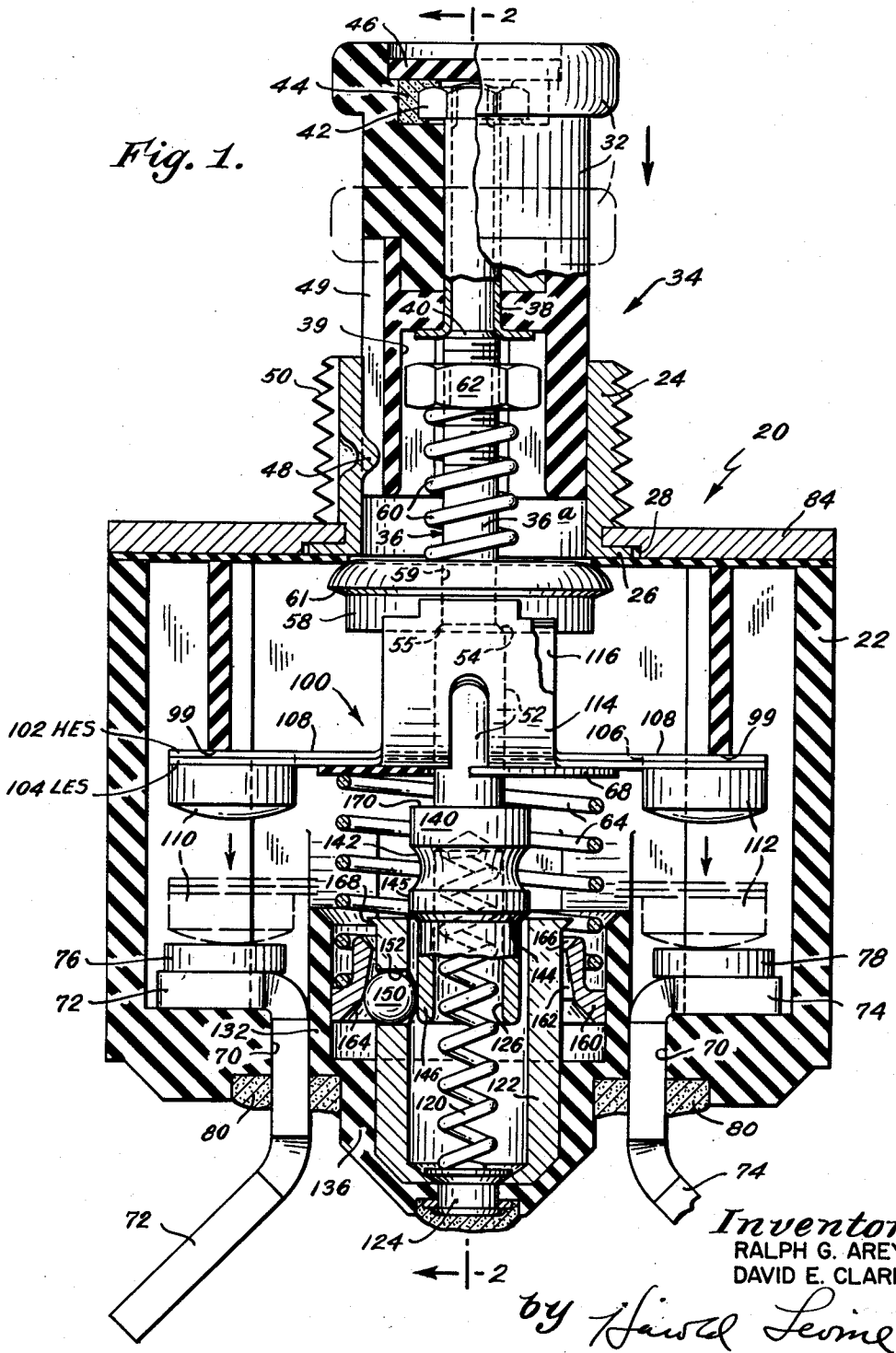
July 3, 1962 R. G. AREY ET AL 3,042,776

ELECTRICAL SWITCHES

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Fig. 1.



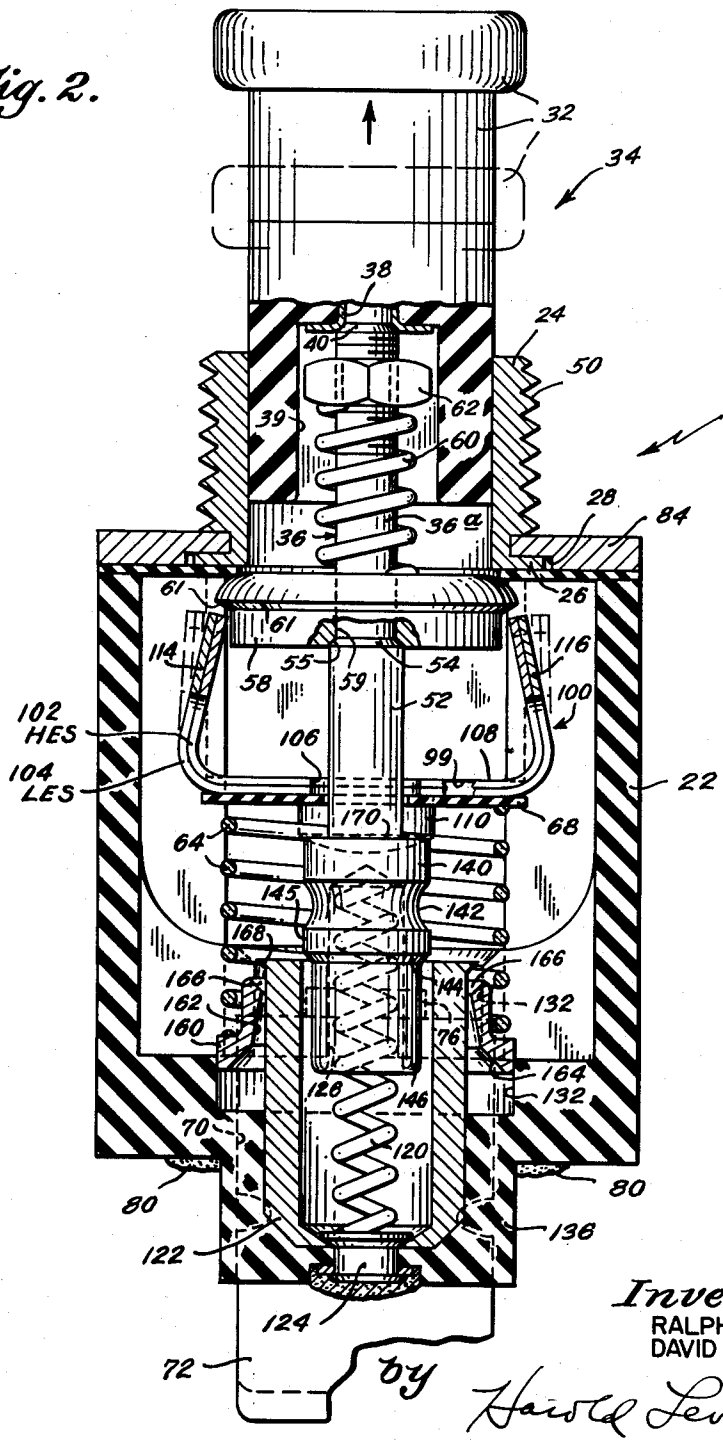
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ELECTRICAL SWITCHES

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Fig. 2.



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ELECTRICAL SWITCHES

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Fig. 3.

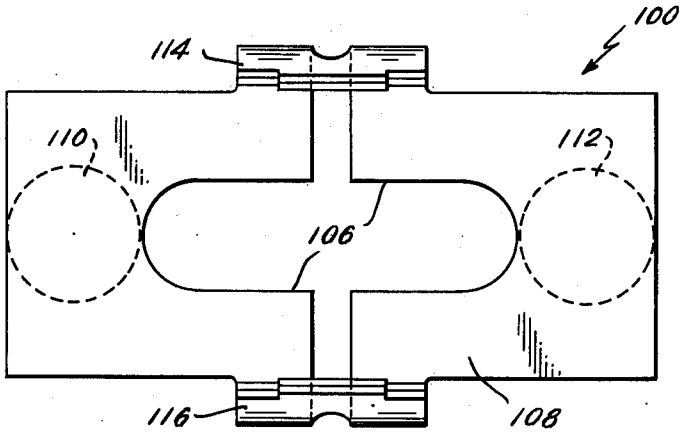


Fig. 4.

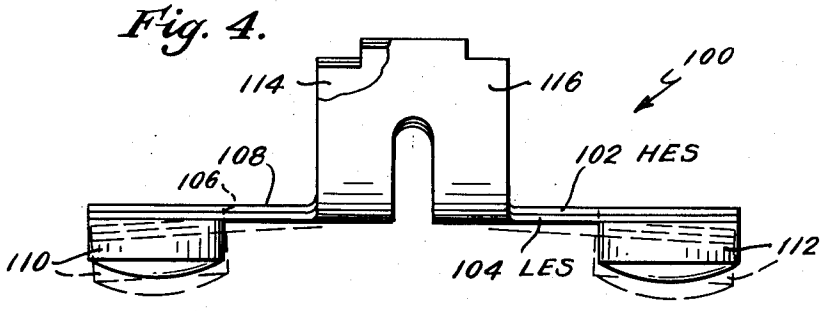
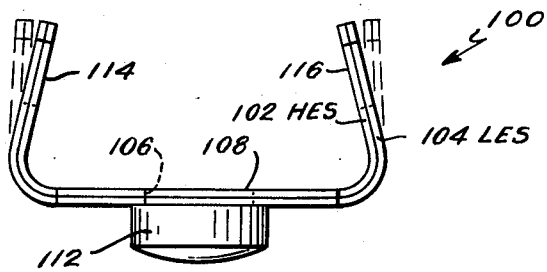


Fig. 5.



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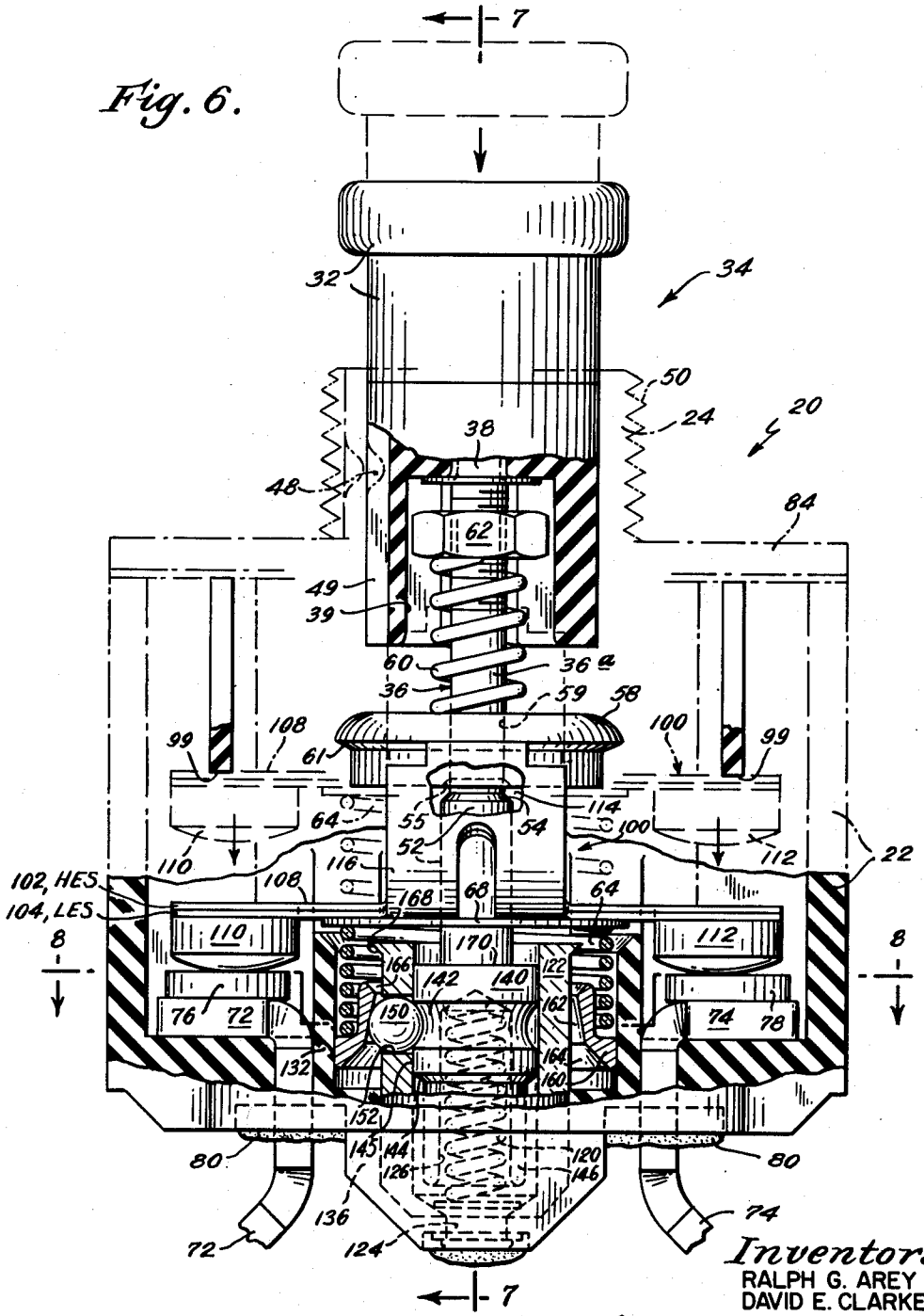
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Fig. 6.



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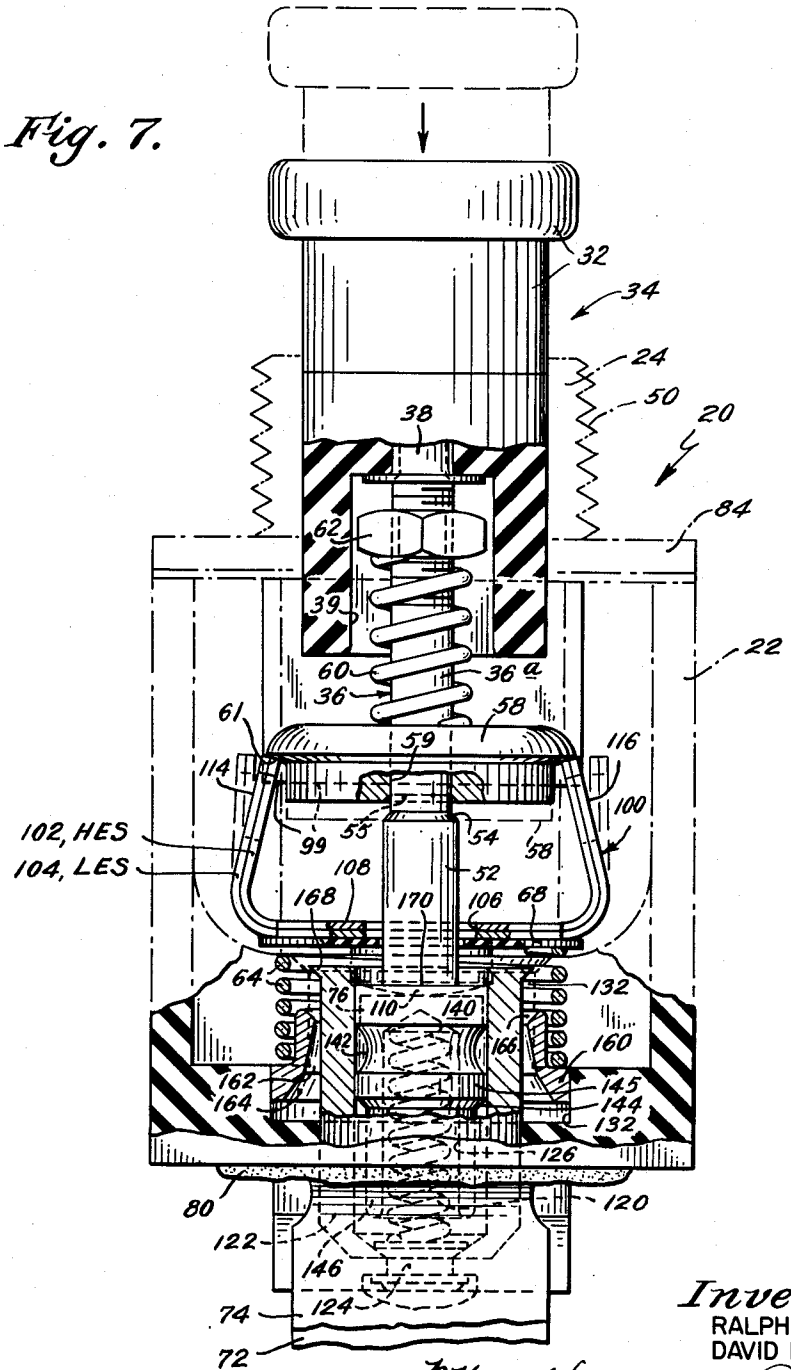
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Fig. 7.



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Fig. 8.

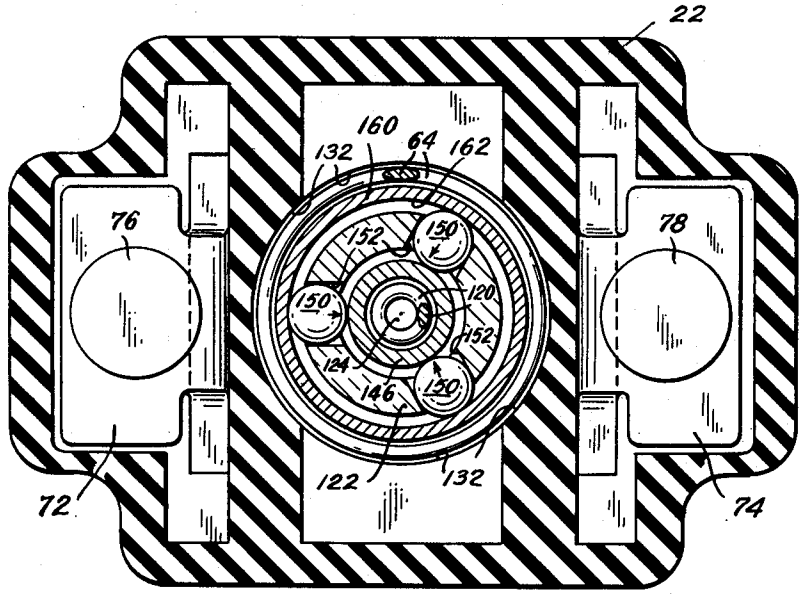


Fig. 9.

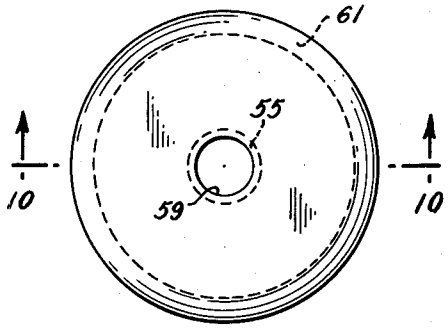


Fig. 11.

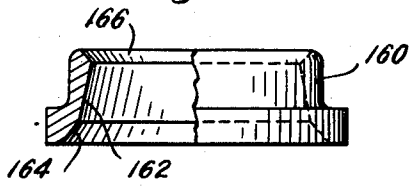
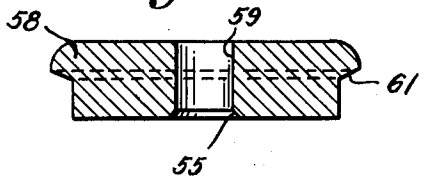


Fig. 10.



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3,042,776

ELECTRICAL SWITCHES

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Filed Sept. 16, 1959, Ser. No. 840,327
17 Claims. (Cl. 200—116)

The instant invention relates to electrical switch structures, and more particularly, to thermally responsive switch structures.

An object of this invention is to provide an improved switch structure incorporating a new and improved combination of interrelated parts.

A further object is to provide such a switch structure which accommodates the use of compressive resilient biasing means for biasing operating parts thereof.

Another object is to provide such a switch structure utilizing a thermal type latch means and a new and improved mechanical latch means, which mechanical latch means functions without upsetting the calibration of the thermally responsive latch means thereof.

A further object is to provide a thermally responsive switch which is also mechanically actuable repeatedly as an on-off switch without upsetting the calibration of the thermally responsive means thereof.

Another object of the invention is to provide such a switch structure which exhibits improved electrical contact pressure characteristics.

Another object of the instant invention is to provide such a switch structure which affords snap-opening and snap-closing of the electrical contacts.

Among the further objects of the instant invention are the provisions of a switch which is durable, accurate, reliable in operation, compact, easily calibratable, has vibration stability, which embodies a minimum number of parts, and which is simple in construction and economical to manufacture.

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 vertical section, with some parts broken away and others in elevation, in a thermally responsive switch embodying the instant invention, showing the parts thereof in full lines in the retracted, contacts-open position and the parts in dashed lines in the reset, contacts-closed position;

FIG. 2 is a vertical section taken on line 2—2 of FIG. 1, with some parts shown in full lines and others in section;

FIG. 3 is a top plan view on an enlarged scale of the thermally responsive member of the switch;

FIG. 4 is a front elevational view of the thermally responsive member shown in FIG. 3;

FIG. 5 is an end view of the thermally responsive member shown in FIGS. 3 and 4;

FIG. 6 is a view similar to FIG. 1, showing the parts thereof in full lines in the reset, contacts-closed position, and showing the parts thereof in dashed lines in the retracted, contacts-open position;

FIG. 7 is a sectional view taken on line 7—7 of FIG. 6, with certain of the parts shown in full lines and others in phantom lines;

FIG. 8 is a plan section taken on line 8—8 of FIG. 6;

FIG. 9 is a top plan view of a part of the resetting means of the switch of the instant invention;

FIG. 10 is a sectional view taken on line 10—10 of FIG. 9; and

FIG. 11 is an elevational view, partly in elevation and partly in section, of a part of the mechanical latching means of the switch of the instant invention.

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

Dimensions of certain of the parts as shown in the drawings have been modified for the purposes of clarity of illustration.

The instant invention relates to electrical switches of the class such as that described and claimed in the earlier-filed copending applications, Serial No. 732,550, filed May 2, 1958, now matured into Patent No. 2,912,546, issued November 10, 1959, and Serial No. 837,754, filed September 2, 1959, now matured into Patent number 3,022,402, issued February 20, 1962.

Referring to FIG. 1, an electrical switch embodying the instant invention is shown taking the form of a circuit breaker indicated generally by the reference numeral **20**. The switch includes a base or casing **22** which carries a bushing **24** having an annularly extending flange **26**, which mates with a correspondingly-shaped recess **28**, provided by a cover member **84** for casing **22** which may be secured thereto in any known convenient manner. Casing **22** and cover **84** may be formed of one of the conventional phenolic, resinous moldable materials. Mounted for slidable movement within and along bushing **24** is a button assembly **32** forming part of the manually operable resetting means **34** of the switch. Manually operable resetting means **34** further includes a stem **36** extending through an aperture **39** in button assembly **32** and through a sleeve **38** disposed in another aperture of smaller diameter in button assembly **32**, as best seen in FIG. 1. Stem **36** is secured in fixed relation to button **32** by means of a beveled portion **40** on stem **36**, which abuts the lower portion of flanged sleeve **38** (as best seen in FIG. 1), and a nut **42** which is threaded onto the upper end of stem **36**, in a suitable recess provided by button assembly **32**. After nut **42** is tightened to secure stem **36** to button assembly **32**, a sealing compound **44** is introduced and a cover member **46** is applied to close the opening in button assembly **32**, all of which is clearly illustrated in FIG. 1.

Bushing **24** provides an abutment or projection **48**, which is received in a vertically extending slot **49** provided by button **32**. Abutment or projection **48**, which interfits with slot **49**, prevents rotation of the push button relative to the switch casing and also provides one means for limiting downward movement of the push button **32**, as viewed in FIG. 1. An annulus or band of a color contrasting with that of the push button member **32** and the bushing **24** may be provided, if desired, to indicate the relative switch positions, in a well-known manner. Bushing **24** is externally threaded, as at **50**, for the reception of a nut or nuts (not shown) for mounting the switch on a support.

Stem **36** is provided with a portion **52** of enlarged diameter, having a beveled portion **54** adjacent the smaller diameter portion **36***a* of stem **36**. Manually operable resetting means **34** further includes an abutment member **58** having an aperture **59** through which the smaller diameter portion **36***a* of stem **36** extends, whereby abutment member or button **58** is slidably mounted on portion **36***a* of stem **36** above beveled portion **54**, as best seen in FIGS. 1, 6 and 7. Compressive resilient biasing means in the form of a compression spring **60** is disposed about reduced diameter portion **36***a* of stem **36**, and resiliently biases member **58** against beveled portion **54** and away from button **32** in a contacts-closing direc-

tion. The upper end of spring **60**, which is disposed about reduced diameter portion **36***a* of stem **36**, abuts a nut **62**, which is in threaded engagement with the portion of the stem **36***a* adjacent sleeve **38**. Aperture **39** has a cross sectional configuration which is complementary to that of nut **62** and thereby serves to prevent relative rotation between nut **62** and button assembly **32**. Adjustment of the compressive biasing force of spring **60** may be effected by rotation of stem **36** relative to nut **62** before nut **42** is tightened and the sealing compound **44** and cover **46** are applied. As will be explained in greater detail below, spring **60** serves as a means for providing desired contact pressure.

As best seen in FIGS. 1, 9 and 10, aperture **59** provided by abutment member **58** has a substantially larger diameter than the outside diameter of smaller diameter portion **36***a* of stem **36**, whereby member **58** has a loose, unconfined fit with this portion of the stem when the resetting means is in the reset contacts-closed position, as shown in FIG. 6. Aperture **59** also includes a countersink or beveled portion **55** engageable with interfitting beveled portion **54** provided by enlarged diameter portion **52** of stem **36** under the bias of spring **60** when the resetting means is in the retracted contacts-open position shown in FIG. 1.

Manually operable resetting means **34** includes an annular abutment **61** on member **58**, and is movable from the positions shown in full lines in FIG. 1 to the positions shown respectively in full lines in FIG. 6, into engagement with a thermally responsive unit indicated generally as at **100** to move the latter from a contacts-open to a contacts-closed position, as will be more fully described below.

Referring now particularly to FIGS. 3–5, the exemplary thermally responsive unit illustrated therein comprises a thermally responsive element formed of a section of composite material. The high-expansion component of the composite material, as shown in the embodiment of the drawing, is indicated at **102** (HES) and the low-expansion component is indicated at **104** (LES). Thermally responsive unit **100** provides a longitudinally extending slot **106** through which enlarged diameter portion **52** of stem **36** extends whereby thermally responsive unit **100** is slidably mounted on stem **36**. Thermally responsive unit **100** provides a longitudinally extending bridging portion **108**, which carries movable contacts **110** and **112** which are electrically connected to the low-expansion side **102** thereof. Thermal unit **100** thus serves as a movably mounted means for carrying movable contacts **110** and **112**. Thermally responsive unit **100** is further provided with and carries a pair of opposed spaced slotted arms **114** and **116**, as best seen in FIGS. 2 and 5.

Accordingly, thermally responsive unit **100** provides an electrically conductive path leading from contact **110** through the bridging portion **108**, through arms **114** and **116**, to contact **112**. Due to the heating of the thermally responsive element **100** upon the flow of electrical current therethrough, the thermally responsive element flexes or warps to the dotted-line condition shown in FIGS. 2, 4, 5 and 7, whereby arms **114** and **116** are deflected away from each other. The distal ends of arms **114** and **116** are engageable with abutment **61** provided by member **58**, and the surface presented by this abutment is tangential to the arc traced by the distal ends of arms **114** and **116** as the latter move away from each other under said warping of the thermally responsive element.

Referring again to FIGS. 1 and 2, thermally responsive member or unit **100** is resiliently biased from the contacts-closed position (shown in full lines in FIG. 6 and in dashed lines in FIG. 1) to the contacts-open position, as shown in full lines in FIG. 1, by means of a compression spring **64** which is disposed about stem **36**. The upper end of compression spring **64** abuts a layer of electrical and heat insulating material **68** provided on

the lower surface of thermal member **100**, as clearly seen in FIGS. 1 and 2. Insulating member **68** serves as an insulator spring seat and prevents short circuiting of the thermal element by spring **64** and stem **36** and localizes the heat at the thermal element. The other end of compression spring **64** abuts a latching ring member **160**, as will be described in greater detail below.

Casing or housing **22** provides a pair of abutments **99** for limiting the extent of upward movement of thermally responsive member **100** from a contacts-closed to a contacts-open position by engagement thereof with the upper surface of bridging portion **108**, as clearly shown in FIGS. 1 and 6. Housing member **22** provides recesses **70** for the reception of terminals **72** and **74**, respectively. Terminals **72** and **74** are so configured as to interfit with casing **22** for rigid mounting. A sealing compound **80** is disposed about terminals **72** and **74** when in final assembled condition. Terminals **72** and **74** respectively carry fixed contacts **76** and **78** for co-operative engagement respectively with movable contacts **110** and **112**, as shown. As is clear from the drawing, thermally responsive member **100** provides a bridging member electrically connecting contacts **76** and **78** when the thermally responsive member is in a contacts-closed position, as shown in FIG. 6.

It will be noted that thermally responsive member **100** is prevented from rotation about its axis and with respect to the casing by the engagement of respective surfaces thereof with adjacent portions of the casing. Referring to FIGS. 1 and 2, it will be apparent that the marginal edges presented by the thermally responsive unit **100** engage adjacent surfaces of the casing to prevent undue lateral shifting thereof as well as to prevent rotation thereof. Further, the slidable mounting of the thermally responsive member **100** on portion **52** of stem **36** also serves to prevent undesired lateral shifting of the thermal element with respect to the casing.

Stem **36** is compressively biased in a contacts-opening direction by means of a compression spring **120**, housed in spring cup **122**, which may be formed of a metallic or phenolic material. One end of spring **120** abuts a rivet **124** which serves to mount spring cup **122** in housing **22**, and the other end of spring **120** is received in an axially extending recess **126** provided by the lower end portion **146** of stem **36**, as clearly seen in FIG. 1.

Housing **22** provides a recess formed by walls **132** and **136** for housing the spring cup and mechanical latching means which will be described in greater detail below. Spring cup **122** is disposed in and is entirely enclosed in the recess provided by housing **22**, as clearly seen in FIGS. 1, 2 and 6. Compression spring **120** thus urges stem **36** and abutment member **58** (through engagement of beveled portion **54** of the stem and beveled portion **55** on the abutment member **58**) and button **32** in a contacts-opening direction.

Switch **20** includes mechanical latching means for latching the stem in a reset, contact-closed position when the thermal element **100** is thermally latched to the stem for movement therewith as a unit in the contacts-closing direction. The mechanical latching means operates independently of the thermal latching and is mechanically actuable repeatedly without upsetting the calibration of the thermally responsive means.

Stem **36** is provided intermediate its lower portion **146** and portion **52**, with a portion **140** of enlarged diameter. The diameter of portion **140** is considerably greater than the diameter of portion **52** of stem **36**. Portion **140** includes a circumferentially or peripherally extending groove which provides a detent surface **142**, as clearly seen in FIG. 1. Adjacent the lower portion of portion **140** is a beveled portion **144**, which intersects with the lowermost portion **146** of stem **36**, which portion **146** is of slightly smaller diameter than that of portion **140**, for a purpose to be described below.

Detent surface or circumferentially extending groove

142 is adapted to receive and mate with a plurality of balls 150 for latching engagement therewith. Referring now to FIG. 8, ball means 150 is shown as exemplarily comprising three balls, circumferentially spaced about stem 36 and mounted for movement in a direction normal to the longitudinal axis of stem 36, toward and away from, or into and out of engagement with, detent surface or groove 142, by means of suitable openings 152 provided by spring cup member 122 (as clearly shown in FIGS. 1 and 8). It should be understood that in the practice of the instant invention a greater or different number of balls could be provided, if desired. It has been found, however, that the employment of three balls, as illustrated, provides a stable mechanical latching arrangement.

Balls 150 are urged for movement into latching engagement with detent surface or groove 142 by movable detent means comprising a latching ring 160, which may, for example, be formed of a hardened stainless steel.

Latching ring 160 is slidably mounted on spring cup 122 and is guided for reciprocal vertical movement between the housing walls 132 provided by casing 22 and the outside circumferential surface of spring cup 122, and is thus confined to reciprocal sliding movement in a vertical direction, as seen in FIG. 1. Latching ring 160 includes an angularly disposed wedging surface 162 which is engageable with balls 150 to urge the latter into engagement with detent surface 142 upon downward movement of latching ring 160, as viewed in FIG. 1. The outer circumferential portion of latching ring 160 is so shaped as to provide a spring seat for the lower end of spring 64 to abut, whereby spring 64 also compressively biases latching ring or detent ring 160 for movement downwardly to urge balls 150 into latching engagement with detent surface 142 when thermal element 100 is moved into the contacts-closed position.

Latching ring 160 includes a lower beveled portion 164 which is disposed at an angle to wedge surface 162 and which permits balls 150 to move outwardly in opening 152, relative to detent surface 142 and spring cup 122 so as to permit disengagement of stem 36 from the balls 150 to thereby permit stem 36 to move outwardly to the retracted, contacts-open position under the bias of compression spring 120.

The angle of beveled surface 162 on the latching ring 160 which engages the balls 150 is such as to render the effective downward thrust of the latching ring 160 and the spring 64 greater than the upward thrust of the stem spring 120 when the thermal element is in the contacts-closed position.

The detent latching ring 160, as shown in elevation in FIG. 11, further includes an upper beveled portion 166 which is adapted to mate with an annularly or circumferentially extending projection 168 provided by spring cup 122 so as to limit upward movement of the detent ring 160.

It should be understood that spring cup 122 and latching ring 160, although shown as circular in cross section, could be of other geometric configurations, if desired.

The operation of circuit breaker 20 will now be described. With parts in the respective positions shown in full lines in FIG. 1, thermally responsive element 100 is in the retracted, contacts-open position, member 58 is in the retracted position and biased by spring 60 against beveled portion 54 provided by enlarged diameter portion 52 of stem 36, and button assembly 32, which is fixed to stem 36, along with stem 36 and member 58, is biased to the retracted position under the bias of compression spring 120, whereby a band formed of a color contrasting with that of the push button 32, if provided, would be visible exteriorly of the casing. It should be noted that in this condition, ball means 150 are disposed outwardly and are loosely in engagement with the circumferential outer surface of the portion 146 of stem 36 (which, as shown, is of lesser diameter than portion 140). Thermal element 100, when in the contacts-open position, is maintained against stop 99 by spring 64, which is in a relatively unstressed condition when in the contacts-open position. Spring 64, when in the relatively unstressed condition in the contacts-open position, exerts little, if any, biasing force on latching ring 160.

When push button 32 is depressed to the advanced or reset contacts-closed position, the parts will take the respective positions shown in full lines in FIG. 6. As movement of push button 32 from the position shown in FIG. 1 to that shown in FIG. 6 ensues, the abutment 61 provided by member 58 moves into thermal latching engagement with the distal ends of each of arms 114 and 116 provided by the thermally responsive element 100, whereby the thermal element 100 and the stem 36 are thermally latched together as a unit for movement in the contacts-closing direction. Continued movement of push button 32 results in the compression of spring 60, (which by proper pressure setting, will provide desired contact pressure) compression of spring 64, which is effective to urge latching ring 160 downwardly, as viewed in FIG. 1, and move wedge surfaces 162 thereof into engagement with balls 150 to urge the latter to move inwardly for latching engagement with detent surface 142 of stem 36. Continued movement of push button 32 toward the reset position shown in FIG. 6 also results in compression of spring 120.

It will be noted that movement of the thermally responsive unit 100 to the contacts-closed position shown in FIG. 6 occurs against the resilient bias exerted by compression springs 60, 64 and 120. It will be further noted that compression spring 64 serves the dual function of biasing thermal unit 100 to a contacts-open position, and that of biasing latch ring 160 into wedging engagement with ball means 150 to urge the latter into latching engagement with stem 36.

With further movement of push button 32 and stem 36 to the reset position shown in FIG. 6, ball means 150 will traverse the axial or longitudinal extent of portion 146 of stem 36 and engage beveled portion 144 adjacent larger diameter portion 140, whereby the resistance to movement of stem 36 to the reset or contacts-closed position will be sharply increased, requiring a greater force to be applied against push button 32. With the application of increased force to push button 32 to overcome the resistance to movement of stem 36 presented by the beveled portion, when ball means 150 traverses the beveled portion 144 and engages the vertical portion 145 of enlarged diameter section 140 (which surface is parallel to the direction of movement of the stem 36), sudden decrease in resistance to movement of the stem to a contacts-closed position results which advantageously affords a snap closing of the contacts. Stated another way, a predetermined resetting force is required to be applied to the button 32 to overcome the resistance to movement of stem 36 in a contacts-closing direction which is presented by beveled portion 144 in engaging balls 150, which resistance diminishes suddenly as the balls 150 traverse the beveled portion 144 and engage the vertical portion 145. At the point where the balls 150 leave wedge surface 144 and engage surface 145, the applied resetting force would be at a maximum and since at this point there is little or no resistance to movement of the stem 36 to the contacts-closing direction, the contacts will be closed with a snap action. This snap closing, which is advantageously afforded by the instant invention, is particularly desirable in eliminating or at least reducing contact erosion, which is generally characteristic of devices which do not afford a quick snap closing of contacts.

When push button 32 has been moved downwardly as seen in FIGS. 1 and 6, to the contacts-closed position sufficiently so that engagement of movable contacts 110 and 112, respectively, with fixed contacts 76 and 78 has taken

place, and latching engagement of balls **150** with detent or latching groove or surface **142** has taken place, when push button **32** is released, the thermally latched unit comprising thermal element **100** and stem **36** will remain mechanically latched in the contacts-closed position by the ball means **150** and detent surface **142** and latch ring **160**, under the bias of spring **64**. The movable abutment **58**, which abuts the thermal element **100** at the distal ends of arms **114** and **116** to provide the thermal latching, by being movable relative to the stem and being spring biased in a contacts-closing direction, provides contact pressure and a gap override to assure desired contact pressure.

With the parts in the contacts-closed, reset position shown in FIG. **6**, an electrically conductive path is established leading from terminal **72** through contact **76**, contact **110**, thermally responsive bridging portion **108**, through each of arms **114** and **116**, contact **112**, to contact **78** and through terminal **74**. Upon the flow of current of sufficiently high values along the electrically conductive path just described, thermally responsive element **100** is heated by the current passing therethrough and expands thereby moving arms **114** and **116** outwardly and away from each other to a dashed-line position as shown in FIGS. 2, 5 and 7.

When the thermally responsive element **100** warps or flexes sufficiently to move the distal ends of arms **114** and **116** out of engagement with abutment **61** provided by member **58** to the broken-line position shown in FIGS. 2 and 7, member **58** moves to the broken-line position shown in FIG. 7 under the bias of spring **60** and thermally responsive unit **100** is no longer restrained in the contacts-closed position and immediately begins to move upwardly to the contacts-open, retracted position, as shown in full lines in FIG. 1, under the resilient bias exerted by compression spring **64**.

Referring now to FIG. 6, as thermally responsive element **100** moves to the contacts-open position shown in dashed lines in this figure under the bias of spring **64**, said spring **64** expands and sharply decreases the biasing force exerted against latch ring **160** which is urging balls **150** into latching engagement with detent surface **142**. As the thermal element in the unlatched condition continues to move upwardly to the contacts-open position shown in dashed lines in FIG. 6, the spring **64** will continue to expand to further decrease the downward thrust against latch ring **160**, to a point at which the effective downward thrust of the latch ring **160** and spring **64** will become less than the upward thrust of spring **120**. At this point, stem **36** will begin to move upwardly and the lower peripherally extending portions of groove **142** will cam balls **150** outwardly against ring **160**. Since latching or detent ring **160** is confined to vertical movement, ring **160** in this condition, will move upwardly against the now relatively unstressed spring **64** until the beveled surfaces **164** are adjacent balls **150**, which will thereby permit balls **150** to move outwardly out of engagement with latching detent surface **142**, whereby stem **36** will then quickly move to the retracted, contacts-open position under the bias of spring **120**. Outward movement of stem **36** under the bias of spring **120** is limited by engagement of member **58** with the casing when bevel **54** of stem **36** is engaged with countersink or beveled portion **55** of member **58**, as clearly shown in FIG. 1.

It should also be noted that after balls **150** are in engagement with the outer surface of portion **146**, when stem **36** has moved to a retracted position as shown in FIG. 1, ring **160** may move downwardly to the position shown in this figure under the force of gravity and the slight force exerted by the now relatively unstressed compression spring **64**. It can thus be seen that switch **20** affords both a snap opening and a snap closing of contacts.

Immediately after tripping of the circuit breaker **20** from the contacts-closed position shown in solid lines in FIG. 6 to the contacts-open position shown in full lines in FIG. 1, thermally responsive member **100** will still be heated and due to the thermal expansion thereof, arms **114** and **116** may be disposed in the outwardly displaced position shown in dashed lines in FIGS. 2 and 7. Accordingly, upon depression of push button **32** from the retracted position (shown in dashed lines in FIGS. 6 and 7 and in full lines in FIG. 1), while the thermally responsive element **100** is still in the heated condition with arms **114** and **116** still deflected outwardly (as shown in the dashed line portions of the figures mentioned above), downward movement of push button **32** and stem **36** fails to bring abutment **61** into engagement with the distal ends of arms **114** and **116**, whereby the thermally responsive member **100** remains in the retracted, contacts-open position. This feature is advantageous in that the movable contacts **110** and **112** cannot be closed against the fixed contacts **76** and **78**, respectively, on the faults which cause tripping of the circuit breaker, until the thermally responsive element **100** has cooled for a sufficient time interval so as to bring arms **114** and **116** into position or alignment for engagement by abutment **61**.

Further, upon depression of the push button from the retracted to the advanced or reset position, while the thermal element is still in the expanded condition with arms **114** and **116** in a condition which does not permit engagement by abutment **61**, the stem **36** will not be latched by the mechanical latching means since spring **64** will not be compressed by downward movement of the button, whereby push button **32**, stem **36** and member **58** are free to move from advanced to retracted position under the bias of spring **120** upon release of the push button.

It should be noted that in this condition, beveled portions **54** of enlarged diameter portion **52** of stem **36** will engage countersink or beveled portion **55** provided by member **58** to move the latter to a retracted position under the bias of spring **120**.

On cooling of the thermally responsive element **100** from the dashed-line position shown in FIGS. 2, 5 and 7 to the full-line position shown in these figures, the parts are again in the conditions and positions as shown in FIG. 1 and are 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 advanced, reset, contacts-closed positions, as shown in dashed lines in FIG. 1 and in full lines in FIG. 6, push button member **32** may be grasped and forcibly pulled outwardly toward retracted position, whereby the manual force applied in conjunction with the upward thrust of spring **120** will be sufficiently greater than the effective downward thrust of spring **64** and the wedging action of latching ring **160** against balls **150** so that latching or detent surface **142** will cam and urge balls **150** outwardly against the wedge surface **162** of latching ring **160**. With the added upward thrust, the stem **36** will move upwardly and the balls **150** will be cammed outwardly to cause latching ring **160** to move upwardly and further compress spring **64** and release the mechanical latching engagement between balls **150** and detent surfaces **142**. As just described, the parts will move to their retracted positions in the following manner.

Stem **36** will move outwardly under the bias of spring **120**; thermal element **100** will move upwardly out of engagement with fixed contacts **76** and **78** under the bias of compression spring **64**; the distal ends of arms **114** and **116**, however, will still be in engagement with abutment **61** of member **58**, which will also move to the retracted position with movement of the thermally responsive member **100**. It should be noted that the upper surface **170** of portion **140** serves to engage the insulating washer **68** to prevent the thermal element from moving downwardly in relation to member **58** whereby to prevent arms **114** and **116** from moving to the underside of this member and out of alignment therewith. Surface

or ledge **170** also may serve to engage the insulating washer **68** and thereby elevate the thermal element upon manual opening of the switch, as described above.

As noted above, the latching forces exerted to retain member **32**, stem **36** and the parts fixed with respect thereto in the reset position, are independent of the forces exerted on thermally responsive member **100**. This is advantageous in that repeated latching and unlatching due to manual on-off switching of the circuit breaker will not upset the calibration of the thermally responsive member.

Circuit breaker **20** is "trip-free" in that the thermally responsive member **100** cannot be retained in a contacts-closed position by forcibly retaining push button **32** in the advanced or reset position upon the occurrence of a current overload through thermally responsive element **100**. If button **32** and stem **36** are restrained in the advanced, reset position by forcibly holding push button **32** in the depressed, advanced position when the thermally responsive element has warped or deformed sufficiently to disengage the distal ends of arms **114** and **116** from abutment **61**, the thermally responsive member will move to the contacts-open position under the bias of compression spring **64** (button **32** and stem **36** will, of course, remain in the advanced position) and member **58** will move away from push button **32** from the full-line position to the broken-line position as shown in FIG. 7, under the bias of spring **60**.

It will thus be noted that members **32** and **58** will move to retracted position under the bias of spring **120** upon release of the external application of the resetting force to the push button. This is because no mechanical latching of the stem **36** can take place unless the thermal element is moved to a contacts-closed position by virtue of the above-described cooperation of spring **64** with the thermal element and the latching ring **160**.

It will be noted (see FIG. 4) that when thermally responsive element **100** warps upon heating thereof, movable contacts **110** and **112** are urged respectively against fixed contacts **76** and **78**, thereby causing an increase in contact pressure. Thus the instant switch affords an increase in contact pressure with an increase in temperature of the thermal element before tripping at an overload. There is maximum contact force at the instant the thermal element trips upon overload. This feature cooperates in assuring snap opening of the contacts from a maximum contact pressure or force to a contacts-open position with no decrease in contact pressure between the movable and fixed contacts occurring during the warping of the thermally responsive element prior to disengagement of the distal ends of the arms **114** and **116** from abutment **61** for the release of the thermally responsive member to contacts-open position.

As arms **114** and **116** move away from each other upon warping of the thermally responsive element **100** due to heating of the latter when the parts are in the full-line, contacts-closed position shown in FIG. 6, it is likely, or possible at least, that one of these arms will move out of engagement with abutment **61** slightly before the other. The result will be that member **58** will tilt about the point of engagement of said other arm and abutment **61** will move laterally relative to portion **36***a* of stem **36** under the force couple effected by the bias of springs **60** and **64**. This tilting and/or lateral movement of member **58** is permitted by virtue of the clearance as described above between the surface of member **58** defining aperture **59** and the outer surface of the stem portion **36***a* of stem **36**. This tilting and/or lateral movement of member **58** permits disengagement of said other arm from abutment **61** and movement of the thermally responsive element **100** to the retracted, contacts-open position, as shown in full lines in FIG. 1, promptly upon disengagement of said one arm from the abutment **61**. Lateral and pivotal realignment of member **58** immediately after release of the thermally responsive element **100** to the retracted, contacts-open position, is effected when countersunk or beveled portion **55** moves into engagement with beveled surface **54** of the enlarged diameter portion **52** of stem **36**, under the bias of spring **60**, thus forcing member **58** back to laterally and pivotally aligned relation with the remaining parts of the switch. Accordingly, abutment **61** which is provided by member **58**, will be realigned for engagement by the distal ends of arms **114** and **116** upon the cooling of the thermally responsive element **100** from the dashed-line position of FIGS. 2 and 5 to the full-line position of these FIGURES.

The switch of the instant invention provides a number of unique and unobvious advantages. One of the advantages of the switch of the instant invention is that the structural arrangement of the operating parts lends itself to the use of compressive resilient biasing means which provides substantial advantages over tension-type springs and the like. For example, the compression spring **64**, which is employed between the thermal latch element and detent means or latching ring **160** provides a number of advantages over that which would be afforded by a tension spring type arrangement which might involve a number of tension springs and linkages.

By use of the compression spring, compactness and miniaturization of the switch structure is permitted and only a single spring element is required. The compression spring **64** affords a simple and quick assembly of parts. All that is necessary to assemble the spring in proper relation is to merely dispose it about the latching ring **160**, before the thermal element **100** is mounted on the stem **36**.

Further, the compression spring arrangement of the switch of the instant invention provides a switch with greater vibration stability than that which might be afforded by a tension spring arrangement. The slidably mounted latching ring **160** with its wedge and beveled surfaces, is a simple one-piece construction which permits quick and easy assembly without the necessity of close tolerances. The ring is assembled in position merely by insertion over spring cup **122** before the latter is fixed to the housing by rivet **124**. The fact that the mechanical latching mechanism is enclosed in the well or recess provided by the casing, rather than being an exposed part of the circuit breaker, provides the unique and advantageous result of preventing contact splatter and other deleterious debris (such as breakdown of housing material which is generally associated with high rupture capacity devices) from interfering with the operation of the mechanical latching mechanism.

Further the latching ring **160** provides a positive wedging action through a direct application of compressive force from spring **64**, which provides a highly efficient arrangement. The direct application of compressive force and compression spring and slidable latch ring arrangement co-operate to provide latching which is more stable and less susceptible to accidental latch release.

The provision of the three latching balls serves to afford a force balance and to increase vibration stability.

Further, the mechanical latching arrangement with its compressive biasing force permits the use of a one-piece thermal element construction, and eliminates any necessity for pivoted parts, pigtail arrangements, or other more complex constructions.

It can be seen from the above that the circuit breaker or switch **20** provides a device which is reliable, compact and which is simple in construction and economical to manufacture.

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

We claim:

1. An electrical switch comprising a base; contact means on said base; movably mounted means carrying movable contact means for engagement with said first-named contact means; manually operable means mounted in said switch for movement relative to said movably mounted means; thermally responsive means for latching said manually operable means and said movably mounted means together as a unit for movement in a contacts-closing direction; mechanical latching means for latching said manually operable means in a contacts-closed position when the latter is latched to said movably mounted means by said thermally responsive means; compressive biasing means compressively urging said mechanical latching means into latching engagement with said manually operable means when the latter is in the contacts-closed position; and said switch also including means providing for snap closing of said first-named and movable contact means.

2. The switch as set forth in claim 1 and wherein said mechanical latching means is disposed in a recess provided by said base.

3. An electrical switch comprising contact means; movably mounted means carrying movable contact means for engagement with said first-named contact means; manually operable means mounted in said switch for movement relative to said movably mounted means; thermally responsive means for latching said manually operable means and said movably mounted means together as a unit for movement in a contacts-closing direction; mechanical latching means for latching said manually operable means in a contacts-closed position when the latter is latched to said movably mounted means by said thermally responsive means; compressive spring biasing means urging said mechanical latching means into engagement with said manually operable means in the contacts-closed position thereof, said biasing means also urging said movably mounted means to a contacts-open position.

4. An electrical switch comprising a base; contact means on said base; movably mounted means carrying movable contact means for engagement with said first-named contact means; manually operable means mounted in said switch for movement relative to said movably mounted means; thermally responsive means engageable with abutment means on said manually operable means for latching said manually operable means and said movably mounted means together as a unit for movement in a contacts-closing direction; compressive biasing means urging said movably mounted means in a contacts-opening direction; mechanical latching means for latching said manually operable means in a contacts-closed position when the latter is latched to said movably mounted means by said thermally responsive means, said mechanical latching means comprising detent surfaces on said manually operable means; detent means supported on said base for movement into and out of engagement with said detent surfaces; a latch member movably mounted with respect to said manually operable means and engageable with said detent means for moving the latter into latching engagement with said detent surfaces, said biasing means also urging said latch member into, and maintaining the same in, engagement with said detent means in the contacts-closed position thereof.

5. An electrical switch comprising a base; contact means on said base; movably mounted means carrying movable contact means for engagement with said first-named contact means; manually operable means mounted on said switch for reciprocal movement relative to said movably mounted means; thermally responsive means engageable with abutment means on said manually operable means for latching said manually operable means and said movably mounted means together as a unit for movement in a contacts-closing direction; said abutment means being slidably mounted on said manually operable means; spring means urging said abutment means for movement relative to said manually operable means in a contacts-closing direction; mechanical latching means engageable with and for latching said manually operable means in a contacts-closed position when the latter is latched to said movably mounted means by said thermally responsive means; and biasing means compressively urging said mechanical latching means into engagement with said manually operable means in the contacts-closed position thereof.

6. In combination; a pair of electrical contacts; resetting means comprising two members; resilient means compressively biasing said two members apart; thermally responsive means operatively connected for movement to open and close said contacts; resilient means compressively biasing said thermally responsive means for movement from contacts-closed to contacts-open position; one of said two members being movable from retracted position to reset position for moving the other of said two members against a portion of the thermally responsive means thereby moving the latter to contacts-closed position and compressing said second-named resilient biasing means; mechanical latch means engageable with said one member for retaining said one member in reset position, said second-named biasing means also compressively biasing said mechanical latch means into engagement with said one member when the latter is moved to the reset position, said thermally responsive means being responsive to temperature change for moving said portion thereof out of engagement with said other of said two members thereby permitting movement of the thermally responsive means to contacts-open position under the bias of said second-named biasing means.

7. In combination; a housing; a pair of electrical contacts in said housing; manually operable resetting means; thermally responsive means operatively connected for movement to open and close said contacts; compressive resilient means biasing said thermally responsive means for movement from a contacts-closed to a contacts-open position, said manually operable resetting means being movable from a retracted position to a reset position into engagement with said thermally responsive means to move the latter to a contacts-closed position and compress said resilient biasing means; mechanical latch means for retaining said manually operable resetting means in reset position, said latch means comprising a detent surface on said manually operable resetting means engageable with ball means mounted for movement into and out of engagement with said detent surface; latch means mounted for movement relative to said ball means and manually operable resetting means, said resilient means also biasing said latch means into engagement with said ball means to move the latter into and maintain the same in engagement with said detent surface whereby to retain said manually operable reset means in the reset position.

8. The combination as set forth in claim 7 and wherein said mechanical latch means is disposed in a recess provided by said housing.

9. In combination; a housing; a pair of electrical contacts in said housing; manually operable resetting means; a thermally responsive member operatively connected for movement to open and close said contacts; compressive resilient means biasing said thermally responsive means for movement from a contacts-closed to a contacts-open position, said manually operable resetting means being movable from a retracted position to a reset position into engagement with said thermally responsive means to move the latter to a contacts-closed position and compress said resilient biasing means; mechanical latch means for retaining said manually operable resetting means in reset position, said latch means comprising a detent surface on said manually operable resetting means; ball means mounted for movement into and out of engagement with

said detent surface; latch means mounted for movement relative to said ball means and manually operable resetting means, said resilient means also biasing said latch means into engagement with said ball means to move the latter into and maintain the same in engagement with said detent surface whereby to retain said manually operable reset means in the reset position; second resilient means biasing said manually operable reset means for movement from reset position to retracted position, said thermally responsive means being responsive to temperature change for moving out of engagement with said manually operable resetting means to thereby permit movement of said thermally responsive means to a contacts-open position under the bias of said first-named biasing means.

10. An electrical switch comprising a base; contact means on said base; thermally responsive means operatively connected for movement to open and close said contact means; a first means compressively biasing said thermally responsive means for movement from a contacts-closed to a contacts-open position; manually operable resetting means comprising two members; resilient means compressively biasing said two members apart, one of said two members being movable from retracted to reset position for moving the other of said two members into engagement with said thermally responsive means to move the latter to a contacts-closed position and compress said first-named biasing means; further resilient means compressively biasing said one member from a reset position to a retracted position; mechanical latch means for retaining said one member in reset position when said other member is in engagement with said thermally responsive means and the latter is in the contacts-closed position, said latch means comprising a peripherally extending latching surface on said one member; ball means mounted on said base for movement into and out of engagement with said latching surface; a latch member movably mounted on said base with respect to said ball means, said latch member having a wedge surface engageable with said ball means to urge the latter into latching engagement with said latching surface, said first-named resilient means compressively biasing said latch member into engagement with said ball means when said thermally responsive means is moved to the contacts-closed position.

11. An electrical switch comprising a base; contact means on said base; movably mounted means carrying movable contact means for engagement with said first-named contact means; manually operable means mounted in said switch for movement relative to said movably mounted means; thermally responsive means engageable with abutment means on said manually operable means for latching said manually operable means and said movably mounted means together as a unit for movement in a contacts-closing direction; compressive biasing means urging said movably mounted means in a contacts-opening direction; mechanical latching means for latching said manually operable means in a contacts-closed position when the latter is latched to said movably mounted means by said thermally responsive means, said mechanical latching means comprising detent surfaces on said manually operable means; detent means supported on said base for movement into and out of engagement with said detent surfaces; a latch member movably mounted with respect to said manually operable means and engageable with said detent means for moving the latter into latching engagement with said detent surfaces, said biasing means also urging said latch member into, and maintaining the same in, engagement with said detent means in the contacts-closed position thereof, said detent means comprising a plurality of balls and said movably mounted latch member being slidably mounted and comprising a latch ring having a wedge surface engageable with said balls.

12. In combination; a housing; a pair of electrical contacts in said housing; manually operable resetting means; thermally responsive means operatively connected for movement to open and close said contacts; resilient means compressively biasing said thermally responsive means for movement from a contacts-closed to a contacts-open position, said manually operable resetting means being movable from a retracted position to a reset position into engagement with said thermally responsive means to move the latter to a contacts-closed position and compress said resilient biasing means; mechanical latch means for retaining said manually operable resetting means in reset position; said latch means comprising a detent surface on said manually operable resetting means engageable with ball means mounted for movement into and out of engagement with said detent surface; latch means mounted for movement relative to said ball means and manually operable resetting means, said resilient means also compressively biasing said latch means into engagement with said ball means to move the latter into and maintain the same in engagement with said detent surface whereby to retain said manually operable reset means in the reset position; said detent surface comprising a peripherally extending groove on said resetting means; latch means comprising a latching ring slidably mounted with respect to said ball means and to said manually operable resetting means, said latch ring having a wedge surface engageable with said ball means for moving the latter into engagement with said peripherally extending groove under the bias of said resilient biasing means to latch said manually operable resetting means in the reset position.

13. In combination; a housing; a pair of electrical contacts in said housing; manually operable resetting means; a thermally responsive member operatively connected for movement to open and close said contacts; resilient means compressively biasing said thermally responsive means for movement from a contacts-closed to a contacts-open position, said manually operable resetting means being movable from a retracted position to a reset position into engagement with said thermally responsive means to move the latter to a contacts-closed position and compress said resilient biasing means; mechanical latch means for retaining said manually operable resetting means in a reset position, said latch means comprising a detent surface on said manually operable resetting means; ball means mounted for movement in and out of engagement with said detent surface; latch means mounted for movement relative to said ball means and manually operable resetting means, said resilient means also compressively biasing said latch means into engagement with said ball means to move the latter into and maintain the same in engagement with said detent surface whereby to retain said manually operable reset means in the reset position; second resilient means compressively biasing said manually operable reset means for movement from reset position to retracted position, said thermally responsive means being responsive to temperature change for moving out of engagement with said manually operable resetting means to thereby permit movement of said thermally responsive means to a contacts-open position under the bias of said first-named biasing means; said detent surface comprising a peripherally extending groove on said resetting means; latch means comprising a latching ring slidably mounted with respect to said ball means and to said manually operable resetting means, said latch ring having a wedge surface engageable with said ball means for moving the latter into engagement with said peripherally extending groove under the bias of said first-named resilient biasing means to latch said manually operable resetting means in the reset position.

14. An electrical switch comprising a base; contact means on said base; thermally responsive means operatively connected for movement to open and close said contact means; a first means compressively biasing said thermally responsive means for movement from a contacts-closed to a contacts-open position; manually operable resetting means comprising two members; resilient means compressively biasing said two members apart, one

of said two members being movable from retracted to reset position for moving the other of said two members into engagement with said thermally responsive means to move the latter to a contacts-closed position and compress said first-named biasing means; further resilient means compressively biasing said one member from a reset position to a retracted position; mechanical latch means for retaining said one member in reset position when said other member is in engagement with said thermally responsive means and the latter is in the contacts-closed position, said latch means comprising a peripherally extending latching surface on said one member; ball means mounted on said base for movement into and out of engagement with said latching surface; a latch member movably mounted on said base with respect to said ball means, said latch member having a wedge surface engageable with said ball means to urge the latter into latching engagement with said latching surface, said first-named resilient means compressively biasing said latch member into engagement with said ball means when said thermally responsive means is moved to the contacts-closed position; and said movably mounted latch member comprising a slidably mounted latching ring.

15. An electrical switch comprising a base; contact means on said base; movably mounted means carrying movable contact means for engagement with said first-named contact means; manually operable means mounted on said switch for reciprocal movement relative to said movably mounted means; thermally responsive means engageable with abutment means on said manually operable means for latching said manually operable means and said movably mounted means together as a unit for movement in a contacts-closing direction; said abutment means being slidably mounted on said manually operable means; spring means urging said abutment means for movement relative to said manually operable means in a contacts-closed direction; mechanical latching means engageable with and for latching said manually operable means in a contacts-closed position when the latter is latched to said movably mounted means by said thermally responsive means; biasing means intermediate said thermally responsive means and mechanical latching means compressively urging said mechanical latching means into engagement with said manually operable means in the contacts-closed position thereof, and also compressively urging said thermally responsive means for movement in a contacts-opening direction.

16. The electrical switch as set forth in claim 10 and wherein said latch member is mounted for slidable movement with respect to said one member and said ball means.

17. In combination: a housing; a pair of electrical contacts in said housing; manually operable resetting means; thermally responsive means operatively connected for movement to open and close said contacts; resilient means compressively biasing said thermally responsive means for movement from a contacts-closed to a contacts-open position, said manually operable resetting means being movable from a retracted position to a reset position into engagement with said thermally responsive means to move the latter to a contacts-closed position and compress said resilient biasing means; mechanical latch means for retaining said manually operable resetting means in reset position, said latch means comprising a detent surface on said manually operable resetting means engageable with ball means mounted for movement into and out of engagement with said detent surface; latch means mounted for movement relative to said ball means and manually operable resetting means, said resilient means also compressively biasing said latch means into engagement with said ball means to move the latter into and maintain the same in engagement with said detent surface whereby to retain said manually operable reset means in the reset position; and said latch means being slidably mounted in said casing for movement relative to said ball means and manually operable resetting means.

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