Sept. 29, 1959 J. SCHMIDINGER 2,906,835

THERMO-RESPONSIVE SWITCH

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Fig. 1.

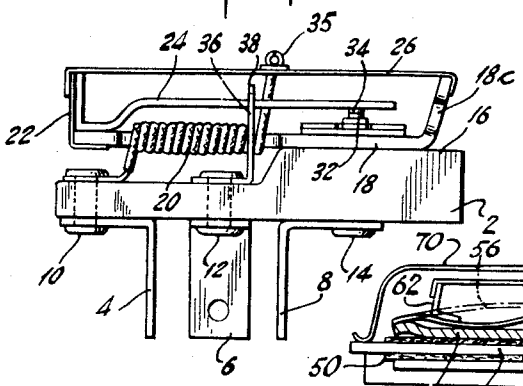

Fig. 7.

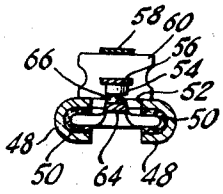

Fig. 6.

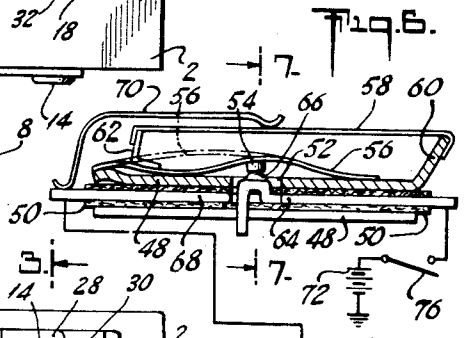

Fig. 2.

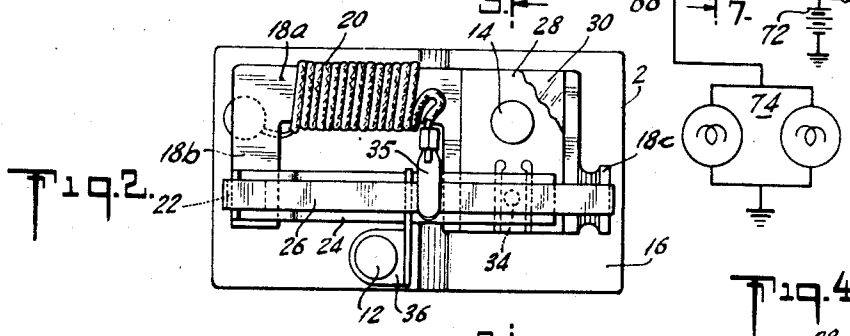

Fig. 4.

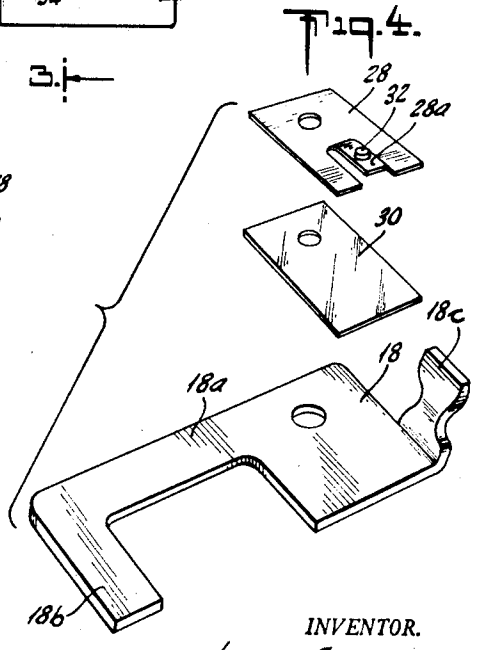

Fig. 3.

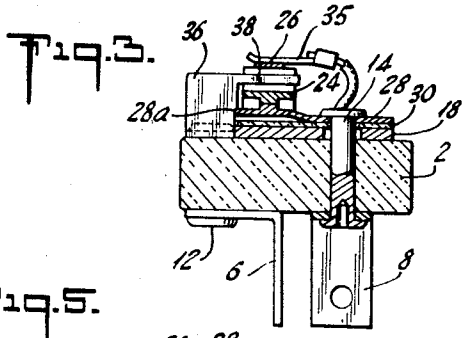

Fig. 5.

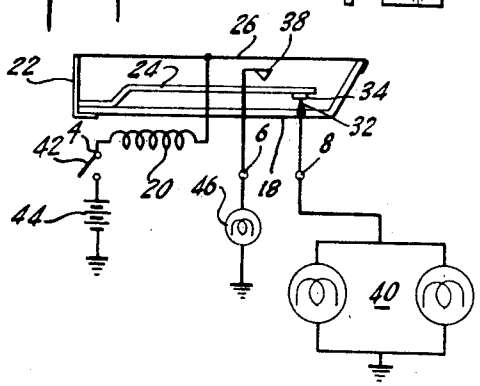

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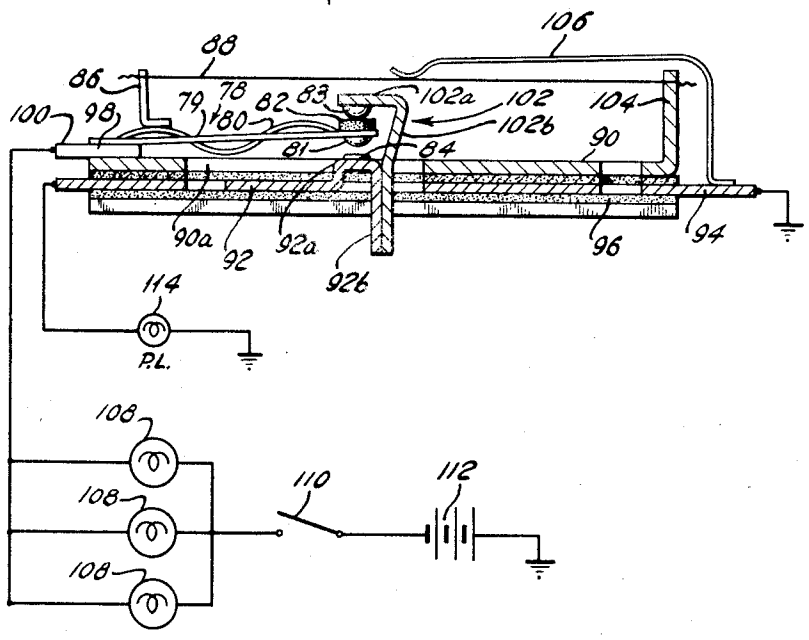
Fig. 8.



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THERMO-RESPONSIVE SWITCH

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Application July 12, 1956, Serial No. 597,502

14 Claims. (Cl. 200—88)

The present invention relates to thermoresponsive switches of the type wherein expansion and contraction of flexible wires or strips with passage of current therethrough actuate circuit controlling contacts and comprises a novel switch of this type which has a number of advantageous features. In the new switch all insulated anchorages, such as glass beads, clamped or riveted plates or the like, for the pull wire or strip are eliminated, permitting the pull wire or strip to be connected under tension between strong metallic parts of the same electrical polarity, thus insuring against any loss of the critically adjusted tensions of the pull means often caused by mechanical failure of such insulated tension anchorages. Also in the new switch, the pull wire or pull strip is connected in series-parallel which permits the use of a much thinner pull strip per given current through the device as compared to devices of this character wherein the pull strip or wire is connected in straight series with the load current through the device. The pull strip, being thinner, heats and cools more rapidly and thus faster starting and operating speeds are obtained. Also in the new switch when used, for example as a series lamp signal flasher, required starting and operating speeds can be obtained at substantially lower terminal resistance as compared to devices which use straight series connected pull means for operating contacts. Furthermore, in the preferred embodiment of the invention wherein the switch is electromagnetically controlled, the contacts are so positioned and arranged as to be broken in a collapsing magnetic field, thereby insuring magnetic spark quenching.

The new switch comprises a contact carrying member biased into one circuit controlling position and a pull strip secured at its ends to metal parts of the same polarity, holding, when cold or cool, the contact carrying member in another circuit controlling position against the bias thereof, an electrical conductor being connected to the pull strip intermediate its ends. In the electromagnetically controlled switch the contact carrying member is an armature of an electromagnet, one end of the winding of which is connected to a point of the pull strip intermediate its ends. Thus when a circuit including a load and a source of energy is connected across the other end of the winding and a contact positioned for engagement when the armature is in attracted position, current will flow in opposite directions through the parts of the pull strip between its anchored ends and the point of attachment of the electrical conductor. The consequent heating and expansion of the pull strip permits the armature to move to retracted position under the influence of a spring, opening the circuit of the coil and pull strip. Upon cooling and contraction of the wire the contacts are again closed and the cycle repeated. The switch may be designed for use as an overload circuit breaker, as a flasher or as a relay. It requires but few and simple parts and is of sturdy construction.

For a better understanding of the invention, reference may be had to the accompanying drawings, of which

Figs. 1 and 2 are side and plan views respectively of an

electromagnetically operated switch embodying the invention;

Fig. 3 is a transverse vertical section of the switch of Figs. 1 and 2 taken on the line 3—3 of Fig. 2;

Fig. 4 is an exploded view of certain of the parts of the switch of Figs. 1 to 3, showing the mounting of one of the stationary contacts;

Fig. 5 is a circuit diagram illustrating use of the switch of Figs. 1 to 3 as a circuit breaker or flasher;

Fig. 6 is a vertical sectional view of a switch of the sprung vane type representing another embodiment of the invention;

Fig. 7 is a transverse sectional view taken on the line 7—7 of Fig. 6; and

Fig. 8 is a longitudinal sectional view, partly in elevation of a switch having a snap plate and representing still another embodiment of the invention.

In the embodiment of the invention illustrated in Figs. 1 to 3, the parts are mounted on a base 2 of insulating material to the under surface of which three terminal prongs 4, 6 and 8 are secured by rivets 10, 12 and 14 respectively. The base 2 is thicker at one end than at the other to provide a shelf or platform 16 to which is secured by the rivet 14 one end of a magnetizable plate 18. The other end of the plate 18 is cut away to provide a generally L-shaped member about the long arm 18*a* of which is wound the coil 20 of the electromagnet, and to the short arm 18*b* of which is secured one arm of an L-shaped leaf spring 22. An armature 24 of the electromagnet is secured to the spring 22, which latter biases the armature toward retracted position. The plate 18 has an upwardly extending portion 18*c* at the anchored end of the plate, and to the upper end of this upwardly projecting part is firmly secured, as by welding, one end of a pull strip 26, the other end of which is similarly anchored to the free end of the spring 22. The tension in the pull strip 26, when the strip is cold or cool, is such as to hold the armature 24 in attracted position. The initial tension in the strip can be adjusted by bending the part 18*c* about its junction with the plate 18. A metallic plate 28 is insulatedly mounted on the anchored portion of plate 18 by means of rivet 14, a sheet 30 of insulating material, for example of mica, being positioned between the plates 18 and 28. A tongue 28*a* formed by slotting the plate 28 and upward bending of the metal between the slots carries a contact 32 positioned for engagement by a contact 34 carried on the underside of the armature 24. Adjustment of the spacing of the contacts can thus be readily effected by adjustment of the tongue 28*a* toward and away from the plane of the plate 28. One end of the winding 20 is connected to the terminal 4 by means of the rivet 10, and the other end of the winding 20 is connected by a short conductor 35 to the pull strip 26 intermediate the anchored ends thereof. Preferably, in order to provide for the circuit of a pilot lamp, a bracket 36 which is supported on the base 2 by means of the rivet 12, has a part 38 extending over the armature 24 and positioned to be engaged thereby when the armature moves to retracted position.

The above described thermo-responsive switch is made of relatively few and simple parts. The pull strip 26 is anchored directly on strong metal parts, the projection 18*c* at one end and the spring 22 at the other, and the only insulation necessary for the whole device is that provided by the base 2 and by the insulating sheet 30 which insulates the plate 18 from plate 28.

Fig. 5 illustrates diagrammatically the operation of the device in control of a lamp circuit. In the circuit of Fig. 5 terminal 8 is connected to the load, which in this particular instance comprises a pair of lamps 40 connected in parallel between terminal 8 and ground. The terminal 4 of the device is connected through a suit-

able switch 42 to the positive terminal of a source of energy indicated as a battery 44, the negative terminal of which is grounded. Terminal 6 is connected through a pilot lamp 46 to ground. With this circuit, when switch 42 is open and the pull strip accordingly cold, contacts 34 and 32 are in engagement, but no current flows through the winding 20. Upon closure of the switch, current flows through the winding 20 through two parts of the strip 26 in opposite directions, through the plate 18, armature 24, and contacts 34 and 32 to terminal 8 and thence through the lamps 40 to ground.

The tension in the pull strip 26 opposing spring 22 is thus reinforced by the magnetic attraction of the armature and firm contact pressure is insured. Assuming that the device is designed to operate as an overload circuit breaker, then the expansion of the pull strip under normal current therethrough will not be sufficient to permit opening of the contacts by the spring 22. Upon a sudden increase in current, however, over and above the normal current, the tension in the pull strip due to the excessive heating current will reduce to an extent sufficient to permit spring 22 to retract the armature 24, thereby opening the circuit at the contacts 32 and 34. The opening of the circuit collapses the magnetic field and thereby provides magnetic spark quenching at the contacts. Opening of the contacts and retraction of the armature closes the circuit through bracket 36 and the armature 24 to the pilot lamp 46 which thereupon lights to indicate that the circuit of the lamp load has been opened. Upon consequent cooling and contraction of the pull strip 26 the armature is again brought into attracted position, closing the circuit and again energizing the lamps 40. If the cause for the excessive current still remains, the cycle will repeat. For operation as a flasher, the dimensions of the pull strip are such as to cause opening of the circuit under normal current conditions.

Figs. 6 and 7 illustrate a non-magnetic type of thermo-responsive switch embodying the invention. The switch of Figs. 6 and 7 is of the sprung vane type disclosed and claimed in various prior patents of the present applicant. (See, for example, Schmidinger Patents 2,074,345, dated March 23, 1937; 2,133,309, dated October 18, 1938; 2,299,767, dated October 27, 1942; and 2,388,712, dated November 13, 1945.) The construction of the new sprung vane type switch is substantially simpler than that of any one of the above mentioned patents and differs from the patented devices in various respects and specifically in that the pull strip is firmly anchored at each end to metal parts of the same electrical polarity.

The simple switch of Figs. 6 and 7 comprises a clamping channel frame 48 provided with an insulating lining 50 and with an opening 52 in its wall for accommodation of a contact 54 carried by a sprung vane 56. The vane 56 is anchored at each end on the frame 48 at points spaced apart a distance less than the length of the vane to cause the vane to assume the buckled position indicated in dotted lines in Fig. 6. A pull strip 58 is firmly anchored at one end to a metallic and bendable projection 60 of the frame 48 and at its other end to one leg of an L-shaped bracket 62 the other leg of which is welded or otherwise secured to the vane 56 adjacent one end thereof. The tension in the pull strip 58 is such as to cause the vane to assume the buckled position shown in full lines in Fig. 6, wherein the contact 54 carried by the vane penetrates the opening 52 in the frame 48. A conducting plate 64 is positioned within the insulating lining 50 at one end of the frame and carries a contact 66 positioned for engagement by the contact 54 when the vane is in buckled position into which it is constrained by the pull strip 58. The plate 64 beyond the stationary contact 66 is bent downwardly and extends beyond the side walls of the channel to provide a means for adjustment of the position of the stationary contact. A second conducting plate 68 is inserted into the other end of the frame 48 within the insulating lining to provide a second terminal for the switch, the first terminal being the plate 64. Plate 68 is connected by a conductor 70 with an intermediate point on the pull strip 58. Plate 64 can be connected to a source of energy, as for example a battery 72, and plate 68 can be connected through a load to the other terminal of the battery 72, as for example through the load comprising lamps 74.

The operation of the above described switch will be readily apparent. When no current flows through the device, as for example when a switch 76 in the line connecting plate 64 with the battery 72 is open, the tension in the pull strip 58 maintains the contacts 54 and 66 in engagement. Upon closure of the switch, current will flow from the battery through the contacts, sprung vane 56 and from both ends of the pull strip to the part 70, plate 68, and the lamp load 74 back to the battery to energize the lamps. Upon heating and consequent expansion of the pull strip, the tension in the pull strip will be reduced sufficiently to permit the vane to spring into the dotted line position, thereby opening the circuit at contacts 54 and 66. The pull strip will thereupon cool and contract and return the vane to contact closing position. Thus the device operates either as an overload circuit breaker or flasher, depending upon the initial adjustment of the tension in the pull strip and upon the particular dimensions of the pull strip. The projecting arm 60 of the frame provides ready means for adjustment of the tension of the pull strip and the extension of the plate 64 issuing from the frame provides ready means for adjustment of the position of stationary contact 66. The device thus comprises essentially but eight parts. These are the channel frame member 48, with its insulating lining 50; the two terminal members 64 and 68; the sprung vane 56; the pull strip 58 with its anchor 62; and the conductor 70. By connecting the pull strip at a point intermediate its length to a terminal of the switch, insulated anchorages for the pull strip are eliminated, facilitating mass production and reducing the number of rejects ordinarily encountered in the manufacture of devices of this type. The switch may be made of relatively small dimensions and is sturdy with few, if any parts subject to wear.

In each of the embodiments of the invention so far described, the pull strip, when cold, maintains contacts closed and when heated by passage of current therethrough permits movement of the contact carrying member to circuit opening position. The devices are thus suitable for use as flashers or overload protectors. In the embodiment of the invention illustrated in Fig. 8 and now to be described the contact carrying member, when the pull strip expands, closes an auxiliary circuit, the main circuit including the pull strip being independent of the position of the contact carrying member. Thus the device operates essentially as a relay.

In Fig. 8, the contact carrying member indicated generally at 78, is a snap plate of the construction described and claimed in applicant's copending application Serial No. 347,380, filed April 7, 1953, and entitled Wire Controlled Snap Switch (now Patent No. 2,761,931). It comprises three metal strips interconnected at their ends, the outer strips 79 being co-planar and the inner strip 80 being biased at its ends to bow outwardly from the plane of the outer strips. The plate 78 is fixedly mounted at one end. The other end, which carries an electrical contact 81 on its under side and an insulating button 82 on its upper side, is free to move between fixed stops 83 and 84, the latter of which is an electrical contact. An angle member 86 is mounted on the central strip 80 adjacent the fixed end of the plate and to the angle member 86 is secured under tension one end of a pull strip 88. The tension applied to the pull strip, whether expanded as a result of passage of current therethrough or contracted when cold, is sufficient to cause the central unbiased portion of the inner strip 80 to flex

oppositely to the biased ends thereof so that the central strip assumes the shape of a relatively flat M, all as described in the said copending application Serial No. 347,380. In accordance with the present invention a metal frame member **90** of U cross section has its side walls turned inwardly to clamp therewithin two flat conductors **92** and **94** which are insulated from the walls of the frame member **90** by a sheet **96** of insulating material folded around the conductors during the clamping operation. Conductor **92** extends from beyond one end of the member **90** to about the central portion thereof where it terminates in a raised shoulder **92***a* upon which is mounted the contact or stop **84**, and a tail portion **92***b* generally perpendicular to the member **90** and protruding out therefrom through the space between the turned in side walls. The shoulder portion **92***a* is disposed within an opening **90***a* in the upper wall of the frame member. Conductor **94** extends from the neighborhood of opening **90***a* to and beyond the other end of member **90** to provide one terminal of the device, specifically shown as a grounded terminal. The snap plate **78** is mounted on a step **98** which is a projection of the copper wall of frame member **90** and which is extended beyond the body of the frame member to provide a second terminal **100** of the device. Stop **83** comprises a button mounted on the underside of an overhanging arm **102***a* of a generally hook shaped member **102**. Member **102** has a shank portion **102***b* which extends through the opening **90***a* in the member **90** and is welded to the tail portion **92***b* of conductor **92**, permitting conjoint adjustment of the position of the stop members. Frame member **90** at the end remote from the terminal **100**, has a bendable extension **104** which is turned upwardly and to the upper end of which is secured under tension the other end of the pull strip **88**. Thus both ends of the pull strip are mechanically and electrically connected to the frame member **90**. Conductor **94** is connected by a flexible lead **106** to the mid point of the pull strip.

In Fig. 8 the snap plate **78** is shown in the position to which it is biased by maximum tension in the pull strip **88**, that is with the insulator button **82** on the free end thereof in engagement with the button or stop **83**. When the pull strip expands the amplitude of curvature of the portions of the central strip **80** reduces causing the free end of the snap plate to move away from stop **83** and snap into position where contact **81** engages contact **84**. For a more complete description of the operation of a snap plate of the general type of plate **78** of Fig. 8, and of its operation during change in tension of the pull strip or wire, reference may be had to the said copending application.

Terminal **100** is connected through a lamp load, comprising three lamps **108** in parallel, and a control switch **110** to the positive terminal of a battery **112**, the negative terminal of which is grounded. Conductor **92** is connected through a pilot lamp **114** to ground. Thus when switch **110** is closed current flows from the positive terminal of the battery, through the lamps **108** in parallel, to terminal **100** and frame member **90**, from both ends of frame member **90** through the halves of the pull strip in parallel to the conductor **106**, conductor **94** and ground. The consequent expansion of pull strip **88** causes plate **78** to snap into position wherein the contact **81** engages contact **84** thus closing a circuit through the snap plate, conductor **92** and pilot lamp **114** to ground. The parts will remain in this position so long as all lamps **108** are functioning and carrying their respective share of the current. Upon failure of one or more of the lamps **108** and consequent reduction of current through the pull strip, the strip will contract and cause plate **78** to snap into position to open the circuit through the pilot lamp. Thus the current through the auxiliary circuit including the pilot lamp is controlled by the switch whereas, in contradistinction to the embodiments of the invention illustrated in Figs. 1 to 7, the circuit of the pull strip is not dependent upon the position of the contact carrying member. The particular circuit shown in Fig. 8 is typical of any one of many circuits which might be advantageously controlled by the switch of Fig. 8.

The invention has now been described with reference to three specific embodiments thereof in each of which a pull strip is anchored at both ends to metallic members of the same electrical polarity. In two of the embodiments the pull strip, when cold, maintains contacts in closed position, the pull strip when heated by passage of current therethrough permitting spring means to open the contacts. In the third embodiment the pull strip when cold maintains contacts in an auxiliary circuit open and when heated by passage of current therethrough permits spring means to close the contacts of the auxiliary circuit. In the electromagnetic thermo switch of one embodiment of the invention magnetic spark quenching is provided. Obviously, various changes in the specific constructions illustrated could be made without departing from the spirit of the invention or the scope of the accompanying claims.

This application is a continuation-in-part of applicant's copending application Serial No. 298,385 filed July 11, 1952 (now abandoned) and also of applicant's copending application Serial No. 347,380 filed April 7, 1953, now Patent No. 2,761,931.

The following is claimed:

1. A thermo-responsive switch comprising a metallic contact carrying member movable between a first and second circuit controlling position and biased toward said first position, a metallic structure conductively connected to said member and supporting the same, an expansible electrically conductive pull strip mechanically and electrically connected at one end to said structure, means for mechanically and conductively connecting the other end of said pull strip to said member under tension such that when cold the strip holds said member against the bias thereof in said second position and when heated by passage of current therethrough permits movement of said member to said first position, said structure and member providing a low resistance path between the ends of said strip, a fixed contact positioned for engagement by the contact carried by said member when said member is in one of said positions, and a permanent untensioned electrical connection to a point of the pull strip intermediate its ends, whereby when said structure and said connection are at different electrical potentials current flow in parallel through the parts of the strip on opposite sides of the electrical connection controls the position of said member carried contact with respect to said fixed contact.

2. The thermo-responsive switch according to claim 1 wherein said fixed contact is positioned for engagement by said member carried contact when said member is held by said strip in said second position, whereby when a circuit including a source of energy is connected across said electrical connection and said fixed contact said member will move back and forth from one position to the other as the strip expands and contracts.

3. The thermo-responsive switch according to claim 1 wherein said fixed contact is positioned for engagement by said member carried contact when said member is in said first position, whereby when a first circuit including a source of energy is connected across said structure and said connection and a second circuit is connected across said contacts, said second circuit may be opened or closed at said contacts by control of current in said first circuit.

4. A thermo-responsive switch comprising a metallic contact-carrying movable member, a fixed contact positioned for engagement by the contact carried by said member when said member is in one position, said member being biased toward a non-contact engaging position, a metallic structure conductively connected to said

member, an expansible electrically conductive pull strip mechanically and electrically connected at one end to said structure, means for mechanically and conductively connecting the other end of said pull strip to said member under tension such that when cold the strip holds said member in said contact engaging position and when heated by passage of current therethrough permits movement of said member to said non-contact engaging position, and an electrical connection to a point of the pull strip intermediate its ends whereby, when said strip is cold and a circuit including a source of energy is connected across said connection and said fixed contact, current flows in parallel through the parts of the strip on opposite sides of the electrical connection, through said structure and member to said fixed contact.

5. The switch according to claim 4 wherein said member is an armature of an electromagnet and is spring biased into retracted position, said strip when tensioned holding said armature in attracted position, and wherein one end of the winding of the electromagnet is connected to said strip.

6. The switch according to claim 5 wherein said fixed contact is insulatedly mounted on the core of said electromagnet to provide magnetic spark quenching upon opening of said contacts.

7. The switch according to claim 4 wherein said contact carrying member is a vane having an inherent constraint therein tending to move it into contact open position, said strip when under tension buckling the vane to contact closing position.

8. A thermo-responsive electromagnetic switch comprising a core of magnetically permeable material, a winding on said core, an armature spring-mounted on said core so as to be biased into retracted position, a tensioned strip of electrically conducting material secured at one end to said armature and at its other end to said core, the tension in said strip opposing the spring bias of said armature, a contact insulatedly mounted on said core and positioned for engagement with said armature in attracted position, an electrical connection between one end of said winding and a point on said strip intermediate its anchored ends and electrical terminals connected respectively with the other end of said winding and said contact.

9. The switch according to claim 8 wherein said core is a magnetizable flat sheet having a portion at one end bent at an angle to the face of the sheet, one end of said tensioned strip being secured to the end of said portion whereby the tension in said strip can be adjusted by adjustment of the angle of said portion relative to the face of the sheet.

10. The switch according to claim 9 including a sheet of insulating material overlying a part of said core, and a metallic plate overlying said sheet and having a tongue pressed outwardly therefrom, said contact being mounted on said tongue and being adjustable relative to said armature by adjustment of the position of said tongue.

11. The switch according to claim 8 including a base of insulating material, said core and said terminals being mounted on said base, a third terminal mounted on the base, a fixed contact supported from said base and positioned for engagement with said armature in retracted position, said last mentioned contact being electrically connected to said third terminal.

12. A thermo-responsive switch comprising a metallic channel member closed along three sides, an insulating sleeve within said member, conducting members clamped in said sleeve at each end of said member and extending outwardly therefrom, said member and sleeve having aligned openings therein, a vane secured at its ends under compression to said member so as to be constrained into a bowed position, a thermo-expansible pull strip secured under tension at one end to said vane and at its other end to said member, the tension in said pull strip buckling said vane in opposition to the constraint therein, a contact carried by said vane and positioned in alignment with said aperture, a contact carried within said channel member by one of said conducting members and positioned for engagement by said vane carried contact when the vane is buckled by said strip, and an electrical connection between the other of said conducting members and a point on said strip intermediate its anchored ends.

13. The thermo-responsive switch according to claim 12 wherein a portion of said contact carrying conducting member beyond the location of the contact extends out through the open side of said channel member to provide means for adjusting the position of the fixed contact.

14. The thermo-responsive switch according to claim 12 wherein said channel member has a portion bent outwardly to provide a tongue for anchorage of one end of said strip.

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