasmuch as the present invention is subject to many variations, modifications and changes in detail, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A thermostat assembly comprising tubular housing means having a closed end and an open end;

thermally responsive means in said housing means including an elastomeric material that expands with increasing heat and contracts with decreasing heat

and having a first end fixedly disposed with respect to said housing means adjacent said open end and a second movable end disposed adjacent said closed end,

retainer means movably disposed in said tubular housing means and including hollow actuator means adapted to operate a first control device through said open end of said tubular housing means and further adapted to accommodate thermostatic means interiorly thereof,

bias means, in said housing biasing said retainer means relative to said housing means, and

said movable end of said thermally responsive means engaging said retainer means and acting in opposition to said bias means to move said actuator means into said tubular housing means with expansion of said elastomeric material in response to increased heat.

**2**. The invention as recited in claim **1** wherein said tubular housing means is made of a material having a high coefficient of thermal expansion, said tubular housing means expanding with increased heat to increase movement of said actuator means into said tubular housing means.

**3**. The invention as recited in claim **1** wherein said retainer means includes a casing having said actuator means at a first end adjacent said open end of said tubular housing means and a second end adjacent said closed end of said tubular housing means, said thermally responsive means is disposed within said casing, and said retainer means further includes operating means engaging said fixed end of said thermally responsive means and extending through said second end of said casing to engage said tubular housing means.

**4**. The invention as recited in claim **3** wherein said first end of said casing has a neck portion, and said actuator means includes a plug inserted in said neck portion.

**5**. The invention as recited in claim **3** wherein said elastomeric material has a central bore therethrough, and said operating means extends through said central bore.

**6**. The invention as recited in claim **5** wherein said retainer means includes a washer disposed at said second end of said casing, said elastomeric material has a first portion abutting said washer and a second portion, said operating means has a head abutting said second portion of said elastomeric material and a stem extending from said head through said central bore in said elastomeric material and said washer to engage said closed end of said tubular housing means, and wherein said bias means comprises a coiled bias spring mounted in compression between said first end of said casing and said head of said operating means.

**7**. The invention as recited in claim **6** and further comprising temperature responsive electrical switch means disposed within said coiled bias spring in said casing.

**8**. The invention as recited in claim **6** wherein said tubular housing means is made of a material having a high coefficient of thermal expansion.

**9**. The invention as recited in claim **1** wherein said thermally responsive means includes a cylinder of said elastomeric material having a central bore therethrough, and said retainer means includes a member extending through said central bore to engage said cylinder of elastomeric material.

**10**. The invention as recited in claim **9** wherein said bias means applies a compressive force to said cylinder of elastomeric material.

**11**. The invention as recited in claim **9** further comprising a hollow stop member having a flanged end engaging said first end of said cylinder of elastomeric material and an opposite end abutting said closed end of said tubular housing means.

**12**. The invention as recited in claim **11** wherein said retainer means defines an annular protrusion adjacent said open end of said tubular housing means, and wherein said bias means is mounted in compression between said annular protrusion and said flanged end of said stop member.

**13**. The invention as recited in claim **12** wherein said retainer means is pinched to provide a radially extending shoulder forming said annular protrusion.

**14**. The invention as recited in claim **1** wherein said thermally responsive means includes a plurality of wafers of said elastomeric material.

**15**. The invention as recited in claim **14** wherein metal washers are disposed between said wafers of said elastomeric material, and said elastomeric material is silicone rubber.

**16**. A dual thermostat assembly comprising

tubular housing means having a closed end and an open end;

retainer means movably disposed in said tubular housing means and adapted to actuate a first control device;

biasing means in said tubular housing means and acting to exert a force against said retainer means relative to said housing means heat expansive and contractive elastomeric means

disposed in said tubular housing means and having a fixed end with respect to said housing means adjacent said open end and a movable end disposed adjacent said closed end and acting on said retainer means in opposition with said biasing means so as to move said retainer means into said tubular housing means with expansion; and

temperature responsive switch means disposed in said tubular housing means and adapted to actuate a second control device in response to temperature conditions of the same medium to which said elastomeric means responds;

said retainer means having a hollow portion accommodating said switch means, and said tubular housing means being made of a heat conductive material whereby said elastomeric means and said switch means respond to temperature conditions of the medium.

**17**. The invention as recited in claim **16** wherein said retainer means is adapted to actuate the first control device through said open end.

**18**. The invention as recited in claim **17** wherein said elastomeric means has a central bore therethrough, said hollow portion of said retainer means is arranged in said central bore, and said switch means is disposed in said hollow portion adjacent said closed end of said tubular housing means.

**19**. The invention as recited in claim **18** wherein said elastomeric means is made of silicone rubber.

20. The invention as recited in claim 18 wherein said retainer means includes cylinder means having a flared end abutting said movable end of said elastomeric means and support means fixed to said cylinder means, and wherein said bias means comprises a coiled bias spring disposed around said cylinder means and having one end abutting said support means.

21. The invention as recited in claim 20 wherein said tubular housing means is crimped to define means for fixing an opposite end of said coiled bias spring and said fixed end of said elastomeric means.

22. The invention as recited in claim 20 further comprising a hollow stop member having one end abutting the closed end of said tubular housing means and a flanged opposite end defining means for fixing an opposite end of said coiled bias spring and said fixed end of said elastomeric means.

23. The invention as recited in claim 20 wherein said support means comprises an annular shoulder formed on said cylinder means.

24. The invention as recited in claim 18 wherein said elastomeric means includes first and second cylinders of elastomeric material having a high coefficient of thermal expansion, said first and second cylinders each having a stationary end fixed in said tubular housing means and a movable end, and said retainer means includes means abutting said movable ends of said first and second cylinders whereby said retainer means is moved by the force from expansion of both of said first and second cylinders in parallel.

25. The invention as recited in claim 17 wherein said elastomeric means has a central bore therethrough, said retainer means includes a first member disposed in said central bore and a second hollow member coinciding with said hollow portion and connected with said first member, and said switch means is disposed in said second member in the center of said tubular housing means.

26. The invention as recited in claim 25 wherein said second member carries a first washer therearound and said tubular housing means includes a second washer fixed therein, and wherein said bias means comprises a coiled bias spring having a first end abutting said second washer and a second end abutting said first washer, said first member has a flared end, said elastomeric means has a stationary end abutting said second washer, and said movable end of said elastomeric means abuts said flared end of said first member.

27. The invention as recited in claim 26 wherein said elastomeric means includes a plurality of wafers of an elastomeric material having a high coefficient of thermal expansion.

28. The invention as recited in claim 27 wherein said elastomeric material is silicone rubber, and a plurality of metal discs are provided adjacent said wafers.

29. The invention as recited in claim 16 wherein said switch means is disposed adjacent said closed end.

30. The invention as recited in claim 29 wherein said elastomeric means is a cylinder having a central bore and is disposed between said open end of said tubular housing means and said switch means.

31. The invention as recited in claim 30 wherein said retainer means extends through said central bore of said cylinder and has a flared end abutting said movable end thereof, and wherein said bias means comprises a coiled bias spring mounted in compression between said flared end of said retainer means and said closed end of said tubular housing means.

32. The invention as recited in claim 31 wherein said switch means includes wires extending through said open end of said tubular housing means, said hollow portion of said retainer means extending through said central bore of said cylinder to accommodate said wires, and said tubular housing means includes a washer abutting a stationary end of said cylinder and captured by crimping said tubular housing means.

33. The invention as recited in claim 16 wherein said retainer means includes a casing having an actuating end adapted to actuate the first control device and an operating end and forming said hollow portion, said elastomeric means is disposed in said casing, and said retainer means further includes an operating member having a head engaging said fixed end of said elastomeric means and stem means extending through said operating end of said casing to engage said tubular housing means.

34. The invention as recited in claim 33 wherein said elastomeric means has its movable end abutting said operating end of said casing and a central bore therethrough, and said stem means extends through said central bore in said elastomeric means.

35. The invention as recited in claim 34 wherein said casing is arranged in said tubular housing means to permit said actuating end to actuate the first control device through said open end, and said stem means of said operating member engages said closed end of said tubular housing means whereby said actuating end of said casing is withdrawn into said tubular housing with expansion of said elastomeric means with response to increased heat.

36. The invention as recited in claim 35 wherein said bias means comprises a coiled bias spring mounted in compression between said head of said operating member and said actuating end within said casing, and said temperature responsive switch means is disposed within said coiled bias spring in said casing.

37. A thermostat assembly comprising

a tubular housing having an open end and a closed end adapted to extend into a medium; and

a thermally responsive subassembly removably disposed in said tubular housing, said subassembly including

casing means slidably disposed in said tubular housing and having a first end adapted to actuate a control device through said open end of said tubular housing and a second end,

a heat expansive and contractive elastomeric material disposed in said casing means and expanding in response to increasing heat of the medium, and

operating means disposed in said casing means in engagement with said elastomeric material, said operating means including stem means movable with respect to said casing means in response to expansion of said elastomeric material and extending through said second end of said casing means to engage said tubular housing whereby said first end of said casing is moved in accordance with expansion and contraction of said elastomeric material.

38. The invention as recited in claim 37 wherein said elastomeric material is disposed adjacent said second end of said casing means, and said stem means extends through said elastomeric material to move into said casing means with expansion of said elastomeric material whereby said first end of said casing means moves into said tubular housing with increased temperature of the medium.

39. The invention as recited in claim 38 wherein said tubular housing is made of a material having a high coefficient of thermal expansion whereby said tubular material expands with increased temperature of the medium to further move said first end of said casing means into said tubular housing.

40. The invention as recited in claim 39 wherein said elastomeric material forms a cylinder having a stationary end abutting said second end of said casing means, a movable end engaging said operating means and a central bore therethrough, said stem means extends through said central bore in said cylinder and engages said closed end of said tubular housing, and a coiled bias spring is mounted in compression between said first end of said casing means and said operating means within said casing.

41. A thermostat assembly comprising a tubular housing adapted to extend into a medium;

capsule means removably disposed within said tubular housing and having an actuating end adapted to actuate a control device in accordance with temperature variations of the medium;

a thermal element disposed within said capsule means, said thermal element including an elastomeric material having a high thermal coefficient of expansion;

operating means disposed in said capsule means, said operating means having a head portion connected with said thermal element and movable in response to expansion thereof and stem means extending from said capsule means in spaced relation from said actuating end, the space between said stem means and said actuating end increasing with decreasing medium temperature and decreasing with increasing medium temperature; and

means engaging said capsule means to move said stem means into engagement with said tubular housing whereby said actuating end of said capsule means is moved into said tubular housing with increasing medium temperature.

42. The invention as recited in claim 41 wherein said tubular housing is made of a material having a high coefficient of thermal expansion.

43. The invention as recited in claim 42 wherein said elastomeric material forms a cylinder having a central bore, and said stem means extends through said central bore.

44. The invention as recited in claim 43 wherein said capsule means has an operating end, said cylinder of elastomeric material has a stationary end abutting said said operating end, and further including a coiled bias spring mounted in compression between said actuating end and said head portion of said operating means within said capsule means.

45. A thermostat assembly comprising tubular housing means having a closed end and an open end;

hollow retainer means movably disposed within said tubular housing means, said hollow retainer means adapted to accommodate an electrical thermostatic switch assembly interiorly thereof and adapted to actuate a control device;

bias means disposed within said tubular housing means and having a stationary end fixed with respect to said tubular housing means and a movable end acting on said retainer means; and

temperature sensing means disposed within said tubular housing means and having a stationary portion fixed adjacent said open end of said tubular housing means and a movable portion disposed adjacent said closed end and acting on said retainer means in opposition to said bias means, said temperature sensing means being constructed of an elastomeric material having a high coefficient of thermal expansion and having a central bore therethrough whereby said elastomeric material uniformly senses temperatures to move said means.

46. The invention as recited in claim 45 wherein said temperature sensing means includes a plurality of wafers of said elastomeric material.

47. The invention as recited in claim 46 wherein said retainer means extends through said central bore in said temperature sensing means.

48. The invention as recited in claim 47 wherein said tubular housing means includes a captured washer having a central bore coaxial with the central bore of said temperature sensing means, said stationary portion of said temperature sensing means abuts said captured washer and said stationary end of said bias means abuts said captured washer.

49. The invention as recited in claim 48 wherein said retainer means carries annular support means, said movable end of said bias means abutting said annular support means.

50. The invention as recited in claim 49 wherein said bias means is a coiled spring, and said retainer means includes a cylinder disposed within said coiled spring, and further comprising temperature responsive switch means adapted to actuate another control device, said switch means being disposed within said cylinder in proximity to said temperature sensing means so as to respond to temperature conditions of the same medium to which said temperature sensing means responds.

51. The invention as recited in claim 50 wherein said tubular housing means is constructed of a heat conductive material having a high coefficient of thermal expansion, and said elastomeric material is silicone rubber.

52. The invention as recited in claim 45 wherein said tubular housing means has a crimped portion to fix said stationary portion of said temperature sensing means in said tubular housing means.

53. The invention as recited in claim 52 wherein said stationary end of said bias means is fixed by said crimped portion of said tubular housing means.

54. The invention as recited in claim 45 wherein said tubular housing means is constructed of a heat conductive material having a high coefficient of thermal expansion.

55. The invention as recited in claim 54 wherein said retainer means extends through said central bore in said temperature sensing means and has a flared end abutting said movable portion of said temperature sensing means.

56. A thermostat assembly comprising

tubular housing means having an open end and a closed end adapted to extend into a medium; and

a thermally responsive subassembly removably disposed in said tubular housing means, said subassembly including

retainer means movably disposed in said tubular housing means and having a first end adapted to actuate a control device through said open end of said tubular housing means and a second end,

bias means engaging said retainer means and acting to exert a force thereon, and

a heat expansive and contractive, elastomeric material carried by said retainer means and having a fixed end with respect to said tubular housing means disposed adjacent said open end and a movable end disposed adjacent said closed end and acting on said second end of said retainer means in opposition to said bias means to move said first end of said retainer means into said tubular housing means with expansion of said elastomeric material in response to increased heat of the medium.

57. The invention as recited in claim 56 wherein said retainer means includes cylinder means having a flared end abutting said movable end of said elastomeric means and an annular shoulder formed on said cylinder means, and wherein said bias means comprises a coiled compression spring disposed around said cylinder means and having one end abutting said annular shoulder.

58. The invention as recited in claim 57 wherein said thermally responsive subassembly further includes a hollow cylindrical stop member disposed around said elastomeric material and having one end abutting said closed end of said tubular housing means and a flanged opposite end defining means for fixing an opposite end of said coiled compression spring and said fixed end of said elastomeric material.

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