TEMPERATURE-SENSITIVE ASSIST FOR TEMPERATURE-CONTROLLED SWITCH

Inventor: Robert N. Levin, Catskill, N.Y.
Assignee: American Thermostat Corporation, South Cairo, N.Y.

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Primary Examiner—Bernard A. Gilheany
Assistant Examiner—F. E. Bell
Attorney—James & Franklin

ABSTRACT

In a conventional type of thermostat the temperature-sensing element, usually in the form of a bimetal strip, acts against a resiliently loaded switch contact, tending to move that contact to switch-open position against the action of the spring loading thereof. In most instances as the bimetal changes its shape progressively in accordance with changes in temperature, the force exerted thereby against by the switch contact that it is tending to open will increase, thereby making the bimetal strip work harder and harder as the temperature changes, and in any event the force against which the bimetal works is comparatively great. These are sources of inaccuracy. To eliminate them an additional temperature-sensitive element is provided, one which normally is comparatively inactive on the switch. However, when a temperature is reached which is close to the desired operating temperature of the switch, that element becomes active on the switch with a force which is not strong enough in and of itself to move the switch to open position. Hence the element, when active, will act to assist the bimetal, thereby enabling the bimetal to work against a relatively low opposing force and thus increasing the accuracy with which the bimetal can control the opening and closing of the switch.

8 Claims, 2 Drawing Figures
TEMPERATURE-SENSITIVE ASSIST FOR TEMPERATURE-CONTROLLED SWITCH

The present invention relates to an improvement in thermostat constructions by means of which the normal temperature-sensing element, when the temperature at which it is to actuate the switch is approached, is assisted in its switching action, thereby to make its control of the switch operation more accurate.

In the conventional thermostat a temperature-sensing element such as a bimetal strip will change its shape gradually and progressively as the temperature to which it is subjected changes. This bimetal strip is made active upon a switch contact which is normally biased strongly in a direction toward the bimetal, the bimetal, when it changes shape sufficiently, engaging that contact and tending to move it against the action of the biasing means active on the contact. As the bimetal continues to bend the switch contact is moved with the bimetal against the action of the biasing means, and this usually results in an increased resistance to movement on the part of the switch contact. While the bimetal is essentially a reasonably accurate temperature-sensing instrumentality, when it acts against an appreciable force, and especially such a force the magnitude of which is not constant, its accuracy becomes degraded. Nevertheless, this drawback to the use of bimetals in thermostats has been accepted in the past because of the necessity of providing sufficient biasing force on the switch contacts so as to ensure that they will have the required characteristics, when the switch is closed, of low resistance and lack of susceptibility to shock and vibration.

In a standard type of thermostat, the switch is defined by a pair of resilient leaves, the limiting position of the first of those leaves, usually moving in the same direction as the bimetal, being adjustable in order to adjust the particular temperature at which the bimetal will be effective to open the switch. When that limiting position is close to the normal position of the bimetal the other spring leaf, the one that the bimetal operatively engages, will not have to move very far before its contact is separated from the contact carried by the first and position-limited leaf. On the other hand, if the limiting position of the first leaf is located relatively remote from the normal position of the bimetal, then the bimetal will have to bend further until it has moved the other leaf which it engages sufficiently initially to cause the first and position-limited leaf to come to a stop and then to cause the other and bimetal-engaged leaf to move away, thereby to separate the switch contacts. The greater the degree of movement of the other and bimetal-engaged leaf, the greater is the resilient force which that leaf experts against the movement of the bimetal. Hence the force which the bimetal will have to overcome will at all times be appreciable, and it will also differ depending upon the particular temperature selected within the range of variation permitted by a given thermostat. It would be preferable if the bimetal were simply a positioning device, acting against no force at all, or, if it must act against force, acting against a small and constant force. When the force against which the bimetal must act is relatively great, and particularly when that appreciable force will vary from one actuating temperature to another, the reliability and accuracy of the thermostat is subject to variation.

It is the prime object of the present invention to devise a thermostat assembly which avoids the abovementioned sources of error. More particularly, it is a prime object of the present invention to provide a bimetal in which the resilient loading of the switch contacts may be maximized to provide for proper permanent electrical connection, but in which the temperature sensing element such as the bimetal, when it is active to actuate the switch, works against a much smaller force than that required for optimum retention of the switch contact in closed position.

Another object of the present invention is to devise a thermostat arrangement in which the operation of the temperature-sensing element, when the temperature range over which the device is adjustable is approached, is assisted so that the temperature-sensing element itself need exert only a minimal force in order to effect its desired switch-actuating operation.

It is a further object of the present invention to devise a thermostat having an actuation-assist feature within the operative temperature range which is simple and inexpensive, and which in particular is adapted for use in conjunction with standard thermostat constructions while adding only a minimal amount to the cost of those constructions.

For convenience of explanation the temperature-sensing element will hereinafter be termed "bimetal," it being understood that temperature-sensing elements other than bimetals could be employed, provided that they, like bimetals, have the property of substantially continuously changing their shape as the temperature to which they are subjected varies.

In accordance with the present invention a mechanical assist to the normal operation of the bimetal is provided by an element which is temperature-sensitive in a different way from the bimetal. Such an element will normally retain its shape without any appreciable change over a significant range of temperatures, but when a particular temperature has been reached, that element will tend to change its shape quite radically and exert an appreciable amount of force in thus tending to change its shape. One substance having that characteristic is a nickel-titanium intermetallic compound known as "Nitinol." It is disclosed in U.S. Pat. No. 3,174,851 of Mar. 23, 1965, entitled "Nickel-Base Alloys," U.S. Pat. No. 3,351,463 of Nov. 7, 1967 entitled "High Strength Nickel-Base Alloys," and U.S. Pat. No. 3,403,238 of Sept. 24, 1968 entitled "Conversion of Heat Energy to Mechanical Energy," all patents being assigned to the United States of America as represented by the Secretary of the Navy. This material has a "memory." If it is given a first shape or configuration and subjected to an appropriate treatment, and thereafter its shape or configuration is changed, it will retain that changed shape or configuration until such time as it is subjected to a predetermined elevated temperature, for example, around 80° F. When it is subjected to that temperature it tends quite strongly to return to its original shape or configuration. This material is available in elongated strip form. The strip can be given a bent configuration and heat treated, and can thereafter be straightened out to substantially liner configuration. It will retain that linear configuration until subjected to the predetermined activating temperature, at which time it will revert to its bent configu-
ration. Within a range of temperatures, the predetermined temperature at which the strip will tend to revert to its "memory" configuration can be varied by altering the proportions of the constituents of the intermetallic compound, as is known to the art.

A strip or other element formed of the material in question can be incorporated into an otherwise conventional thermostat construction, the strip in its normal shape or configuration being relatively inactive on any of the parts of the thermostat. However, when the predetermined activating temperature is reached, which temperature is selected to be somewhat below the range of temperatures over which the thermostat is designed to be effective to actuate a switch, that strip will tend to change its shape or configuration to its bent condition, in which condition it engages one of the switch elements, for example, the same element which is engaged by the bimetal, and tends to move that element in the same direction as the bimetal is moving. Thus the tendency of the "memory" strip to return to its "memory" configuration will be exerted in the same sense as the force which the bimetal is exerting. The force thus exerted by the "memory" strip will be less than that needed to actuate the switch. Thus the "memory" strip will not itself cause the switch to be actuated. It will, however, greatly lighten the load on the bimetal, thus enabling the bimetal, over the operative adjusting range of the thermostat, to work against a much smaller force than has previously been thought necessary when the switch is to be actuated. For example, if the force of 11–18 ounces is thought desirable in order to maintain the switch contacts in closed condition, the memory strip can be designed so that when it is subjected to its activating temperature it will exert a force on the switch contacts of 8–10 ounces, and consequently the bimetal, over the operating adjusting range of the thermostat, need work only against a spring force of from 3–8 ounces.

To the accomplishment of the above, and to such other objects as may hereinafter appear, the present invention relates to a thermostat construction having an assist-action enabling the bimetal or other temperature-sensing element to work against a minimal force over the critical range of operation of the thermostat, all as defined in the appended claims and as described in this specification, taken together with the accompanying drawings, in which:

FIG. 1 is a side elevational view of a typical stack-type thermostat in which the present invention is embodied; and

FIG. 2 is a side elevational view of another embodiment of the present invention.

The thermostat of FIG. 1 comprises a support 2 from which a stack generally designated 4 depends. Mounted in that stack, and separated by insulators 6, are an upper spring leaf 8, a lower spring leaf 10, and a bimetal strip 12. The stack is held to the support 2 by means of a screw 14, as is conventional, the screw being insulated from the elements 8, 10 and 12. The spring leaf carries contact 16 and the spring leaf 10 carries 18, and two contacts 16 and 18 being located opposite one another. The spring leaf 8 is inherently resiliently biased downwardly toward the spring leaf 10, and the spring leaf 10 is resiliently inherently biased upwardly toward the spring leaf 8 with a force sufficiently less than the downwardly biasing force on leaf 8 so that the contacts 16 and 18 are firmly pressed into engagement with one another. Threadedly mounted on the support 2 is an adjustment screw 20 which passes freely through an opening 22 in the spring leaf 8 and terminates in a tip 24 against which the spring leaf 10 is adapted to be moved. The particular threaded location of the screw 20 will determine the limiting upwardly location of the spring leaf 10, since that leaf is always biased upwardly toward the screw tip 24. Under normal circumstances the spring leaf 8, being biased downwardly, will cause the contact 16 carried thereby to engage the contact 18 carried by the spring leaf 10, the leaf 10 bending downwardly against its normal bias while the leaf 8 bends downwardly relaxing its normal bias. This continues until the forces exerted by the leaves 8 and 10 equalize, the contacts 16 and 18 then being urged firmly into engagement with one another. Terminals 26 and 28 are electrically connected to the spring leaves 8 and 10 respectively, and they may be connected to any suitable external circuit, such as a battery 30 or other source of power, a resistor 32 which may be in form of a heater, and an on-off switch 34 adapted to be manually controlled. When the switch 34 is closed, and when the spring leaves 8 and 10 are free to assume their resiliently biased positions, the thus described circuit will be closed and the heater 32 will be energized.

The bimetal 12 may be of the type which will bend upwardly as the temperature to which it is subjected rises. It is provided with a finger 36 which is adapted to engage the underside of the spring leaf 8 as the bimetal 12 bends upwardly, the spring leaf 8 extending out beyond the spring leaf 10 for this purpose. As the temperature to which the bimetal 12 is subjected rises, the bimetal will tend to bend upwardly, and that tendency will be resisted by the inherent resilient biasing of the spring leaf 8, which is biased downwardly against the action of the bimetal 12. When the temperature to which the bimetal 12 becomes sufficiently great, the bimetal 12, acting through the finger 36, will overcome the inherent downward bias of the spring leaf 8 and will lift that spring leaf 8. The spring leaf 10 will move upwardly along with the leaf 8, the contacts 16 and 18 remaining engaged, until the leaf 10 engages the tip 24 of the screw. Thereafter the leaf 10 cannot move any further upwardly, but the leaf 8 will continue to be moved up by the bimetal 12. This will cause the contact 16 carried by the spring leaf 8 to separate from the contact 18 carried by the spring leaf 10, thus opening the circuit to the resistor 32. The particular point in the progressive bending of the bimetal 12 where the contact 16 will be lifted from the contact 18 will be controlled by the temperature to which the bimetal 12 is subjected. The higher the tip 24 of the screw 20, the greater will be the temperature to which the bimetal 12 must be subjected before the contacts 16 and 18 are separated and the circuit controlled by the switch is opened.

All of the above describes the conventional thermostat. It will be noted that in the operation of that thermostat the bimetal 12, in tending to move to switch-opening position, is always acting against the full force of the spring bias on the spring leaf 8. If that bias is on the order of 11–18 ounces, which is thought to be a
desirable value in order to ensure that the contacts 16 and 18 will engage one another with the force and security necessary for the proper electrical operation of the switch, then the bimetal 12 must, at the moment that it opens the switch, be working against a force within that range. Moreover, the particular force against which it will be working at the moment that the switch is opened will vary somewhat depending upon the adjusted position of the switch. When the screw 20 is screwed down, so that the switch will be opened at the low end of the adjustment range, then the spring force exerted by the spring strip 8 and against which the bimetal 12 operates will be relatively low, whereas if the screw 20 is screwed up, conditioning the thermostat to be actuated at a high temperature within its range, the spring leaf 8 will be more distorted than in the previous case, it will therefore exert a stronger downward force on the finger 36 carried by the bimetal 12, and hence the bimetal will have to operate against a stronger force when the switch is to open at a high temperature within its range of operation than when the switch is adjusted to operate in the low temperature area of its range of operation.

In order to minimize the force against which the bimetal 12 must operate when the switch is being opened or closed, and as specifically disclosed by the way of example in Fig. 1, an elongated bimetal-assist element 37 is incorporated into the stack, that element being shown in the form of a strip of appropriate material which extends out beyond the end of the spring leaf 8 and then is bent down, at 38, and up to 40, so as to engage the underside of the spring leaf 8. The element 37 is formed of a material having the characteristic previously described, to wit, that when given a particular shape or configuration it will tend to maintain that configuration until it is subjected to a predetermined temperature, and when that activating temperature is attained, the material will tend to assume a memory configuration different from its normal configuration. The strip 37 is designed to have an activating temperature slightly below the range of temperatures over which the particular thermostat in question is designed to operate. For example, if the low point of the adjusting temperature range of the thermostat is 100°F, then the strip 37 may be designed to have a critical activating temperature of perhaps 90°F. The strip 37 is shown in solid lines in Fig. 1 in its normal configuration. Its memory configuration, to which it tends to return when it has been subjected to the activating temperature, is shown in broken lines in Fig. 1. From the drawing it will be seen that in its normal configuration the horizontal portion of the strip 37 is substantially straight line, whereas in its memory configuration it tends to bend sharply at the line 42. When the strip 37 is in its normal configuration as shown in broken lines its part 40 will not exert any appreciable effect on the spring leaf 8. However, as may be seen from the broken lines of the drawing, when the strip 37 tends to assume its memory configuration, it will tend to lift the spring leaf 8. The spring 37 is so designed as to produce a force, in tending to return to its memory configuration, which is less than the minimum biasing force exerted by the spring leaf 8, so that the strip 37, when it tends to return to its memory configuration, is incapable of moving the leaf spring 8 sufficiently to separate the contact 16 from the contact 18. However, since the force exerted by the strip 37 is in the same direction as the force exerted by the bimetal 12 as it bends upwardly with increased temperature, the bimetal 12, once the strip 37 tends to return to its memory configuration, no longer need act against the entire biasing force exerted by the spring strip 8. For example, if, as has been stated, the normal biasing force is 11–18 ounces, and if the force exerted by the strip in tending to return to its memory configuration is 8–10 ounces, then once the strip 37 has been temperature-actuated the bimetal need work only against the force of 3–8 ounces. This will make the bimetal considerably more accurate in opening and closing the switch in response to temperature changes.

When the temperature to which the thermostat is subjected falls and the bimetal 12 tends to bend downwardly, then the force exerted by the spring strip 8 on the strip 37 will tend to return that strip 37 to its normal condition or configuration, the strip 37 then being ready again to provide its bimetal-assisting function when its activating temperature is reached. In order to assist in restoring the strip 37 to its normal condition, its main length, up to the line 42 where it tends to bend, may be supported on a rigid reinforcing strip 43 which is also mounted in the stack. Both the strip 37 and the reinforcing strip 42, if provided, will have openings 46 and 46' respectively through which the adjusting screw 20 can freely pass.

Fig. 2 discloses another embodiment of the present invention, this time using a conventional switch 48 having terminals 50 and 52 extending therefrom, the switch being mounted in a casing 54 from which an operating member 56 in the form of a button extends, there being a spring or other means within the housing 54 so as normally to urge the button 56 upwardly. When the button 56 is pushed in the status of the switch 48 changes from closed to open or open to closed depending on whether the switch is of the normally closed or normally open type. In accordance with the present invention, the switch 48 is mounted on a support 58. An arm 60 extends up from the support 58 and carries a bimetal strip 62 which, for purposes of illustration, may be considered as designed to bend downwardly progressively as the temperature to which it is subjected increases. The arm 62 carries a finger 64 which engages an arm 66 freely pivotally mounted at 68 on an arm 70 extending up from the support 58. The arm 66 in turn carries a depending finger 72 in line with the button 56. A part 74 extending up from the support 58 carries the memory strip 76, the normal configuration of that strip being shown as substantially straight line and its memory configuration being shown in broken lines in Fig. 2, that memory configuration having the end portion of the strip 76 bend downwardly. As in the embodiment of Fig. 1, a strip 78 of rigid material may be provided immediately below the strip 76 and extending up to the line 80 around which the strip 76 tends to bend when returning to its memory configuration.

In this embodiment the spring acting on the button 56 and tending to urge that button outwardly lifts the arm 66 and acts against the force exerted by the bimetal 62 as the latter bends downwardly with increase in temperature. Thus under normal circum-
stances the bimetal 62 would have to overcome all of the force which normally tends to urge the button 56 upwardly. However, in accordance with the present invention, the memory strip 76, when subjected to its activating temperature, and in tending to change its configuration to its memory state as shown in broken lines in FIG. 2, will itself provide a force tending to overcome some of the biasing force active on the button 56, and hence the bimetal 62, at the temperature where it is designed to open the switch, need not act against the total biasing force on the button 56, but only on a force equal to the difference between that total force and the button-depression-assisting force exerted by the strip 76.

It will be apparent from the above that the advantages of the instant invention are achieved by means of structure which can be very readily incorporated into existing thermostat designs, and with very little increase in cost over and above the cost of the memory element itself. Because that element does not exert any appreciable force on the switch over the normal operative temperature range of the thermostat, the switch contacts are reliably and forcefully pressed against one another, thereby to produce low contact resistance and to resist shock and vibration. On the other hand, when the critical temperatures where the thermostat is to be operative are approached, the memory element provides an assist to the bimetal which permits the bimetal then to operate against only a minimal opposing force and thus to operate more reliably and accurately than has previously been the case.

While but a limited number of embodiments of the present invention have been here specifically disclosed, it will be apparent that many variations may be made therein, all within the scope of the invention as defined in the following claims.

1. A thermostat comprising a switch means and an actuating element operatively connected to said switch means and effective on a change in temperature in a given direction to exert a progressively increasing actuation effect on said switch means, said switch means being active to resist said actuation effect to a predetermined degree and an actuation-assisting means operatively connected to said switch means, normally substantially ineffective to exert an actuation effect on said switch, but effective when a predetermined temperature is achieved close to but somewhat below the desired actuation temperature for said switch to exert on said switch an actuation-aiding effect less than said predetermined degree but in the same sense as the actuation effect exerted by said actuating element and while said actuation effect is being exerted by said actuating element, whereby above said predetermined temperature said actuating element actuates said switch while exerting only a minimal actuation effect thereon.

2. The combination of claim 1, in which said actuation-assisting means comprises an element formed of material having the characteristic that over a given range of temperatures it will tend to retain a given configuration but when subjected to a temperature beyond said range it will tend to change its configuration, said element when in its normal configuration being substantially ineffective to exert said actuation effect on said switch and when in its changed configuration being effective to exert said actuating-aiding effect on said switch.

3. The combination of claim 2, in which said switch means comprises a pair of arms, means biasing said arms toward one another, said arms carrying engageable contacts, means for making electrical connection to said contacts, said actuating element comprising a bimetal element carrying a part engageable with one of said arms and active as the temperature of said bimetal changes in a given sense to move said arm in a given direction away from the other arm, and adjustable stop means engageable by said other arm and effective to limit its movement in said given direction, said element comprising said actuation-assisting means having a part located opposite and engageable with said one arm, said element when its given configuration so locating said part relative to said one arm as not to exert any appreciable operative force on said one arm, and when in its changed configuration so locating said part as to engage said one arm and move it in said given direction, the force exerted by said element in tending to move from said given configuration to said changed configuration being less than that of said means biasing said one arm toward said other arm.

4. The combination of claim 3, in which said arms, said bimetal, and said element are mounted in a stack.

5. The combination of claim 3, in which said arms, said bimetal, and said element are mounted in a stack, said bimetal and said element pressure-engaging said one arm on the same side thereof.

6. The combination of claim 3, in which said element comprises a section connected to said part, said section in its said configuration being substantially straight and said part then being located in the range of movement of said one arm corresponding to engagement between said contacts, said section in its said changed configuration assuming a condition bent in said given direction, thereby to move said part in said given direction to a position beyond said range of movement of said one arm.

7. The combination of claim 2, in which said switch means comprises an operating member, means biasing said member to non-operating position, said bimetal element being operatively connected to said member and active as its temperature changes in said given direction to move said member in a given direction to its operating position against the action of said biasing means, said element comprising said actuation-assisting means having a part located opposite and engageable with said operating member, said strip when in its given configuration so locating said part relative to said operating member and move it in said given direction, the force exerted by said element in tending to move from said given configuration to said changed configuration being less than that of said means biasing said operating member to non-actuating position.

8. The combination of claim 7, in which said element comprises a section connected to said part, said section in its said given configuration being substantially straight and said part then being located in the range of movement of said operating member corresponding to non-actuation of said switch means, said section in its changed configuration assuming a condition bent in said given direction, thereby to move said part in said
given direction to a position corresponding to a switch-actuating position of said operating means.