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ELECTRICAL SWITCHES WITH IMPROVED MECHANICAL LATCHING AND RESETTING MEANS

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FIG. 1.

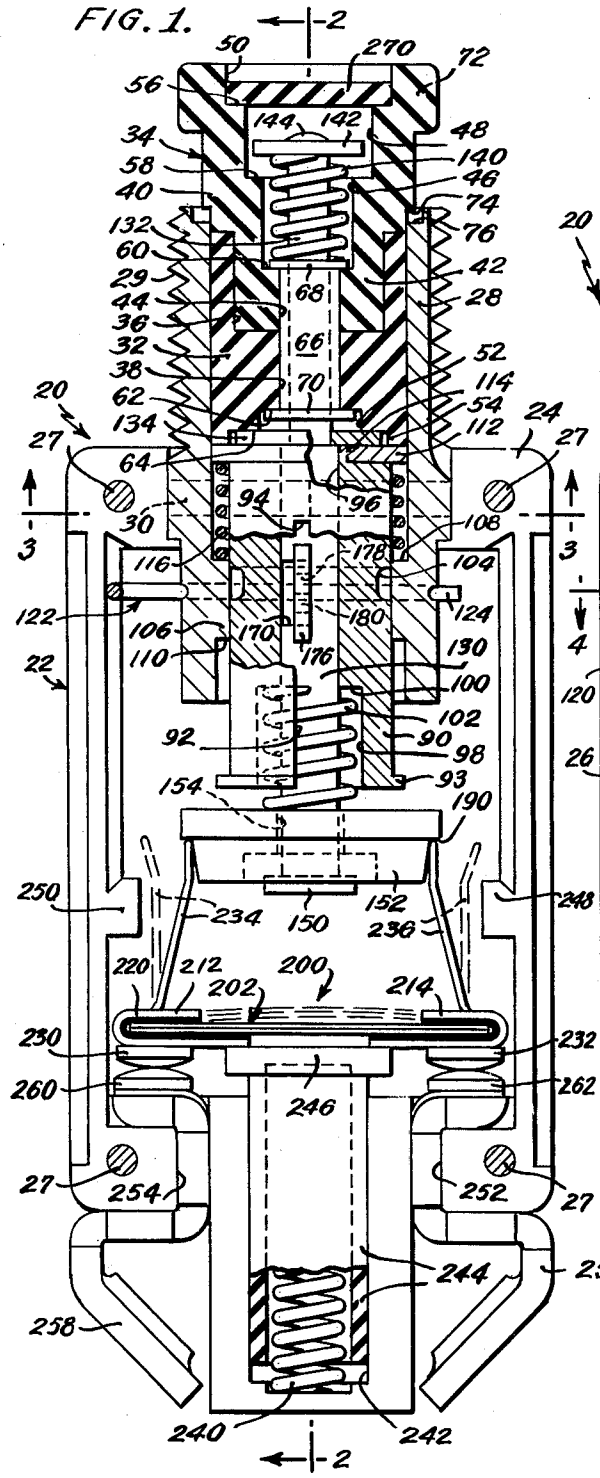
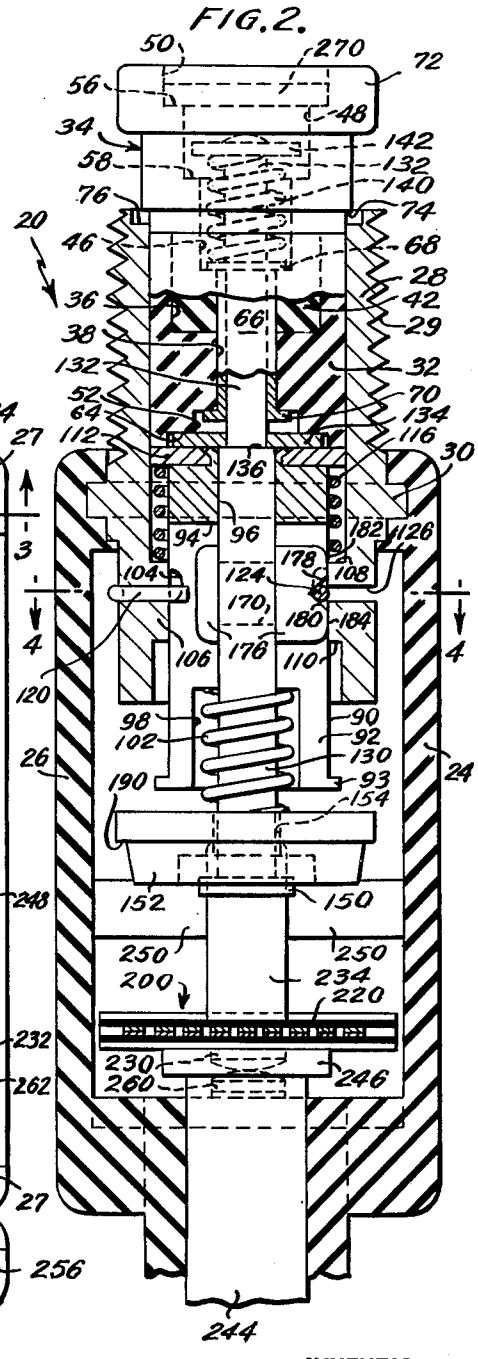


FIG. 2.



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FIG. 3.

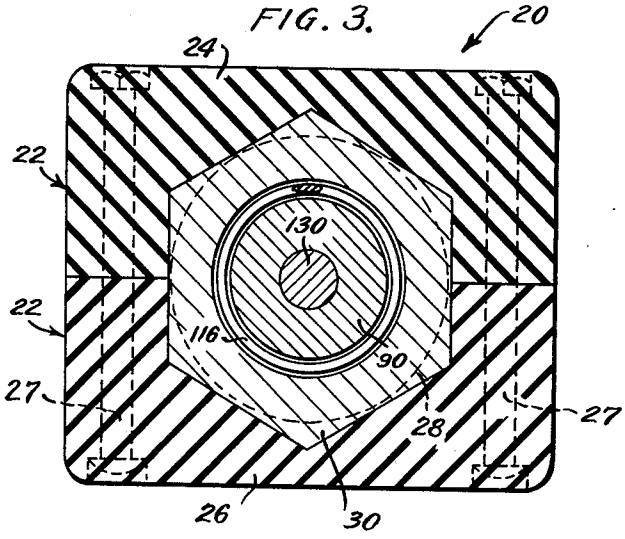


FIG. 4.

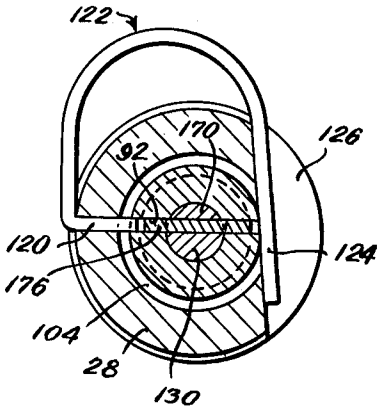
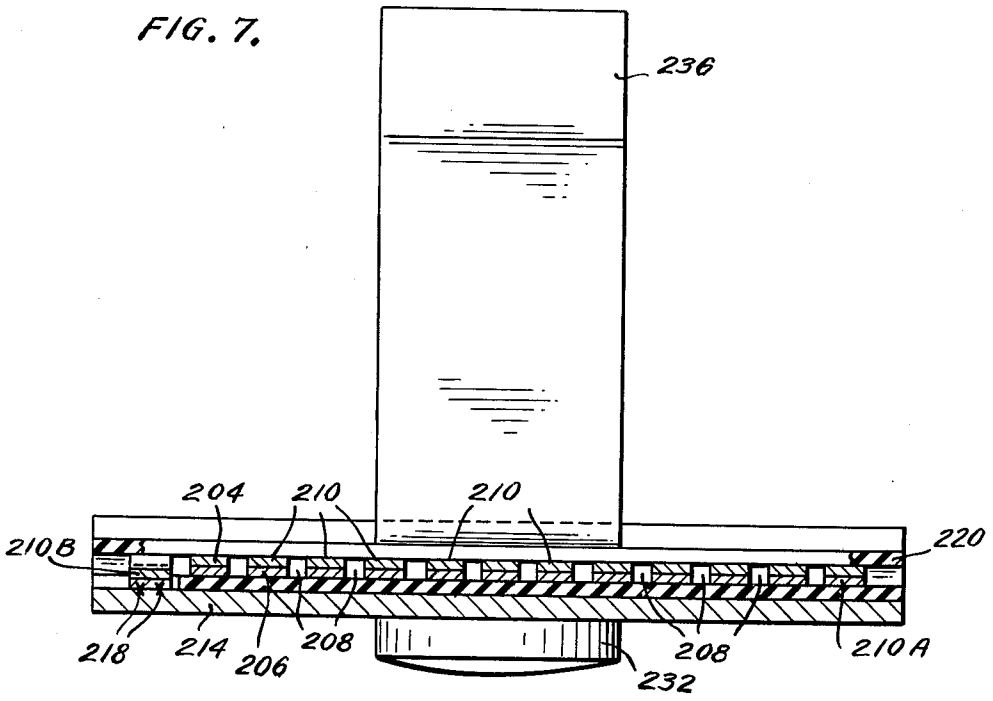


FIG. 7.



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FIG. 5.

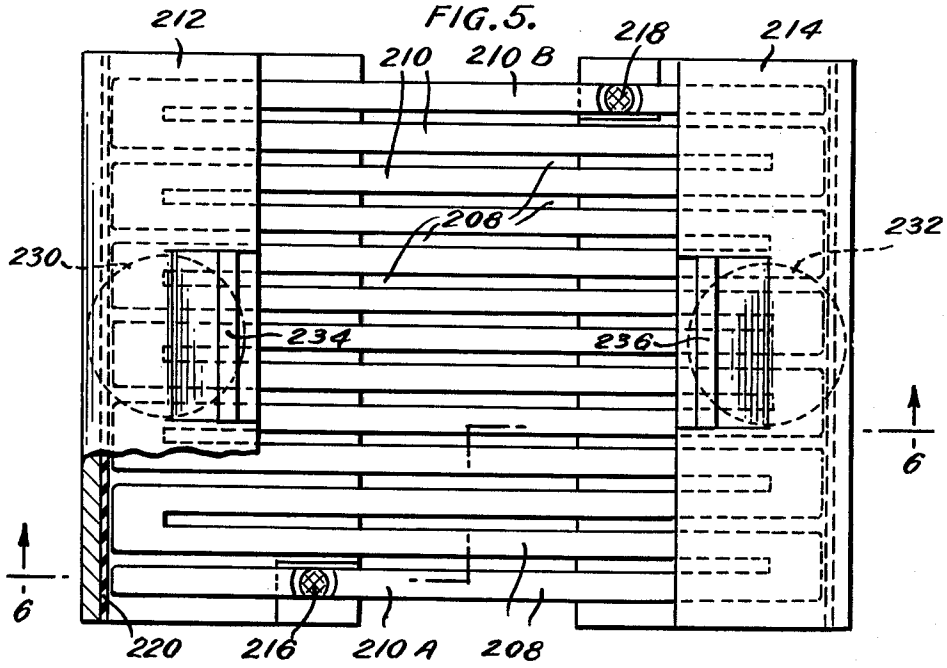
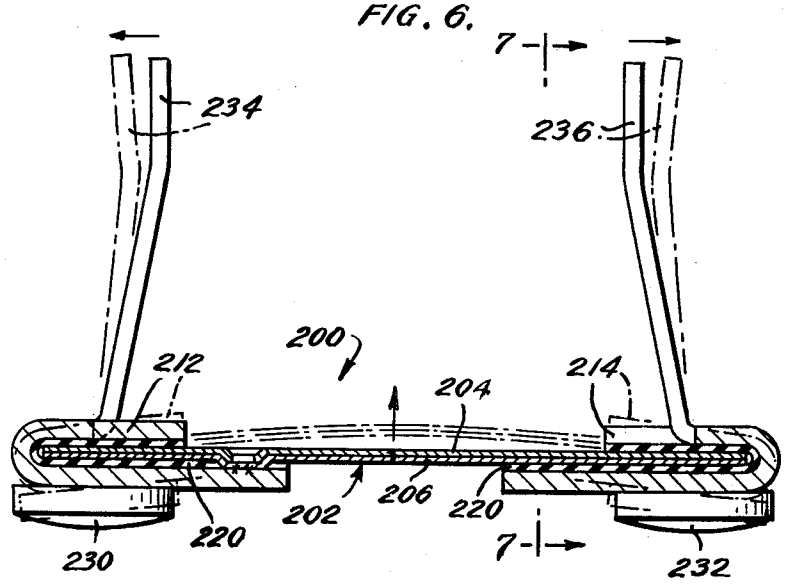


FIG. 6.



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FIG. 8.

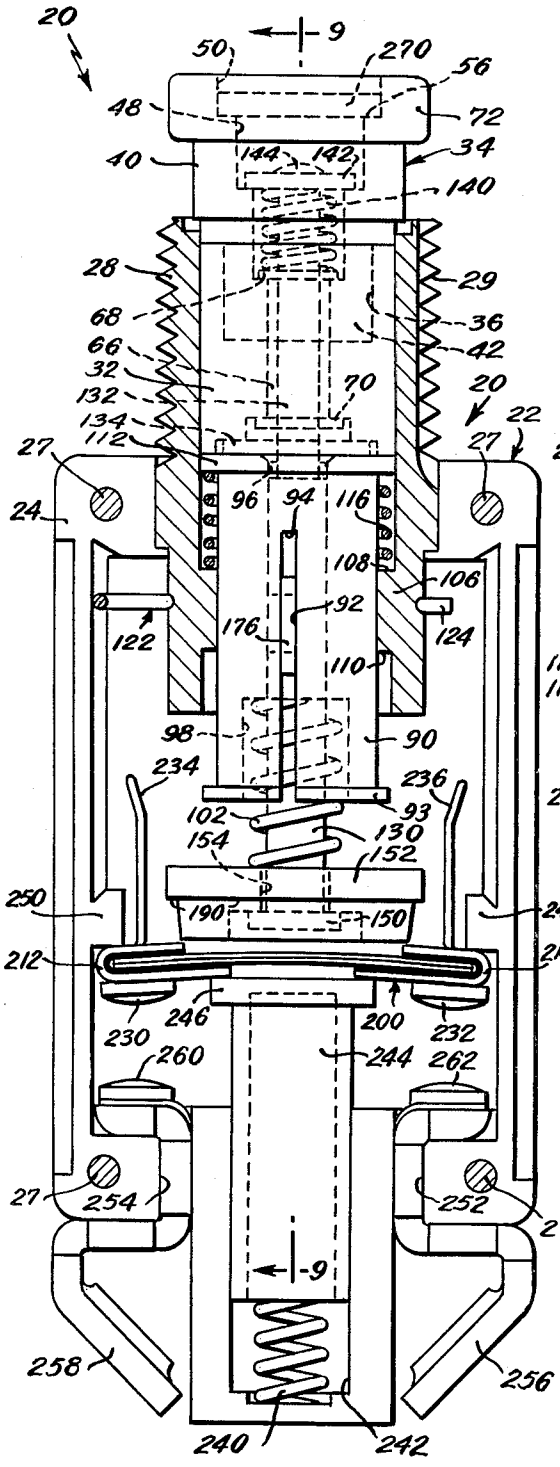
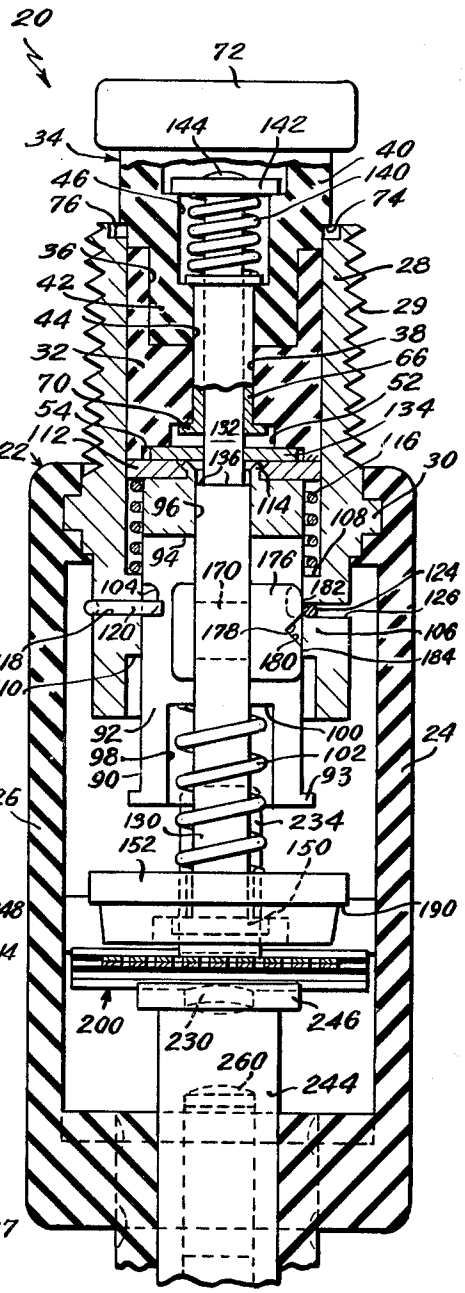


FIG. 9.



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FIG. 10.

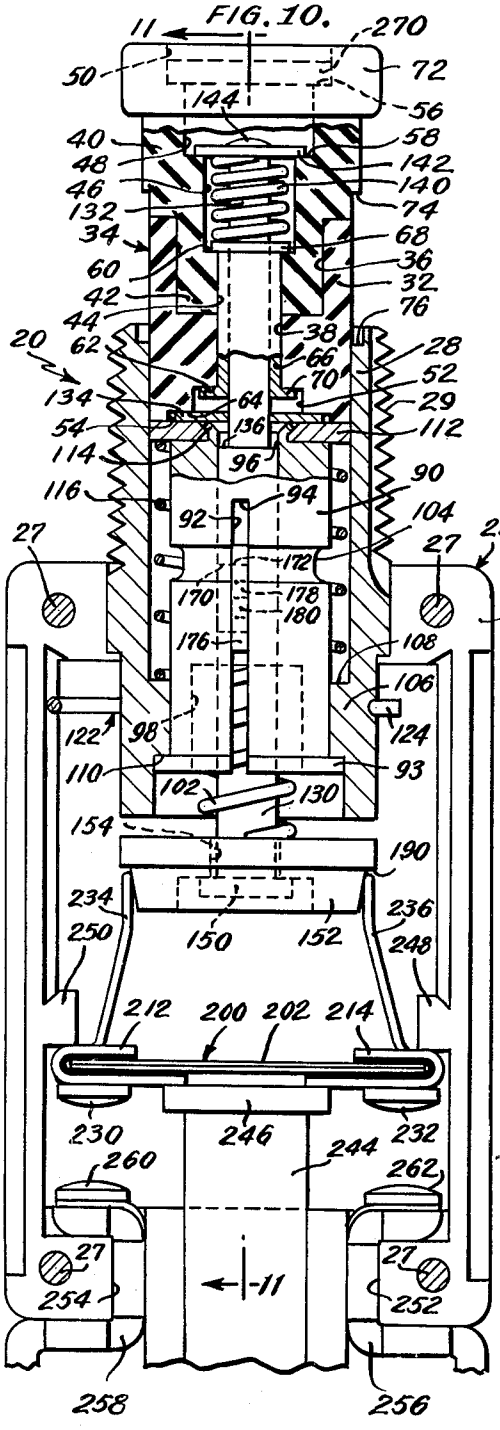
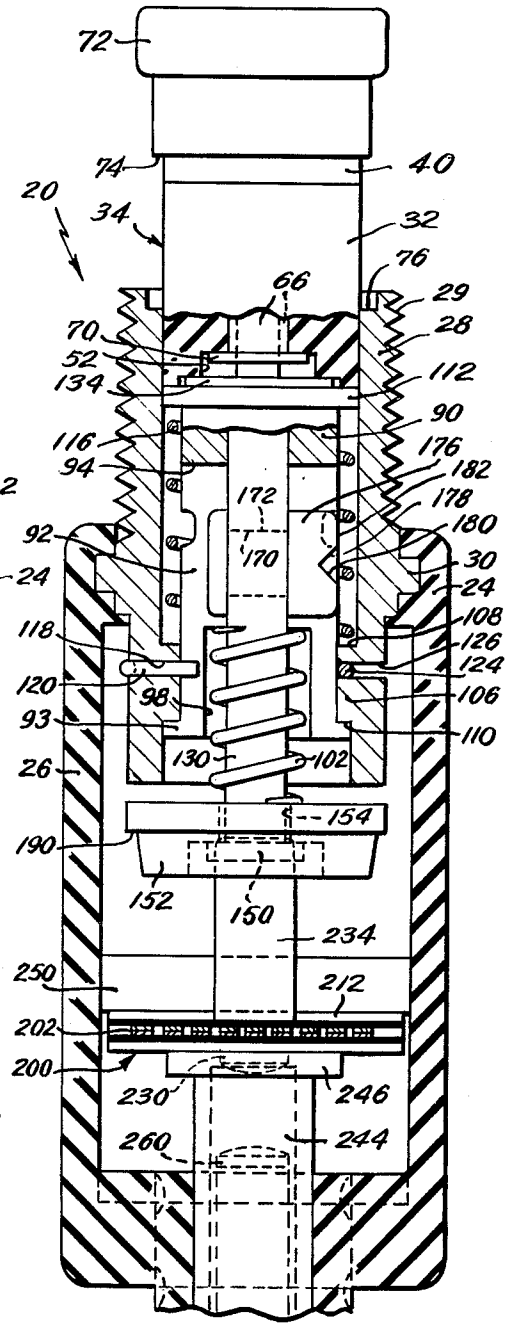


FIG. 11.



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FIG. 13.

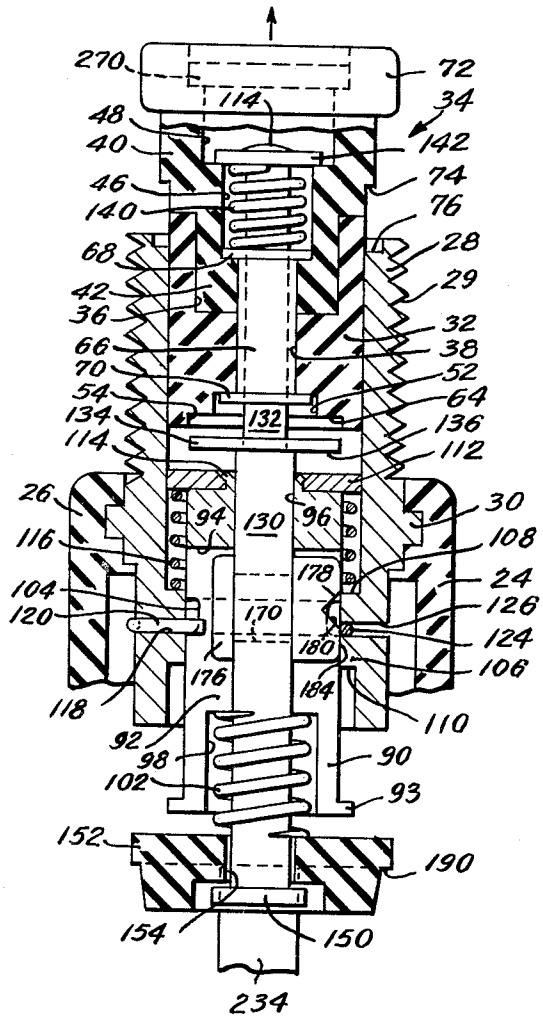
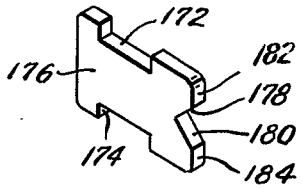


FIG. 12.



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ELECTRICAL SWITCHES WITH IMPROVED MECHANICAL LATCHING AND RESETTING MEANS

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Filed Apr. 8, 1963, Ser. No. 271,405
12 Claims. (Cl. 200—116)

This invention relates to electrical switch structures and more particularly to thermally responsive electrical switch structures.

Among the several objects of this invention may be noted the provision of an improved thermally responsive electrical switch incorporating a new and improved combination of interrelated parts; the provision of a switch which utilizes a thermal type latch means and a new and improved mechanical latch means which functions without deleteriously affecting or upsetting the calibration of the thermally responsive latch means; the provision of a switch of the class described which is also mechanically actuable repeatedly as an on-off switch without deleteriously affecting or upsetting the calibration of the thermally responsive means thereof; the provision of a switch of the class described, the operation of which is trip free; and the provision of a switch which is accurate and reliable in operation, simple in construction, and economical to manufacture and assemble.

Other objects will be in part apparent and in part pointed out hereinafter.

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

In the accompanying drawings, in which one of the various possible embodiments of the invention is illustrated:

FIG. 1 is a view with parts broken away of a thermally responsive electrical switch embodying the instant invention and showing the parts thereof in a reset contacts-closed position, one part of the two part casing being removed and certain of the parts being shown in section;

FIGS. 2 and 3 are sectional views of the switch taken along lines 2—2 and 3—3, respectively, of FIG. 1;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 2;

FIG. 5 is a plan view on an enlarged scale of the thermally responsive member of the switch;

FIG. 6 is a sectional view taken along line 6—6 of FIG. 5;

FIG. 7 is a sectional view taken along line 7—7 of FIG. 6;

FIG. 8 is a view similar to FIG. 1 showing certain of the parts at intermediate positions during the operation of the switch;

FIG. 9 is a sectional view taken along line 9—9 of FIG. 8;

FIG. 10 is a view similar to FIG. 1, but showing the parts in a retracted contacts-open position;

FIG. 11 is a view taken on line 11—11 of FIG. 10;

FIG. 12 is a perspective view of the latch release cam member forming part of the switch shown in FIG. 1; and

FIG. 13 is a fragmentary view similar to FIG. 1 showing the resetting mechanism at an intermediate position during mechanical operation thereof to open the contacts.

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

Dimensions of certain of the parts as shown in the drawings may have been modified and/or exaggerated for the purpose of clarity of illustration.

The switch of the present invention is of the type shown, for example, in U.S. Patent No. 2,912,546, and provides an improved mechanical latching and resetting means over that shown and described in this patent.

Referring now to FIG. 1, an exemplary electrical switch embodying the instant invention is shown taking the form of a circuit breaker generally indicated by reference numeral 20. Switch 20 includes a base or casing 22 comprising a pair of interfitting casing members 24 and 26 formed of a suitable electrical insulating material such as one of the conventional phenolic resinous moldable materials. Members 24 and 26 are fastened together by a plurality of threaded fasteners 27, best seen in FIGS. 1 and 3. Casing 22 mounts a tubular metal bushing 28 formed, for example, of steel or brass, and having a hexagonal mounting flange 30 mating with a correspondingly shaped recess provided by the casing 22. Bushing 28 may be externally threaded, as at 29, for the reception of a nut or nuts (not shown) for mounting the switch on a support.

Mounted for slidable movement within and along bushing 28 is a cylindrical member 32 forming part of a mechanically actuable and manually operable resetting assembly generally indicated at numeral 34. Manually operable member 32 provides a pair of concentric different diameter openings 36 and 38. Resetting means 34 further includes a button member 40 having a cylindrical projecting portion 42 which is received in aperture 36, as best seen in FIG. 1. Member 40 provides an aperture 46 communicating with a smaller diameter aperture 44 which is in aligned registry with and has substantially the same diameter as that of aperture 38. Aperture 46 also communicates with a larger diameter aperture 48, which in turn communicates with an even larger diameter aperture 50 opening exteriorly of button member 40. Member 32 also provides concentric openings 52 and 54 which communicate with opening 44. The junction between openings 50 and 48, openings 48 and 46, openings 46 and 44, openings 52 and 38, and between openings 54 and 52, respectively, provide annularly extending shoulders 56, 58, 60, 62, and 64.

Telescopically disposed in aligned apertures 44 and 38 is a metal tubular, rivet-like fastener 66, deformed or flanged at its ends 68 and 70, respectively about shoulders 60 and 62, to firmly and fixedly secure members 40 and 32 together as a button assembly unit. Members 32 and 40 may be formed of a suitable electrically insulating material like that of casing 22. If desired, member 32 may be formed of a material having a color contrasting with that of the push button member 40 to indicate the condition of actuation of the switch 20.

Push button member 40 has a flanged collar 72, and provides an annular abutment 74 engageable with a recessed abutment portion 76 in the adjacent end of bushing 28 to limit downward movement of push button 40, as viewed in FIG. 1.

Also mounted for slidable movement within and along bushing 28 is a first latch member, cylindrical cup-shaped member 90 formed, for example, of steel or brass or a suitable plastic material and forming part of the mechanical latching assembly according to this invention. Member 90 includes a radially (or diametrically) extending slot 92 which extends completely through the entire diameter of the member 90, and also opens exteriorly of and extends from the bottom of member 90 (as viewed in FIG. 1) along a substantial portion of the length thereof. As seen in FIGS. 1, 2 and 10, the closed end of slot 92 adjacent the top of member 90 provides an abutment surface 94. Member 90 also includes a cylindrical aperture 96 extending along its axis and opening exteriorly of the upper end of member 90, as viewed in FIG. 1. The other end of aperture 96 communicates with a large diameter aperture 98 which opens exteriorly

of the bottom end of member 90 as viewed in FIG. 1. The junction of apertures 96 and 98 provides a shoulder 100, which serves to seat one end of a compression type coil spring 102, which is received and housed within cavity or aperture 98. Member 90 further includes a circumferentially and annularly extending latching groove 104 to provide a detent portion for the mechanical latching arrangement of this invention which will be described more fully below.

Bushing 28 includes a circumferentially and radially inwardly extending projecting portion 106 which provides two annularly extending shoulders 108 and 110 on opposite sides thereof, as seen, for example, in FIG. 1. The upper end of latch member 90 is fixedly connected to a metal washer 112 as by deforming portions 114 of member 90 (adjacent aperture 96) about washer 112. A first spring member, coil type compression spring 116, is telescopically disposed about member 90 and seated against and also confined between the underside of washer 112 and shoulder 108 on bushing 28. Spring 116 thus urges member 90 for movement upwardly (as viewed in FIG. 1) toward a retracted, contacts-open position. Member 90 has an annularly extending flange 93 adjacent the bottom open end thereof, as seen for example, in FIG. 1 which is positioned to abuttingly engage shoulder 110 to limit upward movement of member 90 (under the bias of spring 116) relative to bushing 28, when the parts move to the retracted contacts-open position shown in FIG. 10.

Bushing 28 provides a radially extending aperture 118 communicating with slot 92 and receives therewithin end 120 of a second latch member, spring member generally indicated at 122, to anchor this end of spring 122 to the bushing and to prevent rotation of member 90 about its longitudinal axis. Spring end 120, by extending into slot 92, does not prevent member 90 from vertical movement relative to either spring 122 or bushing 28. As best seen in FIG. 4, spring member 122 is generally J-shaped and includes a long leg and a short leg which provides the bent end portion 120 which is anchored to bushing 28. A portion 124 of the long leg is received in a chord-like slot 126, which, as best seen in FIG. 4, intersects the outer circumference of bushing 28 and extends into the interior thereof. Leg portion 124 acts as a latching member and is spring biased for movement radially inwardly of bushing 28 toward engagement with detent groove 104 to mechanically latch or lock member 90 to bushing 28 against the bias of spring 116.

Manually operable means 34 includes a post 130 formed, for example, of brass or steel and which is telescopically disposed within and extends through apertures 96 and 98 of member 90 for sliding movement relative to latch member 90 and bushing 28. Spring 102 is telescopically disposed about the lower portion of post 130, as seen, for example, in FIGS. 1 and 2. Post 130 includes a reduced diameter upper portion 132 which is telescopically disposed within and extends through tubular member 66 and aperture 46 in member 40. Telescopically disposed about portion 132 is a washer member 134 which is mounted for reciprocal sliding movement thereon. Shoulder 136, provided at the junction between post parts 130 and 132 is positioned for engagement with washer 134 to limit downward movement (as viewed in FIG. 1) of washer 134 relative to post portion 132.

Telescopically disposed about the upper end of post part 132 is a second spring member, compression-type coil spring 140, which is received within spring receiving cavity or aperture 46 of member 40. One end of spring 140 seats against flange 68 of member 66. The other end of spring 140 seats against the underside of a metal washer member 142 which is fixedly secured to the free end of post part 132 as by deforming or heading over a portion of the adjacent end of the post part 132 as at 144. Washer 142 has a sufficiently large diameter so as to be engageable with shoulder 58 to limit downward movement (as viewed in FIG. 1) of the post 130 relative to button members 40 and 32.

Stem or post part 130 at its lower free end (as seen, for example, in FIGS. 1 and 13) includes an annularly extending flange extension or stop 150. Means 34 further includes a circular washer-like member 152 having an aperture 154 through which the free end of post member 130 adjacent stop 150 extends, whereby member 152 is slidably mounted on the post 130. Compressive resilient biasing means or spring member 102, which is disposed about stem or post 130, resiliently biases member 152 for movement against stop 150 and away from latch member 90. Aperture 154, provided by member 152, has a substantially larger diameter than the outside diameter of stem 130, whereby member 152 has a relatively loose, unconfined fit while the resetting means is in the reset contacts-closed position shown in FIG. 1. Post 130 provides a notched portion 170 which is adapted to receive and interfit with correspondingly shaped notched portions 172 and 174 of a latch release plate-like member 176 formed, for example, of stainless steel. Member 176 (which is best seen in FIG. 12) is also received within slot 92 of member 90 for reciprocal sliding movement therein in response to movement of post 130. Slot 92 advantageously also serves to maintain latch release plate 176 in fixed relation to post 130 within notched portion 170 thereof and eliminates the need for welding or other connections between post 130 and member 176.

Member 176 has a V-shaped notch along one side thereof as defined by sloping, converging and intersecting cam surfaces 178 and 180. Edges 182 and 184 of plate 176 respectively adjacent upper and lower cam surfaces 178 and 180, are aligned with each other and also with the circumferential outer edge of cup-shaped latch member 90, as best seen in FIGS. 2, 9 and 11. When the parts are in the reset contacts-closed FIGS. 1 and 2 position, spring 140 serves to position post 130 so that the plate member 176 and its cam surfaces 178 and 180 are positioned adjacent to and in alignment with the latched or interengaged groove 104 and latch spring portion 124 whereby movement of plate member 176, either upwardly or downwardly relative to spring latch member 124, will cam and cause the latter to move radially outwardly within slot 126 (against its inherent spring bias) and out of engagement with detent notch 104 to unlatch member 90 from member 28 and permit the parts to move under the bias of spring 116 from a mechanically latched, reset, contacts-closed position to a mechanically unlatched, retracted, contacts-open position.

Member 152 provides a circumferentially extending annular abutment 190 which is movable from the contacts-open, retracted FIGS. 10 and 11 position to move a thermally responsive unit generally indicated at numeral 200, from a contacts-open to a contacts-closed position as will be more fully described below.

Referring now particularly to FIGS. 5–7, thermally responsive means or unit 200 includes a thermally responsive element 202 formed of a section of compsite metal material. The high expansion component of the material as shown in the embodiment of the drawing is indicated at 204 and the low expansion component is indicated at 206. Element 202 is slotted alternately from opposite sides as at 208, to provide a plurality of transverse lengths 210 electrically connected in series circuit relation. Unit 200 further includes a pair of electrically conductive U-shaped metal strips 212, 214, respectively, each of which encloses one end of each of the lengths 210 of element 202. Lower-most strip 210A and uppermost length or strip 210B (as viewed in FIG. 5) are each respectively electrically connected to U-shaped strips 212 and 214 as by welding as at 216 and 218, respectively. The remaining ends of all of the lengths 210, 210A and 210B are electrically insulated from the adjacent U-shaped strips by means of a layer of electrical

insulating material 220, as best shown in FIGS. 5–7. Insulating material 220 may be any one of a number of well-known kinds, and is interposed between and bonded to each of the U-shaped strips and the remaining ends of the lengths 210, 210A and 210B included thereby. According to one particular example, flat strips of insulating material in the form of glass fiber impregnated with a thermosetting heat curable resin are cut to the desired size and shape, folded about the respective ends of the thermally responsive element 202 to leave the ends of legs 210A and 210B exposed, after which the U-shaped strips 212 and 214 are juxtaposed with element 202, the end of each of lengths 210A and 210B is welded to its respective U-shaped strip, the U-shaped strips are flattened to compress the insulating material between and about the ends of the remaining lengths of the thermally responsive element, and the assembly is then heat cured to effect the bond of the insulating material to and between each of the U-shaped strips and the said remaining lengths enclosed thereby.

Electrically connected to each of U-shaped strips 212 and 214 and carried thereby is a respective one of a pair of electrical contacts 230 and 232. Accordingly, thermally responsive member 200 provides an electrically conductive path leading from contact 230, through U-shaped strip 212, through length 210A of element 202, and then serially through successive lengths 210, through length 210B, and through U-shaped strip 214 to contact 232. As is more fully described in U.S. Patent 2,912,546, slotted thermally responsive element 202 is particularly useful for relatively low current rated (e.g., on the order of 5 amps or less) switches. It will be understood that thermally responsive elements of different ratings can be provided by varying the number and the width of lengths 210 or by eliminating the slotted arrangement as well as varying the composite material of which the element is formed and that thermally responsive elements other than the exemplary element 202 may be employed in the practice of this invention. An example of another thermally responsive element which could be used within the purview of this invention is shown in U.S. Patent 3,022,402, to R. G. Arey, issued February 20, 1962.

Each of U-shaped strips 212 and 214 respectively carries an arm 234 and 236 which may be formed integrally with the respectively U-shaped strip as shown. Upon heating of the thermally responsive element 202, in response to heat generated by the flow of electrical current therethrough and/or increase in ambient temperature, element 202 will flex or warp to the broken-line condition shown in FIG. 6 whereby arms 234 and 236 are deflected outwardly away from each other. The distal ends of arms 234 and 236 are engageable with abutment 190 (provided by the member 152) and the surface presented by this abutment is tangential to the arc traced by the distal ends of arms 234 and 236 as the latter move away from each other under the warping action of the thermally responsive element. Member 152 may be formed of a suitable electrically insulating material such as a conventional moldable phenolic resinous material. If desired, two metal plates (not shown) may be secured to member 152 to serve as the abutment surface 190 for engagement by the distal ends of arms 234 and 236 to avoid or minimize problems of galling or gouging of the abutment surface by arms 234 and 236 and to minimize friction between the arms and the abutment 190.

Referring now to FIGS. 1 and 2, thermally responsive unit 200 is resiliently biased for movement from the FIGS. 1 and 2 reset contacts-closed position to the retracted, FIGS. 10 and 11 contacts-open position by means of a compression spring 240. One end of spring 240 abuts the closed end of a socket 242 provided by casing members 24 and 26 and the other end of this spring abuts the closed end of a socket providing member 244 which telescopically interfits with and is slidable within socket 242 whereby member 244 is biased for movement upwardly as viewed in FIGS. 1 and 2 against the adjacent portions of U-shaped members 212 and 214 of the thermally responsive unit 200. Member 244 is formed of an electrically insulating material such as one of the conventional moldable phenolic resinous materials and includes a flanged upper end 246 which is engageable with adjacent portions of U-shaped members 212 and 214. Casing members 24 and 26 provide a pair of spaced abutments 248, 250, which are engageable with the upper surfaces of U-shaped members 212 and 214 as best seen in FIGS. 10 and 11 to limit the extent of upward movement of unit 200 under the bias of spring 240.

Each of casing members 24 and 26 provides complementary shaped recesses 252, 254, for respectively receiving electrically conductive terminals 256 and 258. It will be clear from the drawings that the mutually engaging and interfitting surfaces of casing members 24 and 26 and terminal members 256 and 258 are configured and interfitted for rigid mounting of the terminals on the casing. Terminal members 258 and 256 respectively mount and are electrically connected to stationary electrical contacts 260 and 262 which are positioned for respective engagement with movable contacts 230 and 232.

As is clear from the drawings, thermally responsive unit 200 acts as a bridging member to electrically connect stationary contacts 260 and 262 when the unit 200 is in the reset contacts-closed position shown in FIG. 1.

It will be noted that member 244, thermally responsive unit 200 and member 152, are prevented from rotation about their respective axis with respect to the casing by the engagement of respective surfaces thereof with adjacent portions of the casing. It will also be noted from FIGS. 1 and 2 that the marginal edges presented by the thermally responsive unit 200 are engageable with the adjacent surfaces of the casing to prevent undue lateral shifting thereof, as well as to prevent rotation thereof. Push button 40 and member 32 may include a longitudinally extending slot (not shown) in which may be received a rib or a projection (also not shown) formed integrally with bushing 28, for preventing push button member 40 and member 32 from rotating relative to bushing 28. A suitable slot and rib arrangement for this purpose is shown in U.S. Patent 2,912,546.

Assembly of the manually operable means 34 as a separate subassembly can be effected as follows: Members 32 and 40 are preassembled as a separate unit held together by tubular fastener 66. Member 152 is telescopically disposed about post 130, after which spring 102 is also telescopically disposed about post 130 with one end thereof bearing against member 152. Cam plate 176 is then assembled with post 130 by interfitting the notched portions 172, 174 of plate 176 with notched portion 170 of post 130. Thereafter, cup-shaped member 90 is telescopically disposed about the post to slidably receive plate 176 in slot 92 thereof to maintain plate 176 within the notched portion 170 of post 130 and to house spring 102 within aperature 98 thereof. The post assembly thus far described is then inserted into the bushing 28. Thereafter, spring member 116 is telescopically disposed about member 90 with one end of the spring being seated against shoulder 108 provided by the bushing 28. Washer 112 is then secured to the upper end of member 90 as by deforming as at 114 to confine spring 116 intermediate washer 112 and shoulder 108. Washer 134 is then disposed about the reduced diameter portion 132 of the post so that it rests on shoulder 136. The button subassembly of parts 40 and 32 is then disposed about the reduced diameter portion 132 of the post 130, and spring 140 is telescopically disposed about the free end of reduced diameter portion 132 through the openings 50 and 48 of the member 40 so that spring 140 is received within the spring well 46 and one end thereof engages or seats against flange 68 of the member 66. Next, washer 142 is applied about the free end of reduced diameter portion 132 and is fixedly connected thereto as by heading

over as at 144. This confines spring 140 within the recess 46 and seats the other end of the spring 140 against the washer 142 as shown. Thereafter, the open end of the button 40 may be closed with a plug 270 which may be marked with the rating of the electrical switch and force fitted into the recess 50, as clearly shown, for example, in FIG. 1. Latching spring 122 is then applied about the bushing 28 by inserting end 120 into aperature 118 and locating latching portion 124 in the slot 126. The completed subassembly 34 can then be quickly and easily mounted on casing 22 by disposing hexagonal flange 30 in the mating casing recess.

The operation of circuit breaker 20 will now be described. With the parts in the respective positions shown in FIGS. 10 and 11, thermally responsive unit 200 is in the retracted, contacts-open position, member 152 is in the retracted position and biased by spring 102 against the stop 150 (provided by post 130) and button members 40, 32 and latch member 90 are biased upwardly (as seen in FIG. 10) by compression spring 116 which brings washer 112 into abutting engagement with washer 134 (which abuts shoulder 64) and with the bottom surface (as seen in FIG. 10) of member 32 and biases fixedly interconnected button members 40 and 32 to the retracted outward position whereby portion 32 (which is formed of a color contrasting with that of push button member 40) is visible from outside of the casing. Member 42 while biased to the retracted position by spring 116 also moves shoulder 58 into abutting engagement with washer 142 which in turn biases stem 130, latch release plate 176, and member 152 carried by stop 150 for movement upwardly to the retracted position shown in FIGS. 10 and 11. Cam surfaces 178 and 180 of the latch release plate 176 are not in alignment with either the latching groove 104 or latch spring portion 124, in the FIGS. 10 and 11 position of the switch. Movement in the contacts-opening retracted direction of member 90 and button members 40 and 42 under the biasing influence of coil spring 116, is limited by engagement of flange 93 of member 90 with shoulder 110 of bushing 28.

To reset the switch to the contacts-closed position (shown in FIGS. 1 and 2) from the contacts-open position (shown in FIGS. 10 and 11), push button member 40 is depressed to the advanced reset position whereby the parts take the respective contacts-closed positions shown in FIGS. 1 and 2. As movement of the push button member 40 from the FIGS. 10 and 11 to the FIGS. 1 and 2 positions ensues, member 32 abuts washer 134 and causes the latter to slide downwardly on post part 132 against washer 112, which in turn, causes latch member 90 (which is fixed to washer 112) to move downwardly against the bias of spring 116 to compress spring 102 and urge member 152 downwardly to move abutment 190 into engagement with distal ends of each of arms 234 and 236 provided by the thermally responsive unit 200, to move the latter to close the respective pairs of contacts 230, 260 and 232, 262. It will be noted that thermally responsive unit 200 is thermally latched to the reset mechanism via engagement of the distal ends of arms 234 and 236 with abutment 190 so that the thermally responsive unit 200 can be moved to the contacts-closed position and maintained in this position, as will be described in greater detail below.

After button member 40 has moved in the contacts-closing direction sufficiently to cause thermal latching between arms 234, 236 and member 152, continued downward movement of button 40 causes washer 134 to engage shoulder or abutment 136, and thereafter, move post 130 and the latch plate 176 carried thereby downwardly so that the camming surfaces 178 and 180 are in alignment with latching groove 104 (of member 90). Thereafter continued downward movement of button 40 will result in downward movement of post 130, plate 176 and latch part 90, together as a unit with latching groove 104 remaining in alignment with cam surfaces 178 and 180 so that when latch member 90 has moved downwardly sufficiently to align latching groove 104 with groove 126, latch spring portion 124 can move into engagement with the latching groove 104 under its inherent spring bias to mechanically latch the parts together in a contacts-closed position, such as shown in FIGS. 1 and 2. Groove 104 is considerably larger than the diameter of spring wire finger 124 for tolerance purposes and to permit ease of manufacture and assembly. Further downward movement (as viewed in FIG. 1) after mechanical latching is resisted by engagement of shoulder 74 (on button 40) with shoulder 76 provided by bushing 28. When the push button 40 is released the mechanical latch members 124 and 90 retain the push button assembly 34 in the reset position against the bias of spring 116. Member 152, which is thermally latched to the unit 200, retains the unit 200 in the contacts-closed advanced position under the bias exerted by the spring 102. It may be noted at this point that none of the force exerted by the spring 116 is transmitted to or directly affects the forces on or action of the thermally responsive unit 200. It will be noted that spring 102 exerts a considerably greater spring force than that exerted by spring 140.

The purpose of spring 140 as noted above, is primarily for positioning post 130 and latch release member 176 for alignment with latching groove 104 and latch spring portion 124 after the parts have been moved to the FIG. 1, contacts-closed position.

With the parts in the contacts-closed reset position shown in FIGS. 1 and 2, an electrically conductive path is established leading from terminal 258, to stationary contact 260, to movable contact 230, through the thermally responsive element 202, to contact 232, to stationary contact 262, to terminal 256. Upon the flow of electrical current of sufficiently high values along the electrical current path just described, thermally responsive element 202 will warp or flex toward the dotted line position shown in FIGS. 1 and 6 thereby moving arms 234 and 236 outwardly from each other toward the broken line position shown in FIGS. 1 and 6. When the thermally responsive element 202 warps and/or flexes sufficiently to move the distal ends of arms 234 and 236 out of engagement with abutment 190 provided by member 152 to the broken line position shown in FIG. 1 and to the solid line position shown in FIG. 8, member 152 will move to the position shown in FIGS. 8 and 9 under the bias of spring 102. Thermally responsive unit 200 is no longer thermally latched to or restrained in the contacts-closed position and immediately begins movement to the contacts-open, retracted position shown in FIGS. 8–11 under the resilient bias exerted by compression spring 240. Upward movement of the thermally responsive unit 200 is limited by engagement with abutments 248 and 250 provided by the casing 20. In FIGS. 8 and 9 the parts are shown in an intermediate position which results immediately after thermal tripping or disengagement between the thermal unit 200 and the member 152 and prior to opening of the button or movement of the button to the retracted position under the bias of spring 116.

Referring now to FIGS. 8 and 9, member 152 after being unlatched from the arms 234 and 236 moves downwardly under the bias of spring 102 into engagement with abutment 150 causing downward movement of post 130 and latch release plate 176 to move camming surface 178 thereof into engagement with latch spring portion 124 to cam the latter out of engagement with groove 104 and to move outwardly in slot 126 against its resilient bias to mechanically unlatch the parts. After unlatching, member 176 continues to move downwardly until the side surface 182 blocks re-entry of latch spring portion 124 into engagement with latching groove 104. In this condition, the parts are unlatched and free to move to the retracted contacts-open position under the bias of spring 116, as shown in FIGS. 10 and 11.

Immediately after tripping of circuit breaker 20 from the contacts-closed, FIGS. 1 and 2 condition to the contacts-open FIGS. 10 and 11 condition, unit 200, as shown in FIGS. 8–11, may still be heated and due to warping of element 202, arms 234 and 236 will be disposed in the outwardly displaced positions as shown in the dashed lines in FIGS. 1 and 6 and in solid lines in FIG. 8. Accordingly, in this condition, depression of push button 40 from the FIGS. 10 and 11 retracted position and resulting downward movement of member 152 fails to bring abutment 190 into engagement with the distal ends of arms 234 and 236 whereby the thermally responsive unit remains in its retracted contacts-open position, as shown in FIGS. 8–11. This feature is advantageous in that the movable contacts cannot be closed against the fixed contacts until the thermally responsive element 200 has cooled for a significant or sufficient time interval. Also upon depression of the push button from the retracted to the advanced (or reset) position while the thermally responsive element is in this heated (e.g., FIG. 8) condition, mechanical latching between latch spring portion 124 and latching groove 104 cannot take place because member 152 (under the bias of spring 102) retains post 130 and latch release plate 176 in the position shown in FIG. 11 with surface 182 preventing latch spring 124 from moving into engagement with groove 104, whereby the push button or manually operable means 34 remain free to move from the advanced position to the retracted contacts-open position under the bias of spring 116 upon release of the push button.

Upon cooling of the thermally responsive member 200 from the warped condition, shown in dotted lines in FIGS. 1 and 6 to the full line position shown in these figures, the parts are again in the condition and positions shown in FIGS. 10 and 11, ready for resetting of the circuit breaker, as just described.

Circuit breaker 20 is further capable of being manually actuated for use as an on-off electrical switch. In this regard, with the parts in the FIG. 1 and 2 reset, contacts-closed position, push button 40 may be grasped and forcibly pulled outwardly toward retracted position whereby the parts will move to an intermediate position, as shown in FIG. 13. As the button 34 is grasped and pulled outwardly from the reset FIGS. 1 and 2 position, to the FIG. 13 intermediate position, shoulder 58 moves into engagement with washer 142 to move post 130 upwardly as seen in FIGS. 2 and 13. During this movement, member 152 remains thermally latched to thermal unit 200 by the engagement of the distal ends of arms 234 and 236 with abutment 190. Upward movement of post 130 causes corresponding upward movement of latch release plate 176 causing cam surface 180 (of member 176) to move into engagement with latch spring portion 124 to cam the latter out of engagement with groove 104 and into groove 126. After unlatching, surface 184 of latch release member 176 blocks re-entry of spring portion 124 into engagement with detent groove 104. Mechanical unlatching takes place prior to engagement of abutment or flange 150 with member 152 so that the thermal unit remains thermally latched to member 152 until after mechanical unlatching has effected. Thereafter, the parts are free to move to the FIGS. 10 and 11 retracted position under the bias of spring 116. FIG. 13 shows the position of the parts just after latch spring portion 124 has been cammed out of engagement with groove 104 and prior to movement of the parts to the retracted FIG. 10 position under the biasing force of spring 116. Surface 94 is adapted to engage member 176 to limit upward movement (as seen in FIG. 13) of post 130 and member 176 relative to member 90.

As noted above, the latching forces exerted to retain manually operable assembly 34 and the parts connected therewith, in the reset position, are independent of the forces exerted on thermally responsive member 200. This is advantageous in that repeated latching and unlatching

due to manual on-off switching of the circuit breaker does not deleteriously affect or upset the calibration of the thermally responsive unit. Circuit breaker 20 is also "trip-free" in that the thermally responsive member 200 cannot be retained in the contacts-closed position by forcibly retaining push button 40 in the advanced position, upon the occurrence of current overload through the thermally responsive element 202. If push button 40 is forcibly retained or held in the depressed, advanced position when the thermally responsive element warps sufficiently to disengage the distal ends of arms 234 and 236 from abutment 190, unit 200 will move to the contacts-open position under the bias of spring 240 (manually operable assembly 34 will, of course, remain in the advanced position as long as a force is applied to depress the push button 40) and member 152 will move away from member 90 against stop 150 to the position shown in FIG. 9. FIGS. 8 and 9 show the respective position of the parts after tripping of the thermally responsive member 200 from the contacts-closed to the contacts-open position and just prior to movement of the manually operable means 34 to the retracted position under the bias of spring 116. It will be noted from FIGS. 8 and 9 that the manually operable means 34 will quickly move to the retracted position under the bias of spring 116 upon release of the push button, this being because edge 182 of member 176 prevents latch spring portion 124 from moving into engagement with groove 104 until the thermally responsive element is moved to the contacts-closed position to stress spring 102 and disengage member 152 from abutment 150 carried by post 130.

A feature of the structural arrangement of the operating parts of the instant invention is that it lends itself to the use of compressive resilient biasing means for many of the springs which affords substantial advantages over tension springs and the like. Another feature of the present invention is that the contacts cannot be "teased open" by manual operation. The switch of the present invention permits manual snap opening of the contacts since mechanical unlatching occurs prior to thermal unlatching.

It will also be noted that the thermally responsive element 200 warps upon heating thereof in a direction to urge contacts 230 and 232 against contacts 260 and 262 respectively. Also compression spring 240 acts against a portion of the thermally responsive member 202 between the contacts 230 and 232 on a line substantially perpendicular to a line connecting the latter contacts and the thermally responsive element 202 warps upon heating thereof in a direction to urge said portion upwardly (as viewed in FIG. 1) to decrease the deflection of spring 240. As pointed out in U.S. Patent 2,912,546, spring 240 is of conventional form which follows Hooke's law in that the force exerted thereby is directly proportional to the deflection thereof. It will be clear that spring 240 need not follow Hooke's law for the beneficial result to be pointed out following, but only that the force exerted thereby decrease with decrease in deflection thereof (and vice versa). Furthermore, it will be clear that the force exerted by member 152 of the manually operable resetting means 34 under the bias of compressive spring 102 acts against the thermally responsive element 202. Since abutment 190 presents a surface tangential to the arc traced by the distal ends of arms 234, 236 upon heating of the thermally responsive element, the force exerted against element 202 by member 152 under the bias of spring 102 remains constant, and any decrease in the force exerted by spring 240 is reflected by an increase in the pressure between engaged contacts 230, 260 and 232, 262, respectively. It will be clear therefore, that so long as the force exerted by member 152 against the thermally rsponsive unit 200 under the bias of compression spring 102 does not decrease as element 202 warps from the full line to the broken line position, shown in FIGS. 1 and 6, and since any expansion of spring 240 to accommodate

such warping of the thermally responsive element can result only in a decrease in the force exerted by the latter spring with a concomitant increase in the pressure exerted by the contacts 230 and 232, respectively, against contacts 260 and 262, no decrease in contact pressure will occur during warping of element 202 until the distal ends of arms 234 and 236 move out of engagement with abutment 190 for release of unit 200 to move to the contacts-open position.

As arms 234 and 236 move away from each other upon warping of element 202, it is likely or possible at least, that one of these arms will move out from engagement with abutment 190 slightly before the other. The result will be that member 152 will tilt about the point of engagement of said other arm and move laterally relative to stem or post 130 under the force couple exerted effected by the bias of springs 102 and 240. This tilting and lateral movement of the member 152 is permitted by virtue of the clearance described above between the surface of member 152 defining aperture 154 and the outer surface of post 130. This tilting and lateral movement of member 152 permits disengagement of the other arm from abutment 190, as described in the aforementioned U.S. Patent 2,912,546, and also permits movement of unit 200 to the retracted, FIGS. 10 and 11, contacts-open position promptly upon disengagement of the other arm from the abutment 190. Lateral and pivotal realignment of member 152 takes place immediately after release of unit 200 to the retracted, FIGS. 10 and 11, contacts-open position under the bias of spring 102. Accordingly, abutment 190, provided by member 152, will be realigned with the distal ends of arms 234 and 236, upon cooling and return warping of the element 202 from the broken line to the full line position shown in FIGS. 1 and 6.

It will be seen from the foregoing that compression spring 102 advantageously serves a dual function of (1) providing desired contact pressure when member 152 is thermally latched to the thermal unit 200 in the contacts-closed position, and (2) of causing downward movement of latch release plate 176 (as viewed in FIG. 1) when arms 234 and 236 move out of engagement with abutment 190 to unlatch member 152, to cause spring latch 124 to move out of engagement with groove 104 to permit the manually operable assembly 34 to move to the retracted contacts-open position under the biasing force exerted by spring 116.

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

As many changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings, shall be interpreted as illustrative and not in a limiting sense, and it is also intended that the appended claims shall cover all such equivalent variations as come within the true spirit and scope of the invention.

I claim:

1. In combination: a tubular member; a manually operable member having a portion disposed in said tubular member for reciprocal sliding movement therein between first and second positions; a cylindrical latch member disposed in said tubular member for movement relative to and with said manually operable member; a first spring member urging said cylindrical member for movement against said manually operable member to move the latter to said first position; said manually operable member being movable against and with said cylindrical member as a unit toward said second position; said cylindrical member providing an annularly extending latching groove; said tubular member providing a slot communicating with said groove when said cylindrical member is in said second position; a second latch member having a portion disposed in said slot and spring biased for movement into engagement with said groove to latch said manually operable member and cylindrical member in said second position against the bias of said first spring member; a post member slidably mounted in aligned apertures in said manually operable member and in said cylindrical latch member for movement relative thereto; said post carrying a latch release member disposed in a slot provided by said cylindrical member; said latch release member being movable against said second latch member to move the latter out of engagement with said latching groove to permit said manually operable member and cylindrical member to move to said first position under the bias of said first spring member.

2. The combination as set forth in claim 1 and wherein said latch release member includes a cam surface positioned for engagement with said second latch member when the latter is in engagement with said latching groove.

3. The combination as set forth in claim 2 and including a second spring member positioning said latch release member so that the cam surface thereof is positioned to engage said second latch member when the latter engages said latching groove.

4. The combination as set forth in claim 2 and wherein said latch release member includes a second cam surface diverging from said first cam surface toward said tubular member and positioned for engagement with said second latch member whereby said second latch member can be moved out of engagement by said latch release member, in response to movement of said latch release member in each of two opposite directions.

5. An electrical switch comprising a base; first contact means on said base; movably mounted means carrying movable contact means for engagement with said first contact means; manually operable means mounted in said switch and including an abutment member mounted for movement relative to said movably mounted means; thermally responsive means for latching said abutment member and said movably mounted means together as a unit for movement in a contacts closing direction; said manually operable means further including a first latch member having a detent portion; first spring means urging said first latch member, abutment member and manually operable means for movement in a contacts opening direction; means mounting and spring biasing a second latch member for movement toward engagement with said detent portion to mechanically latch said manually operable means in a contacts-closed position only when said abutment member is latched to said movably mounted means by said thermally responsive means; said manually operable means also including a latch release member mounted for movement relative to said first and second latch members for moving said second latch member out of engagement with said first latch member to permit said manually operable means to move to a contacts-open position under the bias of said first spring means.

6. An electrical switch comprising a base; first contact means on said base, movable contact means mounted for movement into and out of engagement with said first contact means; a tubular member mounted on said base; said switch including manually operable means for moving said movable contact means into engagement with said first contact means; said manually operable means including a manually operable member having a portion disposed in said tubular member for reciprocal sliding movement therein between contacts-open and contacts-closed positions; a cylindrical latch member disposed in said tubular member for movement relative to and with said manually operable member; a first spring member urging said cylindrical member for movement against said manually operable member to move the latter to said contacts-open position; said manually operable member being movable against and with said cylindrical member as a unit toward said contacts-closed position; said cylindrical member providing an annularly extending latching groove; said tubular member providing a slot communicating with said groove when said cylindrical member is in said contacts-closed position; a second latch

member having a portion disposed in said slot and spring biased for movement into engagement with said groove to latch said manually operable member and cylindrical member in said contacts-closed position against the bias of said first spring member; a post member slidably mounted in aligned apertures in said manually operable member and in said cylindrical latch member for movement relative thereto; said post carrying a latch release member disposed in a slot provided by said cylindrical member; said latch release member being movable against said second latch member to move the latter out of engagement with said latching groove to permit said manually operable member and cylindrical member to move to said contacts-open position under the bias of said first spring member.

7. The switch as set forth in claim 6 and wherein said latch release member includes a cam surface positioned for engagement with said second latch member when the latter is in engagement with said latching groove.

8. The switch as set forth in claim 7 and wherein said latch release member includes a second cam surface diverging from said first cam surface toward said tubular member and positioned for engagement with said second latch member whereby said second latch member can be moved out of engagement by said latch release member, in response to movement of said latch release member in each of two opposite directions.

9. The switch as set forth in claim 7 and wherein said latch release member is plate like in form and includes a notched portion interfitting with a correspondingly shaped notched portion on said post to mount said latch release member on said post.

10. The switch as set forth in claim 6 and including a second spring member positioning said latch release member so that the cam surface thereof is positioned to engage said second latch member when the latter engages said latching groove.

11. An electrical switch comprising a base; first contact means on said base, movable contact means mounted for movement into and out of engagement with said first contact means; a tubular member mounted on said base; said switch including manually operable means for moving said movable contact means into engagement with said first contact means; said manually operable means including a manually operable member having a portion disposed in said tubular member for reciprocal sliding movement therein between contacts-open and contacts-closed positions; a cylindrical latch member disposed in said tubular member for movement relative to and with said manually operable member; a first spring member urging said cylindrical member for movement against said manually operable member to move the latter to said contacts-open position; said manually operable member being movable against and with said cylindrical member as a unit toward said contacts-closed position; said cylindrical member providing an annularly extending latching groove; said tubular member providing a slot communicating with said groove when said cylindrical

member is in said contacts-closed position; a second latch member having a portion disposed in said slot and spring biased for movement into engagement with said groove to latch said manually operable member and cylindrical member in said contacts-closed position against the bias of said first spring member; a post member slidably mounted in aligned apertures in said manually operable member and in said cylindrical latch member for movement relative thereto; said post carrying a latch release member disposed in a slot provided by said cylindrical member; means mounting said latch release member on said post for movement therewith relative to said groove and second latch member for causing unlatching thereof; said post including a flange engageable with an abutment member slidably mounted on said post; said abutment member being engageable with said movable contact means to move and maintain the latter to a contacts-closed position; spring means urging said movable contact means for movement in a contacts opening direction; spring means urging said abutment member for movement in a contacts closing direction toward engagement with said flange and movably mounted means; said abutment member being prevented from engaging said flange when said movable contact means are in said contacts-closed position; thermally responsive means for disengaging said abutment and movable contact means to permit the latter to move to a contacts-open position under the bias of said movable contact urging spring means and permit said abutment to move against said flange under the bias of said abutment member urging spring means to move said post and latch release member relative to said second latch member to cause the latter to move out of engagement with said latching groove to permit said manually operable member and cylindrical member to move to said contacts-open position under the bias of said first spring member.

12. The switch as set forth in claim 11 and including second spring means positioning and aligning said latch release member for unlatching said first and second latch members in response to movement of said post when said manually operable means is in said contacts-closed position.

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