

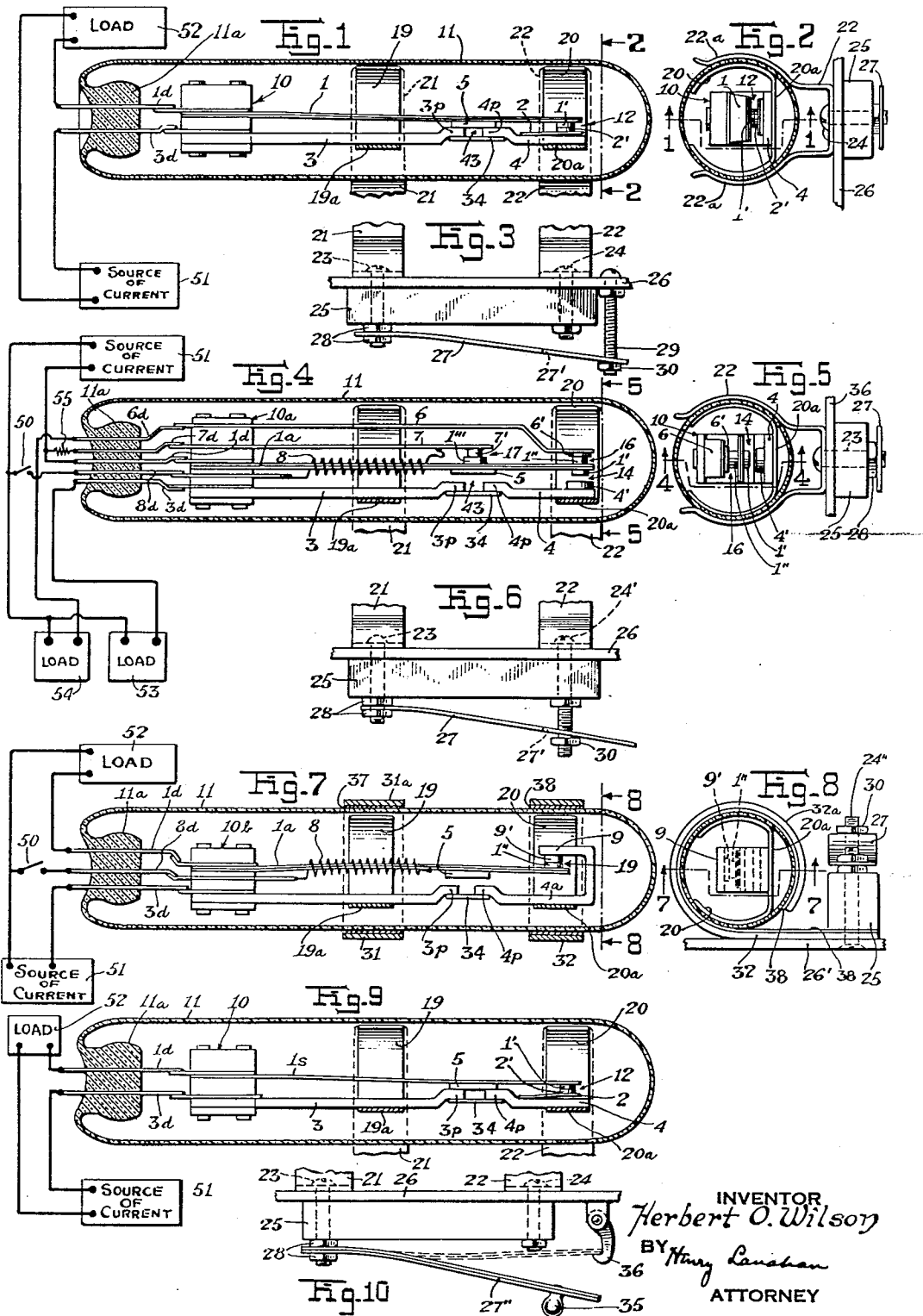
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H. O. WILSON

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ELECTRIC SWITCH

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ELECTRIC SWITCH

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18 Claims. (Cl. 200—122)

This invention relates to electric switches and more particularly to switches whose poles are moved by forces other than direct manual manipulation—for example, by temperature-developed force.

The invention especially, though in certain aspects non-limitatively, contemplates devices of the class described in the form of vacuum switches or relays.

It is an object of my invention to provide improved means for causing abruptness in the openings and/or closings of such switches.

It is another object to provide improved means for obtaining rapidity of throw of such switches.

It is another object to provide improved means for obtaining snap action in the throw of an enclosed switch.

It is another object to provide novel means for regulating such snap action, particularly in vacuum switches.

It is another object to provide novel means for regulating the mean operating temperature of thermally operating switches, particularly vacuum switches.

It is another object to provide novel means for regulating the difference between throwing and rethrowing temperatures in thermally operating switches, particularly vacuum switches.

It is another object to provide novel means for regulating the frequency of operation of switches arranged for recurrent throw and rethrow, particularly vacuum switches so arranged.

Still another object is to provide an improved structure for a vacuum switch and associated external magnetic system.

Other and allied objects will more fully appear from the following description and the appended claims.

In the description reference is had to the accompanying drawing, of which:

Figure 1 is a view, principally cross-sectional but partly diagrammatic, of a switch assembly according to my invention, in which for example, the switch device is adapted for thermostatic action;

Figure 2 is a view taken cross-sectionally along the line 2—2 of Figure 1, and extended to show additional components of the assembly;

Figure 3 is an elevational view of those additional components;

Figures 4, 5 and 6 are views respectively analogous to Figures 1, 2 and 3, but illustrating a modified switch assembly according to my invention, in which for example the switch device is adapted for relay action;

Figures 7 and 8 are views respectively analogous to Figures 1 and 2, but illustrating a further modified assembly according to my invention, in which for example the switch device is adapted for flasher action; and

Figures 9 and 10 are views respectively analogous to Figures 1 and 3, but illustrating a still further modified assembly according to the invention.

In Figure 1 I have illustrated a simple thermostatic switch according to my invention. In this figure will be seen the bimetallic arm 1 terminally clamped in the conventional insulating stack or assembly 10; beneath the arm 1, and terminally secured to the bottom of the stack 10, is seen a core or pole system comprising pole members 3 and 4 of magnetic material—preferably longitudinally aligned and held, by a bridging plate or member 34 of non-magnetic material secured to each, in terminally spaced relation with the gap 43 therebetween. On the bottom of the bimetallic arm 1, longitudinally above the gap 43, is secured the armature 5 of magnetic material; the armature preferably overhangs both pole members, and the terminal portions of the latter actually so overhung are conveniently designated as poles 3p and 4p. The bimetallic arm 1 is extended for a distance beyond the armature 5, and to its bottom near its extremity is secured a contact 1'. Below this contact is provided a cooperating contact 2'; and while this may be rigidly secured (as to the top of pole member 4) it has in this figure been illustrated as resiliently carried, by a small and light leaf spring 2 which is in turn conveniently terminally secured to the top of pole member 4. Contacts 1' and 2' form a switch 12 which will be closed whenever the armature 5 is in contact with or within a very slight distance of the poles.

The bimetallic arm 1 may respond to increasing temperature by the development of upward bending force tending to raise the armature, and of course by upward movement in compliance with that force when otherwise unrestrained. The poles 3p and 4p, however, are intended to be magnetized, as by passage of a magnetic field serially through portions of the two pole members adjacent the gap 43 in manner and by means hereinafter set forth more in detail; and the effect of this magnetization is to provide a poleward (i. e., as illustrated, a downward) attracting force on the armature.

In a structure such as I have illustrated the rate of increase of this attraction as the armature approaches the poles is very steep; and there will exist some range of armature movement adjacent the poles wherein this rate will be larger than the rate of increase of the restoring force developed in arm 1. This is a range of instability and the armature, once entering it, will fly through it to the poles with increasing acceleration—producing a snap action in the armature movement. The magnitude of this range may be increased by increasing the strength of magnetization of the poles and/or by decreasing the

strength (i. e., force per unit displacement) of the armature support and vice versa. This support being a bimetallic arm or other temperature-responsive member, the change of its temperature usually does not markedly influence its strength as above defined; the predominant effect of temperature change is rather to alter the mean position of the armature from which displacement-generated force is reckoned. Accordingly this temperature change usually does not markedly alter the magnitude of the range of instability.

In a typical adjustment of the structure of Figure 1 the normal pressure of armature 5 against the poles will be the force of the magnetic poleward attraction, either increased or partially reduced by the force of arm 1 according to the adjustment of the latter. (The force of arm 1 may be considered as modified, but in Figure 1 preferably only minutely, by the upward force of spring 2 so long as switch 12 is closed.) As the temperature of arm 1 is in any way raised, however, the arm 1 loses any downward force it may have had, and increases in upward force. Ultimately there will be reached some temperature, depending on the adjustment of the arm and on the strength of magnetic poleward attraction, at which the upward arm force will equal or infinitesimally overpower the poleward armature attraction, so that the net force is zero or infinitesimally away from the poles; and at this temperature the armature will fly upwardly through and beyond the instability range. In this process the armature will desirably have travelled slightly upwardly before the switch 12 opens, as a result for example of the resilience and adjustment of spring 2 so that a material velocity of armature and arm movement at the time of switch opening is readily assured. As the bimetallic arm—now holding the armature above the instability range—cools, it will move the armature downwardly until at some temperature lower than the above-mentioned switch-opening temperature the armature will just enter the instability range; it will forthwith fly down to the illustrated position of contact with the poles, closing the switch 12 while the parts are traveling at very substantial velocity.

The switch-opening and switch-closing temperatures, and hence the mean "operating" temperature between them, may be jointly shifted upwardly or downwardly by a bending adjustment of the bimetallic arm 5, influencing the mean position which it tends to assume at any given temperature. The "spread" or difference between the opening and closing temperatures may be adjusted by alteration of the range of instability, e. g., by altering the strength of the arm or, usually more conveniently in a given structure, by altering the strength of magnetization of the poles. When the temperature spread is adjusted by magnetization strength change, however, there is also a shift of mean operating temperature which if undesired must be counteracted appropriately—as by the arm bending adjustment above-mentioned.

The apparatus so described may be enclosed within an evacuated glass or other sealed envelope 11—by which is meant one which has been substantially evacuated of air, but optionally including when desired a filling of a gas for one or another special purpose known in the art. Through the stem 11a of the envelope may pass lead-in wires 1d and 3d, respectively electrically connected with arm 1 and spring 2 (connection

to the latter being conveniently established through pole members 3 and 4 and the plate 34 therebetween). By way of example the switch of Figure 1 may be considered a thermostat, arranged to keep a circuit (such as a heating circuit) closed at lower temperatures and to open it at higher temperatures. Accordingly I have illustrated a current source 51 connected to a load 52, to the temperature of which the bimetallic arm 1 may be responsive, the connection being made through the switch 12 by means of lead-in wires 1d and 3d.

For magnetizing the poles of the device of Figure 1 I may employ a magnet external to the envelope 11, preferably in a structure having external field localizing means in close association with regions along the envelope as immediately hereinafter described. For cooperating with these means I may provide internally of the envelope two spring rings 19 and 20 of magnetic material such as steel, each for example in the form of a leaf spring bent into shape of the letter C (i. e., an almost closed circle), excepting preferably for a small central flattened portion 19a or 20a. Each of these rings 19 and 20 fits snugly and preferably presses against the interior wall of the envelope 1 (excepting in its flattened portion 19a or 20a). Longitudinally they are positioned on opposite sides of the gap 43; the interior surface of the flattened portion 19a of 19 is secured against the bottom or outer surface of pole member 3, and the interior surface of the flattened portion 20a of 20 is secured against the bottom or outer surface of pole member 4. The rings may thus form a significant mechanical support and centralizing means for the pole members (to which in turn other internal elements are supported through the insulating stack 10); at the same time they form efficient internal means for collecting an external magnetic field and passing it through the portion of the pole member system which includes poles 3p and 4p and gap 43 therebetween. This ring structure internal of the envelope has been disclosed in my co-pending application—Serial No. 108,420, filed October 30, 1936—in connection with certain external electromagnetic structure, and is in itself subcombinationally claimed therein.

An external magnetic structure according to the instant invention for the device of Figure 1 appears more in detail in Figures 2 and 3. It may comprise a pair of mutually spaced clips 21 and 22, of preferably resilient magnetic material such as steel, magnetically connected with the respective extremities of a bar magnet 25, and each at least partially and preferably tightly surrounding the envelope 1 immediately opposite a respective one of the rings 19 and 20. In the structure of Figures 1, 2 and 3 these clips are shown of usual fuse-clip form—i. e., of generally U formation, modified by outward bulges such as 22a immediately on each side of the U—and having their central portions or bases secured to the magnet 25 by screws 23 and 24 of magnetic material. (The magnet and clips may if desired be positioned on opposite sides of a supporting member or plate 26 of non-magnetic material, through which the screws 23 and 24 pass.) The clips form at once a mechanical support for the device (when of the described form permitting the ready mechanical insertion or removal of the device without the use of tools), and at the same time provide efficient field localizing means for cooperation with the internal rings 19 and 20.

A special feature of adjustability is shown in

connection with the external magnetic system. This consists in an adjustable magnetic shunt on the magnet 25, provided by the strip 27 of magnetic material, preferably resilient and outwardly biased, clamped near one end by nuts 28 (preferably of magnetic material) on screw 23 adjacent one magnet extremity, and having its other end slotted (as indicated by 27') and extended to engage another screw along which it may be adjusted toward and away from the other magnet extremity. While a screw of magnetic material may be used as this last mentioned screw, such practice tends to impair the full effect of the shunt, and I have accordingly preferred to employ a screw 29 of non-magnetic material, held for example in plate 26, and carrying one or more nuts 30 for adjustment of the strip 27.

Adjustment of the shunt effectively controls the strength of magnetization of the poles, thereby providing an adjustment external to the envelope of an internal function. This adjustment may be employed as a final manufacturing adjustment to compensate for slight irregularities of various parameters, and /or from time to time deliberately to re-establish operating characteristics of the device—for example, the mean operating temperature of the switch, above discussed.

Figures 4, 5 and 6 illustrate a switch device according to the invention, modified and elaborated in several respects relative to the device above described. In these figures many of the components have been illustrated as similar to those already described—for example the envelope 11; the pole members 3 and 4, bridging plate 34 and collecting rings 19 and 20. The bimetallic arm again carrying the armature 5 and contact 1' has been designated as 1a in view of a different direction of operation; and the insulating stack has been designated as 10a in view of a greater build-up. But now by way of typical changes the bimetallic arm 1 may keep the armature 5 normally out of contact with the poles 3p and 4p and be heat-responsive to move the armature polewardly; a heater winding 8 may be provided about the bimetallic arm so that the device may function as a relay and not merely as a thermostat; the resiliently carried contact 2' of earlier figures may be replaced by a contact 4' secured to the top of pole member 4, to form with contact 1' a switch 14; and additional switches such as 16 and 17 may be provided above the arm 1 and closed when the arm is in an upward position. To form the switch 16 a spring 6, preferably of non-magnetic material such as beryllium copper, may be clamped in the stack 10a and extended to terminate over the extremity of arm 1a; and cooperating contacts 1'' on top of arm 1 and 6' on the bottom of spring 6 may be provided, adjacent the arm and spring extremities. To form the switch 17 a spring 7, also preferably of non-magnetic material, may be clamped in the stack 10a between spring 6 and arm 1 and extended to terminate over the armature 5; and cooperating contacts 1''' on the top of arm 1 above the armature and 7' thereabove on the bottom of the spring 7 may be provided. Springs 6 and 7 may be electrically connected with lead-in wires 6d and 7d, respectively. The heater winding 8 may be connected between a lead-in wire 8d and the spring 7. An external magnetic system similar to that of earlier figures has been illustrated, excepting that the magnet-holding screw 24 of magnetic

material has been replaced by a longer screw 24' of non-magnetic material to serve the function of the separate non-magnetic screw 29 of Figure 3; this causes some effective magnetic gap between clip 22 and the magnet, but this is not objectionable if plate 26 is not unduly thick.

The upward extent of the instability range from the poles and the mean positions of springs 6 and 7 are desirably so adjusted that as armature 5, moving downwardly in response to heating of arm 1a, comes into the instability range the switches 16 and 17 will yet remain closed, opening only while the armature is engaged in its rapid poleward travel across this range. And the contacts 1' and 4' of switch 14 are preferably of such thickness that switch 14 closes before the armature strikes the poles—its continued movement to the poles causing a downward bowing of the bimetallic arm 1a.

The switch device or relay of Figures 4, 5 and 6 has been shown, by way of example, connected to a source 51 so as to be operated by it and in turn to control selectively the connection to the source of two loads 53 and 54. Thus one terminal of the source is connected to one terminal of each of the two loads; the other source terminal is connected (through lead-in wire 1d and arm 1a) to the contacts 1' and 1'' of the alternately closed switches 14 and 16 respectively, while the other contacts (4' and 6') of these respective switches are connected (through lead-in wires 3d and 6d) to the other terminals of the respective loads. The heater winding 8 is connected, through a control switch 50 and lead-in wire 8d on one side and through arm 1a on the other, across the source; but the connection through arm 1a is shown as made through switch 17, and this switch as shunted by an external resistance 55 (between lead-in wires 1a and 6a) the purpose of this arrangement being to reduce the heater current upon poleward armature throw to a value just or only a trifle more than sufficient to maintain the pole-contacting armature position during continued closure of the control switch 50.

The relay so constructed and employed is one which throws at the end of a predetermined time interval after closing of control switch 50 (assuming starting from a given normal temperature), and which re-throws at the end of another predetermined interval after opening of that control switch. A particular function in such a relay of the adjustability of pole magnetization (as by adjustment of the external shunt 27), over and above functions already apparent, is the regulation of the mentioned time intervals. The first of these intervals is decreased by an increase of the magnetization (with consequent decrease of the "throwing" temperature), while the second is increased by an increase of the magnetization (with consequent increase of the temperature spread between "throw" and "re-throw"). An excellent means is therefore provided by the external adjustment for, among other things, establishing such relationship as may be desired between the two time intervals.

In Figures 7 and 8 I show my invention embodied in a "flasher", i. e., in a switch which automatically oscillates between open and closed conditions, to supply current intermittently to a load. In this device will again be seen the envelope 11; the bimetallic arm 1a with heater winding 8, armature 5 and contact 1''; an insulating stack 10b; and the pole members, bridging plate 34,

and collecting rings 19 and 20, the pole member 4 of earlier figures, however, now appearing as 4a, extended upwardly and terminating in the folded over portion 9 above the contact 1' and here supporting a cooperating contact 9' which forms with that contact a switch 19. The heater winding 8 may be connected at one end again to the lead-in wire 3d, but at the other end directly to the bimetallic arm 1a. This arm normally keeps the armature 5 out of contact with the poles and is heat-responsive to move the armature polewardly, as in Figure 4. The arm may be bent adjacent stack 10b so that at normal temperatures it tends to be directed upwardly away from stack 10, but in view of the movement limitation of its extremity by contact 9' it will be forced to bow upwardly in its intermediate portion.

While the external structure of earlier figures may be employed, I have shown in Figures 7 and 8 a slightly modified such structure which is hereinafter more detailedly described. For a typical circuit a main control switch 50 and the heater winding 8 and switch 19 may be serially connected across a current source 51, and a load 52 and the switch 19 also serially connected across that source.

Assuming switch 50 closed, the arm 1a will be heated and will tend to bend its extremity and the armature downwardly; this progressively overcomes the initial upward force on the armature, which may become subject to the action of the instability range without having executed any appreciable movement from its initial position. Then, of course, it will execute rapid movement to the poles, opening switch 19. Switch 19 being open, the arm 1a will cool; and when its temperature has fallen by the temperature "spread" for which the system is adjusted, the armature will fly upwardly, closing switch 19, and coming to rest with a net upward force. The arm heating begins again, and when its temperature has risen by the same "spread" the armature will again fly downwardly across the instability range and the cycle is repeated; and so on.

The load, like the heater winding, is in series with switch 19, and so receives current at the same intervals as that winding. The length of the whole cycle is immediately influenced by the temperature spread, which was above noted to be responsive to strength of pole magnetization; accordingly adjustment of the external magnetic shunt affords excellent control of the flashing frequency. (Adjustment to weaker pole magnetizations, which reduces the temperature spread and thus increases flashing frequency, should be limited to keep an instability range extensive enough always to embrace the armature.) In flashing use, unlike the usual case of the use illustrated in Figure 2, the bimetallic arm after initial heating is not further permitted to return to ambient temperature, but for throw and rethrow depends upon opposite temperature changes which are equal in absolute value; accordingly the relation between "on" and "off" periods is determined almost entirely by the relative heating and cooling rates of the arm, and is not materially altered by the shift of mean operating temperature inherently accompanying magnetization change.

In Figures 7 and 8 I have shown a slightly modified external magnetic structure. The fuse-type clips 21 and 22 have been replaced by clips 31 and 32, each of magnetic material and generally in the form of the letter J, but with the curving portion 31a or 32a of each continued to form

an almost-closed circle surrounding the envelope. The straight extremity of each clip may be clamped against a respective extremity of the magnet, for example between the magnet and a base 26' of non-magnetic material. This clamping may be performed by two screws such as 24'', both if desired of non-magnetic material, on the upwardly extending portions of which may be provided the adjustable magnetic shunt 27 of earlier figures.

I also show in Figures 7 and 8 means for simultaneously improving both the mechanical support of the envelope by the clips and the close spacing of the external field localizing means to the internal collecting rings 19 and 20. This means comprises lining members 37 and 38 for the respective clips, of relatively thin magnetic material, preferably especially resilient and tending to collapse into a circle smaller than the envelope cross section. Each lining member therefore tends to make excellent contact with the envelope; at the same time the high reluctance which would characterize long serial paths through it is substantially obviated by its close backing at all points with the main clip.

The devices of Figures 4 and 7 may obviously be employed as thermostats, switch 50 being maintained open.

In any of the three switch devices above described the bimetallic arm may be maintained at approximately constant temperature (in Figures 4 and 7, by keeping switch 50 open) and adjusted so that with stronger pole magnetizations armature 5 is in contact with the poles (as in Figure 1) the arm thus functioning as a simple spring. Now the adjustment of shunt 27 to reduce the pole magnetization may be made to release the armature from the poles, so that it flies upwardly through the instability range and thus throws the device. And of course for such use the bimetallic arm may be replaced by a simple spring as has been indicated by the spring 1s in the device of Figure 9, which may for example be otherwise similar to the showing of Figure 1. Figure 10, completing the illustration of the modified device, shows a knob 35 for conveniently moving the shunt, and a latch 36 for engaging the shunt in strongly shunting position.

In Figure 10, by way of illustration of further possibilities, the shunt has been shown as being itself a bimetallic arm 27'' of which at least one of the two elements (preferably the upper) is of magnetic material. The normal or solidly illustrated position of shunt 27'' may be its position for one temperature, change of temperature in a predetermined direction raising the shunt toward the magnet and serving to throw the switching device internal of the envelope. Thus there is provided a vacuum switch operated by an external thermally responsive element.

It is to be understood that the broader aspects of my invention are not limited to particular switch uses, or to specific contact and/or contact-supporting arrangements or other details, those which have been shown being typical rather than comprehensive. Likewise it will be understood that the proportions, dimensions, spacings and the like which have been illustrated are not intended in any way as limitative, many of them having been somewhat exaggerated over the possibly most typical ones in the interest of clear illustration. In the appended claims it is my intention to claim my invention, including its various novel combinations, sub-combinations

and elements, as broadly as the state of the art will permit.

I claim:

1. In a switch assembly including a sealed envelope, a switching device therewithin, and means for throwing said device: means within said envelope adapted upon magnetization to impart snap action to said throwing, and a magnetic system outside of said envelope for continuously magnetizing said means.
2. In a switch assembly including a sealed envelope, a member movable therewithin, and means for producing movement of said member: means within said envelope adapted upon magnetization to render unstable the movement of said member within at least a portion of its movement range, and a permanent magnetic system outside of said envelope for magnetizing said last mentioned means.
3. In a switching assembly including a sealed envelope and therewithin a switching device: means comprising a thermally responsive member within said envelope, for throwing said device; and continuously magnetized means, including a magnet outside of said envelope, for imparting snap action to said throwing.
4. In a switch assembly including a sealed envelope, a switching device therewithin, and means for throwing said device: means for imparting snap action to said throwing, and adjustable means outside of said envelope for regulating said snap action.
5. In a switch assembly including a sealed envelope, a member movable therewithin, and means for producing movement of said member: means for rendering unstable the movement of said member within a range coinciding with at least a portion of its total movement range, and adjustable means outside of said envelope for varying said range of instability.
6. In a switch assembly including a sealed envelope and a switching device therewithin: means, comprising a thermally responsive member within said envelope, for operating said device; and adjustable means outside of said envelope for varying the thermal response of said member.
7. In a switch assembly including a sealed envelope and a switching device therewithin: means, comprising a thermally responsive member within said envelope, for throwing said device in opposite directions at two respective temperatures; and adjustable means, outside of said envelope and free of direct mechanical connection with said member, influencing said operating means to vary the mean between said temperatures.
8. In a switch assembly including a sealed envelope and a switching device therewithin: means, comprising a thermally responsive member within said envelope, for throwing said device in opposite directions at two respective temperatures; and adjustable means, outside of said envelope and free of direct mechanical connection with said member, for influencing said operating means to vary the difference between said temperatures.
9. In a switch assembly including a sealed envelope and a switching device therewithin: operating means within said envelope energizable to continuously oscillatorily throw said device in recurrent cycles; means for energizing said operating means; and adjustable means outside of

said envelope for influencing said operating means to vary the duration of each said cycle.

10. In a switch assembly including a switching device: operating means energizable to continuously oscillatorily throw said device in recurrent cycles; means for energizing said operating means; and adjustable magnetic means for influencing said operating means to vary the duration of each said cycle.

11. In a switch assembly including a sealed envelope, a switching device therewithin; and control means for said device movable selectively to two positions: operating means, responsive with a delay to movement of said control means to a first position, for throwing said device, and responsive with a delay to movement of said control means to a second position, for rethrowing said device; and adjustable magnetic means outside of said device for influencing said operating means to vary the relative periods of said two delays.

12. In a switch assembly including a magnetically responsive switching device: means for throwing said device comprising a device-influencing magnet and thermally responsive magnetic shunt means for altering the influence of said magnet on said device.

13. In a switch assembly including a sealed envelope and a magnetically responsive switching device therewithin: means for throwing said device comprising a device-influencing magnet and thermally responsive magnetic shunt means outside of said envelope for altering the influence of said magnet on said device.

14. In a switch assembly including a sealed envelope and a magnetically responsive switching device therewithin: a device-influencing magnet; and movable means, outside of said envelope and shunting said magnet, for throwing said device.

15. In a switch assembly including a sealed envelope and therein a magnetic circuit: a source of magnetic field outside of said envelope, and resilient envelope-supporting clips magnetically linking said source with said internal magnetic circuit.

16. In a switch assembly including a sealed envelope and therein a magnetic circuit: a source of magnetic field outside of said envelope, and substantially V-shaped clips magnetically connected with said source, said envelope being insertable in said clips for simultaneous support of said envelope and energization of said magnetic circuit.

17. In a switch assembly including a sealed envelope and therein a magnetic circuit: mutually spaced internal field collectors respectively forming terminals of said internal magnetic circuit and positioned adjacent the interior wall of said envelope; a source of magnetic field outside of said envelope; and clips magnetically connected with said source and clampingly engaging said envelope opposite said internal collectors respectively.

18. In a switch assembly including a sealed envelope, a magnetic circuit therewithin, and an external magnetic system: envelope-surrounding means magnetically linking said internal circuit and external system, and thin resilient lining means of magnetic material for said envelope-surrounding means.

HERBERT O. WILSON.

CERTIFICATE OF CORRECTION.

Patent No. 2,180,701.

November 21, 1939.

HERBERT O. WILSON.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, line 11, for the word "after" read alter; page 5, first column, line 54, claim 7, before "influencing" insert for; and second column, line 49, claim 16, for "V-shaped" read U-shaped; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 23rd day of January, A. D. 1940.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

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