Dec. 7, 1943. W. E. STILWELL, JR 2,335,888

OVERLOAD PROTECTIVE ELECTROMAGNETIC SWITCH

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Fig. 1.

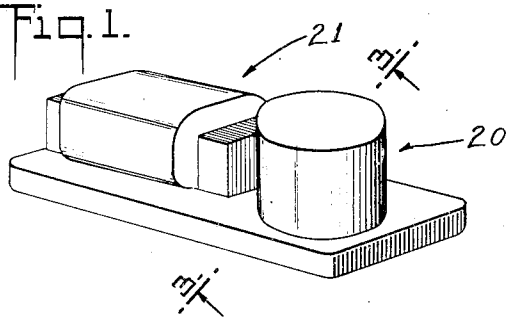


Fig. 2.

Fig. 4.

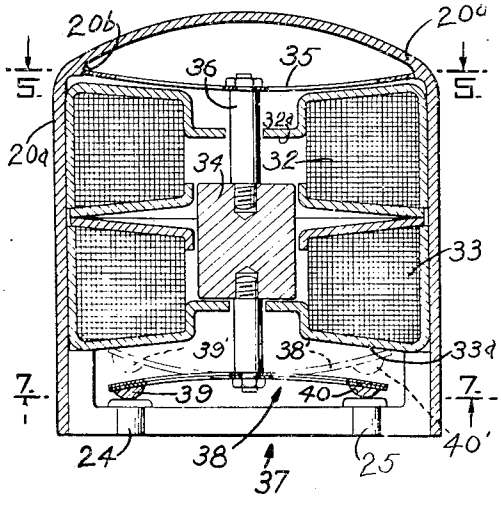
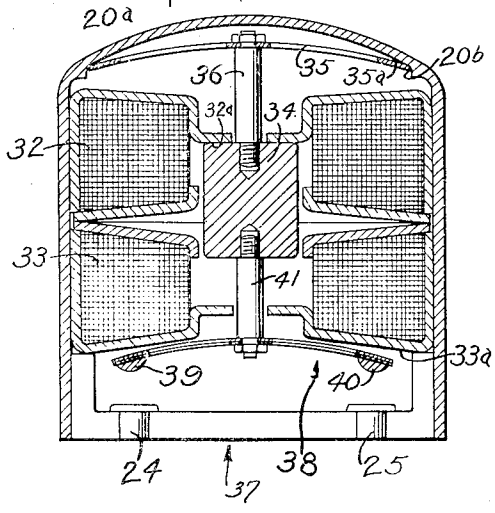


Fig. 3.



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OVERLOAD PROTECTIVE ELECTROMAGNETIC SWITCH

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Fig. 5.

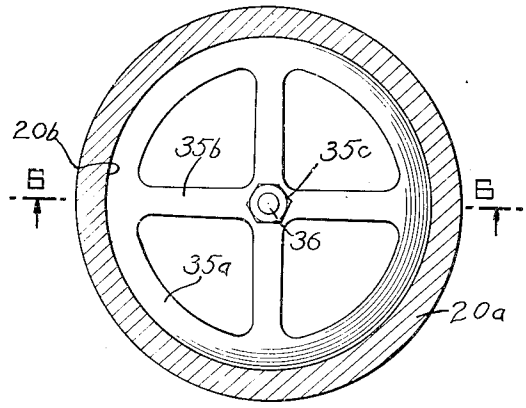


Fig. 8.

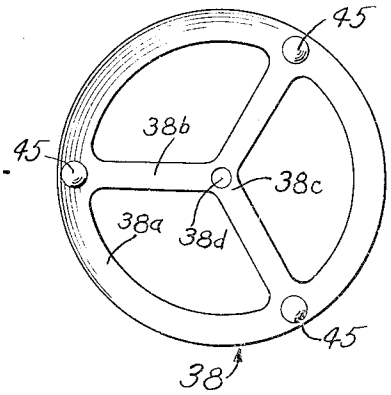


Fig. 6.

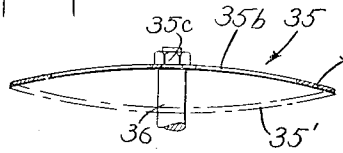


Fig. 9.

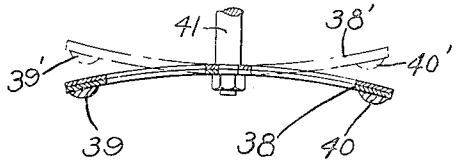
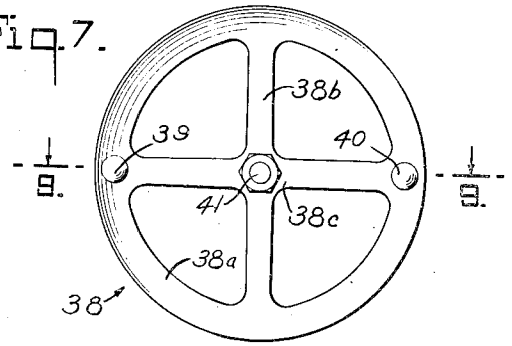


Fig. 7.



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OVERLOAD PROTECTIVE ELECTROMAGNETIC SWITCH

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Fig. 10.

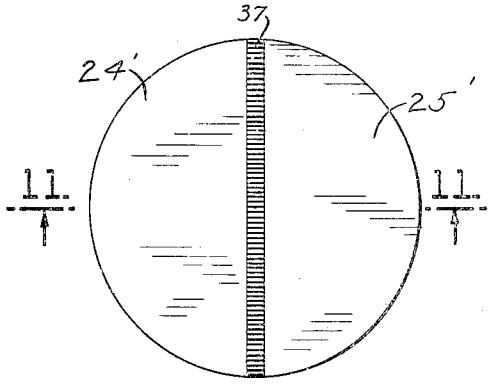


Fig. 11.

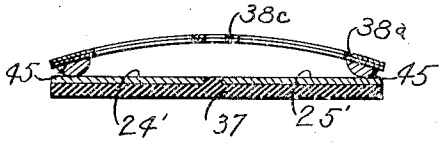


Fig. 12.

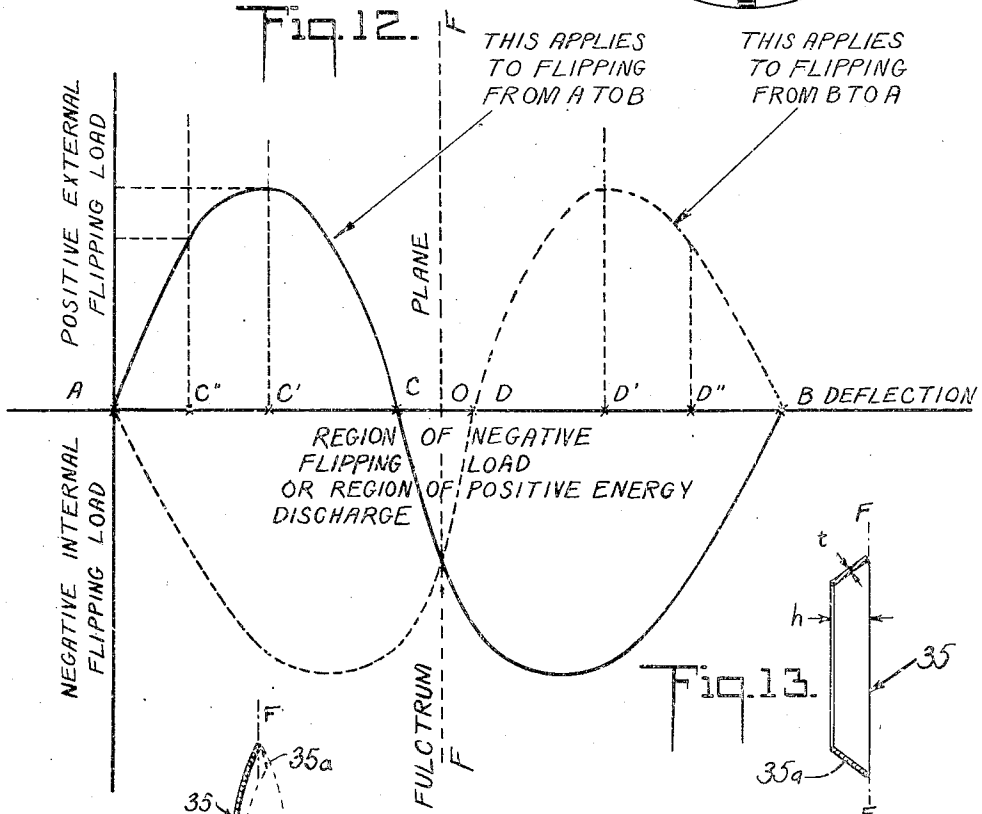
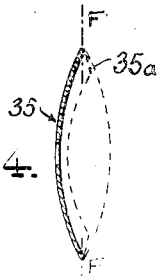


Fig. 13.

Fig. 14.



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Patented Dec. 7, 1943

2,335,888

UNITED STATES PATENT OFFICE

2,335,888

OVERLOAD PROTECTIVE ELECTRO-MAGNETIC SWITCH

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Application March 12, 1942, Serial No. 434,313

20 Claims. (Cl. 200—88)

The invention relates to overload protective electro-magnetic switches.

A feature of the invention resides in providing a self-closed low voltage magnetically operated switch arranged to make and break electrical circuits such as encountered in industrial and household wiring systems.

A feature of the invention is to provide a self-enclosed low voltage remotely controlled magnetically actuated switch for high voltage, preferably having such dimensions as to fit completely within a standard outlet box or standard panel board, in accordance with the permissible standards and specifications of the Underwriters Laboratories and the National Electric Code.

A feature of the invention resides in providing a switch device having the hereinabove described characteristics and which includes a low voltage magnetically operated high voltage switch actuator element which is completely responsive to momentary energization, and preferably wherein the high voltage circuit making and breaking switch is rapid and positive of action.

A feature of the invention resides in providing a low voltage magnetically operated switch for high voltage load circuits wherein the low voltage magnetic actuator elements are electrically shielded and insulated from the high voltage contact elements, and wherein the device as a whole is electrically and mechanically shielded from external forces and disturbances, and preferably arranged to be immune to explosions as well as undeflected by vibrational deflections.

The invention is particularly adapted to attain the above objectives and to be produced by mass production methods insuring durability, dependability in action, and low expense.

Optimum actuation of the magnetically operated switch is attained by means of a device herein defined as a toggle spring, preferably self-contained, having the characteristics, inter alia, of two positions, of equilibrium, coordinated respectively with the stroke end positions of the plunger or equivalent of the magnetically operated switch, requiring a uniformly applied load to cause the toggle spring to flip, and having a negative internal flipping load.

A particular feature of the present invention is the provision of overload protection in a magnetically operated switch, of the above or other approved character.

Overload protection is preferably afforded by the provision of thermally responsive means carried by the plunger or equivalent of the magnetically operated switch. Desirably, such thermally responsive means includes circuit-closing means of bi-metal or other suitable thermostat organization, carrying contacts for engagement with terminals of the load circuit, whereby under overload condition and consequent heating of the bi-metal, such contacts are "snapped" out of engagement with the load circuit terminals.

Preferably, such bi-metal means comprises a circuit-closing member of bi-metal material and of toggle-spring formation. Such toggle-spring bi-metal member may have either one or two positions of stable equilibrium. In the employment of such bi-metal member of one position of equilibrium, upon cooling the bi-metal circuit-closing member flips back to circuit-closing position and reestablishes the load circuit.

In the employment of such bi-metal member of two positions of equilibrium, heating due to overload causes the member to flip from circuit-closing position to circuit-opening position coincident to one of its positions of equilibrium at which position it remains upon cooling. To restore circuit closing of the load circuit, the magnetically actuated switch is first operated to its "off" position, thereby mechanically flipping such bi-metal member to its other position of stable equilibrium, and then the magnetically actuated switch is operated to its "on" position, bringing such bi-metal member to its circuit-closing position and restoring the load circuit.

Further features and objects of the invention will be more fully understood from the following detail description and the accompanying drawings, in which

Fig. 1 is an elevational perspective view illustrating generally a unitary assembly of an embodiment of the invention with a co-ordinated transformer. The view indicates in substantially actual dimensions a preferred embodiment of the invention and a transformer designed in correspondence therewith which has successfully passed requirements for circuit breaker tests.

Fig. 2 is a diagrammatic view of an electrical circuit illustrating generally the objectives of embodiments of the invention.

Fig. 3 is a central vertical section on line 3—3 of Fig. 1, on an enlarged scale, of a preferred embodiment of the invention, embodying a toggle spring for maintaining and flipping the switch plunger and a bi-metal circuit-closing member, the movable parts being shown in normal, i. e. non-operated positions.

Fig. 4 is a central sectional elevation corresponding to Fig. 3, illustrating the movable parts of the switch in circuit-on position, and also in

dot-and-dash line movement of the bi-metal circuit-closing member to its open position, arising under overload.

Fig. 5 is a detail sectional view on line 5—5 of Fig. 4.

Fig. 6 is a detail transverse section of the toggle spring per se, on line 6—6 of Fig. 5.

Fig. 7 is a front elevation of a preferred bi-metal circuit-closing member provided with two contacts;

Fig. 8 is a front elevation of another preferred bi-metal circuit-closing member provided with three contacts.

Fig. 9 is a detail sectional view on line 9—9 of Fig. 7, indicating also in dot and dash outline the open circuit position of the bi-metal member arising under overload.

Fig. 10 is a plan view of a preferred arrangement of load circuit contacts and mounting of the same.

Fig. 11 is a detail sectional view on line 11—11 of Fig. 10, and including the embodiment of the three contact bi-metal member shown in Fig. 8.

Fig. 12 is a graph illustrating certain characteristics of the toggle spring and the association of the same in magnetically actuated switches of the type illustrated in Figs. 3 and 4.

Fig. 13 is a diagrammatic central sectional view illustrating the relationship of variation of "dishing" of the rim to certain attributes of toggle springs of single and dual positions of stable equilibrium.

Fig. 14 is a diagrammatic view illustrating in cross-section the toggle spring in one of its positions of stable equilibrium and indicating in dotted outline the position of its rim portion relative to its central and "legged" portion at the instant of flipping of the rim toward and to its second position of stable equilibrium.

Referring to the drawings, Fig. 1 illustrates in perspective a magnetically operated switch embodying the invention, indicated generally at **20**, mounted on a common base with a co-ordinated transformer **21**, the aforesaid in substantially full size. This assembly of relatively micro overall dimensions has successfully met tests of withstanding repetitive overload or short-circuit opening during momentary overload such as is occasioned by motor starting, but opening quickly under permanent overloads or short-circuits. As an example, one such successfully tested magnetically operated switch and co-ordinated transformer transforming 125 volt line voltage to 46 volt remote control switching voltage has the overall physical dimensions to enable the same to be installed in a 1⅜" x 1⅜" x 3 ⅝" outlet box.

In the circuit diagram of Fig. 2, the magnetically operated switch is indicated generally at **20**, the transformer at **21**, the high voltage wires at **22, 23**, and the high voltage terminals at **24, 25**. Fig. 2 discloses also the employment of low voltage switch legs **26, 27, 28**, which may comprise inexpensive wire such as #18 or #20, as contrasted with heavier, more expensive and heavily insulated wire, such as the usual #10 to #14 required by law for 125 and upward volt lines. If desired, any number of double throw switching stations, indicated generally at **29**, may be provided in the low voltage circuit wherein each station includes means, such as manually operable buttons **30, 31**, for permitting selective remote control, for "on" and "off" positions of the switch plunger. The terms high and low voltage as herein employed, serve to distinguish the customary 125–250 volt systems used in house and industrial wiring systems from the 6 to 50 volt circuit preferably for remote control of embodiments of the invention.

A preferred embodiment of the invention is shown more particularly in Figs. 3 and 4, **32, 33** indicate a pair of electrically independent coils selectively operated by the push buttons **30, 31**, or equivalent, of any of the switching stations for energizing one or the other of the coils **32, 33** but never both at the same time. These "on" and "off" coils are shown mounted in a suitable housing **20a** which may be of any suitable material. The spools of the coils **32, 33** are fixed within the housing **20a** in their positions indicated in Figs. 3 and 4, by any suitable means.

The plunger or armature for the coils **32, 33** is indicated at **34** and may be of any suitable cross-section, usually circular, and is dimensioned for appropriate longitudinal stroke movement, axially of the coil spools. The plunger **34** is fabricated from any suitable magnetic material, such as, by way of example, iron.

To impart a maximum driving force to the plunger **34**, coupled with a positive complete stroke in first one and then in an opposite direction along the longitudinal axis of the plunger, means are provided for establishing a dead center point relative to which the plunger will assume one or the other of two normal positions of its longitudinal travel. As one such means, there is provided the toggle spring **35** which is connected at a central zone to the drive rod **36**, as by the indicated thread and nut connection. The characteristics of preferred forms of the toggle spring **35** are set forth more particularly hereinafter; however, it is here stated that the toggle spring **35** comprises a rim portion and thereto connected radially extending or "spoke" portions merging in a central portion provided with an opening through which the connected end of the drive rod **36** is passed.

The opposite end of the drive rod **36** is suitably connected to the plunger **34**, as by tapping and threading as indicated.

The terminals **24, 25** of the load circuit are fixedly secured to and carried by suitable high voltage terminal blocks, which may, in turn, be individually secured to a common non-conducting block denoted generally at **37**, suitable provision being made for the attachment of the electrical conductors, as is well understood by the art.

Suitable means for circuit-closing the terminals **24, 25** are provided, under control of the "on" and "off" coils **32, 33**. Pursuant to the present invention, such circuit-closing means providing for overload protection comprises a member carried by the plunger usually indirectly, such member being of thermostat material, usually bi-metal, carrying suitable contacts whereby under circuit closure position the load current traverses such bi-metal or thermostat material. One preferred form of such thermostat, i. e., bi-metal circuit-closing member is shown in Fig. 7, denoted **38** and carrying two contacts **39, 40**. As shown, such member comprises a rim portion **38a**, radial or "spoke" portions **38b**, in this instance four such "spokes." These "spokes" merge into the central portion **38c**, which is provided with a recess or opening **38d**. As appears from Figs. 3 and 4, the bi-metal member **38** may be carried by the plunger **34** through the intermediation of the rod **41**, which may be secured to the plunger by tapping and

threading, as shown, and to the bi-metal circuit-closing member **38** through its central opening **38***d*, as by threading the appurtenant end of the rod **41** and tightening nut, as shown. The drive rods **36** and **41** are preferably of brass, or other suitable non-magnetic material.

As indicated hereinabove, the bi-metal circuit-closing member **38** may have a single position of equilibrium or two positions of equilibrium, at normal temperatures. Its contacts **39, 40** are secured to such member **38** upon its face which is concavely flexed at normal temperature, as is illustrated in Fig. 3, and in full outline in Fig. 4.

Fig. 3 indicates the essential parts of the magnetically operated switch in "off" position; the toggle spring **35** is of the type having two positions of stable equilibrium. The bi-metal member and its contacts are in "off" position, i. e., retracted relative to the load circuit contacts **24, 25.**

By reason of the flipping characteristics of the toggle spring **35**, discussed more fully hereinafter, operation of the "on" button and excitation of the "on" coil **33**, need be but for an instant, to effect positive longitudinal movement of the plunger **34** and associated parts to attain and maintain pressure engagement of the circuit-closing contacts **39, 40** of the bi-metal member **38**, with the load circuit contacts **24, 25.** Further as also pointed out more fully hereinafter, the circuit-closing engagement of the circuit-closing contacts **39, 40** with the load current contacts **24, 25**, is effected in advance of full attainment of the second position of stable equilibrium of the toggle spring **35**, i. e., its downwardly flexed position, shown in full outline in Fig. 4. Moreover, under the condition of load circuit flow and consequent heating of the circuit-closing bi-metal member **38** and any resulting yielding movement of its rim **38***a* and its contacts **39, 40**, pressure of engagement of the contacts **39, 40**, with the contacts **24, 25**, is fully maintained by the positive action of the toggle spring **35.** Such maintained pressure continues until the predetermined overload condition is attained, at which status the bi-metal member **38** reaches its position of instantaneous flipping, namely, toward and to its upwardly flexed formation, whereby the load circuit is instantaneously opened, by the open-snapping upward movement of the contacts **39, 40**, away from the load circuit contacts **24, 25.**

Assuming the bi-metal member **38** to have a single position of equilibrium at normal temperatures, namely, at its downwardly flexed position shown in full outline in Fig. 4, upon cooling, after overload circuit-opening, the bi-metal member **38** will flip from its upwardly flexed position indicated in dot-and-dash outline in Fig. 4, to its downwardly flexed and short-circuiting position, i. e., its full outline position shown in Fig. 4.

Assuming the bi-metal member **38** to have two positions of stable equilibrium, namely, one position shown in Fig. 3 and in full outline in Fig. 4, and its other position in upwardly flexed status, indicated in dot-and-dash outline in Fig. 4, upon cooling subsequent to flipping to circuit-opening position under overload condition, such type of "two-position" by-metal member **38** will remain in its upwardly flexed, i. e., circuit-opening position.

To restore closing of the load circuit, the magnetically actuated switch is first operated to "off" position and then operated to "on" position. As indicated in Fig. 4, upon upward flexing of the bi-metal member **38**, under overload condition, its rim **38***a* is brought into engagement with the lower face (indicated at **33***a* in Fig. 4) of the lower spool of the switch coil **33**, whereby upon operation of the switch to "off" position, and consequent retraction, i. e., upward movement of the plunger **34** and appurtenant parts, the bi-metal member **38** is mechanically flexed from its upwardly flexed position to its downwardly flexed position, viz., its normal position as shown in Fig. 3, preparatory upon operation of the switch to "on" position, to restore circuit-closing of the load circuit by engagement of its circuit-closing contacts **39, 40** with the load circuit contacts **24, 25.**

It will be observed that during the stage of load circuit closing, the contact engaging movement of the contacts **39, 40**, relative to the fixed contacts **24, 25**, results in a highly effective wiping of the mutually engaging surfaces under sustained pressure.

Referring to Figs. 5 and 6, the toggle spring **35** comprises a rim portion **35***a*, a plurality of radially extending or "spoke" portions **35***b*, which merge into a central portion **35***c*, which may be provided with a central opening **35***d*, for reception and securement to its drive rod **36.** The toggle spring **35** is held in position within the casing **20***a* by engagement therewith of its rim **35***a*. Usually a kerf, indicated at **20***b*, see Figs. 3, 4, and 5, suffices, for the reception therein of the edge of the rim portion **35***a*.

The toggle spring **35** consists of two intra-dependent spring systems, one effected in its rim portion **35***a* which is dished to form the sides of a shallow truncated pyramid or cone and is permanently "set" in this shape. The other spring system is effected in the central portion, **35***c*, joined to the inner circumference of the rim **35***a* by the indicated "spoke" elements **35***a*, the "spoke" elements having no permanent set, with the result that the "spoke" elements each have a curvature tangential to the slant, i. e., "dishing" of the rim. Fig. 6 illustrates in full outline one position of stable equilibrium of the toggle spring **35**, which position corresponds to the upwardly flexed position of the toggle spring **35** shown in Fig. 3, in its assembly with the plunger **34** and therewith coordinated parts. The second position of stable equilibrium of the toggle spring **35** is that indicated by its dot-and-dash position **35'**, illustrated in Fig. 6, and also in Fig. 4.

The number of "spokes" **35***b* of the toggle spring **35** is usually four as indicated in Fig. 5, but may be two in number, i. e., extending in common direction, viz., diametrically, from rim to rim through the central portion **35***c*. Three "spokes" may be embodied, similarly as in the construction of the bi-metal member **38**, discussed more fully hereinafter.

Predicated upon tests carried out under practical operating conditions, roll hardened beryllium copper as the material of the toggle spring **35**, yields highly satisfactory results.

The toggle spring **35** of selected material may have a circular, square or other polygonal rim periphery.

To provide two positions of stable equilibrium, the rim **35***a* is dished to form the side of a shallow truncated pyramid or cone and is permanently set in this shape. Inwardly of the inner circumference of the rim **35***a* are interstices, i. e., blanked-out portions, producing a "legged" or

"spoked" center portion which has a curvature substantially tangential to the "slant" or "dishing" of the rim **35***a* but has no permanent set. Thus the permanently set rim **35***a* holds the conjoined center portion **35***c* in bowed elastic tension.

Based upon test results of toggle springs having a variation of range of "slant," i. e. "dishing" of the rim and possessing two points of stable equilibrium, there appears the indication of definite relationship of the degree of "slant" or "dishing" relative to the thickness of the rim portion. To illustrate such relationship, see Fig. 13, assuming h to represent the "height" of the truncated pyramid or cone referred to above, and t the thickness of the rim portion **35***a*, when

$$\frac{h}{t}>\sqrt{8}$$

the toggle spring has two points of stable equilibrium.

Referring now to the graph, Fig. 12, the values in the direction of abscissae represent "deflection" and values in the direction of ordinates represent respectively "positive external flipping load" and "negative internal flipping load." A, the intersection of abscissae and ordinates represents one position of stable equilibrium and B represents the second position of stable equilibrium. The curve in full outline represents the "flipping" from A to B. The curve in dash outline represents the "flipping" from B to A. These graphs depict the flexing characteristics of variant types of two position toggle springs adapted to function as the positive actuating means represented by the toggle spring **35** of the assembly illustrated in Figs. 3, 4 and 5.

Other characteristics are, in addition to the above referred to h/t ratio of the rim **35***a* greater than $\sqrt{8}$, and that such dished rim has a permanent set and that the "legged" center portion is held in bowed elastic tension by the rim, that the stiffness moduli of the "legged" center portion and of the rim cause the "flipping" load be transmitted to the rim substantially without destroying the geometric arch of the center portion, and kinematically that the speed of flipping of the rim with the accompanying momentary storage of a surplus amount of potential energy in the leg-rim joints, results in the "legged" center portion being pulled through the fulcrum plane, i. e. the plane passing through the edge fulcrum points of the rim **35***a* indicated FF in Fig. 13 and also represented by the line FF in the graph, Fig. 12, drawn midway between the points A and B. A representation of the above concatenation of individual and conjoint flexing of the respective parts of the toggle spring is indicated in Fig. 14 (showing the toggle spring **35** in central section) wherein the positions of the toggle spring in its left-hand sectional view and its indicated right-hand dash outline respectively correspond to the points A and B of the graph of Fig. 12. The dotted outline represents the curved formation assumed by the toggle spring at the instant of positive flipping, i. e. the instant at which the rim **35***a* has just initiated its flipping movement.

Successful results in the production of toggle springs having two positions of stable equilibrium have been had by striking on both sides the material in a blanking and forming die conforming to the above geometric and metallurgical requirements.

In such blanking and forming operation, the die is not permitted to strike the "legged" center portion; optimum results are had by the die so striking and forming the rim that the circumference of the rim is foreshortened, thus automatically putting a bow in the "legged" center portion. Satisfactory toggle springs have also been produced by letting the die lengthen without permanently setting the legs.

In contrast to a dual position toggle spring, a toggle spring having one position only of stable equilibrium, may be produced by striking the material on one side only in an appropriate blanking and forming die.

As indicated above, the flexing of the toggle spring **35** is limited in advance of its position of stable equilibrium in the "on" position of the switch by the physical engagement of the circuit-closing contacts with the load circuit contacts. Such limitation may be represented by the point D'' see Fig. 12. By such limitation, positive force exerted by the toggle spring in maintaining pressure of the circuit-closing contacts upon the load circuit contacts, is represented by the ordinate value through D'', see Fig. 12. Such limitation represented by the point D'' also insures absence of "hum" when the load current is of alternating character, affords immunity against vibrational acceleration, and in general exercises a damping effect.

At C' and D' are indicated maximum values of the "on" and "off" flipping movements of the toggle spring **35**. The spacing CD is of high significance, and represents the positive, i. e. kinetic energy discharged by the toggle spring in flipping from one position to its other position of stable equilibrium.

Similarly, limitation of positioning of the toggle spring **35** at its open-circuit position, say at the point C'', shown in the graph, Fig. 12, precludes tripping of the toggle spring, and consequent operation of the switch to "on" position, under condition of vibration, as when installed on an airplane or the like, or by explosion or like external vibration or force.

The geometric configuration of the thermostatic member **38** corresponds generally to that of the toggle spring **35**. Usually bi-metal thermostat material is employed. Starting with flat material, the geometric configuration is had by blanking and forming, to obtain a center portion **38***c*, having "legged" or "spoke" portions **38***b*, and a rim portion **38***a* having a common curvature approximating that indicated in Fig. 9 and illustrated generally in Fig. 3. Such bi-metal member possesses one point of stable equilibrium, namely its configuration imparted by the blanking and forming operation. Its contacts such as **39**, **40**, see Figs. 7 and 9, are secured upon its concave face, in proper relation to the contacts of the load circuit, such as **24**, **25**, see Figs. 3 and 4. These contacts are preferable of silver.

As is indicated above, the bi-metal member **38** may possess two positions of stable equilibrium, namely by imparting a "dishing," i. e. "slant," see Fig. 13, (referred to above with respect to the toggle spring **35**) represented by h/t; when its h/t is greater than 2.83, then the bi-metal member **38** possesses two points of stable equilibrium.

In an assembly such as is illustrated in Figs. 3 and 4, upon operating the magnetically actuated switch to its "on" position, force is initially imparted by the "on" coil, such as the "on" coil **33**, centrally of the toggle spring **35**, followed instantly by the force of the toggle spring **35** represented by the full outline curve AB of the graph, Fig. 12, effecting the engagement under

the combined electro-magnetic and flipping forces of the circuit-closing contacts **39, 40** with the load circuit contacts **24, 25**. In such movement, the bi-metal member **38** shall not flip, which requires that the modulus of rigidity of the bi-metal member **38** be greater than the modulus of rigidity of beryllium copper or equivalent material of the toggle spring **35**.

As indicated above, a mere edge lodgment of the toggle spring **35** within the casing **20** may be provided for, and the to and fro longitudinal, i. e. stroke movements of the plunger had by proper dimensioning of the contour of the plunger relative to the inward faces of the spools of the "off" and "on" coils **32, 33**. In practical application, axial rotation takes place, with resulting rotational movement of the contacts **39, 40** relative to the fixed load circuit contacts **24, 25**. To avoid "missing" of engagement of the short-circuiting contacts relative to the load circuit contacts, the load circuit contacts are preferably formed and mounted, as indicated in Fig. 10, to provide wide facial areas, as of semi-circular or segmental formation indicated at **24'** and **25'**, suitably spaced by insulation indicated at **37**, which insulation may be integral with or otherwise a part of the insulating base, also designated **37**. To further insure against "missing" of engagement of the circuit-closing contacts with the load circuit contacts, the bi-metal member **38** may be provided with three contacts, such as the contacts **45, 45, 45**, illustrated in Fig. 8. In the instance of three circuit-closing contacts, such as **45, 45, 45**, it is advantageous to form the bi-metal member with three legs or "spokes" **38***b*, in mutual radial relation.

It will be observed that the instantaneous release of the contacts of the overload protective means from the load circuit contacts, effected by the nature of flipping of the thermostat member per se is enhanced by the nature of flipping of the toggle spring from its "on" position toward its "off" position. This coaction serves also to effect the important function of mutual "wiping" of the concerned contacts.

In summary of the aforesaid, the invention in variant forms thereof, provides remote control of the main circuit, overload protection, trip free, and automatic reset upon cooling of the thermal element; and remote control of the main circuit, overload protection, trip free, and remote control of the manual reset after a time delay—plus low voltage remote control of the high voltage main circuit.

Whereas, the invention has been set forth in specific embodiments, it is understood that variations and modifications may be made without departing from the spirit of the invention.

I claim:

1. In an overload protective electro-magnetic switch, the combination of contacts arranged to be connected in the load circuit, double acting solenoid means, longitudinally shiftable drive rod means responsive to said double acting solenoid means, thermally responsive means carried by said longitudinally shiftable drive rod means, circuit-closing contacts carried by said thermally responsive means, resilient means for urging said drive rod means toward the respective ends of its stroke, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-responsive-means-carried contacts with said load circuit contacts.

2. In an overload protective electro-magnetic switch, the combination of contacts arranged to be connected in the load circuit, double acting solenoid means, longitudinally shiftable drive rod means responsive to said double acting solenoid means, thermally responsive means carried by said longitudinally shiftable drive rod means, circuit-closing contacts carried by said thermally responsive means, resilient means for urging said drive rod means at the respective ends of its stroke, said thermally responsive means including a thermostat member having a rim portion and thereto connected radially extending portions, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-responsive-means-carried contacts with said load circuit contacts.

3. In an overload protective electro-magnetic switch, the combination of contacts arranged to be connected in the load circuit, double acting solenoid means, longitudinally shiftable drive rod means responsive to said double acting solenoid means, thermally responsive means carried by said longitudinally shiftable drive rod means, circuit-closing contacts carried by said thermally responsive means, resilient means for urging said drive rod means at the respective ends of its stroke, including a member having a rim portion and thereto connected radially extending portions, said rim portion and said radially extending portions being formed of thermostat material, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-responsive-means-carried contacts with said load circuit contacts.

4. In an overload protective electro-magnetic switch, the combination of contacts arranged to be connected in the load circuit, double acting solenoid means, longitudinally shiftable drive rod means responsive to said double acting solenoid means, thermally responsive means carried by said longitudinally shiftable drive rod means, circuit closing contacts carried by said thermally responsive means, resilient means for urging said drive rod means at the respective ends of its stroke, said radially extending portions merging in a central portion, said central portion being provided with a recess receiving said drive rod means, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-responsive-means-carried contacts with said load circuit contacts.

5. In an overload protective electro-magnetic switch, the combination of contacts arranged to be connected in the load circuit, double acting solenoid means, longitudinally shiftable drive rod means responsive to said double acting solenoid means, thermally responsive means carried by said longitudinally shiftable drive rod means, circuit-closing contacts carried by said thermally responsive means, resilient means for urging said drive rod means at the respective ends of its stroke, said thermally responsive means including a thermostat member having a rim portion and thereto connected radially extending portions, said bi-metal member having a position of equilibrium effecting closure between said terminals and said contacts when said drive rod means is in circuit-closing position, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-re-

sponsive-means-carried contacts with said load circuit contacts.

6. In an overload protective electro-magnetic switch, the combination of contacts arranged to be connected in the load circuit, double acting solenoid means, longitudinally shiftable drive rod means responsive to said double acting solenoid means, thermally responsive means carried by said longitudinally shiftable drive rod means, circuit-closing contacts carried by said thermally responsive means, resilient means for urging said drive rod means at the respective ends of its stroke, said thermally responsive means including a thermostat member having a rim portion and thereto connected radially extending portions, said bi-metal member having two positions of equilibrium, one position effecting closure between said terminals and said contacts when said drive rod means is in circuit-closing position, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-responsive - means - carried contacts with said load circuit contacts.

7. In an overload protective electro-magnetic switch, the combination of contacts arranged to be connected in the load circuit, double acting solenoid means, longitudinally shiftable drive rod means responsive to said double acting solenoid means, thermally responsive means carried by said longitudinally shiftable drive rod means, circuit-closing contacts carried by said thermally responsive means, resilient means for urging said drive rod means at the respective ends of its stroke, said thermally responsive means including a bi-metal member having a rim portion and thereto connected radially extending portions, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-responsive-means-carried contacts with said load circuit contacts..

8. In an overload protective electro-magnetic switch, the combination of contacts arranged to be connected in the load circuit, double acting solenoid means, longitudinally shiftable drive rod means responsive to said double acting solenoid means, thermally responsive means carried by said longitudinally shiftable drive rod means, circuit-closing contacts carried by said thermally responsive means, resilient means for urging said drive rod means at the respective ends of its stroke, including a member having a rim portion and thereto connected radially extending portions, said rim portion and said radially extending portions being formed of bi-metal, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-responsive-means-carried contacts with said load circuit contacts.

9. In an overload protective electro-magnetic switch, the combination of contacts arranged to be connected in the load circuit, double acting solenoid means, longitudinally shiftable drive rod means responsive to said double acting solenoid means, thermally responsive means carried by said longitudinally shiftable drive rod means, circuit-closing contacts carried by said thermally responsive means, resilient means for urging said drive rod means at the respective ends of its stroke, said thermally responsive means including a bi-metal member having a rim portion and thereto connected radially extending portions, said bi-metal member having a position of equilibrium effecting closure between said terminals and said contacts when said drive rod means is in circuit-closing position, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-responsive-means-carried contacts with said load circuit contacts.

10. In an overload protective electro-magnetic switch, the combination of contacts arranged to be connected in the load circuit, double acting solenoid means, longitudinally shiftable drive rod means responsive to said double acting solenoid means, thermally responsive means carried by said longitudinally shiftable drive rod means, circuit-closing contacts carried by said thermally responsive means, resilient means for urging said drive rod means at the respective ends of its stroke, said thermally responsive means including a bi-metal member having a rim portion and thereto connected radially extending portions, said bi-metal member having two positions of equilibrium, one position effecting closure between said terminals and said contacts when said drive rod means is in circuit-closing position, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-responsive - means - carried contacts with said load circuit contacts.

11. In an overload protective electro-magnetic switch, the combination of contacts arranged to be connected in the load circuit, double acting solenoid means, longitudinally shiftable drive rod means responsive to said double acting solenoid means, thermally responsive means carried by said longitudinally shiftable drive rod means, circuit-closing contacts carried by said thermally responsive means, resilient means for urging said drive rod means at the respective ends of its stroke, said radially extending portions merging in a central portion, said central portion being provided with a recess receiving said drive rod means, said thermally responsive means including a thermostat member having a rim portion and thereto connected radially extending portions, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-responsive-means-carried contacts with said load circuit contacts.

12. In an overload protective electro-magnetic switch, the combination of contacts arranged to be connected in the load circuit, double acting solenoid means, longitudinally shiftable drive rod means responsive to said double acting solenoid means, thermally responsive means carried by said longitudinally shiftable drive rod means, circuit-closing contacts carried by said thermally responsive means, resilient means for urging said drive rod means at the respective ends of its stroke, said radially extending portions merging in a central portion, said central portion being provided with a recess receiving said drive rod means, said thermally responsive means including a bi-metal member having a rim portion and thereto connected radially extending portions, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-responsive-means-carried contacts with said load circuit contacts.

13. In an overload protective switch, the combination of contacts arranged to be connected in a load circuit, double acting solenoid means, lon-

gitudinally shiftable drive rod means responsive to said solenoid means, circuit-closing means carrying contacts cooperating with said load circuit contacts, said circuit-closing means including thermostatic material, resilient means operative upon said drive rod means when in contact closing position for positively effecting contact engagement under maintained pressure independently of movement of said circuit-closing means incident to heating of its thermostatic material, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-responsive-means-carried contacts with said load circuit contacts.

14. In an overload protective switch, the combination of contacts arranged to be connected in a load circuit, double acting solenoid means, longitudinally shiftable drive rod means responsive to said solenoid means, circuit-closing means comprising thermostatic material carrying contacts cooperating with said load circuit contacts, resilient means operative upon said drive rod means when in contact closing position for positively effecting contact engagement under maintained pressure notwithstanding movement of said circuit-closing contacts relative to said load circuit contacts incident to heating of its thermostatic material, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-responsive-means-carried contacts with said load circuit contacts.

15. In an overload protective switch, the combination of fixed contacts arranged to be connected in a load circuit, double acting solenoid means, longitudinally shiftable drive rod means responsive to said solenoid means, circuit-closing means carrying contacts cooperating with said load circuit contacts, said circuit-closing means including thermostatic material, resilient means operative upon said drive rod means when in contact closing position for positively effecting contact engagement under maintained pressure independently of movement of said circuit-closing means incident to heating of its thermostatic material, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-responsive-means-carried contacts with said load circuit contact.

16. In an overload protective switch, the combination of fixed contacts arranged to be connected in a load circuit double acting solenoid means, longitudinally shiftable drive rod responsive to said solenoid means, circuit-closing means comprising thermostatic material carrying contacts cooperating with said load circuit contacts, resilient means operative upon said drive rod means when in contact closing position for positively effecting contact engagement under maintained pressure notwithstanding movement of said circuit-closing contacts relative to said load circuit contacts incident to heating of its thermostatic material, and means for positively limiting the stroke of said drive rod means in its "on" position beyond that normally determined by the engagement of said thermally-responsive-means-carried contacts with said load circuit contact.

17. In an overload protective electrical switch, the combination of electrical coil means; longitudinal shiftable drive rod means responsive to said electrical coil means; a member having two positions of stable equilibrium associated with said drive rod means to control the "off" and "on" positions of said drive rod means in correspondence to the two positions of stable equilibrium of said member; thermostatic overload protective means carried by said drive rod means; switch contacts carried by said thermostatic means; load circuit contacts positioned to be normally engaged by said switch contacts when said drive rod means is in its "on" position; said member, said drive rod means, said thermostatic means and said switch contacts being arranged to normally effect engagement of said switch contacts with said load circuit contacts in advance of the "on" position of stable equilibrium of said member.

18. In an overload protective electrical switch, the combination of electrical coil means; longitudinally shiftable drive rod means responsive to said electrical coil means; a member having two positions of stable equilibrium associated with said drive rod means to control the "off" and "on" positions of said drive rod means in correspondence to the two positions of stable equilibrium of said member; thermostatic overload protective means carried by said drive rod means; switch contacts carried by said thermostatic means; load circuit contacts positioned to be normally engaged by said switch contacts when said drive rod means is in its "on" position; said member, said drive rod means, said thermostatic means and said switch contacts being arranged to normally effect engagement of said switch contacts with said load circuit contacts in advance of the "on" position of stable equilibrium of said member; said thermostatic means having a single position of stable equilibrium at which position said switch contacts normally engage said load circuit contacts.

19. In an overload protective electrical switch, the combination of electrical coil means; longitudinally shiftable drive rod means responsive to sail electrical coil means; a member having two positions of stable equilibrium associated with said drive rod means to control the "off" and "on" positions of said drive rod means in correspondence to the two positions of stable equilibrium of said member; thermostatic overload protective means carried by said drive rod means; switch contacts carried by said thermostatic means; load circuit contacts positioned to be normally engaged by said switch contacts when said drive rod means is in its "on" position; said member, said drive rod means, said thermostatic means and said switch contacts being arranged to normally effect engagement of said switch contacts with said load circuit contacts in advance of the "on" position of stable equilibrium of said member; said thermostatic means having two positions of stable equilibrium, at one position of stable equilibrium said switch contacts normally engage said load circuit contacts.

20. In an overload protective electrical switch, the combination of electrical coil means; longitudinally shiftable drive rod means responsive to said electrical coil means; a member having two positions of stable equilibrium associated with said drive rod means to control the "off" and "on" positions of said drive rod means in correspondence to the two positions of stable equilibrium of said member; means for limiting the "off" position of said drive rod means in advance of the "off" position of stable equilibrium of said member; thermostatic overload protective means carried by said drive rod means; switch contacts

carried by said thermostatic means; load circuit contacts positioned to be normally engaged by said switch contacts when said drive rod means is in its "on" position, said member, said drive rod means, said thermostatic means and said switch contacts being arranged to normally effect engagement of said switch contacts with said load circuit contacts in advance of the "on" position of stable equilibrium of said member, said thermostatic means having a single position of stable equilibrium at which position said switch contacts normally engage said load circuit contacts.

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