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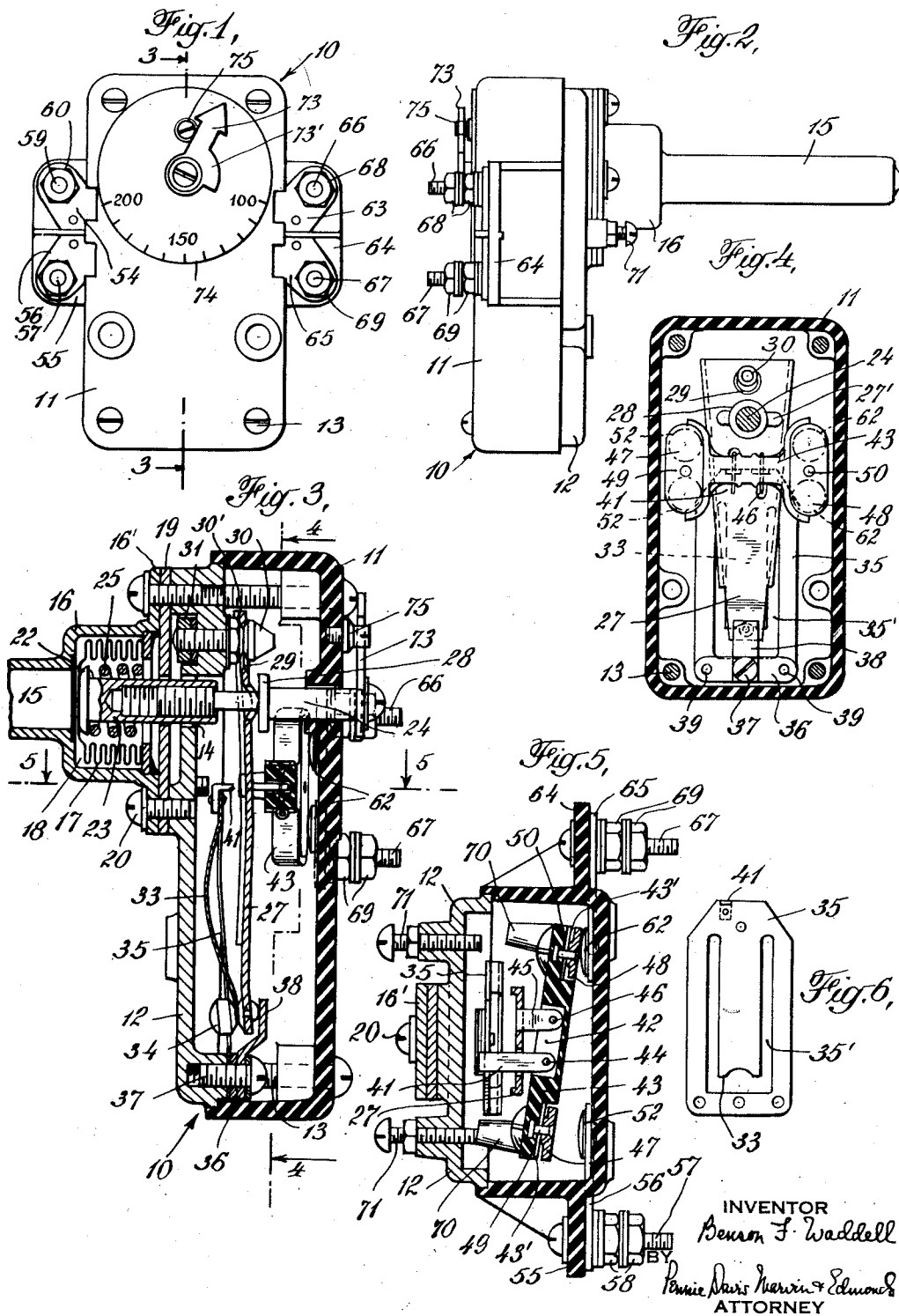
B. F. WADDELL

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REGULATOR

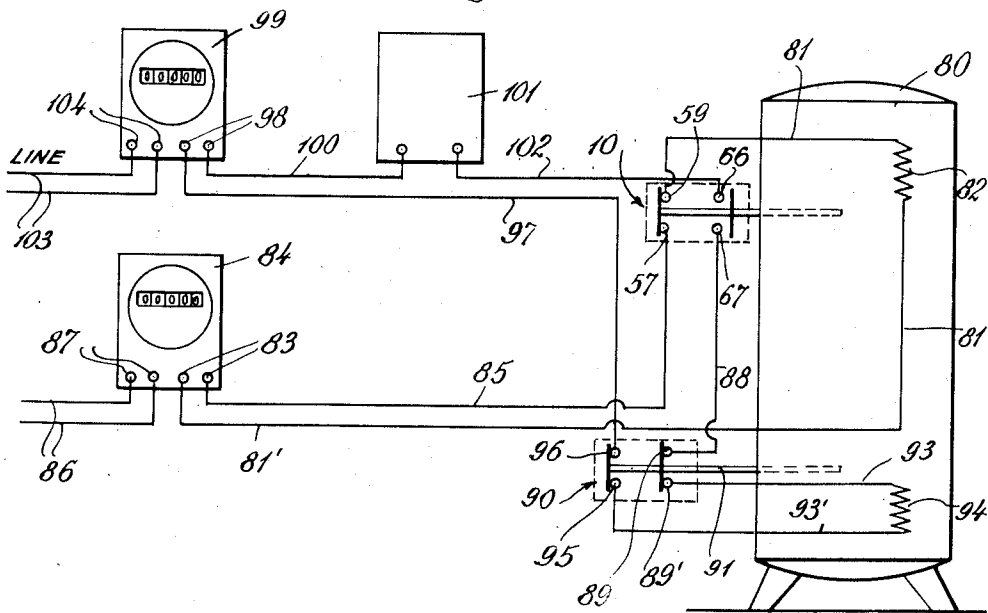
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REGULATOR

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Application November 8, 1937, Serial No. 173,378

18 Claims. (Cl. 200—140)

This invention relates to regulators for use on electrical appliances, such as heaters, refrigerators and the like, to control the temperature in an oven, cooling chamber or similar space. More particularly, the invention is concerned with a novel temperature regulator including a double-throw snap-acting mechanism for actuating a switch or other element adapted to control the temperature of the appliance. The new regulator is positive and reliable in operation and is of a simple construction adapted for manufacture at low cost.

For illustrative purposes, the principles of the present invention will be described in connection with a thermoresponsive switch in a regulator for use on water heaters. It will be understood, however, that the invention is not limited to this use.

One feature of the present invention resides in the provision of a double-throw snap-acting mechanism of compact construction which is adapted for sensitive and positive operation without the use of parts requiring delicate adjustment. A snap-acting mechanism made in accordance with my invention comprises a compression spring coacting with a laterally movable member which is pivoted or otherwise fixed against endwise movement. The spring is connected near one end to the laterally movable member, and the free end of the spring is movable through the plane of the member from one side to the other. Normally, the spring is compressed with its free end on one side of the plane of the member, so that the spring exerts an expansive force at an angle to the member and biases the member laterally in one direction to an initial position. Movement of the free end of the spring through the plane of the member causes the spring to exert an expansive force at an angle to the plane of the member in the opposite direction and thereby snap the member away from its initial position. A cross-arm is connected to the laterally movable member and is movable thereby about a pivot when the member is snapped by the spring, whereby the ends of the arm are given a double-throw movement in opposite directions.

In the preferred form of the new regulator, the laterally movable member is in the form of a flexible strip fixed at one end and connected at its free end to one end of the spring. The spring extends outwardly from the free inner end of the strip toward the fixed end thereof and is engaged at its outer end with a bar which extends inwardly toward the free end of the strip to a pivot. A thermo-responsive device is connected to the bar

and is operable to move the bar about its pivot relative to the flexible strip to force the outer end of the spring back and forth through the plane of the strip, whereby the strip is snapped laterally from one position to the other relative to the bar. The cross-arm is pivotally connected to the bar and the flexible strip at spaced points of the cross-arm. Accordingly, when the free end of the flexible strip is snapped relative to the bar in response to movement of the outer end of the spring through the plane of the strip, the cross-arm will be swung rapidly in a clockwise or counter-clockwise direction, depending on the direction of the movement of the strip relative to the bar. The cross-arm may be provided at each end with a conductor cooperating with a pair of fixed contacts, whereby movement of the cross-arm in one direction will make one pair of contacts and break the other pair, and movement of the arm in the opposite direction will have the reverse effect.

Another feature of the present invention resides in the provision of a novel means for controlling the operation of the regulator. The control means preferably includes a shaft rotatably mounted in a casing and connected to a snap-acting mechanism in the casing, the snap-acting mechanism being operable by thermo-responsive means at a critical temperature. The shaft extends through the front wall of the casing and may be rotated to operate the snap-acting mechanism independently of the thermo-responsive means and also to vary the response of the snap-acting mechanism to operation of the thermo-responsive means, so that the critical operating temperature of the thermo-responsive means may be regulated. A dial, preferably in the form of a pointer, is fixed to the shaft outside the casing and cooperates with a scale of temperature graduations marked on the front wall of the casing. The graduations indicate the critical operating temperature of the thermo-responsive means corresponding to different positions of the pointer and shaft, whereby the pointer may be readily set to adjust the mechanism to a desired operating temperature.

Still another feature of my invention resides in the provision of a regulator including novel thermo-responsive means which may be readily installed on a hot water tank. The thermo-responsive means preferably includes a bellows mounted on the rear face of the casing and operatively connected to the snap-acting mechanism. A rigid metallic tube partly encloses the bellows and extends rearwardly from the casing, the tube being filled with a thermo-responsive

fluid for actuating the bellows. The regulator is adapted to be mounted on the tank with the metallic tube extending either directly into the water or into a metallic socket fixed in the tank and immersed in the water. Heat from the water is conducted through the socket and the metallic tube to the fluid in the tube and causes the fluid to expand or contract the bellows in response to changes in the temperature of the water in the tank.

These and other features of my invention may be better understood by reference to the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a front view of one form of the new regulator adapted for use on a hot water heater;

Fig. 2 is a side view of the regulator shown in Fig. 1;

Fig. 3 is an enlarged section on the line 3—3 in Fig. 1 with part of the regulator broken away;

Fig. 4 is a reduced section on the line 4—4 in Fig. 3;

Fig. 5 is a section on the lines 5—5 in Fig. 3;

Fig. 6 is a detailed view of the principal element of the snap-acting mechanism of the new regulator;

Fig. 7 is a section on the same line as Fig. 3, showing the snap-acting mechanism in a different position, and

Fig. 8 is a schematic view showing one application of the new regulator to a water heater.

The regulator of the present invention preferably includes a thermo-responsive snap-acting mechanism of the type disclosed in my copending application Serial No. 180,710, filed December 20, 1937. It will be understood, however, that the principles of the invention may be employed in regulators of other types as well.

Referring to the drawings, the numeral 10 designates a casing made up of a front section 11, preferably of insulating material, and a rear section 12. The front and rear sections of the casing are held together by bolts 13 extending through the front section 11 near the corners thereof and threaded into the rear section 12. The rear section of the casing is provided with an opening 14 communicating with the interior of the casing, and mounted over the opening 14 is a metallic tube 15 having an enlarged cylindrical portion 16, the tube being arranged with the open end of its enlarged portion 16 toward the casing. A flexible metal bellows 17 is sealed within the enlarged portion 16 of the tube to form an annular space 18 between the tube and bellows constituting an expansible and contractible chamber. The open enlarged end of the tube 15 is sealed to the casing by an annulus 19 disposed between the rear section 12 of the casing and a flange 16' on the enlarged portion 16 of the tube. The tube and annulus are held tightly against the casing by bolts 20 extending through the flange and annulus and threaded into the rear section 12 of the casing. The expansible and contractible chamber 18 and the tube 15 are filled with a thermo-responsive liquid, such as chlorinated diphenol, which actuates the bellows 17 in response to a change in the temperature of the water in the tank.

A disk 22 lies against the rear end of the bellows, and a stem 23 secured at one end to the disk extends through the front end of the bellows, the annulus 19 and opening 14. The stem 23 has a rod 24 threaded in the front end thereof, the rod extending forwardly from the stem through the casing. A spring 25 arranged between the disk 22 and annulus 19 tends to keep the bellows ex-

panded by urging the stem 23 and rod 24 to the left, as shown in Figure 3. It will be apparent that expansion of the liquid in tube 15 and chamber 18 will contract the bellows 17 against the action of spring 25 and force the stem 23 and rod 24 to the right. Movement of rod 24 by the bellows controls the operation of a snap-acting mechanism which will now be described.

The rod 24 extends forwardly from its threaded end through an opening in a rigid bar 27 and is formed with a shoulder 28 which normally engages lugs 27' on the front face of the bar at opposite sides of the opening (Fig. 4). The bar 27 is relatively thin and narrows in width toward its lower end, as shown in Figs. 3 and 4. Near its upper end above the rod 24, the bar 27 is provided with a circular opening 29 through which a headed pin 30 extends. The pin 30 passes through the rear section 12 of the casing and is secured by a nut 31 threaded on its outer end, the nut being received in a recess formed in the rear face of section 12. The pin 30 is formed inwardly from the head with a hexagonal section 30', whereby a spanner may be applied to the pin to facilitate tightening of the nut 31 thereon. The portion of the bar 27 surrounding the opening therein is beveled to provide a knife edge extending around the opening, as shown in Fig. 3. The knife edge near the top of the bar is disposed in a circumferential recess formed in the pin 30 between the head and the hexagonal section 30'.

The bar 27 is normally maintained in tension by a strip of spring metal 33 disposed behind the bar substantially parallel thereto. The spring 33 is engaged at its lower end with a knob 34 fixed on the lower end of the bar. As shown particularly in Figs. 3 and 4, the spring 33 is curved slightly at its lower end and fits into a recess between the head of knob 34 and the bar 27. The upper end of spring 33 is integral with the free upper end of a strip of spring metal 35 for confining the spring against expansion in an upward direction. The strip 35 is substantially rectangular in form and is clamped at its lower end to the rear section of the casing by means of a cross member 36. The member 36 is held in position against the lower end of strip 35 by a bolt 37 which extends through the member 36 and strip 35 and is threaded into the rear section 12 of the casing. A stop 38 is interposed between the cross member 36 and the head of the bolt, the stop extending forwardly and upwardly from the bolt and terminating in front of the knob 34 on bar 27. Preferably, the flexible strip 35 is further secured at its lower end by pins 39 connected to the rear section of the casing and extending through the strip 35 and cross member 36. The spring 33 extends downwardly from the free end of flexible strip 35 in a central longitudinal slot 35' (Fig. 6) formed in the strip intermediate its ends, the slot 35' and integral spring 33 of the strip being preferably formed by a stamping operation. Normally, the spring 33 lies in the plane of flexible strip 35, but when the parts are assembled the spring is distorted out of the plane of the strip and confined in compression in a bowed form between the free end of strip 35 and the knob 34, as shown in Fig. 3.

A leg 41 is riveted to the flexible strip 35 at the free end thereof and on one side of the center line of the strip, as shown particularly in Figs. 3 and 5. The leg 41 extends outwardly through an opening in bar 27 and into a slot 42 formed in a cross-arm 43. The cross-arm 43 is made of insulating material and is pivotally connected

to the outer end of leg 41 by a cotter pin 44 extending through the cross-arm and the leg. The bar 27 is stamped intermediate its ends to form an outwardly extending projection 45 which likewise extends into the slot 42 in the cross-arm in spaced relation to the leg 44. A cotter pin 46 extends through the cross-arm and the projection 45 and permits the cross-arm to rock transversely with respect to the bar 27. The ends of the arm 43 are enlarged so that the arm has the general form of an H, the enlarged ends of the arm being recessed on the front face of the arm as shown at 43'. Pivotaly mounted in the recesses 43' at opposite ends of the cross-arm are conducting members 47 and 48 (Figs. 4 and 5). The conducting members 47, 48 are secured to the cross-arm by pivot pins 49 and 50, respectively, which permit the conducting members to rock endwise in a plane transverse to the cross-arm.

The conducting member 47 cooperates with a pair of contacts 52 fixed on the inside of the front section 12 near one side of the casing. One of the contacts 52 is electrically connected to a metal strip 54 which extends through the adjacent side of the casing and terminates on the broad face of a bracket 55 integral with the front section 11 of the casing. The other contact 52 is electrically connected to a second metal strip 56, the strip 56 extending outwardly through the side wall of front section 11 in spaced parallel relation to the strip 54 and likewise terminating on the front face bracket 55. A terminal bolt 57 extends through openings formed in the bracket 55 and flexible strip 56 and is secured by lock nuts 58 threaded on the bolt in front of the bracket. Similarly, a second terminal bolt 59 extends through openings in the bracket 55 and the other flexible strip 54 is held in position by lock nuts 60.

The other conducting member 48 cooperates with a pair of contacts 62 fixed on the inside of the front of the casing opposite contacts 52. A conducting strip 63 is connected to one of the contacts 62 and extends outwardly through the adjacent side wall of the casing, the strip 63 terminating on the front face of a bracket 64 integral with the front section 11 of the casing. Another metallic strip 65 spaced from strip 63 extends through the side wall of the casing from the other contact 62 and likewise terminates on the front face of bracket 64. Terminal bolts 66 and 67 extend through the bracket and conducting strips 63 and 65, respectively, and are secured by lock nuts 68 and 69, respectively, in front of the bracket 64.

It will be apparent that when the cross-arm 43 is rocked on the projection 45, the ends of the arm will move in opposite directions with respect to the contacts, whereby one of the conducting members 47, 48 will engage its cooperating contacts and the other conducting member will move away from its contacts. The movement of the ends of the cross-arm away from the contacts is limited by internal projections 70 on the rear face of the cross-arm near the ends thereof, each of the projections 70 being arranged to engage the threaded end of a bolt 71 when the corresponding end of the cross-arm is moved a predetermined distance away from the contacts. The bolts 71 are threaded through the rear section 13 of the casing and are adjustable with respect to the projections 70 on the cross-arm.

The rod 24 extends outwardly through the front of the casing and is adapted to be rotated in the

stem 23 by a pointer 73 fixed on the end of the rod over the outer face of the front section 11. The pointer 73 cooperates with a scale of temperature graduations 74 marked on the outer face of the front section 11. A stop 75 is fixed to the front section of the casing and extends outwardly in the path of rotation of the pointer 73, so as to limit the rotation of the pointer. Preferably, the pointer is provided with an integral arcuate portion 73' which is arranged to engage the stop 75 and prevent the pointer from being moved beyond the highest temperature graduation on the scale 74.

The regulator of the present invention is adapted for various uses where it is desired to obtain a double-throw action in response to changes in temperature. In Fig. 8 of the drawings I have shown diagrammatically an installation of the new regulator on a water heater. As there shown, the casing 10 is suitably mounted on a hot water tank 80 with the metal tube 15 extending into a socket (not shown) which is fixed to the tank near the top and immersed in the water. The tube 15 fits closely in the socket of the tank, whereby heat from the water in the tank may be conducted through the socket and the tube. The terminal 59 of the regulator is connected by a wire 81 to a high resistance heating element 82 disposed in the hot water tank near the top thereof. From the heating element 82, a wire 81' leads to one of the outlet terminals 83 of a watt-hour meter 84. The other outlet terminal 83 of the watt-hour meter is connected by a wire 85 to terminal 57 of the regulator cooperating with terminal 59. The watt-hour meter 84 is supplied with current through two busses 86 leading from a main power line (not shown), the busses 86 being connected to terminals 87 of the watt-hour meter.

The terminal 67 of the regulator is connected by a wire 88 to one terminal 89 of a single-throw, double-pole switch 90, which is mounted on the tank 80 near the bottom thereof. The switch 90 is of the thermoresponsive type, preferably of the construction described and illustrated in my copending application Serial No. 180,710, filed December 20, 1937, and has a thermosensitive element 91 which fits closely into a socket (not shown) fixed in the lower part of the tank. A terminal 89', in circuit with terminal 89 when the switch is closed, is connected by a wire 93 to a second high resistance heating element 94 disposed in the hot water tank near the bottom thereof. From the heating element 94, a wire 93' leads to a terminal 95 at the other pole of the switch 90. A terminal 95', in circuit with terminal 95 when the switch is closed, has a wire 97 leading therefrom to one of the outlet terminals 98 of a watt-hour meter 99. The other outlet terminal 98 is connected by wire 100 to one side of a clock-operated time switch 101. The other side of switch 101 is connected by a wire 102 to the terminal 66 of the regulator cooperating with terminal 67. The watt-hour meter 99 is supplied with current through two busses 103 leading from the main power line (not shown), the busses 103 being connected to terminals 104 of the meter 99. The purpose of the time-operated switch 101 is to permit the busses 103 to supply current to the lower heating element 94 in the tank during "off-peak" periods of the main power line. During normal or "on-peak" operation of the power line, the upper heating element 82 in the tank is adapted to be supplied with current through the busses 86.

In operation, the single throw switch 90 near the bottom of the tank is turned off when the heater is not in use, whereby the terminals 95, 96 and 89, 89', respectively, are electrically disconnected. The double throw switch 10 near the top of the tank is also turned off when the heater is not in use, so that the pointer 73 is in its "off" position (Fig. 1). When the pointer 73 is in its "off" position, the parts of regulator 10 are in the position shown particularly in Fig. 3. As there shown, the lower end of spring 33 is slightly to the right of the plane of the flexible strip 35. Accordingly, the lower end of bar 27 is urged to the right against the stop 38 by the expansive action of the spring, while the free upper end of the flexible strip 35, together with the leg 41, is urged by spring 33 in the opposite direction away from contacts 52 and 62. Under this condition, the cross-arm 43 is biased in a clockwise direction (Fig. 5) about the leg 45 on bar 27, whereby the conducting member 48 is held firmly in engagement with contacts 62, and the projection 70 at the opposite end of the cross-arm is seated on the inner end of the bolt 71, the terminals 57 and 59 being electrically disconnected. Thus, when the switches 10 and 90 are turned off, the circuits through the heating elements 82 and 94 are open. It will be observed that the spring 33 normally urges the free upper end of the flexible strip 35 and the free lower end of bar 27 away from the anchored ends of the responsive members, so that the members are subjected to tension.

When the heater is to be used, the switch 90 is turned on and is set to be opened by its thermoresponsive means at a desired temperature. Also, the pointer 73 is moved in a clockwise direction from its off position (Fig. 1) so as to screw the rod 24 inwardly in the stem 23. This causes the bar 27 to move in a clockwise direction about its pivot 30, so as to force the lower end of spring 33 to the left against the compression thereof. As the lower end of spring 33 moves to the left from its normal position as seen in Fig. 3, it passes through the plane of the flexible strip 35, and when the lower end of the spring is slightly to the left of the plane of the strip, the spring will reverse its action with respect to the flexible strip and the bar 28. That is, the spring will now force the free upper end of confining strip 35 to the right and simultaneously urge the free lower end of bar 27 further toward the left until the parts reach the position shown in Fig. 7. In this position of the mechanism, the spring 33 urges the upper end of flexible strip 35 and the leg 41 connected thereto toward the right and urges the bar 27 and the lug 45 thereon toward the left so that the cross arm 43 is biased in a counterclockwise direction (Fig. 5), whereby the conducting member 47 is held in engagement with contacts 52 and conducting member 48 is held in a retracted position with respect to contacts 62. The pointer 73 is preferably set to a temperature about 15° lower than that for which the single throw switch 90 is set, so that the upper switch 10 will be turned off by its thermoresponsive means before the switch 90 is opened by its thermoresponsive means.

Bridging of the contacts 52 by conducting member 47 establishes a circuit which is traceable from one side of the power line through one of the busses 86, watt-hour meter 84, wire 85, terminal 57, one of the contacts 52 (Fig. 5), conducting member 47, the other contact 52,

terminal 59, wire 81, heating element 82, wire 81', and back through the watt-hour meter 84 and the other buss 86 to the opposite side of the power line. The upper heating element 82 will thus be energized. The lower heating element 94 in the tank will remain deenergized, since conducting member 48 of the double throw switch is not now in position for connecting terminals 66 and 67 through which the element 94 is energized.

The expansive action of spring 33 snaps the free end of flexible strip 35 to the right (Fig. 7) immediately upon movement of the lower end of the spring to the left through the plane of the flexible strip. During the snap action of the parts, the lower end of bar 27 and the corresponding end of spring 35 will be snapped to the left by the expansive action of the spring, until the upper end of the spring and the flexible strip strikes the intermediate portion of the bar, as shown in Fig. 7. That is, when the bar is in the position shown in Fig. 7, it is held against further movement to the left by the expansive action of the spring 33 on the intermediate portion of the bar tending to urge the bar to the right. With the parts in this position, the action of the spring 33 and flexible strip 35 tends to urge the bar to the right back toward its initial position (Fig. 3), but is prevented from doing so by reason of the engagement of shoulder 28 with the lugs 27' on the bar.

As the water near the top of tank 80 is heated by element 82 to the temperature for which pointer 73 is set, the bellows 17 of the regulator moves the rod 24 and its shoulder 28 toward the right from the position shown in Figure 7, and thereby permits the lower end of spring 33 to pass back through the plane of the confining strip 35. When the water near the top of the tank is at the desired temperature, the lower end of the spring assumes a position to the right of the plane of strip 35, whereupon the expansive action of the spring will snap the lower end of the bar further to the right and the upper end of the confining strip 35 to the left. This movement of the confining strip will swing the cross-arm 43 in a clockwise direction so as to engage conducting member 48 with contacts 62 and disengage conductor 47 from contacts 52. Thus, the circuit previously traced through heating element 82 will be broken, and another circuit will be prepared which is traceable from one side of power line 103 through watt-hour meter 99, wire 100, time switch 101, wire 102, terminal 66, one of the contacts 62, conductor 48, the other contact 62, terminal 67, wire 88, terminals 89 and 89' which are electrically connected by switch 90, wire 93, heating element 94, terminals 95 and 96 which are likewise electrically connected by switch 90, wire 97, and back through watt-hour meter 99 to the other side of power line 103.

If the circuit previously traced to the lower heating element 94 is prepared in the manner described at a time when the power line is in an "off-peak" condition, that is, when the power demand is low, the time switch 101 will be closed, whereby the circuit traced through the lower heating element 94 is completed. The element 94 will thus be energized by relatively low cost electrical energy and will operate to heat the water near the bottom of the tank and thereby store up a considerable supply of hot water. When the water near the bottom of the tank is heated to the temperature for which the lower

switch 90 is set, the latter switch will be opened by its thermoresponsive means so as to deenergize element 94. If the time switch 101 is open when the circuit through heating element 94 is prepared, the latter element will remain deenergized. The water near the top of the tank will then cool below the temperature for which the double throw switch 10 is set to operate. Under this condition, the outer end of bellows 17 (Fig. 3) will be moved to the left under the action of spring 25, the thermoresponsive liquid in tube 15 contracting to permit this movement. This movement of the bellows is transmitted through the stem 23 and rod 24 to the shoulder 28 which urges bar 27 to the left, thereby forcing the lower end of spring 33 back through the plane of flexible strip 35 to the left-hand side thereof. Thereupon, the cross-arm 43 is snapped in a counter-clockwise direction (Fig. 5) in the manner previously described, so as to connect the contacts 52 and disengage the contacts 62. The upper heating element 82 will then be reenergized so as to heat the water near the top of the tank to the desired temperature.

It will be observed that the double throw switch of the present invention is of a simple construction and operates in a positive manner in response to changes in temperature of the liquid in tube 15. The switch may be operated manually at will by moving the pointer 73 over the face of the casing, and the pointer may be set to any desired operating temperature of the switch.

I claim:

1. In a regulator, a laterally movable member, means for securing the member against endwise movement, a spring connected at one end to the member and having its opposite end on one side of the plane of the member, the spring normally exerting a force on the member at an angle thereto to urge the member laterally in one direction to an initial position, means for moving said opposite end of the spring through the plane of the member to cause the spring to exert a force on the member at a different angle thereto and urge the member in the opposite direction, a cross-arm pivoted at a point intermediate its ends, means connecting one of said spring and movable member to the cross-arm at a point distant from said pivoted point, and control means connected to the cross-arm near the opposite ends thereof.

2. In a regulator, a laterally movable member, means for securing the member against endwise movement, a spring connected at one end to the member, a movable bar engaging the opposite end of the spring and confining the spring in compression with said opposite end thereof on one side of the plane of the member, the spring normally exerting an expansive force at an angle to the member to urge the member in one direction to an initial position, means for moving the bar to force said opposite end of the spring through the plane of the member, whereby the spring exerts an expansive force on the member at a different angle to urge the member in the opposite direction, a cross-arm pivotally connected to the bar at a point intermediate the ends of the arm, means connecting one of said spring and movable member to the cross-arm at a point spaced from said pivotal point, and control means mounted on the cross-arm near the opposite ends thereof.

3. In a regulator, a snap-acting mechanism comprising a laterally movable member, a spring

disposed between the ends of said member and exerting a substantially endwise force on the member to subject the member to tension and bias the member laterally in one direction, means for moving the member in the opposite direction against the action of the spring to a position in which the biasing action of the spring in said one direction is suddenly rendered less effective, a cross-arm pivotally mounted on said member, a pivotal connection between the cross-arm and the spring, and control means connected to the cross-arm near the opposite ends thereof.

4. A regulator, a snap-acting mechanism comprising a pivoted member, means connected to said member near the free end thereof for exerting a force on the member at an oblique angle thereto in a direction away from the pivoted end of the member, said means normally subjecting the member to tension and biasing the member in one direction about its pivot, means for moving the member against the biasing action of the first means in the opposite direction about its pivot to a position in which the biasing action of the first means is suddenly reversed to snap the member in said opposite direction, a cross-arm pivotally connected to said member at a point intermediate the ends of the arm, means connecting said first means to the cross-arm at a point spaced from said pivotal point, and control means mounted on the cross-arm near the opposite ends thereof.

5. A regulator comprising a laterally movable bar, a member having one end disposed between the ends of the bar and movable laterally relative thereto, means for securing the bar and member against endwise movement, a spring confined in compression between one end of the bar and one end of the member and normally exerting an expansive force at an angle to the member to urge said end of the member in one direction relative to the bar, the bar and member being movable relatively against the action of the spring to a critical position in which the expansive force of the spring is substantially parallel to the member, means for moving the bar and member relatively beyond said critical position to cause the spring to reverse its action and urge said end of the member in the opposite direction relative to the bar, a cross-arm pivotally connected to the bar at a point intermediate the ends of the arm, means connecting one of said spring and movable member to the cross arm at a point spaced from said pivotal point, and control means mounted on the cross-arm near the opposite ends thereof.

6. A regulator comprising a laterally movable bar, means for securing the bar against endwise movement, a member fixed at one end and movable laterally relative to the bar, the free end of the member being disposed inwardly from one end of the bar, a compression spring extending outwardly from the free end of the member with its outer end connected to the bar on one side of the member, the spring normally urging the bar in one direction relative to the member, means for moving the outer end of the spring to the other side of said member to cause the spring to urge the member in the opposite direction relative to the bar, a cross-arm pivotally connected to the bar at a point intermediate the ends of the arm, means connecting one of said spring and movable member to the cross-arm at a point spaced from said pivotal point, and control means mounted on the cross-arm near the opposite ends thereof.

7. A regulator comprising a laterally movable bar, means for securing the bar against endwise movement, a flexible member anchored at one end near one end of the bar with its free end disposed inwardly from said end of the bar, a spring extending from the free end of the member outwardly toward said end of the bar and movable relative to the plane of said member, a connection between the bar and the outer end of the spring for subjecting the spring to compression with its outer end on one side of the plane of said member, the spring normally exerting an expansive force in one direction relative to the plane of the member to urge the free end of the member away from the bar, means for varying the relative positions of said bar and member to move the outer end of the spring through the plane of the member to the opposite side thereof, whereby the spring snaps the free end of the member toward the bar, a cross-arm pivotally connected to the bar at a point intermediate the ends of the arm, means connecting one of said spring and movable member to the cross-arm at a point spaced from said pivotal point, and control means mounted on the cross-arm near the opposite ends thereof.

8. A regulator comprising a laterally movable bar, means for securing the bar against endwise movement, biasing means coacting with the bar including a flexible strip connected to the bar near one end thereof and extending inwardly from said end of the bar and a pair of flexible legs integral with the inner end of the strip and extending outwardly on opposite sides thereof toward said end of the bar, means for fixing the outer ends of said legs to confine the strip in compression between the inner ends of the legs and the outer end of the bar with the outer end of the strip disposed on one side of the plane of the legs, said strip normally urging the inner ends of the legs in one direction relative to the bar, means for moving the outer end of the strip through the plane of the legs to the opposite side thereof to cause the strip to snap the legs in the opposite direction relative to the bar, a cross-arm pivotally connected to the bar at a point intermediate the ends of the arm, means connecting said biasing means to the cross-arm at a point spaced from said pivotal point, and control means mounted on the cross-arm near the opposite ends thereof.

9. In a regulator, a snap-acting mechanism comprising a bar pivoted at one end, a spring including a pair of spaced parallel legs having their inner ends disposed inwardly from the free end of the bar and an intermediate leg integral with the inner ends of said parallel legs and extending outwardly toward the free end of the bar, the intermediate leg normally lying in the plane of said parallel legs, means for fixing the outer ends of said parallel legs near the free end of the bar, a connection between the bar and the outer end of the intermediate leg for confining the intermediate leg in compression against said parallel legs with the outer end of the intermediate leg distorted out of the plane of the parallel legs on one side thereof, the intermediate leg normally urging the inner end of the spring away from the bar, means for moving the bar about its pivot to force the outer end of the intermediate leg through the plane of said parallel legs to the opposite side thereof, a cross-arm pivotally connected to the bar at a point intermediate the ends of the arm, means connecting said spring to the cross-arm at a point spaced from said pivotal

point, and control means mounted on the cross-arm near the opposite ends thereof.

10. In a regulator, a snap-acting mechanism comprising a bar pivoted at one end, a flexible member fixed at one end near the free end of the bar and extending inwardly therefrom, a spring confined in compression between the inner end of said member and the free end of the bar with its outer end distorted out of the plane of the member on one side thereof, the spring normally urging the inner end of said member away from the bar, means for moving the outer end of the spring through the plane of said member to the opposite side thereof to cause the spring to snap the inner end of the member toward the bar into engagement with the intermediate portion thereof, whereby the spring urges the bar away from the member toward its initial position, a cross-arm pivotally connected to the bar at a point intermediate the ends of the arm, means connecting one of said spring and flexible member to the cross-arm at a point spaced from said pivotal point, and control means mounted on the cross-arm near the opposite ends thereof.

11. In a regulator, a snap-acting mechanism comprising a bar pivoted at one end, a compression spring engaged at its outer end with the bar near the free end thereof, a flexible member connected at one end to the spring intermediate the ends of the bar, means for fixing the other end of the flexible member near the free end of the bar to compress the spring, the spring normally subjecting said bar and flexible member to tension, means for moving the free end of the bar and the outer end of the spring relative to the plane of said member, a cross-arm pivotally connected to the bar at a point intermediate the ends of the arm, means connecting one of said spring and flexible member to the cross-arm at a point spaced from said pivotal point, and control means mounted on the cross-arm near the opposite ends thereof.

12. A regulator comprising a laterally movable bar, a member having one end disposed inwardly from one end of the bar and movable laterally relative thereto, means for securing the bar and member against endwise movement, a compression spring connected at its outer end to the bar on one side of said member and at the other end to the member near the inner end thereof, the spring normally exerting an expansive action at an angle to the member to urge the inner end thereof away from the bar, means for moving the outer end of the spring to the opposite side of the member to cause the spring to snap the inner end of the member against the bar and urge the bar away from the member, a cross-arm pivotally connected to the bar at a point intermediate the ends of the arm, means connecting one of said spring and member to the cross-arm at a point spaced from said pivotal point, and control means mounted on the cross-arm near the opposite ends thereof.

13. A regulator comprising a bar, pivoted at one end, a compression spring connected to the free end of the bar and extending inwardly toward its pivoted end, a flexible strip connected to the inner end of said spring and extending outwardly toward the free end of the bar, means for fixing the outer end of said strip, the spring normally exerting an expansive force on the bar at an angle thereto whereby the bar is urged in tension in one direction about its pivot, a cross-arm pivotally connected to the bar at a point intermediate the ends of the arm, means connect-

ing one of said spring and flexible strip to the cross-arm at a point spaced from said pivotal point, and control means mounted on the cross-arm near the opposite ends thereof.

14. In a regulator, the combination of a cross-arm, mechanism for moving the cross-arm about an axis intermediate its ends, conducting members mounted transversely on the cross-arm near the opposite ends thereof and each movable relative to the cross-arm about an axis at an angle to said first axis, and a pair of fixed contacts cooperating with each of said conducting members and adapted to be selectively engaged thereby when the cross-arm is moved about said first axis.

15. A regulator comprising a casing, a bar pivoted near one end in the casing, a flexible strip fixed to the casing near the free end of the bar and extending inwardly therefrom, a cross-arm pivotally mounted on the bar at a point intermediate the ends of the arm, means connecting said flexible strip to the cross-arm at a point spaced from said pivotal point, a spring confined in compression between the free end of the bar and the inner end of the strip with its outer end on one side of the plane of the strip, the spring normally urging the inner end of the strip and said member laterally in one direction, means for actuating the bar to move the outer end of the spring through the plane of said strip to the other side of the plane thereof, whereby the spring snaps the inner end of the strip and said member laterally in the opposite direction to move the cross-arm about an axis through said pivotal point, a conductor carried by said cross-arm near each end thereof and movable thereon about an axis at an angle to said first axis, and a pair of fixed contacts in the casing near each end of the cross-arm adapted to be bridged by the adjacent conductor.

16. In a thermo-responsive double-throw electric switch, a casing having two pairs of contacts mounted therein, an oscillating member in the casing adapted to close said pairs of contacts alternately, a flexible member fixed at one end in the casing, a lever in the casing pivoted at one

end, a spring exerting a force on the free ends of said flexible member and lever, a thermo-responsive element for moving the lever about its pivot to change the plane of force exerted by the spring on said flexible member, whereby the flexible member will flex in a direction opposite to a movement imparted to the lever by the thermo-responsive element, a link attached to the flexible member, a second link attached to the lever, and means for pivotally connecting said links to the oscillating member in spaced relationship, whereby a movement of the lever in one direction causes the oscillating member to close one pair of contacts, and a movement of the lever in the opposite direction causes the oscillating member to close the other pair of contacts.

17. In a thermo-responsive double-throw electric switch, two pairs of contacts, an oscillating member adapted to close said pairs of contacts alternately, a snap mechanism including two links adapted to move in opposite directions, a thermo-responsive element operatively connected to the snap mechanism for moving the links, and means for pivotally connecting said links to the oscillating member in spaced relationship, whereby movement of the thermo-responsive element in one direction operates the oscillating member through the snap-acting mechanism to close one pair of contacts, and movement in the opposite direction operates the oscillating member through the snap-acting mechanism to close the other pair of contacts.

18. In a regulator, an oscillating member, control means near the opposite ends of the member and operable thereby alternately as the member oscillates, actuating means for said member including a pair of relatively movable links, pivotal means for connecting one of the links to said member intermediate its ends to pivotally support the member independently of the other link, and means for connecting said last link to the member at a point spaced from said pivotal means to oscillate the member about the pivotal means.

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