Nov. 1, 1949 L. J. KOCI 2,486,714

COMPENSATING THERMOSTAT

Filed Aug. 26, 1947

FIG. 1

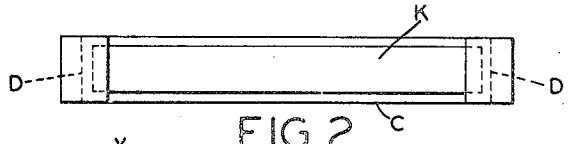


FIG. 2

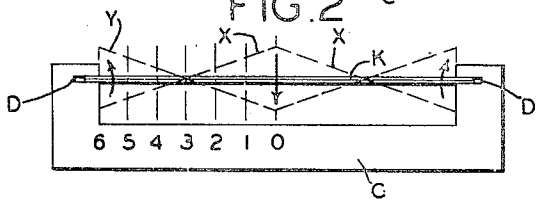


FIG. 3

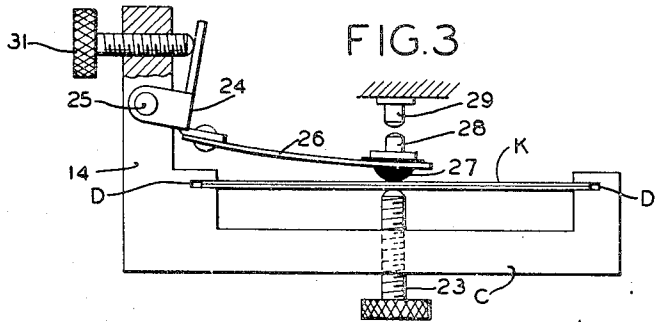


FIG. 4

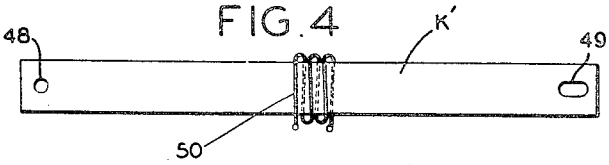
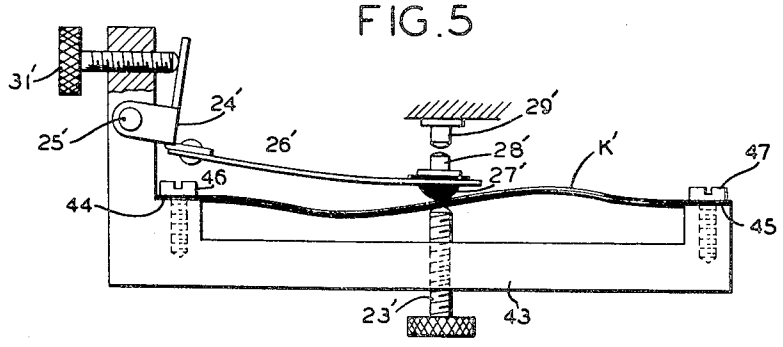


FIG. 5



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COMPENSATING THERMOSTAT

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2 Claims. (Cl. 60—23)

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This invention relates to compensating thermostats embodying the principle of my patent for Thermostat, No. 2,332,518, granted October 26, 1943, and is a continuation-in-part of my application Serial No. 507,529, filed October 25, 1943, and now abandoned.

The novel principle of said patent may be described thus: that if one portion of a generally straight strip of unreversed bimetallic material (of any normal shape and variation in section modulus) is rigidly fastened or restrained against both angular and translational motion and a second portion of the strip at a point longitudinally removed from said first mentioned portion is subject to action including a reactive couple or moment acting to restrain angular motion of said second portion by permitting minimum restraint to translational motion of said second portion in a direction normal to the general length of the strip, then said second portion will exhibit a thermostatic action in the line of said direction but directed in one way or the opposite depending on whether said second portion or the portion immediately adjacent to said rigidly fastened portion, is heated. Said invention is claimed generically in said parent application and also claimed as to certain species which include the principle that the relative magnitude of the two opposite thermostatic actions above described can be varied by variation of the effective section modulus of the strip or by other means which may serve to alter the degree of restraint to angular motion of said second portion.

The present invention has for its object the embodiment of the first described principle in a form characterized by a strip of thermostatic material having constant or uniform section modulus from end to end for use where it is desired to obtain a thermostatic action proportional to a difference in temperature between different portions spaced lengthwise of the strip, that is, in the case of a temperature gradient existing lengthwise of the strip.

According to the present invention the thermostatic strip will be supported at its ends in an application where the difference in temperature occurs between the middle portion and the end portions of the strip, or it may be supported at only one end with the opposite end or second portion free to move in a direction normal to the length of the strip but subject to a reactive couple as described in said patent.

As will appear hereinafter, this form of my invention is useful in cases where the sole thermostatic action depends upon temperature difference as distinguished from those cases in which the thermostatic action is dependent solely on absolute temperature.

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Other objects and attendant advantages will be appreciated by those skilled in this art as the invention becomes better understood in connection with the accompanying drawing, in which—

Figure 1 is a plan view of a thermostat embodying the present invention;

Figure 2 is a side elevation of the structure shown in Figure 1;

Figure 3 shows an application of my invention in a thermostatic switch or means for making and breaking an electric circuit;

Figure 4 is a plan view of a thermostatic strip designed for a modified mounting, in accordance with my invention; and

Figure 5 is a side elevation of the modified form, incorporated in a thermostatic switch.

Reference is made to the abovementioned patent for a further description of the novel principle first above described, whereby a main thermostatic action in one direction and a compensating thermostatic action in the opposite direction are obtained in a single strip of non-reversed, non-reentrant, thermostatic material, to obtain a net thermostatic action in a direction normal to the general length of the strip. In my said patent I have used the terms "A effect" and "B effect" in explaining the thermostatic action; and these terms will be used in a similar manner, hereinafter.

In Figures 1, 2, and 3 are shown a diagrammatic embodiment of the present invention. Here, the letter C designates a frame structure having upstanding ends provided with coplanar slots D within which the end portions of a bimetallic strip K are positioned so as to be free to have longitudinal movement but restrained against both angular and translational movement under temperature changes. The strip K is of a form having constant or uniform section modulus from end to end. In the present case this uniform section modulus is obtained by making the strip of uniform thickness and uniform width. Assuming that the underside of the strip is the high temperature side, if the strip is heated at its end portions as by conduction from the frame structure C, the central portion of the strip will tend to move upwardly in the direction indicated by the end arrows in Figure 2, this being the "A effect" above mentioned; and conversely, if the central portion of the strip is heated to a temperature above that of the end portions the strip will tend

to move downwardly at the central portion in the direction indicated by the center arrow in Figure 2, this being the "B effect" above mentioned. Where the thermostatic strip is of uniform section modulus throughout its length as in the present case, a uniform change in temperature of the strip throughout its length will produce no lateral movement of the strip, that is, movement normal to the face of the strip, for the reason that the A and B effects are equal and the tendency of the middle portion of the strip to move downward is exactly balanced by the tendency of the end portions to move the middle portion upward. It will be seen that if one of these effects can be caused to predominate, the balance will be disturbed and the net movement in one direction or the other with uniform change in temperature of the strip, can be produced. This net movement is the resultant thermostatic action in a direction normal to the general length of the strip and may be described as the vector sum of the A and B effects. As will be noted in the present invention, such a strip of uniform width and thickness will deflect only when there exists a temperature gradient between the middle portion and the end portion. Wherever I refer to uniform change in temperature whether such change be a rise or fall with respect to an existing temperature condition, I mean the application of an identical change in temperature to all parts of the thermostatic strip. This explanation is offered to eliminate the possibility of confusion with the condition of a temperature gradient along the length of the strip, which temperature gradient is necessary in the present form of the invention in the performance of a temperature indicating or controlling function.

Referring to Figure 2, I have illustrated graphically and diagrammatically the thermostatic action when heat is applied to different portions of the strip along its length. For example, if an incremental length of the strip at its middle portion at the section line O is heated, say 10 degrees, the middle portion of the strip will move downward in proportion to the width of the section diagram X at said section line O. This is the B effect. This effect diminishes as the point of heat application moves toward the left or the right; for example, if now a like incremental length at the section line 1 is heated 10°, motion at the middle portion of the strip at section line O will move downward an amount proportional to the width of the section diagram X at said section line 1, and similarly if a like incremental length at the section line 2 is heated 10° the resultant motion of the middle portion of the strip will be less and of a magnitude corresponding to the reduced width of the diagram X at the section line 2. If now the strip is similarly heated 10° at the section line 3, there will result no motion of the middle portion of the strip, for the reason that this section 3 is located at the nodal point of the diagram, that is, the point at which the thermostatic action reverses. If the strip is similarly heated 10 degrees at the section lines 4 or 5 the thermostatic action would be in the opposite direction, that is, upward and of relative magnitude indicated by the width of the section diagram Y at the given point. This description as well as the diagram is theoretical for the purpose of illustrating the principle; and it will be apparent that the width of the section diagrams X and Y represents relative magnitude of deflection of the strip at the middle point O in response to a unit rise in temperature at any given point along its length, because in the example of a unit rise of 10° at any given section line there is gradual heat conduction to adjoining portions of the strip.

The diagram Figure 2 shows a very desirable characteristic of my invention, namely, that of a gradually reducing thermostatic response in one direction, passing through a nodal point (i. e., the point of no response), and then into a gradually increasing response in the opposite direction, considering the effect of the application of heat to successive points along the length of the strip. This is of particular utility when compared with prior compensating thermostats; for example, prior instances of applying compensation usually have involved the use of a second thermostat distinct from the main thermostat and acting in a direction opposite from the main thermostat, or a second thermostat fastened to the otherwise free end of the main thermostat but reversed in the location of its high temperature side. If we consider the effect of the application of heat to successive points along the length of the latter mentioned structure it would be apparent that as we proceed from the fixed end of the main thermostat strip we would obtain gradually decreasing thermostatic action in one direction as far as motion of the free end of the strip is concerned until we encounter the junction of the two strips at which there would be a very sudden transition to maximum thermostatic action in the opposite direction followed by gradually decreasing thermostatic action in this same opposite direction as we approach the free end of this combination strip. As distinguished from such prior structures, my invention locates that portion of the thermostat having maximum primary thermostatic response closest to the region of the temperature which it is desired to control and locates that portion of the thermostat possessing maximum opposition or compensating response in a region closest to that region whose temperature variations it is desired to compensate. In practical cases these two regions are seldom separated by an accurate dividing line or plane but gradually merge one into the other; and for this reason it is highly desirable that the response of the remaining portions (i. e., those possessing less than maximum response) of any compensating thermostat shall show the same characteristic, that is, the gradual merging of the main response into that of the secondary.

In Figure 3 I have shown the thermostatic strip K applied in a thermostatic switch for controlling an electric circuit. This mounting of the strip K is the same as in Figures 1 and 2. A screw 23 threaded in the frame portion C is arranged for adjustment to act as a stop to limit the downward movement of the strip intermediate its ends, in this instance at the middle point. A lever 24 pivoted at 25 to an upright portion 14 of the frame, carries a leaf spring 26 which extends forwardly along the strip K and carries on its under side an insulation button 27 adapted to contact the strip and on its top side a contact 28 positioned to engage a stationary contact 29 to control a circuit (not shown) for exercising a control function. A thumb screw 31 in the end portion 14 permits of adjustment of the position of the lever 24 and the spring 26 whereby to apply more or less lateral pressure on the strip and thus change the value of the temperature gradient at which the strip will act to flex the spring 26 and move the contact 28 into or out of engagement with the contact 29. The station-

ary contact 29 also acts as a stop to limit the upward movement of the strip. Here, the thermostatic strip is mounted in the same manner as in Figures 1 and 2 so that its end portions are subject to angular restraint and to the reactive couple explained in my parent application, by permitting a limited amount of movement in a direction along the length of the strip in the slots D—D provided for reception of these ends. Theoretically, the thermostatic action is as described above in reference to Figures 1 and 2. However, this form is limited in its application because of the resistance to sliding motion of the portions of the strip in the slots D—D. As abovementioned, the temperature gradient which is necessary in the present form of the invention is established along the length of the strip by suitable heating means such as a resistance element or coil 50 applied only to a central portion of the strip, as shown diagrammatically in Figure 3. The ends of the strip will obviously respond to the temperature of the support C which in turn will respond to the temperature of the room or enclosure in which the device is located. In this example the heat developed by the heater 50 is the primary medium the temperature of which is to be indicated or controlled and the temperature of the room or enclosure is the second medium the variations in temperature of which it is desired to compensate for. In actual practice I prefer to rigidly clamp the end portions of the strip against both angular and longitudinal movement and to provide softness of the strip in the longitudinal direction by any of several means such, for example, as by buckling the strip as shown in Figure 5. In this form the strip K' is of uniform section modulus from end to end as in the form first above described. The strip K' is supported in a frame structure similar to that of Figures 1, 2, and 3, having a central portion 43 provided with supporting abutments 44 and 45, against the upper surface of which are secured the end portions of the strip K' by suitable means such as large headed screws 46 and 47, the screws passing through openings 48 and 49, respectively. These screws serve to secure the ends of the strip against the supporting abutments 44 and 45 and to prevent relative angular movement of the ends of the strip. Here the screws 46 and 47 fixedly clamp the terminal end portions and hold the strip under lengthwise compression so that the intermediate portion of the strip is buckled, substantially as shown. With this construction it is possible to obtain friction-free snap acting operation of the switch of a degree determined by the amount of longitudinal compressive stress to which the strip is subjected. In other respects the thermostatic switch of Figure 5 is the same as in Figure 3 and like reference numerals with prime marks are applied to like parts.

It will be apparent from the foregoing that in the present invention I employ a thermostatic strip having constant section modulus from end to end, and that this is useful wherever it is desired to obtain a thermostatic action proportional to a difference in temperature between the middle portion of the strip and the two end portions. In any case it should be observed that this form is useful only when it is desired to obtain a thermostatic action resulting from a difference in temperature along the length of the strip. If all parts of this strip are at the same temperature irrespective of what this temperature may be there will be no net thermostatic action or deflection of the middle portion thereof normal to the direction of its length. There will be an increased internal stress under such changes in temperature within the thermostatic strip but as far as any useful motion or other action is concerned there will be none evident.

In further explanation of the invention, we assume a case where it is desired to have a circuit breaker such as shown in Figure 5 which will function to open a circuit established by an original closed contact relation between contacts 28' and 29'. It is desired that such circuit breaker respond as a result of temperature rise of the middle portion of the thermostatic strip, thus establishing a temperature gradient between the middle and end portions thereof, and the device as a whole possesses no response to variation in ambient temperature. It is clear that if a simple uncompensating thermostat were used for instance in case the thermostat of Figure 5 were pivotally supported at its ends, then the breaking of the circuit would be strictly in response to the temperature of the thermostat irrespective of whether the thermostat rose in temperature because of an accompanying rise in ambient temperature or whether the thermostat rose in temperature because of the heating effect of the heating coil. However, by clamping a thermostat of uniform width at the ends against angular motion in the manner shown in Figure 5 a rise in ambient temperature alone would result in no thermostatic action tending to open the circuit as explained above and only a difference in temperature between the middle and end portions would result in such thermostatic action. In this assumed case such difference in temperature is obtained because of the heat imparted to the middle of the thermostat alone by virtue of current flowing through the heating coil and such temperature difference will of course be proportional to the square of the magnitude of such current flow. Also, heat might be concentrated on a central portion of the thermostat strip by other means. In any case such a form, that is, a strip of uniform width would find application wherever the middle of the thermostat is made mainly responsive to the temperature of a primary medium (in this case the heater coil) and unavoidably responsive to a lesser degree to the temperature of an uncontrolled secondary medium (in this case the ambient atmosphere) and where it is desired to effectively compensate for the unavoidable response of the middle portion to the temperature of said uncontrolled medium. In another instance, it may be more desirable (for example, where it is desired to control the temperature of a solid metallic object) to have the end portions made mainly responsive to the temperature of said primary medium (in this case the metallic solid) and unavoidably responsive to the temperature of the ambient uncontrolled atmosphere and to have the middle portion mainly responsive to said atmosphere to effectively compensate for variations in temperature thereof in the net thermostatic action.

It is believed that this invention provides a compensating thermostat which is desirable from the viewpoint of efficiency, dependability, accuracy, economy in cost of manufacture, and maximum freedom from the effect of transient conditions.

While I have described and illustrated specific embodiments of the invention, this has been by

way of illustration and not limitation, and I do not wish to be limited except as required by the appended claims, in which I claim:

1. A thermostatic device for compensating for the effect of variations in temperature of an uncontrolled second medium, comprising a non-reversed, non-reentrant strip of thermostatic material of constant section modulus from end to end, means supporting one portion of the strip against both angular motion and motion in a direction normal to its length, means subjecting a second portion of the strip longitudinally spaced from the first mentioned portion to a reactive couple acting to restrain angular motion of the second portion but offering minimum restraint to said second portion in a direction normal to the length of the strip for the purpose of producing an effective thermostatic action at said second portion in the line of said direction in one way or the opposite depending on temperature gradient between said first and second portions in response to heating of one of said portions to a greater degree than the other, heating means constituting said primary medium applied only to one of said portions of the strip to establish said temperature gradient, said second medium constituting the temperature of the room or enclosure in which the device is located, one said portion being mainly responsive to the temperature of the primary medium and thereby producing a primary thermostatic effect in said one direction and the other portion being mainly responsive to the temperature of an uncontrolled, second medium and thereby producing a secondary or compensating effect in the opposite direction to compensate for the effect of any variation in temperature of said uncontrolled medium.

2. A compensating thermostat having means for producing a main thermostatic action in one direction in response to a temperature rise of a primary medium and a thermostatic action in the rise of an uncontrolled second medium resulting in a net effective thermostatic action which is the vector sum of said main and secondary thermostatic actions, said means comprising a non-reversed, non-reentrant strip of thermostatic material, a support for so mounting a first portion of the strip as to restrain said portion against angular and lateral motions, means for applying a couple acting to restrain angular motion of a second portion of said strip while permitting minimum restraint to lateral motion of said second portion in a line of action normal to the general length of said strip, the strip having constant section modulus from end to end, heating means constituting said primary medium applied only to one of said portions of the strip to establish a temperature gradient between said first and second portions of the strip, said second medium constituting the temperature of the room or enclosure in which the device is located, one of said portions of the strip being mainly responsive to the temperature of said primary medium and unavoidably responsive to a lesser degree to the temperature of said uncontrolled medium, and said other portion of the strip being mainly responsive to the temperature of said second medium so as to compensate for the unavoidable response of said one portion of the strip to the temperature of said uncontrolled medium, said resultant thermostatic action being in response solely to temperature gradient lengthwise of the strip.

LUDVIK J. KOCI.

REFERENCES CITED

The following references are of record in the file of this patent:

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2,284,383	Elmer	May 26, 1942
2,382,928	Whitney et al.	Aug. 14, 1945

Certificate of Correction

Patent No. 2,486,714 November 1, 1949

LUDVIK J. KOCI

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 8, line 3, strike out the words "opposite direction in response to a temperature" and insert the same before "rise", column 7, line 42;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 4th day of July, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

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