June 30, 1936. W. A. SAUL 2,046,187

THERMOSTAT

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FIG. 1.

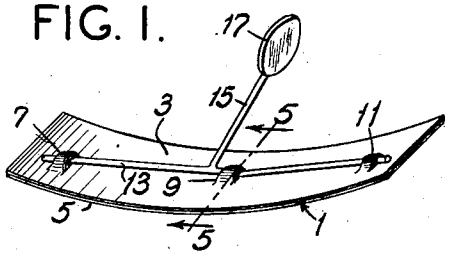


FIG. 2.

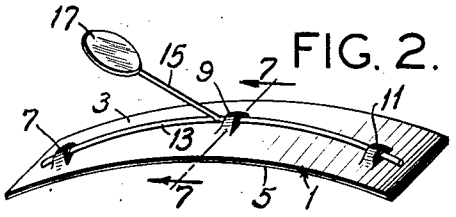


FIG. 3.

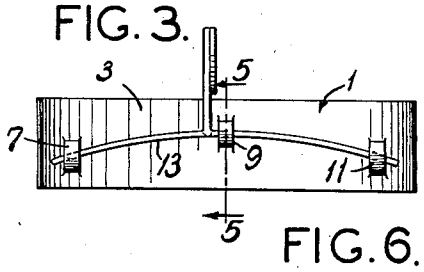


FIG. 4.

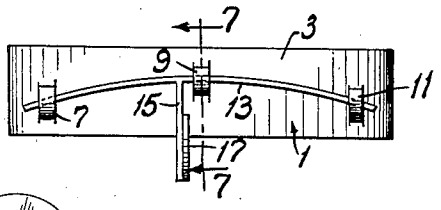


FIG. 6.

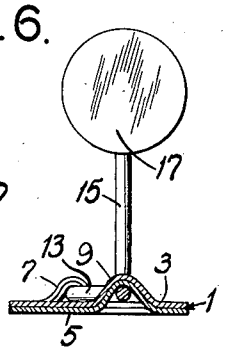


FIG. 5.

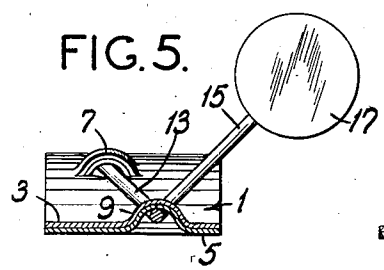


FIG. 7.

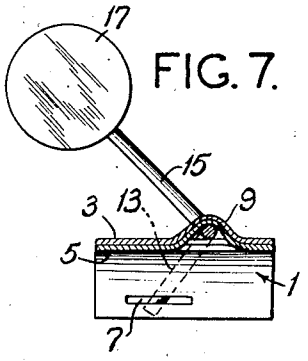


FIG. 8.

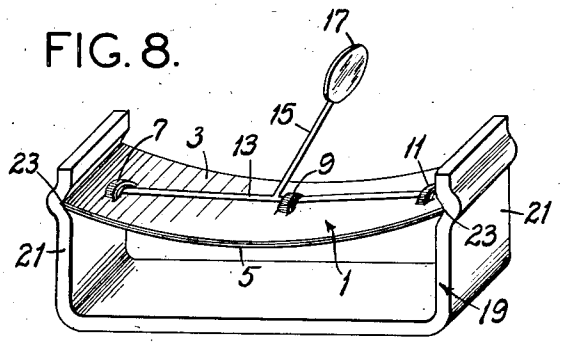


FIG. 9.

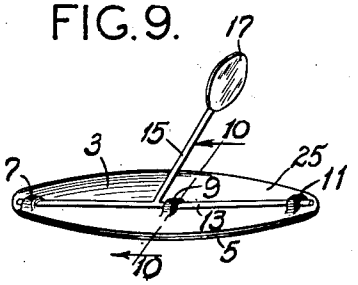


FIG. 11.

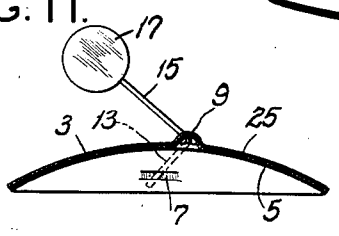
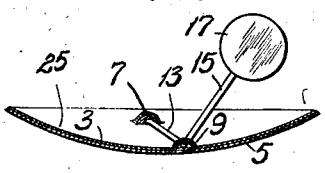


FIG. 10.



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FIG. 12.

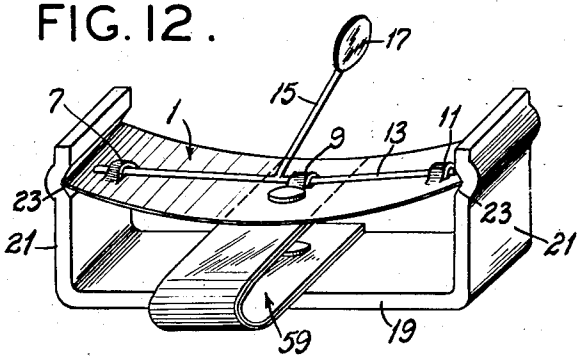


FIG. 19.

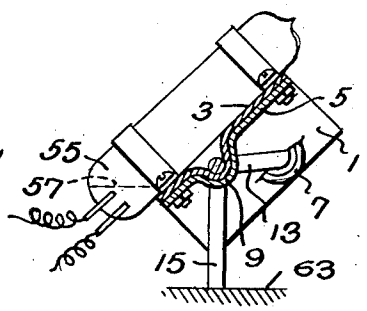


FIG. 13.

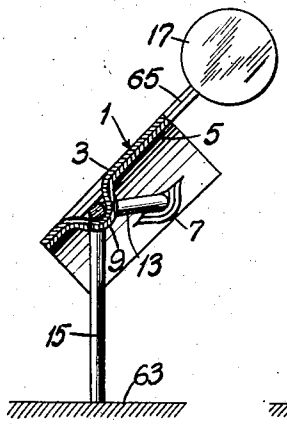


FIG. 14.

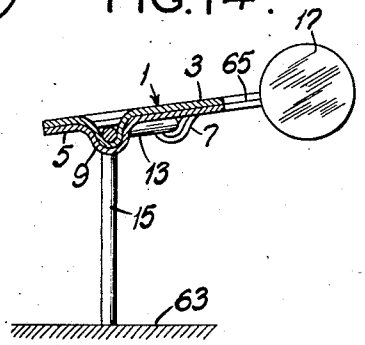


FIG. 15.

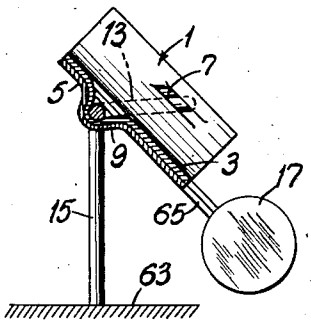


FIG. 16.

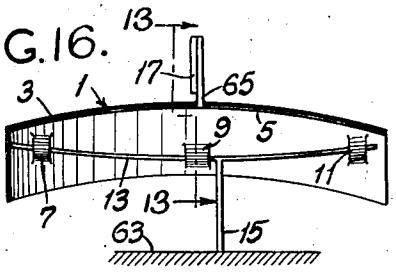


FIG. 18.

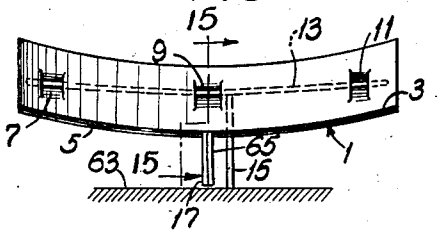
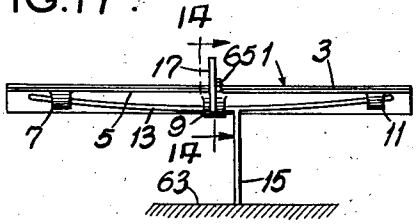


FIG. 17.



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UNITED STATES PATENT OFFICE

2,046,187

THERMOSTAT

Waldo A. Saul, Lexington, Mass., assignor to General Plate Company, Attleboro, Mass., a corporation of Massachusetts

Application August 22, 1934, Serial No. 740,878

13 Claims. (Cl. 297—15)

This invention relates to thermostats, and with regard to certain more specific features, to thermostats having associated therewith an element or combination of elements adapted to effect a control in a new manner.

Among the several objects of the invention may be noted the provision of a thermostat of the class described having associated therewith, in a new manner, an element or combination of elements whereby the change of curvature of the thermostat in response to temperature variation is translated into a utilizable movement; and a thermostat of the class described in which the said relative movement is utilizable to perform a variety of functions, such as signal, valve, and switch operation and the like. Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, features of construction, and arrangements of parts which will be exemplified in the structures hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which are illustrated several of various possible embodiments of the invention,

Fig. 1 is a trimetric view of one embodiment of the invention;

Fig. 2 is a trimetric view similar to Fig. 1, showing the thermostat in its position of opposite curvature;

Fig. 3 is a top plan view of the thermostat of Fig. 1;

Fig. 4 is a top plan view of the thermostat of Fig. 2;

Fig. 5 is a cross section through the thermostat of Fig. 1, taken substantially along lines 5—5 of Figures 1 and 3;

Fig. 6 is a cross section similar to Fig. 5, illustrating a position of the thermostat intermediate the Fig. 5 and Fig. 7 positions;

Fig. 7 is a cross section through the thermostat of Fig. 2, taken substantially along the lines 7—7 of Figures 2 and 4.

Fig. 8 is a trimetric view of a second embodiment of the invention;

Fig. 9 is a trimetric view of a third embodiment of the invention;

Fig. 10 is a cross section through the thermostat of Fig. 9, taken substantially on line 10—10 of Fig. 9;

Fig. 11 is a cross section similar to Fig. 10, but illustrating the thermostat of Fig. 9 in an alternative position;

Fig. 12 is a trimetric view of a fourth embodiment of the invention;

Fig. 13 is a cross section of a fifth embodiment of the invention, taken substantially along line 13—13 of Fig. 16;

Fig. 14 is a cross section similar to Fig. 13, illustrating that embodiment in a more advanced position, and taken substantially along line 14—14 of Fig. 17;

Fig. 15 is a cross section similar to Figures 13 and 14, illustrating that embodiment in a still more advanced position, and taken substantially along line 15—15 of Fig. 18;

Figures 16, 17 and 18 are front elevations of the Fig. 13 embodiment, corresponding in position, respectively, to Figures 13, 14 and 15; and

Fig. 19 is a cross section similar to Fig. 13, but illustrating an electrical switch (sixth) embodiment of the invention.

Similar reference characters indicate corresponding parts throughout the several views of the drawings.

In the group comprising Figures 1 through 7, numeral 1 indicates a sheet or strip or plate of composite thermostatic material, such as bimetal. In the example shown, the upper portion 3 of the plate 1 comprises a metal having a relatively high coefficient of thermal expansion, while the lower portion 5 comprises a metal having a relatively low coefficient of thermal expansion. Hence, when the temperature rises, the plate 1 will exhibit a tendency to change its curvature from that shown in Fig. 1 to that shown in Fig. 2. It is assumed that the plate is initially formed, for the respective "low" temperature at which it is to operate, with the curvature shown in Fig. 1.

Struck from the plate 1 are three loops 7, 9, and 11, which serve as retainers for a bent wire 13. The loops 7, 9, and 11 do not lie in a straight line; that is to say, loop 9 (the central loop) is displaced sidewardly from a straight line connecting loops 7 and 11 when the plate 1 is flat. The wire 13 is of such a diameter, and is so bent, that it passes under the loops 7, 9, and 11. It is not necessarily shaped so as to lie on the surface of the plate 1 between the loops, but may be so made. The wire 13 is made of a stiff resilient material such as spring steel, phosphor bronze or the like. The loops 7, 9, and 11, while holding the wire 13 in relatively close confinement, permit it a slight degree of lateral freedom in movement relative to the plate 1, as will be pointed out more particularly hereinafter.

Extending at right angles from the wire 13

is welded or otherwise immovably affixed a wire 15, which carries on its end a signal flag 17. The wire 15 and flag 17 serve herein as exemplary of the various objects or elements that may be attached to the thermostat to be controlled thereby. They may be replaced, for example, by a movable contact assembly adapted to cooperate with a fixed contact to effect circuit control, or by a rotatable mercury switch (such as is shown, in connection with another embodiment of the present invention, in Fig. 19).

In connection with the operation of this embodiment of the invention, certain of the theoretical aspects underlying the present invention will be pointed out. The bimetallic plate 1, for example, may be considered as a mathematical surface having a curvature. For purposes of definition, it will be stated that a normal to this mathematical surface is a line intersecting the surface and perpendicular to a plane tangent to the surface at the point of intersection. Any plane that contains this normal line is called a normal plane, and the line of intersection of this normal plane with the surface is called a normal section of the surface. Any plane which intersects the surface and which contains no normal lines, is termed an oblique plane, and the line of intersection of such an oblique plane with the surface is called an oblique section of the surface. Now, it is a mathematical proposition that, if it is possible at all (depending upon the nature of the given curve), a plane may be passed through a given point on a surface so as to cut that surface in the form of a given curve having an assigned form only by taking the cutting plane, in general, in a definite position.

The invention embodies the above-stated geometry. The axial lineal element, or wire 13, is hypothetically a curve of assigned form or forms, and, by reason of its articulation to the bimetallic plate 1 (the curved surface), it corresponds to a section curve of the surface. The wire 13, if it is a plane curve, determines a plane which is an oblique plane (it cannot be normal for reasons to be advanced hereinafter). Since the wire is substantially stiff, the shape of the curve of the wire 13 can be altered only within limits. However, the shape (or curvature) of the plate 1 does alter in response to temperature changes. In the abstract, mathematical sense, a second form or curvature of the plate 1 is a new surface, and, in order that the shape curve of the wire 13 shall conform to this new surface and to an oblique section thereof, or parallel to the oblique section but displaced therefrom, it is necessary that the hypothetical oblique plane containing the wire 13 shall move to a new position of obliquity, the motion involving a rotation through a definite angle determined by the extent of change of curvature of the plate 1. Expressed concretely, this rotation of the hypothetical plane to a new angle of obliquity is a rotation of the wire 13 relative to the plate 1, with a consequent change of position of the signal flag 17.

While the wire 13 theoretically represents a complete lineal section of the curved plate 1, there is practically no need for it to be complete, it being sufficient that it comprise three points of contact with the plate 1 (the loops 7, 9, and 11), because three points geometrically serve to locate definitely their corresponding oblique section of the plate 1, and in addition also define the oblique, hypothetical plane which changes its angle of obliquity. Hence, from a practical standpoint, the shape of the wire 13 intermediate the points 7, 9, and 11 is of no consequence, so long as the points 7, 9, and 11 lie in the desired oblique section of the plate 1.

The points 7, 9, and 11 should lie in a plane determining an oblique, and not a normal section of the curved plate 1. The reason for this may be made clear by pointing out the objection to a normal section. A normal section, theoretically at least, would produce a "dead center" condition; the lineal element so positioned would resist relative movement between it and the curved surface, the normality producing, instead of a force tending to produce a relative movement, a force tending to press the lineal element and the curved surface more closely together. This condition would be one of instability, because a slight disturbance or malformation in either direction would initiate the motion, which might then with equal probability be in either direction, and hence not practically utilizable. However, a definite obliquity in one direction, no matter how small, causes the action to be direct, positive, and unidirectional, and hence practically utilizable.

From the above considerations, it will be seen that the invention comprises an element, the curvature of which changes in response to temperature variations, and a second element containing at least three points articulated to the first element and prevented from assuming a straight-line relationship with respect to each other, the three points defining a plane which cuts an oblique section on the plate 1 except when the plate 1 is itself flat. Under the latter condition the plane of the points may lie in a plane parallel to the plate.

The practical operation of this embodiment of the invention may be summarized as follows: Since no end confinements are provided for the plate 1, in the present embodiment, its change of curvature from the Fig. 1 form to the Fig. 2 form will be gradual, and continuous. This means that the tendency of the plate 1, as it starts from its Fig. 1 position, will be to straighten or flatten out. Since the wire 13 is journalled to the plate at three points determining an oblique section in the Fig. 1 position, it will undergo a rotation about a hypothetical axis connecting the loops 7 and 11, to compensate for the change of curvature of the plate 1. Then, as the plate 1 passes from flat position to the position of reverse curvature shown in Fig. 2, this rotation of the wire 13 will continue in the same direction. This rotation of the wire 13 relative to the plate 1 will be seen more clearly in Figures 5, 6, and 7. Fig. 6 also illustrates the condition of the three points positioned in a plane parallel to the plane of the sheet or plate. The rotation of the wire 13 causes angular movement of the wire 15, and the signal 17 is thus moved from one side to the other. No dead center condition is presented so long as the plane of the three points is not normal to the plate.

The embodiment of the invention thus far described is slow-acting; that is, it has, between its extreme positions, an indefinite number of relatively stable intermediate positions each corresponding to a definite ambient temperature. It is useful, for example, as a thermometer, if the flag 17 be replaced by a pointer, and a suitable scale be provided. Then, it provides for a quite considerable angular or rotary movement of the pointer for a relatively slight change of curvature of the plate 1, a feature which is desirable for accurate calibration.

Fig. 8 shows how the slow-acting plate 1 of Fig. 1 may be caused to operate with a snap-action. The difference comprises the addition of a supporting base 19, which has two upright ends 21 having notches 23 therein to receive the ends of plate 1. If the base 19 and ends 21 be sufficiently rigid to resist bending outwardly as the plate 1 tends to straighten itself with increasing temperature, the plate 1 stores its energy until it has accumulated sufficient, whereupon it snaps or moves substantially instantaneously to its position of opposite curvature. Thus the flag 17 is moved instantaneously between its two extreme positions. It will be understood, of course, that the wire 13, etc., are provided in this embodiment in the same form and manner as in the Fig. 1 embodiment.

The transformation of a slow-acting strip or plate of composite thermostatic material into a snap-acting strip or plate, in the above manner, is treated at length in John A. Spencer Patent Nos. 1,602,510 and 1,813,776, and in Eli E. Gregory Patent No. 1,845,998.

In Figures 9, 10, and 11 is shown the adaptation of the invention to a non-developable, dished theromstatic disc 25, which is by itself the subject of John A. Spencer Patent No. 1,448,240. The wire 13 is now applied to the disc 25 in an approximately diametrical manner; that is, the loops 7 and 11 are at diametrically opposite points on the disc 25, but the loop 9 is displaced from the geometrical center of the disc a slight amount in order that it will not lie on the diametrical straight line connecting the loops 7 and 11, thus again determining an oblique, rather than a normal section of the curved surface represented by the disc 25. The disc 25 moves, with changing temperature, from a curvature or dishing in one direction, to an opposite dishing or curvature, with a snap action, in accordance with the teachings of Patent No. 1,448,240. In so doing, it rotates the wire 13 and moves the signal 17 in much the same manner as the Fig. 1 embodiment.

In all of the embodiments heretofore described, the plate 1 has been made of composite thermostatic material. It is not essential that this be so in all cases. Fig. 12, for example, illustrates an embodiment of the invention in which the plate 1 is a monometallic resilient sheet, such as spring brass or steel. The wire 13 and signal flag 17 are mounted thereon by the loops 7, 9, and 11 in the same manner as in the Figures 1 and 8 embodiments; in fact, the support 19 in the present embodiment is the same as the support of the Fig. 8 embodiment. Between the support 19 and the central region of the plate 1 there reacts a U-shaped bimetallic strip 59, the strip 59 being attached at one end to the support and at the other end to the plate 1. As the temperature rises, the U-shaped strip tends to open out; this it can do only by overcentering the plate 1 to a position of opposite curvature. On cooling, the reverse action takes place, the ends of the strip 59 tending to come together to overcenter the plate 1 back to the Fig. 12 position. The motions of plate 1 are thus identical to those of a bimetallic plate, and the wire 13 is thus rotated in the same manner as in the Fig. 8 embodiment. Thus it will be seen that the present invention covers an embodiment wherein the curvature-changing element is not capable of thermostatic movement by itself, but is activated to change its curvature by an outside temperature responsive element. Pressure responsive elements could be used equally well, or elements responsive to other changes.

The U-shaped bimetallic strip 59 is itself exemplary of many temperature responsive devices that might be employed. For example, a gas or fluid-filled bulb and bellows system might replace the strip 59, or a rod-and-tube thermostat. Other thermally or pressure susceptible devices too numerous to mention might also be employed.

In all of the embodiments heretofore described, the wire 13 has been considered as the movable, and the plate 1 the stationary element of the couple. In the embodiment of the invention shown in Figures 13 through 18, the reverse is the case, the wire 13 now being relatively stationary, and the plate 1 relatively movable. This relationship is achieved by embedding or otherwise suitably holding the end of wire 15 in a stationary base 63, and leaving the plate 1 free for movement. The parts are otherwise the same as in the Fig. 1 embodiment of the invention, except that the signal 17 is mounted on a projection 65 extending from the plate 1. The operation of this embodiment is the same as that of the Fig. 1 embodiment, with the exception that the wire 13 is now stationary while the plate 1 undergoes both change of curvature and rotary movement around a hypothetical axis passing through the loops 7 and 11. The coextensive change of shape and rotary movement of the plate 1 is indicated by the successive sectional views, Figures 13, 14, and 15, and the successive elevational views, Figures 16, 17, and 18. The embodiment may obviously be made snap-acting, in any of the manners heretofore described, if desired.

Similarly, the various snap-acting embodiments of the invention heretofore described may likewise be made in accordance with the teachings of the Fig. 13 embodiment, by fixing the angular position of the "rotating" wire and permitting the plate to undergo both the rotation and the change of shape about the wire. For example, the wire 15 of the Fig. 9 embodiment may be held rigid, thereby forcing the disc 25 to rotate about the wire 13.

It will be noted that when a wire or bent shaft is used its disposition between the three points must be such that it will not interfere with the change of curvature of the plate 1.

In all of the embodiments heretofore shown and described, the useful work of the thermostat has been either as a signal or, impliedly, as a control such as a valve. It will be obvious that the relative movement characteristic of the invention may likewise be employed for the actuation of an electric switch. As exemplary of this feature of the invention, Fig. 19 shows the embodiment of Fig. 13 with the signal flag 17 thereof replaced by a mercury switch 55 carried directly on the plate 1. Upon change of position (rotation) of the plate 1 in response to temperature changes, the switch 55 is rotated, thereby moving the pool of mercury indicated by numeral 57 to make and break contacts. It is obvious that other forms of electrical contacts may well be used, and that this or any other forms of electrical contacts may be applied to the other embodiments of the invention.

My copending application Serial No. 641,456, filed November 5, 1932, shows a further specific embodiment of the present invention wherein the disc 25 of the Fig. 9 embodiment of this application is replaced by a snap-acting, radially corrugated thermostatic disc of the general type shown in John A. Spencer Patent 1,895,590, dated January 31, 1933.

In all of the embodiments of the invention, as

shown in the drawings, the extent of curvature of the various thermostatic elements has been exaggerated relative to their size, in order more clearly to show the effects of the change of curvature. In practical embodiments of the invention, these curvatures are relatively slight.

It is also to be noted that the thicknesses of the plates throughout the drawings have been greatly exaggerated with respect to the sizes of the plates, in order to show more clearly their bimetallic construction, where such (specifically) is used.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in carrying out the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A thermostat comprising means the curvature of which changes in response to temperature variations, and second means articulated to said first means, said second means containing three spaced points determining a non-normal plane to the first means, said three points always maintaining a non-linear relationship.

2. A thermostat comprising means, the curvature of which changes in response to temperature variations, and second means articulated to said first means, said second means containing at least three spaced points, said points determining a hypothetical plane which is oblique to the first means at certain temperatures, said three points never reaching a straight line position with respect to each other during changes of curvature of said first means, whereby, upon change of curvature of said first means, the angle of obliquity of said hypothetical plane changes.

3. A thermostat comprising a plate of composite thermostatic metal, the curvature of which changes in response to temperature variations, and which at one temperature is substantially flat, an element of substantially lineal form articulated to said plate at at least three spaced points, said points at certain temperatures determining an oblique section of said plate, and at said one temperature lying in a plane parallel to the plane of the plate, said three spaced points comprising means securely attached to said plate, whereby, upon changes of curvature of said plate, relative rotary motion is had between said plate and said lineal element.

4. A thermostat as set forth in claim 2, in which the thermostatic plate comprises a non-developable disc.

5. A thermostat as set forth in claim 2, in which the first means is relatively fixed in position, whereby the second means undergoes movement.

6. A thermostat as set forth in claim 2, in which the second means is relatively fixed in position, whereby the first means undergoes movement.

7. A thermostat as set forth in claim 2, in which the means articulating the first and second means together permit a degree of lateral lost-motion between said first and second means.

8. A thermostat comprising a plate of composite thermostatic material, an element, means connecting said element to said plate at the extremities of said plate, and additional means connecting said element to a central point on said plate, said central point being displaced from a normal plane passing through the two outer points of contact of said element with said plate.

9. A thermostat comprising a plate of composite thermostatic material, an element, means connecting said element to said plate at the extremities of said plate, and additional means connecting said element to a central point on said plate, said central point being displaced from a normal plane passing through the two outer points of contact of said element with said plate, at least one of said connecting means providing for a limited degree of lateral lost-motion between said element and said plate.

10. A thermostat comprising a plate of composite thermostatic material, an element, means connecting said element to said plate at the extremities of said plate, and additional means connecting said element to a central point on said plate, said central point being displaced from a normal plane passing through the two outer points of contact of said element with said plate, said plate being held in a relatively fixed position, whereby, upon change of curvature of said plate incident to variation of external temperature, said element is forced to rotate.

11. A thermostat comprising a plate of composite thermostatic material, an element, means connecting said element to said plate at the extremities of said plate, and additional means connecting said element to a central point on said plate, said central point being displaced from a normal plane passing through the two outer points of contact of said element with said plate, said element being held in a relatively fixed position, whereby, upon change of curvature of said plate incident to variation of external temperature, said plate is forced to rotate about said element.

12. A thermostat comprising a plate of composite thermostatic material, an element, means connecting said element to said plate at the extremities of said plate, and additional means connecting said element to a central point on said plate, said central point being displaced from a normal plane passing through the two outer points of contact of said element with said plate, said plate being in the form of a dished disc, whereby it is adapted, upon change of external temperature, to snap into a position of opposite curvature.

13. A thermostat comprising a plate of composite thermostatic material, an element, means connecting said element to said plate at the extremities of said plate, and additional means connecting said element to a central point on said plate, said central point being displaced from a normal plane passing through the two outer points of contact of said element with said plate, said plate being in the form of a dished disc, whereby it is adapted, upon change of external temperature, to snap into a position of opposite curvature, said disc being held in a relatively fixed position, whereby, upon reversal of curvature of said disc, said element is forced to rotate.

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