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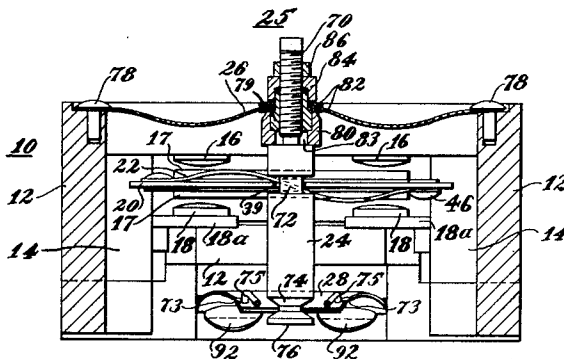
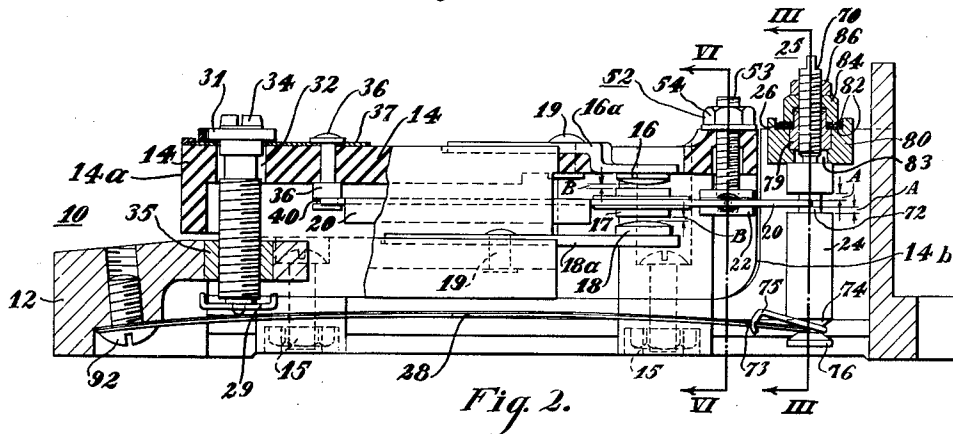
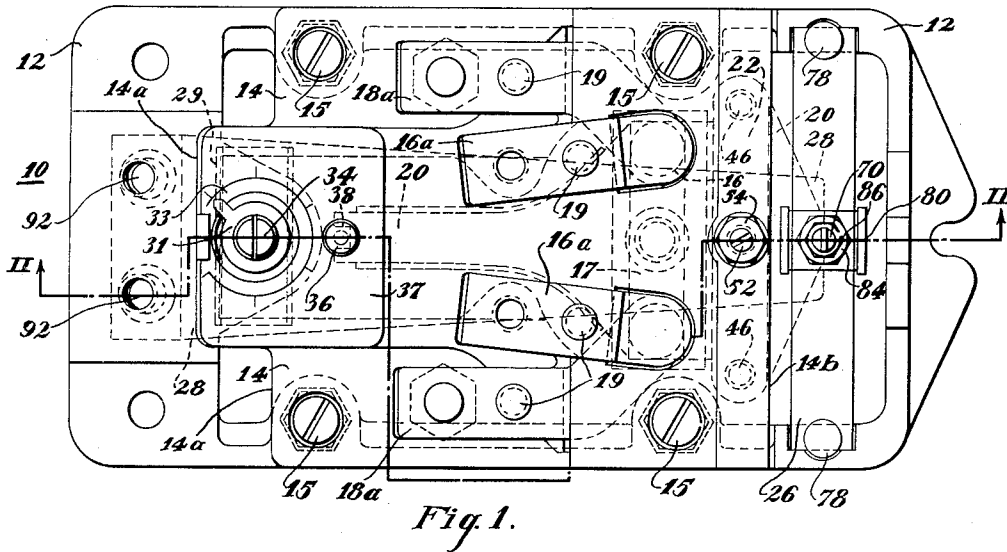
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2,189,627

HEAVY DUTY SNAP-ACTING THERMOSTAT

Filed March 25, 1938

4 Sheets-Sheet 1



WITNESSES:

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HEAVY DUTY SNAP-ACTING THERMOSTAT

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4 Sheets-Sheet 2

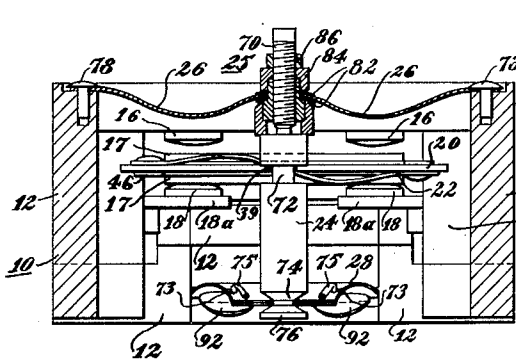


Fig. 4.

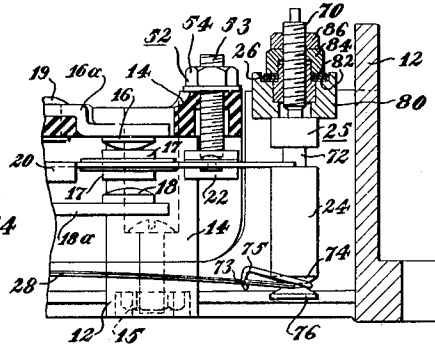


Fig. 5.

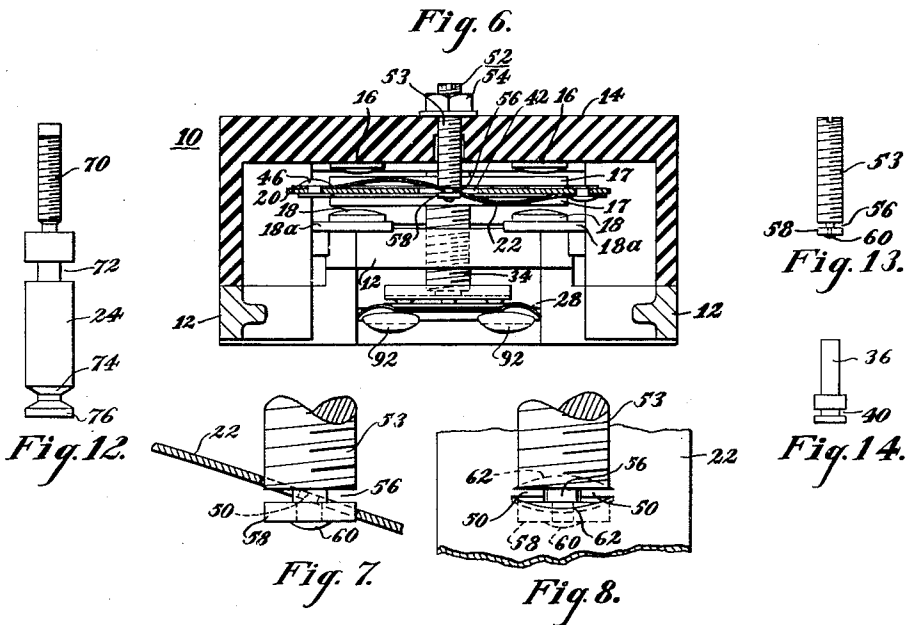


Fig. 6.

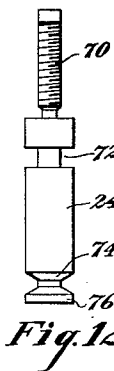


Fig. 12.

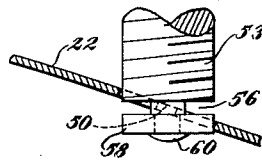


Fig. 7.

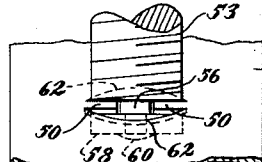


Fig. 8.

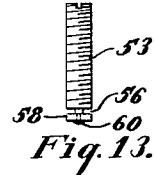


Fig. 13.

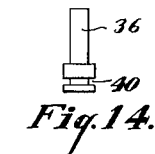


Fig. 14.



Fig. 9.



Fig. 11.



Fig. 10.

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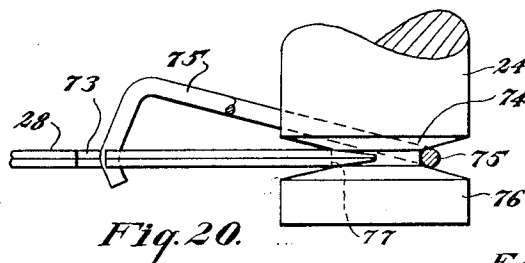
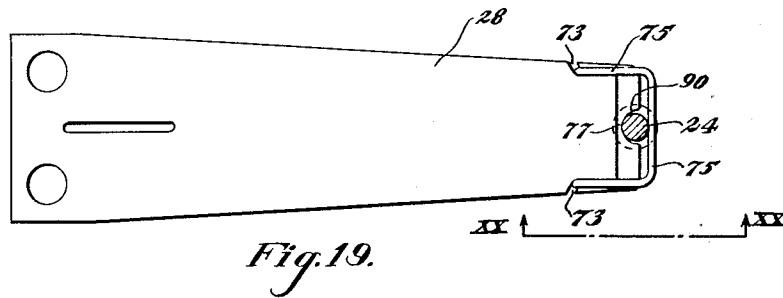
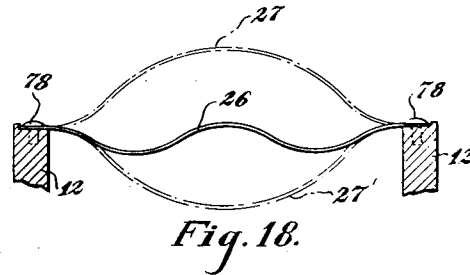
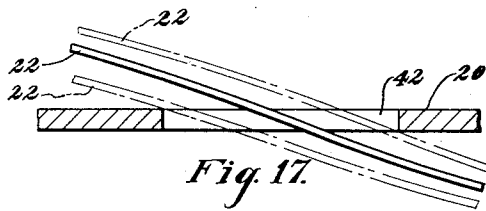
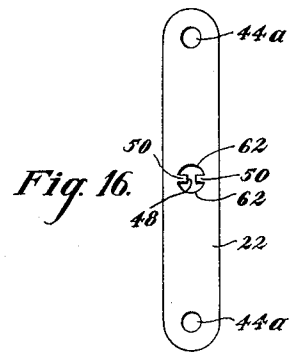
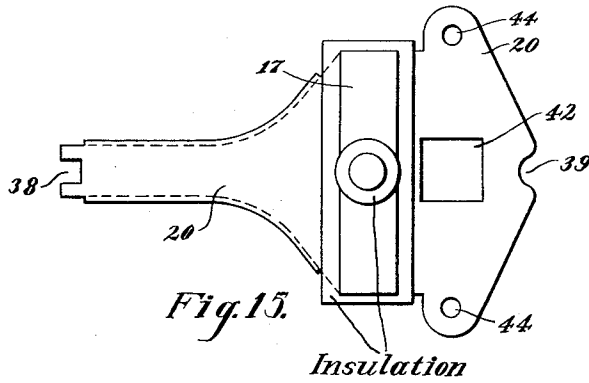
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2,189,627

HEAVY DUTY SNAP-ACTING THERMOSTAT

Filed March 25, 1938

4 Sheets-Sheet 3



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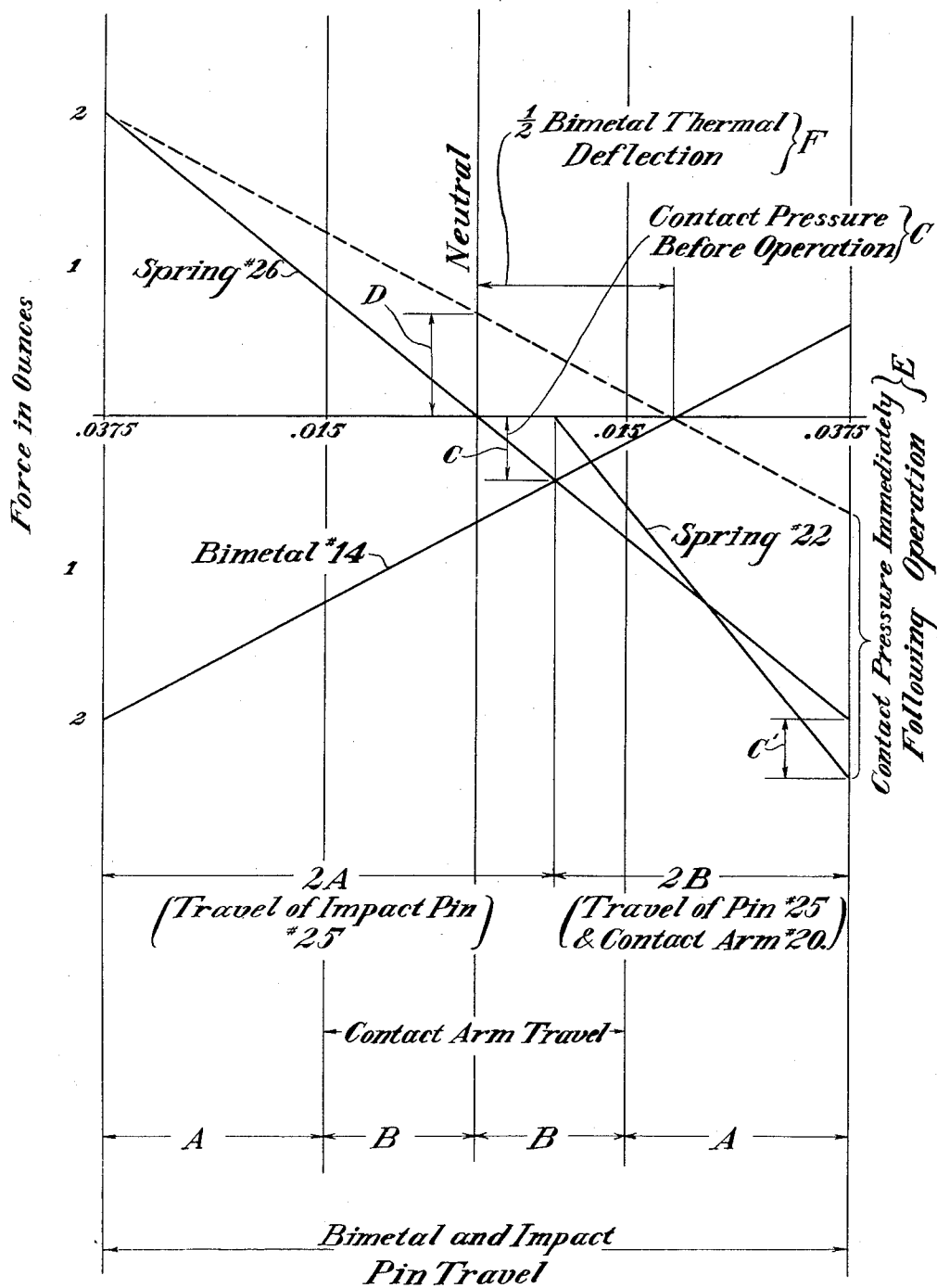
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2,189,627

HEAVY DUTY SNAP-ACTING THERMOSTAT

Filed March 25, 1938

4 Sheets-Sheet 4



WITNESSES:

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Displacement in Inches

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Fig. 21.

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UNITED STATES PATENT OFFICE

2,189,627

HEAVY DUTY SNAP-ACTING THERMOSTAT

Earl K. Clark, Mansfield, Ohio, assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application March 25, 1938, Serial No. 198,077

11 Claims. (Cl. 200—138)

My invention relates to snap-acting thermostats, and more particularly to a heavy-duty snap-acting thermostat particularly adapted for use in water heaters.

5 An object of my invention is to provide a sensitive snap-acting thermostat which may be mounted directly against a water tank wall and operate with a bimetal to water temperature ratio of 1:1, in contrast with the now well-known method of mounting such thermostats on the head of the water heating element, which, therefor have a bimetal to water temperature ratio of, say 2:1.

10 A further object of my invention is to provide a heavy-duty snap-acting thermostat which will have a uniform average temperature range of operation with a constant amplitude over its whole range, so that such thermostat may be marked directly in degrees, such as Fahrenheit or centigrade.

20 A further object of my invention is to provide a positive-action snap-acting heavy-duty thermostat capable of handling at least five kw. of power with a low heating rate of say, from about 5 to 15 degrees per hour and a cooling rate of, say, 2 degrees per hour.

30 A further object of my invention is to provide a snap-acting thermostat having a plurality of springs or resilient members compressed into elastic curves between rigid supports for producing the snap action of such thermostat by eliminating frictional factors and by possessing a freedom of overcenter action.

40 A still further object of my invention is to provide a snap-acting thermostat having a plurality of springs or resilient members compressed into elastic curves between rigid supports, whereby such members cannot be jarred loose from such supports so as to alter the calibration of the thermostat; thus producing a thermostat which will have a permanent calibration.

50 A further object of my invention is to provide an elastic or resilient supporting member for exerting a decreasingly biasing action upon a device supported thereby as the device and resilient member move away from a given position. This action, in turn produces a snap action of the supported device without any frictional engagement between such device and resilient member.

55 A further object of my invention is to provide a resilient member which when rigidly attached to a movable device will prohibit the movement of such device in the plane thereof but will per-

mit and ensure snap-action of the device in a direction normal to the plane thereof.

A further object of my invention is to provide a thermostat in which the contact pressure does not diminish to zero at the snapping temperature but maintains a minimum irreducible contact pressure until switching takes place by impact.

Other objects of my invention will either be pointed out specifically in the course of the following description of a device embodying my invention, or will be apparent from such description.

In the accompanying drawings:

Figure 1 is a top plan view of a device embodying my invention;

Fig. 2 is a side view, partially in elevation and partially in section, taken along the broken line II—II of the device shown in Fig. 1;

Fig. 3 is a sectional view taken along the line III—III of Fig. 2;

Fig. 4 is a view similar to Fig. 3 with the device in one of its operative positions;

Fig. 5 is a fragmentary view, taken along the right-hand end of the line II—II of Fig. 1, with the device in its second operating position;

Fig. 6 is a sectional view taken along the line VI—VI of Fig. 2;

Figs. 7, 8 and 9 are enlarged elevational views of portions of the device shown in Figs. 1 and 2;

Fig. 10 is a sectional view taken along the line X—X of Fig. 9;

Fig. 11 is a sectional view taken along the line XI—XI of Fig. 10;

Figs. 12, 13 and 14 are elevational views of various parts incorporated in the device shown in Figs. 1 and 2;

Figs. 15 and 16 are top plan views of two members constituting parts of the device embodying my invention;

Figs. 17 and 18 are views indicating various positions of portions of the device embodying my invention;

Fig. 19 is an elevational and partial sectional view illustrating the mounting of a bimetallic member in the device shown in Figs. 1 and 2;

Fig. 20 is an enlarged partial elevational view taken in the direction indicated by line XX—XX of Fig. 19; and

Fig. 21 is a graph illustrating the operating principle of the device embodying my invention.

Referring to the accompanying drawings, I show a heavy-duty water heater thermostat or instantaneous thermo-switch 10 including a casing 12, an inner insulating switch support mem-

ber 14 having mounted thereon stationary contacts 16 and 18, a movable contact arm 20 mounted near one end on resilient member 22 and operatively associated with an impact pin assembly 25. The impact pin assembly 25 includes an impact pin 24 which is rigidly attached to a second resilient member 26 and operatively associated with a heat-responsive device 28.

As is hereinafter described in greater detail, and as shown in Figs. 1 to 6, inclusive, and 21, the movable contact arm 20 is rotatably attached at one end to the inner insulating switch support member 14 and operatively associated with the impact pin assembly 25 at the other end. A resilient member 22 is rigidly attached to the movable contact arm 20 and to an adjusting screw assembly 52 which in combination act as a second support for the contact arm 20. A movable contact 17, mounted intermediate the ends of arm 20, selectively engages either pair of stationary contacts 16 or 18 as the contact arm 20 moves in response to the movement of the operatively associated impact pin assembly 25. The resilient member 22 through the cooperative action of adjusting screw assembly 52 biases the contact arm 20 so that the movable contact 17 will always have a positive contact pressure with either cooperating stationary contact 16 or 18, and produces a snap-action of the contact arm 20 as it is moved from one operating position to another. In addition, the impact pin assembly 25, including the frictionlessly operating resilient member 26, is operatively associated with the heat responsive device 28 and transmits the movements of such device to the contact arm 20. The resilient member 26 applies a force to the impact pin assembly 25 and heat responsive device 28 which tends to hold them in one of their limiting positions, and as they move, to decreasingly resist the movement thereof away from said position. This in turn produces a snap action of the impact pin assembly 25 and heat responsive device 28 as the temperature of the device reaches a predetermined operating value. Inasmuch as the contact arm 20 is operatively associated with the impact pin assembly 25, and, therefore, the heat responsive device 28, the contact arm 20 will be moved from one operating position to another in response to the movements of heat responsive device 28. This movement will be snap acting in both directions, due to the combined action of resilient member 22 and the snap action of the impact pin assembly 25.

Referring to the thermostat 10 in greater detail, the casing 12 is preferably made of a die-cast construction and of such metallic material that it will withstand severe mechanical shock and readily conduct heat. However, it is to be understood that the casing 12 may be formed of any material desired and may be made in any manner whatsoever so long as it affords suitable means for mounting the operative parts of the thermostat thereon.

The inner switch support member 14 is preferably formed of substantially flat suitably apertured insulating material and, in general, is rectangular in shape, having end surfaces indicated by the reference characters 14a and 14b. Member 14 supports the movable contact arm 20 and stationary contacts 16 and 18, as hereinafter described in detail. Member 14 is rigidly attached to the casing 12 by a plurality of screws 15. The inner support member 14 has an aperture 32 extending vertically therethrough,

through which a suitable control shaft 34 may be inserted, as hereinafter described.

Stationary contacts 16 and 18 (two of each) are respectively mounted on bent straps 16a and 18a, which are preferably rigidly attached to different portions of the insulating inner support member 14 by rivets 19, whereby the two contacts 18 will be respectively positioned substantially directly below the two contacts 16 and spaced a predetermined distance apart therefrom. The movable contact arm 20, having contacts 17 insulatedly attached thereto, is mounted upon the supporting member 14 in such a manner that contacts 17 will be free to engage either set of the stationary contacts 16 or 18, as hereinafter more fully described.

The movable contact arm 20, shown in detail in Fig. 15, is guided or movably supported at one end thereof by means of shoulder pin 36, which functions, in this instance, as a fulcrum. The shoulder pin 36, shown in Fig. 14, is rigidly attached to the inner support member 14 substantially as shown in Figs. 1 and 2. The movable contact arm 20 has a notch 38, in this instance substantially rectangular in shape, positioned within one end thereof. The notch 38, when operatively associated with an annular notch 40, positioned within the shoulder pin 36, permits the contact arm 20 to be supported thereby.

The notch 38 located within the movable contact arm 20 is slightly larger than the notched portion of the shoulder pin 36 but yet smaller than the main portion of the shoulder pin so that as the arm 20 is positioned within the notch 40 of shoulder pin 36, the contact arm 20 will be free to move or rotate about the shoulder pin as a fulcrum.

The contact arm 20 has a substantially rectangular aperture 42 located therein. The aperture 42 is positioned on the central or longitudinal axis somewhat near the movable end of the contact arm 20, substantially as shown in Fig. 15. The rectangular aperture 42 is substantially wider than the resilient member 22 whereby the resilient member 22 may be positioned within or inserted through the aperture 42. A plurality of small circular apertures 44 are located within the contact arm 20 on a transverse axis bisecting the rectangular aperture 42, for attaching the resilient member 22 to the contact arm 20, as hereinafter described.

The resilient member 22, preferably a flat strip of spring material as shown in Fig. 16, has a plurality of small apertures 44a located near the ends thereof. These apertures 44a permit the resilient member 22, which is longer than the distance between apertures 44 and preferably longer than the width of the contact arm 20, to be rigidly attached to the movable contact arm 20 by means of rivets 46 which extend through the apertures 44a and 44, substantially as shown in Figs. 3, 4 and 6.

Inasmuch as the resilient member 22 is longer than the distance between the apertures 44, located within the movable contact arm 20, it is apparent that the resilient member 22, as it is rigidly attached to the contact arm 20 with the central portion extending through aperture 42, will be biased into and confined to an elastic curve with one end attached to the top surface and the other end attached to the lower surface of the contact arm 20, substantially as shown in Figs. 3, 4 and 6.

The resilient member 22, when rigidly attached

at its ends to the contact arm 20, will have an unstable position along substantially a horizontal plane in the center of its configuration. Due to this instability, the central portion of the member 22 will tend to move to one or the other of its extreme vertical positions within the aperture 42. However, the side walls of the aperture 42 limit this unstable movement, substantially as shown by dotted lines in Fig. 17.

10 An irregularly shaped aperture 48 is located substantially in the central portion of the resilient member 22, as shown in Fig. 16. A plurality of protruding tongues 50 extend within the aperture 48, for a purpose hereinafter described.

15 An adjusting screw assembly 52, including screw 53, has a threaded engagement with the insulating inner support member 14 and is prevented from turning therein by means of a lock nut 54, substantially as shown in Figs. 2, 5 and 6.

20 The adjusting screw assembly 52 has an annular notch 56 formed in the lower portion thereof, as shown in Figs. 6, 7, 8 and 13. The notch 56 is formed by means of a washer 58 positioned upon the end of screw 53 whereupon the end is riveted over upon the washer 58, as shown at 60 in Fig. 13, rigidly attaching the washer to the screw 53. With the adjusting screw assembly 52 formed in such a manner, it is apparent that such assembly may be inserted within the aperture 48 of resilient member 22 before the washer 58 is positioned or rigidly attached to the lower end of the screw 53.

25 The tongues 50, located within aperture 48 in resilient member 22, extend within notch 56, as shown in Fig. 8, and permit free rotational motion of the adjusting screw assembly 52 relative to the resilient member 22 after the screw 53 is assembled therewith, but will prevent the relative transverse movement of the resilient member 22 with respect to the adjusting screw assembly 52. This structure, in turn, prohibits the transverse movement of contact arm 20 along its longitudinal axis with respect to the adjusting screw assembly 52.

30 The projected width of the tongues 50 upon the axis of the adjusting screw assembly 52 is substantially the same as the width of slot 56, as shown in Fig. 8. However, it is to be understood that these dimensions are to be such that there shall be no binding action therebetween. This prevents relative movement of the resilient member 22 along the axis of adjusting screw 53.

35 The main sides 62 of the aperture 48, located within the resilient member 22, when such member is rigidly attached to the movable contact arm 20 and compressed into its predetermined elastic curve, will contact the outer peripheral portion of the lower end of adjusting screw assembly 52, as shown in Fig. 7, prohibiting any transverse movement of the contact arm 20 along its transverse axis with respect to the adjusting screw 53.

40 Because of the configuration of resilient member 22 when it is operatively associated with adjusting screw assembly 52, one main side 62 will contact the screw 53 above the notch 56, as shown in Fig. 7, while the other main side 62 will contact the washer 58 below the notch 56, the washer 58 being equivalent to an extension of screw 53.

45 It is, therefore, obvious that with the movable contact arm 20 mounted upon insulating support 14 by means of adjusting screw assembly 52 and resilient member 22, at one end, and by shoulder pin 36 at the other end, as hereinabove described, such contact arm 20 will be prohibited from

moving in its plane by reason of the cooperative action of the rigidly attached resilient member 22 and adjusting screw assembly 52, and shoulder pin 36. However, it is to be understood that, due to the contact arm 20 being supported at one end by resilient member 22 and due to the resiliency of member 22, and its fundamental elastic curvature, the movable end of contact arm 20 will be permitted to move substantially vertically or axially to the adjusting screw assembly 52 with a snap action.

50 The adjusting screw 53 permits the central portion of the resilient member 22 to be positioned substantially midway between the stationary contacts 16 and 18. With the contact arm 20 positioned substantially at the midpoint between the stationary contacts 16 and 18, the vertical biasing action of the resilient member 22 upon such member 20 will be substantially zero. In other words, since the vertical biasing action of resilient member 22 upon contact arm 20 will be substantially zero, the contact arm 20 theoretically could remain in a neutral position. However, it is to be understood that because of the inherent characteristics of member 22, it would be practically impossible to position the contact arm 20 in this neutral position. Accordingly, it will be apparent that this description of contact arm 20 is merely for the purpose of explaining the operation of such arm.

55 Should the contact arm 20, when positioned at a neutral position, be forced either upwardly or downwardly from this neutral position, by some external force, the resilient member 22 would become unbalanced. The member 22 would then force the arm 20 to move in the vertical direction of the externally applied force with an accelerating motion, until the movable contacts 17 positioned on arm 20 would engage the stationary contacts 16 or 18. It is, therefore, obvious that this accelerating action of the resilient member 22 upon arm 20 produces a snap-action thereby, and ensures a positive contact pressure at all times.

60 With the adjusting screw 53, resilient member 22 and contact arm 20 adjusted in such a manner, the contact arm 20 will, when in either static or limiting position, have an equal biasing action or contact pressure between movable contacts 17 and the cooperating stationary contact 16 or 18. The amount of this biasing action or contact pressure is shown as C or C' in Fig. 21, and is that force which is exerted by resilient member 22 independently of any exterior or additional forces.

65 The unstable positions of spring 22, with respect to contact arm 20, within the aperture 42 of arm 20, produce an equivalent condition of instability in contact plate 20 with respect to its movement between stationary contacts 16 and 18, when resilient member 22 is supported by adjusting screw 53, as hereinabove described. It, therefore, follows that after screw 53 has been properly adjusted, moving contact assembly 17 has a position of instability at the center of its travel, midway between contacts 16 and 18, and that contact 17 is biased equally into engagement with both the upper pair of stationary contacts 16 and the lower pair of stationary contacts 18.

70 The correct adjustment of screw assembly 52 is obtained by the vertical movement of the screw 53 in threaded engagement with insulating switch support 14 and is such that the component of force of resilient member 22 in the direction of the adjusting screw axis will be zero when the

contact arm is in its central position, midway between the two stationary contacts 16 and 18.

The impact pin assembly 25, shown in Figs. 2, 3, 5, 9, 10 and 11 includes an impact pin 24, the second resilient member 26, and a spring guide member 80 operatively associated with the impact pin 24. The impact pin 24 shown in Fig. 12 has an upper threaded portion 70, an annular notch 72, substantially in the center thereof, and a tapered annular notch 74 positioned in the lower end 76 thereof.

The guide member 80 shown in Figs. 10 and 11 has a plurality of upwardly or vertically extending guides 81 located thereon and a vertically extending aperture 83 therethrough. A vertically extending insert 78 is positioned within the aperture 83, and has a vertically extending threaded aperture 85 positioned substantially in the center thereof. The guide member, including insert 78, is then threaded on the upper threaded portion 70 of impact pin 24 by means of the threaded aperture 85 in insert 79.

Inasmuch as the guide member 80 has a threaded engagement with impact pin 24, such guide member may readily be adjusted to any desired position thereon. This structure permits the central portion of the resilient member 26, operatively associated with the guide member 80 as hereinafter described, to be movably adjusted with respect to its end supports 78. This structure, in turn, permits the resilient member to be positioned at such a point with respect to pin 24 that such pin will move an equal distance above and below a neutral plane.

The second resilient member 26 is preferably a flat strip of spring material and is rigidly attached at its ends to the casing 10 by means of rivets 78, or the like, and likewise rigidly attached at substantially the center, to the impact pin assembly 25, as hereinafter described and as is clearly shown in Fig. 3. This resilient member 26 is forced to retain the double symmetrical elastic curve, as shown in Fig. 3, due to the cooperative action of the impact pin assembly 25 and the rigid end supports, as hereinafter described. The impact pin assembly forces the resilient member to substantially retain this elastic curvature which would otherwise assume a stable form of curvature.

The resilient member 26 is longer than the distance between its rigid supports on rivets 78. It, therefore, follows that the member 26 if not restrained, would then, when forced longitudinally inwardly from either one or both ends, assume one of the limiting stable elastic curves shown by dotted lines 27 and 27', in Fig. 18, or a curve similar to 22 shown in Fig. 6. It is understood that such member may assume a position which would be the reverse of the curve, as shown by 22 in Fig. 6.

It is, therefore, obvious that, should the central portion of the resilient member 26 be retained substantially in a plane parallel to the member 26 or in a curvature other than that which such member would normally assume, such member will be restrained or prohibited from assuming one of its normal stable elastic curves as the ends thereof are biased inwardly. However, it is to be understood that, due to the inherent characteristics of the resilient member 26, such member will attempt to assume one of the stable elastic curves 27 or 27', depending on which side of the neutral the central portion is positioned in respect thereto.

It, therefore, follows that, as the central por-

tion of the resilient member attempts to assume a curve similar to 27 or 27', it will exert a force normal to the plane of such resilient member. The force so exerted by the resilient member 26 will be substantially directly proportional to the distance of travel of the central portion of such member from its neutral position. This is clearly shown by Fig. 21. In other words, it is to be understood that the closer the central portion of the resilient member be biased to a central or neutral position, from the normal assumable curvature, the less such vertical force will be. The resilient member 26 compressed into the stable elastic curve produces a freedom of over-center action.

It, therefore, follows that the vertical biasing force of the resilient member 26 may also be varied by adjusting the horizontal force. This force value may be adjusted in an additional manner; namely, by adjusting or varying the positions of the end supports, it being understood that the closer such supports are positioned (or moved) towards the central portion, or in this instance towards the impact pin assembly 25, the greater the horizontal force. Accordingly, as hereinabove described, the vertical force will be increased. The vertical force may also be obviously reduced, by moving the end supports of resilient member 26 away from its central portion.

It is obvious that the greater the vertical or normal displacement of the central portion of the resilient member, the greater will be the force required to move such central portion toward its neutral, and that the closer such central portion approaches the neutral, a correspondingly smaller amount of force will be required to continue the movement. In other words, as hereinabove described, the vertical biasing force of the resilient member 26 is substantially directly proportional to the vertical displacement of the center of such spring from its neutral or dead center position. Accordingly, should the central portion be biased towards the neutral with a substantially constant value of force, it follows that the resilient member 26 will be accelerated due to the net acting or accelerating force. This condition results in an energy of motion, which, in addition to the applied substantially constant force, will cause the central portion to pass through the neutral. The inherent action of the resilient member 26 will then aid the applied force, resulting in the central portion travelling with a continued acceleration.

It is to be understood that the so-called neutral position of the central portion of the resilient member 26 will be that position from which both the relative upward and downward biasing forces of the resilient member will be equal, or that position in which the central portion would be in when it exerts a zero vertical force component. In this instance, this neutral position is substantially in a straight line with the end supports or rivets 78. The resilient member 26 is confined to substantially the curvature, shown in Fig. 18, by means of the cooperating action of the impact pin assembly 25 and bimetallic member 28. The impact pin assembly 25 has the effect of substantially breaking the member 26 into two separate resilient members. In other words, the resilient member 26 may be formed of at least two resilient members mounted in a straight line upon a rigid support at one end and upon, say, the impact pin 25 at the other end, it being understood that the two members be in a straight line.

This structure then operates as a single member.

Inasmuch as the resilient member 26 is unstable in this particular curvature, the impact pin 24 rigidly attached thereto likewise is correspondingly unstable. This instability results in a tendency for the resilient member 26, as such member moves from an upper to a lower position, to revert to the form of curvature illustrated by 22. This action results in a corresponding biasing force to be present in the lower end of impact pin assembly 25. The impact pin assembly 25 then has the tendency to wobble or move in a plane normal to and along the longitudinal axis of resilient member 26. However, inasmuch as the lower end of impact pin assembly 25 is firmly attached to and restrained from movement in this plane by the bimetallic member 28, such impact pin assembly 25 will be limited to substantially a vertical movement along the axis of impact pin 24.

The resilient member 26 has an aperture located substantially in the central portion thereof, not shown. The impact pin assembly 25 is inserted through the aperture in resilient member 26 and rigidly attached thereto as follows: The upper end of the threaded portion 70 and the upper end of insert 79, which extends above the guide 80, are inserted through the aperture located within the resilient member 26. The protruding portions 81 and insert 79 in combination with the top surface of support 80 function, among other things, as a saddle or support for the resilient member 26.

A plurality of differential convex washers 82 are positioned above the guide 80 within the upwardly extending protruding portions 81 and are in juxtaposition with the resilient member 26, one above such member and one below. A nut 84 positioned on impact pin 24 biases such washers against the saddle of guide 80 supporting resilient member 26 in its double elastic curve, substantially as hereinabove described. The nut 84 has a recess 87 located in its lower face to permit telescope engagement with the upper end of insert 79 to ensure adjustable contact with convex washers 82 at all times. Inasmuch as the nut 84 is threaded on impact pin 24, the position of such nut with respect to guide 80 may be readily changed, and, according, the shape of the central portion of the resilient member 26 may be readily changed. The changes in shape of the central portion adjust the horizontal force exerted by the rigid end supports of such member. It, therefore, follows that, inasmuch as the vertical force is proportional to the horizontal force exerted by the rigid supports, the vertical force transmitted from the resilient member 26 to impact pin 24 may be readily adjusted to any desirable value by merely adjusting the position of nut 84.

A lock nut 86 may be positioned upon the threaded portion 70 of impact pin 24 to lock the nut 84 in position, insuring the maintenance of a predescribed elastic position of the resilient member 26 and convex washers 82, as hereinabove described.

The heat-responsive device 28 is, in this instance, a bimetallic member, and preferably formed of a flat bimetallic finger or strip, substantially as shown in Fig. 19. The bimetallic member 28 has a circular notch 90 located in one end thereof to cooperate with the tapered notch 74 of the impact pin 24, as hereinafter described. The other end of the bimetallic member 28 is

rigidly attached to the casing 12 of the thermostat 10 by means of screws 92, as shown in Fig. 2. The bimetallic member 28 is preferably attached to the casing 12 at a slight angle so that the normal or unrestrained position of the free end of the bimetallic element will be above its restrained position, as shown in Fig. 2, to enable adjustable pressure to be applied to the bimetal member 28 through adjusting screw 34, at all points throughout its temperature range.

The adjusting screw 34 is rotatably attached to the casing 12 and extends through the insulating support member 14. The screw 34 has a threaded engagement with the bushing 35 which is rigidly attached to the casing 12. The adjusting screw 34 may then be moved vertically with respect to the casing 12, as it is rotated within the bushing 12.

If it is desired, a removable scale plate 37 may be positioned upon the support member 14. A scale 33 marked in degrees is located upon the plate 37, and is positioned about the adjustable screw 34. A pointer 31 is rigidly attached to screw 34 so that it cooperates with the scale 33, and thus gives a visual indication of the particular temperature setting of the thermostat.

A fulcrum plate 29, shown in Fig. 2, is flexibly attached to the bottom of the adjusting screw 34. The fulcrum plate 29 contacts the bimetallic member 28, and, as the adjusting screw 34 is raised or lowered with respect to the casing 12, changes the curvature of the bimetallic member. The operating temperatures of the bimetallic member 28 are therefore changed. The fulcrum plate 29, therefore, operates as an adjustable fulcrum about which the bimetallic member 28 flexes. Accordingly, the vertical movement of the fulcrum plate 29 resulting from the operation of adjusting screw 34 controls the thermal operation of the thermostat 10.

Bimetallic member 28 is initially formed at normal room temperatures to a degree of curvature which will be just annulled at the midpoint of its temperature range so it will permit the most favorable, substantially 90° angular, relationship with the impact pin 24. However, it is to be understood that the bimetallic heat-responsive device 28 may be attached to the casing 12 in any manner desired, so that its movements will be readily transmitted to the impact pin 24 in a manner as hereinafter described.

The bimetallic member 28 is operatively associated with impact pin 24 through the cooperation of circular notch 90 with the tapered annular notch 74 of pin 24. This cooperation is maintained through the action of a clip spring 75 which biases the impact pin into engagement with the bimetallic member. The clip spring 75 is preferably of a material having substantially the same diameter as the width of the base of notch 74, as shown in Fig. 20. The clip spring is positioned within the notch 74 of impact pin 24, and has its ends hooked into notches 73 located within the bimetallic member 28, as shown in Fig. 19. This cooperating action prevents undue longitudinal movement of impact pin 24 with respect to bimetallic member 28.

Relatively unlimited angular movement of bimetallic member 28 with respect to impact pin 24 is permitted by the tapering of the bimetallic element 28 beyond the base of annular notch 90, as shown by Fig. 20. This movement is substantially about an axis transverse to the bimetallic member 28 and normal to the axis of the impact pin 24 at the base of annular notch 75

90. The points of contact 77, shown in Figs. 19 and 20, between the bimetallic member 28 and impact pin 24 are, in other words, fulcrum points through which the cooperating forces of bimetallic member 28 and impact pin 24 are transmitted, one to the other. The tapered portion of bimetallic member 28 is such that, as the member 28 flexes about fulcrum plate 29, it will transmit a vertical force to the impact pin 24 without any binding action or additional contact between member 28 and the tapered sides of notch 74. This action provides a free angular movement between the member 28 and the impact pin 24 without any lost motion relative thereto longitudinal to the pin.

The bimetallic member 28 is, accordingly, free to flex about the adjusting screw 34 and, therefore, to move the impact pin 24 substantially normal to the plane of the bimetal, without undue friction or binding action between the moving end of the bimetallic member 28 and the impact pin 24.

As hereinabove described, the compressing of the convex differential washers 82 against the guide member 80 controls the lateral compression of the resilient member 26 against its supports in the casing 12. It, therefore, follows that, inasmuch as resilient member 26 and bimetallic member 28 are operatively associated, the adjustment of nut 84 directly controls the differential of temperature in the bimetallic heat-responsive member 28. This results from the fact that the vertical biasing action or component of the resilient member 26 is directly proportional to both its lateral compression and the vertical displacement of the center of such resilient member 26 from its neutral or dead-center position, as hereinabove described and shown in Fig. 21.

As further hereinabove described, the vertical biasing force of the resilient member 26 is directly proportional to the vertical displacement of the center of such spring or the vertical displacement of the impact pin 24 from its dead-center position. In other words, assume in this instance, that, with the impact pin 24 being displaced vertically .0375 inch from its dead-center position, the vertical biasing force of the resilient member 26 will be substantially two ounces, as is shown in Fig. 21. It is, therefore, apparent that the operatively associated bimetallic heat-responsive member 28 will remain in its extreme fixed position until a corresponding counterbalancing force is created therein, due to the annulment of its deflection, resulting from a change in its temperature. A counterbalancing force will be obtained at a point slightly before the thermostat's operating temperature is reached.

Fig. 21 shows the conditions which exist, at a given operating temperature, and those which exist throughout the travel of the bimetallic member 28 and associated parts as they snap from one position to another at that same temperature. The bimetallic elastic curve, shown transposed as the dotted line, is above the curve representing the overcenter resilient member 26, and shows the bimetal and biasing spring component exactly balanced just prior to its snapping temperature. Fig. 21 represents these conditions regardless of the direction of operation of the thermostat. It is understood that the left side of the graph represents the starting action of the thermostat.

When the force produced by the bimetallic

heat-responsive device 28 becomes slightly greater than the force exerted by spring 26, or in this instance, two ounces, it is apparent that such force will overcome the biasing action of the resilient member 26. The free end of bimetallic member 28, and the impact pin 24, will then move in a vertical direction or in a direction normal to resilient member 26 until they reach a second static position. As the impact pin 24 starts moving, the vertical distance between the original fixed or static position of the resilient member 26 and the neutral position will be reduced, whereupon the biasing action of the resilient member 26 toward the original position will likewise be reduced, as can be readily seen from Fig. 21. This value will be zero at the dead center position. The bimetallic force is likewise reduced. However, this force is reduced at a lesser rate than that of the resilient member 26.

The bimetallic member 28 will, therefore, have a differential or positive accelerating force, which is represented as D on Fig. 21, when the impact pin and bimetal are at their neutral position. This accelerating force produced by the bimetallic member 28, in addition to the kinetic force, causes the impact pin and member 28 to progress beyond the neutral position. As they pass the neutral position, the resilient member 26 reverses its action of its forces and aids the travel. The accelerating force is the net difference between the biasing force of resilient member 26 and the operating bimetallic member 28, and is directly proportional to the distance moved from the original static position at a constant temperature. This condition, in turn, ensures the desired snap action of the bimetallic member 28 and impact pin 24.

As the bimetallic member 28 changes in temperature so as to return to its original position, it builds up an equal and opposite force from that which it possessed when snapping from its first static position. However, as hereinabove described, the resilient member 26 will, through the cooperation of impact pin 24, hold the bimetallic member in the second static or fixed position until the force produced by the bimetallic member again equals, or is greater than, the two-ounce setting of the resilient member 26. When the bimetallic member 28 does develop a force equal to or greater than two ounces, the free end thereof, in cooperation with the impact pin 24, will return to its original fixed or first static position with a snap action, in a manner hereinabove described.

It is, therefore, obvious that due to the predetermined configuration of the resilient member 26 and the mounting of impact pin 24 upon substantially the central portion of the resilient member 26, such resilient member 26 insures a snap action of the bimetallic member 28 and the impact pin 24, and therefore, prohibits any creeping action of the bimetallic member.

When assembling the thermostat 10, the notch 39 of contact arm 20 is positioned within the slot 72 of impact pin 24. The notch 72 has a width of substantially 2A as shown on Figs. 2 and 21 plus the thickness of the contact arm 20. This permits the impact pin assembly to move a distance of 2A from a static position before the contact arm 20 is engaged.

The contact arm 20 has a distance of travel between the upper and lower contacts 16 and 18 of 2B shown on Figs. 2 and 21. Accordingly, the impact pin assembly moves a distance of 2A plus 2B before it is restrained in its travel by

the engagement of the movable contacts with the second set of stationary contacts 16 or 18. It will be understood that, when the impact pin assembly 25 has traveled a distance of 2A plus B, the contact arm 20 will be substantially in its neutral position. It, therefore, follows that during the last "B" distance of travel the resilient member 22, located upon the contact arm 20, will aid such travel and ensure a snap-action of the contacts with an increased "making" contact pressure. This contact pressure, at the conclusion of a making operation, is shown as C' on Fig. 21, in contrast to total contact pressure of E.

It is, therefore, obvious that inasmuch as the impact pin assembly moves a distance of 2A before engaging the contact arm 20, the contacts will be prevented from creeping. Accordingly, it is apparent that the thermostat would be snap-acting in operation regardless of the type or character of the heat-responsive device.

With the thermostat 10 operatively associated with a plurality of circuits (not shown), and the bimetallic member 28 operatively associated with a body such as a water heater (not shown) that is heated in accordance with the operation of such thermostat, the thermostat will, due to the operation of the bimetallic member 28, control the operations of the circuits, as hereinafter described. The number of controllable circuits depends upon the number of contacts mounted upon contact arm 20 and insulated support 14, as will be understood. Since such circuits are well known in the art and form no part of my present invention, I have not deemed it necessary to illustrate the same.

Assuming that the movable contact arm 20, the impact pin 24 and bimetallic member 28 are in their lower positions, and that the bimetallic member 28 is subjected to the body (not shown) which is being heated, the bimetallic member 28 will attempt to bend or flex upwardly as such body is heated. However, due to the downward biasing action of the main resilient member 26, through impact pin 24 on the bimetallic member 28, such bimetallic member will remain in its original position until the upward force produced therein exceeds the downward biasing action of the resilient member 26. This will occur when the heated body has arrived at the predetermined set value, at which it is desired to disconnect the power supply from the heating element. When the upward force produced by the bimetallic member 28 slightly exceeds the downward biasing action of the spring 26, the impact pin 24 will be moved upwardly with a snap action, in a manner hereinabove described.

Due to the cooperative action of impact pin assembly 25 and movable contact arm 20, the bimetallic member 28 and impact pin 24 will move a distance 2A, as hereinabove described and shown on graph (Fig. 21), before the impact pin 24 contacts the movable contact arm 20. By the time the impact pin 24 strikes the movable contact arm 20, such pin has attained a sufficient momentum or kinetic energy in addition to the upward force of the bimetallic member 28 to cause the movable contact arm 20 to be carried across the air gap 2B.

As the impact pin 24 first strikes contact arm 20, it need only move such contact arm a distance B before the action of its cooperating resilient member 22 would cause such arm to proceed on with a snap action, as hereinabove described. However, the impact pin 24 and con-

tact arm 20 will move together, resulting in a contact pressure immediately following the operation of the thermostat substantially equal to E, shown in Fig. 21. At the conclusion of this operation, the power supply will be disconnected from the heating element and the heated body will slowly cool.

The bimetallic member 28 will then tend to reverse its flexure as the body cools, producing a force in an opposite direction from that resulting in its original operation. The large contact pressure immediately following the operation will then be reduced, to that shown as C in Fig. 21, which is the amount due to the resilient member 22 biasing the movable contact arm 20 against the stationary contacts 16 or 18. It, therefore, follows that the movable contact arm 20 will be biased against the stationary contacts, with a minimum positive force C or C', regardless of the position of the contacts or the heating cycle, except during the switching operation.

As the body continues to cool, the bimetallic member will bias the impact pin towards the original position with an increasing force. Then as the bimetallic member again overcomes the reverse action of the resilient member 26, the thermostat will operate in its reverse cycle in a manner similar to that hereinabove described. However, in this case the bimetallic member 28 will force the impact pin downwardly against the action of the resilient member 26.

The impact pin assembly 25 again moves a distance of 2A before engaging contact arm 20. The contact arm 20 also moves a distance of 2B with the impact pin assembly 25 before the movable contacts 17 and lower stationary contacts 18 reengage. This action will also be snap-acting in a manner hereinabove described.

It is, therefore, obvious that a thermostat built in accordance with my invention will be snap-acting in action in both directions, regardless of the number of contacts embodied therein, and that such thermostat will be made so snap-acting, due, among other things, to the action of the second resilient member which, while being rigidly attached to the heat-responsive device, nevertheless decreasingly resists the movement of the heat-responsive device from an initial static position.

It is further obvious that due to the ability to regulate the operation of the heat-responsive device, by means of adjusting the vertical action of resilient member 26, the thermostat may be adjusted to operate on practically any desired temperature amplitude; and that, due to the ruggedness of the assembled thermostat, such thermostat will not become unadjusted regardless of the amount of shock or vibrations to which it may normally be subjected.

Various modifications may be made in the device embodying my invention without departing from the spirit and scope thereof, and I desire, therefore, that only such limitations shall be placed thereon as are imposed by the prior art and the appended claims.

I claim as my invention:

1. A heavy-duty thermostat, including a stationary and a cooperating movable contact, a heat-responsive device for operating said movable contact, a first resilient member for movably supporting said movable contact, and means comprising a second resilient member compressed into an elastic curve for producing a snap action of said device and movable contact.

2. A heavy-duty thermostat, including a stationary and a cooperating movable contact, a heat-responsive device for operating said movable contact, a first resilient member for movably supporting said movable contact, and means comprising a frictionlessly operating resilient member for biasing the heat-responsive device and first resilient member for snap action, said second-named resilient member being compressed into an elastic curve to produce a freedom of overcenter action.

3. A heavy-duty thermostat, having a plurality of cooperating contacts including at least one movable contact, a resilient member for movably supporting said movable contact, said resilient member being rigidly attached to the movable contact, a heat-responsive device, a frictionlessly operated resilient member for biasing the heat-responsive device for snap action, and means comprising the heat-responsive device and the first-named resilient member for producing a snap action of the movable contact.

4. In a thermostat including a casing, a frictionless resilient member rigidly attached to the casing and compressed into an elastic curve, a bimetallic heat-responsive device biased for snap action by said resilient member, a contact bar movably mounted within the casing, a second resilient member confined to an elastic curve and rigidly attached at both ends to the contact bar for biasing the contact bar for snap action, and means including the snap action of the bimetallic heat-responsive device for producing snap action of the contact bar.

5. In a thermostat comprising, in combination, a casing, a frictionless resilient member rigidly attached to the casing and compressed into an elastic curve, an impact pin rigidly attached to substantially the central portion of the resilient member, a bimetallic heat-responsive device rigidly attached at one end thereof to the casing and operatively associated with the impact pin at the other end thereof for producing a snap action of the heat-responsive device, a shoulder pin attached to the casing, a contact bar loosely mounted to the casing at one end by means of a shoulder pin, and a second resilient member confined to an elastic curve and rigidly attached at its end to the contact bar for movably supporting the second end of the contact bar and for producing a snap action of such contact bar.

6. A thermostat including a plurality of cooperating contacts, a movable contact arm for supporting one of the contacts, and a resilient member movably supporting the contact arm, said resilient member being rigidly attached at both ends thereof to the arm with substantially

one-half thereof on one side of the arm and the other half on the other side of the arm.

7. A thermostat including a plurality of cooperating contacts, a movable contact arm for supporting one of the contacts, and a resilient member movably and adjustably supporting the contact arm, said resilient member being rigidly attached at both ends thereof to the arm and extending through the arm with substantially one-half thereof on one side of the arm and the other half on the other side of the arm.

8. A thermostat including, in combination, a supporting structure, a plurality of cooperating contacts, a movable contact arm for supporting one of the contacts, a resilient member movably supporting the contact arm, and an adjusting pin operatively associated with the supporting structure and resilient member for adjusting the operation of the contact arm, said resilient member being rigidly attached at both ends thereof to the contact arm and extending through the arm with substantially one-half thereof on one side of the arm and the other half on the other side of the arm, the adjusting pin being attached to substantially the central portion of the resilient member.

9. A thermostat including, in combination, a movable contact arm, a resilient member biased into an elastic curve and rigidly attached to the contact arm, and a second resilient member operatively associated with the first resilient member for producing a snap-acting motion of the contact arm.

10. A thermostat including, in combination, a casing, a movable contact arm, a resilient member biased into an elastic curve and rigidly attached to the contact arm, and a second resilient member operatively associated with the first resilient member and rigidly attached to the casing for producing a snap-acting motion of the contact arm, and means attached to the second resilient member and operatively associated with first resilient member and contact arm for retaining the second resilient member within a double elastic curve.

11. A thermostat comprising, in combination, a plurality of cooperating contacts including a movable contact, an impact pin operatively associated therewith, a plurality of resilient members, one of which is adapted to actuate said movable contact, and a heat-responsive device, the other of said resilient members and said heat-responsive device being fitted to the impact pin and said one resilient member loosely contacting said pin to produce snap-acting movement of the movable contact at a predetermined temperature setting of the heat-responsive device.

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