June 18, 1940. L. K. DAVIS 2,204,791

MOVEMENT PRODUCING DEVICE

Original Filed May 31, 1935

Fig. 1

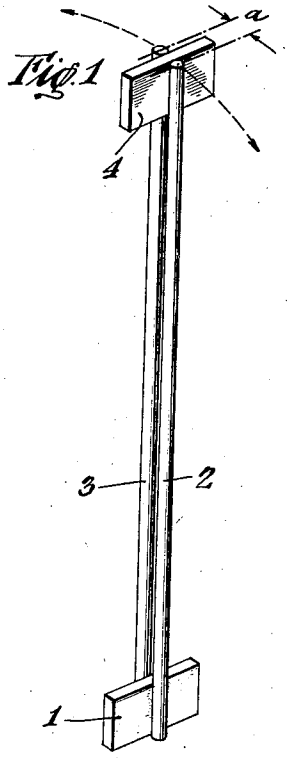



Fig. 2

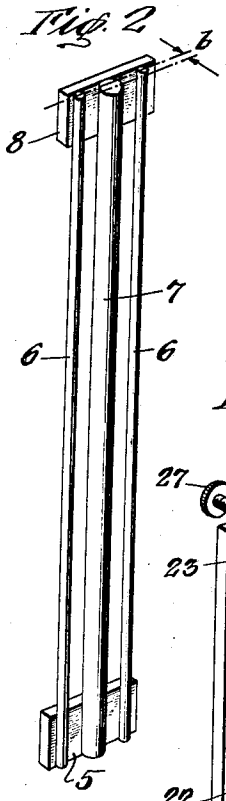



Fig. 3

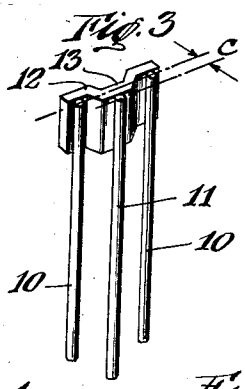



Fig. 4

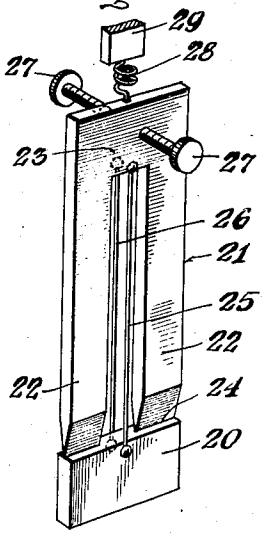



Fig. 5

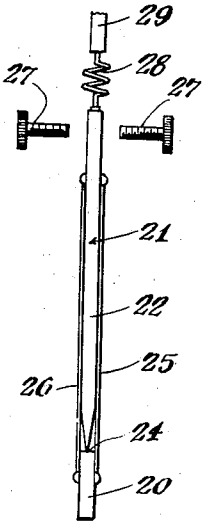



Fig. 6

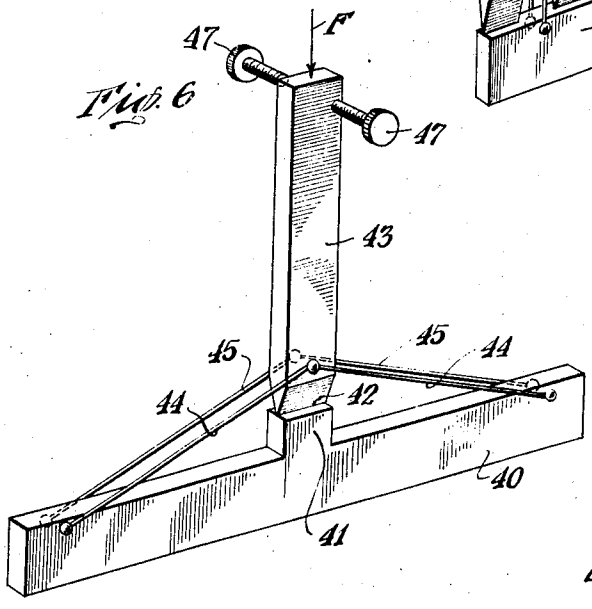
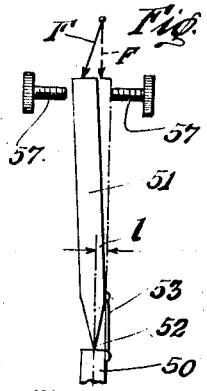



Fig. 7




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## MOVEMENT-PRODUCING DEVICE

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Application May 31, 1935, Serial No. 24,180
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7 Claims. (Cl. 297—11)

This invention relates to movement-producing devices, and particularly to thermostats, hygrostats and the like, which are responsive to a predetermined change in the physical condition of the surrounding medium to produce movement of a member, whereby to indicate such change or to operate an associated device such as a valve, switch, indicator or other device.

In one principal, illustrative embodiment, the invention consists in a device of the class described having an angularly movable member, and one or more pairs of spaced, elongate members attached to the movable member on opposite sides of the pivot thereof, and responsive to undergo dissimilar changes in length upon a change in the temperature, humidity or other preselected physical condition of the surrounding medium, whereby to move the movable member about its pivot. The elongate members may be spaced close together to provide a high sensitivity of the device by attaching them to opposite faces of the movable member, where the latter is thin, or by forming them of different diameters and attaching them to the same face of the movable member, or by attaching them to variably offset portions of the movable member, or in other ways.

In one embodiment of the invention, the movable member may be mounted for angular movement substantially free of retarding effects except those due to the elongate members, and may have associated with it means for establishing a position of instability of the movable member whereby, when the elongate members move the movable member a predetermined amount, it is thereafter moved rapidly by the associated means and independently of the action of the elongate members.

A feature of the invention consists in the provision of a device of the class described, wherein the element which is responsive to change its length is of small mass relative to its length, and is so attached to the other elements of the device that a relatively large proportion of the area of the former is exposed to the surrounding medium whereby the device is quickly responsive to a change in the preselected condition of the surrounding medium.

Another feature of the invention is the provision of a device of the class described, consisting of relatively few and simple parts which may be independently formed and treated, and readily assembled with simple tools and operations after being partially or completely formed.

The invention also consists in certain new and original features of construction and combinations of parts hereinafter set forth and claimed.

Although the novel features which are believed to be characteristic of this invention will be particularly pointed out in the claims appended hereto, the invention itself, as to its objects and advantages, and the manner in which it may be carried out, may be better understood by referring to the following description taken in connection with the accompanying drawing forming a part thereof, in which

Fig. 1 is a perspective view of a thermostat constructed according to the invention;

Fig. 2 is a similar view of another embodiment of the invention;

Fig. 3 is a fragmentary perspective view of a portion of still another embodiment;

Fig. 4 is a somewhat diagrammatic perspective view of a thermostat constructed according to the invention adapted to operate with a "snap-action";

Fig. 5 is an end elevational view of the device shown in Fig. 4;

Fig. 6 is a perspective view of a modified form of the device shown in Fig. 4; and

Fig. 7 is an end elevational view of a further modification.

In the following description and in the claims, various details will be identified by specific names for convenience, but they are intended to be as generic in their application as the art will permit.

A thermostat constructed according to the invention comprises a stationary member 1, supported by suitable means (not shown), a pair of elongate rods 2 and 3 of dissimilar thermal expansibilities, secured to the support 1 as by welding, and extending therefrom in spaced parallel relation, and a movable member or top piece 4 inserted between the free ends of the rods 2 and 3, and secured thereto.

The rods 2 and 3 are constituted by materials having different thermal expansibilities, and are shown as being of the same diameter but may be made, if desired, of different diameters.

Preferably, each rod is formed from a single material which may be said to be more or less homogeneous, such as an element, compound, alloy or the like. In any case, each rod is so formed that it is substantially homogeneously expansible throughout, when subjected to a suitable stimulus. In other words, it has a substantially uniform coefficient of thermal expansibility throughout all portions, as distinguished from "bimetal," which is constituted by two materials of dissimilar thermal coefficients joined over a substantial area to form a unitary member of which the several component materials have different thermal expansibilities.

The rods 2 and 3 may be of the same length and diameter, and may be attached to opposite faces of the stationary member 1 and the movable member 4 respectively at corresponding points. However, the rods 2 and 3 may be of different lengths and/or diameters, and may be attached

to different points on the associated members, if the sizes, arrangement and thermal expansibilities are suitably selected to provide a differential expansibility of the rods 2 and 3.

Assuming the rod 2 to have a greater thermal expansibility than the rod 3, upon an increase in temperature, the rod 2 elongates to a greater extent than the rod 3. The rod 3 tends to restrain the elongation of the rod 2, and hence a force movement is produced which tends to move the member 4 angularly and causes the rods 2 and 3 to be bowed, whereby the upper ends of the rods 2 and 3 are moved in the direction indicated by the arrow, and carry the movable member 4 out of its initial position. Upon a decrease in temperature, a reverse action takes place, and the rods 2 and 3 move toward their initial positions, and, upon a further decrease in temperature, are bent in the opposite direction by their differential contraction.

The movement of the movable member 4 may be utilized in ways known to those skilled in the art for actuating a switch, a valve, an indicator, or other associated device, or the member 4 may itself constitute one element of such device, or may be employed, without other elements, to indicate by its movement, a change in temperature.

It will be observed that the force exerted by the rods 2 and 3 upon the member 4, to move the same angularly, may be considered as exerted on a lever arm *a* equal in length to the distance between the longitudinal axes of the rods 2 and 3. It will likewise be seen that the longer this arm, the greater will be the differential elongation or contraction of the rods necessary to move the member 4 through a predetermined angle. Thus, the smaller the arm *a*, the greater will be the angular movement of the member 4 upon a predetermined differential elongation or contraction of the rods 2 and 3.

One manner in which this distance between the longitudinal axes of the rods may be made very small is illustrated in Fig. 2. In this embodiment, a support 5 is mounted by suitable means (not shown), and has secured to one face thereof a pair of rods 6 of similar thermal expansibilities, and a rod 7 disposed intermediate the rods 6, and having a different thermal expansibility and a greater diameter. Secured to the upper ends of the rods 6 and the rod 7, is a movable member 8, the rods being so arranged that they all are secured to the same face of the movable member 8.

Thus, the distance *b* between the axis of the rod 7 and a plane passing through the axis of the rods 6 is equal to the difference in the radii of the rods 6 and the rod 7, and hence may be made very small by providing complementary rods varying only slightly in diameter.

The operation of this form of thermostat is analogous to that of the first form. Upon a differential elongation of the rods 6 and the rod 7, the movable member is moved angularly about a pivot lying in a plane passing between and parallel to the longitudinal axes of the rods 6 and the rod 7, and causes the upper ends of the rods to be moved as above-described. Upon a decrease in temperature, the differential contraction causes movement of the member 8 in an opposite direction.

The use of a plurality of rods of similar expansibilities serves to balance the stress set up in the top member 8, and prevents the same from twisting when the differential elongation of the rods takes place.

The separation of the axes of the rods may be accomplished in other manners than that shown in Fig. 2, another of which is shown in Fig. 3, and consists in forming the movable member with an offset portion. In this form, a plurality of rods 10 of similar thermal expansibilities are provided, and are attached in spaced relation to the same face of a movable member 12 which is provided with an offset portion 13, to which is attached the end of a rod 11 having different thermal expansibility than the rods 10.

It will be seen that the distance *c* between the axis of the rod 11 and a plane passing through the axes of the rods 10 may be made as small as desired, by suitable proportioning of the offset portion 13.

The foregoing embodiments of the invention have been disclosed as employing rods to provide the differential expansion action, but it is within the contemplation of the invention to employ wires of very small diameters. Where wires are employed which have insufficient stiffness to exert a push when elongated by an increase in temperature, it is necessary to provide suitable means tending to separate the top member and the support, to maintain the wires under tension. In this form, the differential action which imparts movement to the movable member is effected in a somewhat analogous manner to that where rods are used, but the action results from the change in the differential pull of the wires when the temperature changes.

A thermostat, constructed to operate with a "snap-action," is illustrated in Figs. 4 and 5. The thermostat comprises a base 20, suitably supported, on which rests a U-shaped member 21 having a pair of parallel legs 22 and a top connecting portion 23. The legs 22 are provided with tapered portions at their lower ends, forming "knife-edges" 24 bearing upon the top surface of the base 20, and providing a pivotal "line contact" between the base 20 and the member 21. Suitably connected to a face of the base 20 and to the corresponding face of the top portion 23, is a wire 25 which is normally under sufficient tension to maintain it taut. A wire 26 having a different thermal expansibility than the wire 25 is similarly connected to the other faces of the base 20 and the portion 23.

Suitably mounted above the member 21 is a spring support 29, to which is connected a coil spring 28 suitably attached to the top edge of the member 21. The spring is so proportioned and disposed that, when the member 21 is in vertical position, the spring 25 is under compression, thus establishing the vertical position of the member 21 as a position of instability from which the spring 25 tends to force it in either direction.

Suitable adjustable stop members 27 are provided on each side of the top portion 23 of the member 21 for limiting its movement in either direction.

Assuming the member 21 to be resting against the right-hand stop 27, and assuming the wire 25 to have a greater thermal expansibility than the wire 26, upon an increase in temperature the wire 25 elongates more rapidly than the wire 26, thus decreasing the tension exerted by the wire 25 tending to hold the member 21 against the stop 27. The force exerted by the wire 26 tending to rotate the member 21 in a counterclockwise direction (as viewed in Fig. 5) then becomes greater than the force exerted by the wire 25, and the member 21 is moved toward and through the vertical position. As the member 21 moves

through the vertical position, the spring 28 exerts a force upon the upper end of the member 21 to rotate it rapidly into position against the left-hand stop member 27.

Thus, it will be observed that, upon a predetermined change in temperature, the movable member 21 is moved from its initial position toward its other position, and is "snapped" into the other position with an accelerated action which gives a positive indication that the movement from one position to the other has taken place.

A thermostat of relatively high sensitivity may be constructed by disposing the thermally-responsive wires at an angle to the movable member. The thermostat embodying this feature is illustrated in Fig. 6, and comprises a support 40 having an upstanding portion 41 upon which rests a knife-edge portion 42 of a movable member 43. A pair of wires 44, having similar thermal expansibilities, each are connected at one end to the movable member 43 at a point near the tapered portion, and at their other ends are connected respectively to the opposite end portions of the support 40. A second pair of wires 45, having similar thermal expansibilities, but different from the wires 44, are connected to the opposite faces of the movable member 43 and the support 40, in a manner similar to that in which the wires 44 are connected.

Suitable stops 47 are provided similarly to those in the previously described form. Also, a suitable force-exerting means (not shown), which may be a spring, is provided for exerting a force F on the top end of the movable member 43 for establishing the vertical position of the movable member 43 as a position of unstable equilibrium.

The operation of this form of thermostat is similar to that of the form illustrated in Figs. 4 and 5, except that a predetermined elongation or contraction of the wires effects a correspondingly greater extent of movement of the point of attachment of the wires to the movable member, than where the complementary wires lie in a plane perpendicular to the line of the pivot of the movable member.

It will be obvious that in the form illustrated in Figs. 4 and 5, the extent of movement of the point of attachment of either wire to the movable member is the same as that of the elongation or contraction of the wire; whereas, in the form illustrated in Fig. 6, the extent of movement of the point of attachment of the wire is substantially greater than the elongation or contraction of the wire, thus providing a multiplying action which provides a relatively greater angular movement of the movable member in accordance with a small change in the length of the wires than is provided by the same change in the length of the wires in the previously described form.

In Fig. 7 is shown a thermostat constructed in a manner substantially similar to those previously described, but employing only a single thermally-responsive wire. The thermostat comprises a support 50, on which is pivotally supported a movable member 51 having a knife-edge 52. Suitable means (not shown) are provided for exerting a force F upon the upper end of the movable member, as indicated by the arrow, to bias the upper end of the movable member 51 in a counterclockwise direction (as viewed in Fig. 7). A single wire 53 is connected between the support 50 and the movable member 51, and is normally under tension.

The position of instability of the movable member 51 occurs when the force moment, exerted by the force F tending to rotate the movable member 51 in a counterclockwise direction, is balanced by the force moment exerted by the wire 53 tending to rotate the movable member 51 in a clockwise direction. Assuming the movable member 51 to be in the position of instability, an increase in temperature will cause the wire 53 to elongate and thus decrease the force exerted thereby, whereupon the moment exerted by the force F becomes greater, and moves the movable member 51 in a counterclockwise direction. As the movable member 51 is moved angularly out of the position of instability, the lever arm l becomes increasingly less, and thus the moment exerted by the wire 53 becomes increasingly less. Owing to this decrease in the moment exerted by the wire 53, the predominance of the moment exerted by the force F increases and the movable member 51 is moved rapidly in a counterclockwise direction.

Assuming the movable member 51 to be in its position of instability, upon a decrease in the temperature, the wire 53 contracts and rotates the movable member 51 in a clockwise direction. Upon this happening, the lever arm l becomes increasingly larger, and thus the predominance of the moment exerted by the wire 53 over the moment exerted by the force F becomes rapidly larger, and the movable member 51 is moved rapidly toward the vertical position.

Suitable stop members 57 are provided and disposed at such positions so as to prevent the movable member 51 from being moved to such an extent in a counterclockwise direction that the arm l becomes zero, and to prevent the movable member 51 from assuming a vertical position from which it would be impossible for the forces heretofore explained to return the movable member 51 to its position of instability.

Various other modifications of the invention may be made, as will be aparent to those skilled in the art. It is not necessary that the thermal responsive members be limited to the special forms here shown, but may be constituted by wires, rods, strips or other elongate members of relatively small mass.

Various means for attaching the thermally-responsive members to the other members may be employed. In the case of rods, they may be threaded, pinned, welded and may be adjustably or otherwise secured in any one of a variety of ways. In the case of wires, they may be soldered, wound around pins of the "piano type," or otherwise secured in any suitable fashion, either adjustably or non-adjustably.

The inventive concept may be applied to other devices than thermostats, for instance, the wires or rods may be coated with platinum oxide or other material which becomes heated upon contact with certain substances, such as gases, and a device can be employed to detect and indicate the presence of such gases. In this device, the presence of certain gases causes the platinum oxide to become heated, and thus changes the temperature of the thermally-responsive member, whereupon the movable member is moved to actuate suitable indicating apparatus and other associated devices.

Another adaptation of the present invention consists in employing hygroscopic filaments instead of the wires or rods shown. In this form of the invention, a change in the relative humidity of the atmosphere surrounding the device causes differential elongation or contraction of the humidity-responsive member or members to

move the movable member attached thereto, and thus indicate the change in relative humidity or effect the operation of an associated device to indicate or record the predetermined change in relative humidity.

One important advantage of the present invention results from the use of responsive members of relatively small mass which react very quickly to change their lengths in accordance with a change in the external stimulus. In the thermostat, for example, the wire has a relatively small diameter, and hence is heated or cooled very quickly in accordance with the change in the temperature of the surrounding atmosphere, and hence actuates the movable member without substantial lag. Also, since the responsive members are not connected directly to each other, and are attached to the associated members at relatively small portions of their lengths, a relatively large area of the responsive members is exposed to the surrounding medium whereby the members are quickly responsive to a change in the physical condition of the medium.

Another feature of the invention which adds to the sensitivity of the device is the manner in which the movable member is supported, and moves with substantially no friction. As will be understood by those skilled in the art, the knife-edge may be formed of hardened material, and may be extremely sharp so as to be substantially frictionless, and the spring arrangement may be made to exert a relatively light force upon the movable member and permit movement thereof with very little retarding force.

As will be apparent, the device may be constructed, according to the present invention, to consist of relatively few parts of simple construction, and the assembly thereof may be made with relative ease and without the necessity of employing complicated or expensive machinery. Inasmuch as the several parts may be separately formed and then assembled, any desired mode of formation or treatment, such as heat treatment, may be given any one of the component parts individually and without affecting the condition of any of the other parts.

While certain novel features of the invention have been disclosed and are pointed out in the annexed claims, it will be understood that various omissions, substitutions and changes may be made by those skilled in the art without departing from the spirit of the invention.

What is claimed is:

1. A thermostat comprising a support, a pair of elongate members of dissimilar thermal expansibilities and dissimilar cross sectional dimentions, means rigidly securing said elongate members to said support in spaced parallel relation, a movable member, and means rigidly securing said elongate members to the same plane face of said movable member, whereby the centers of action of said elongate members are offset in the direction of movement.

2. In a thermostat, a movable member comprising a plurality of elongate elements extending in the same general direction and having different co-efficients of expansion, means for rigidly securing said elements together at spaced points so that the distance between centers of action of said elements in the direction of movement is less than one-half the combined cross dimension of any two dissimilar elements in the direction of movement, said elements being unattached between said spaced points.

3. In a movement producing device, a movable member comprising a plurality of elongate elements extending in the same general direction and being susceptible of differential change in length upon a change in the condition of the surrounding medium, said elements being spaced in a second direction substantially perpendicular to the direction of their lengths, means for fixedly mounting said member so that said differential change produces a flexure in said elements in a direction substantially at right angles to said first and second directions.

4. In a thermostat, a fixed support, a central elongate member rigidly secured to said support, a pair of second elongate members rigidly secured to said fixed support on opposite sides of said first elongate member and extending in the same general direction therewith, means for rigidly securing the free ends of said elongate members together, said first and second elongate members having different expansion co-efficients, the projections of said first and second elements on a plane parallel to their lengths and to their direction of movement overlapping.

5. In a movement-producing device, a movable member, a stationary member, a plurality of dissimilar elongated elements susceptible to differential change in their effective lengths upon change in the condition of the surrounding medium, means for rigidly securing said elements at one end to said movable member and at the other end to said stationary member so that the distance between the effective centers of action of any two dissimilar elements in the direction of movement is less than one-half the combined cross dimension of said dissimilar elements in the direction of movement.

6. In a movement-producing device, a support, a plurality of separate elongate members of different effective transverse dimensions and each homogeneously susceptible to differential change in effective length upon change in condition of the surrounding medium, means rigidly securing said members to said support at one end, and means rigidly connecting said members at a point remote from said support the difference in transverse dimensions providing an offset of the centers of action of said members, said members being unconnected between said support and said rigid connection, the connected unsupported ends of said members being active, upon a predetermined change in the condition of the surrounding medium, to move as a unit transversely to the length of said members and in the direction of offset.

7. In a device responsive to change in physical condition, a movable member comprising a plurality of elongate, self-supporting, individual, uniformly expansible elements extending in the same general direction and having different co-efficients of expansion, means for rigidly connecting said elements together at spaced points so that the axes thereof are offset in the directions of both least and most resistance to flexure, whereby said elements flex between said spaced points in response to change in condition.

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