May 7, 1957 W. F. DEHN ET AL 2,791,656

CONTACT ACTUATING QUICK ACTION SWITCH

Filed June 29, 1953

2 Sheets-Sheet 1

Fig. 1.

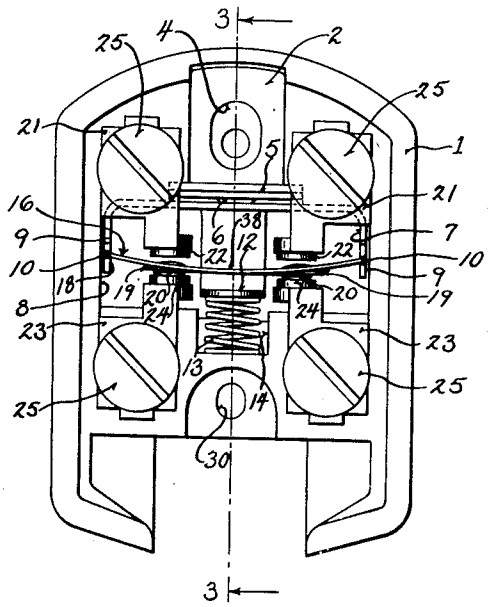


Fig. 3.

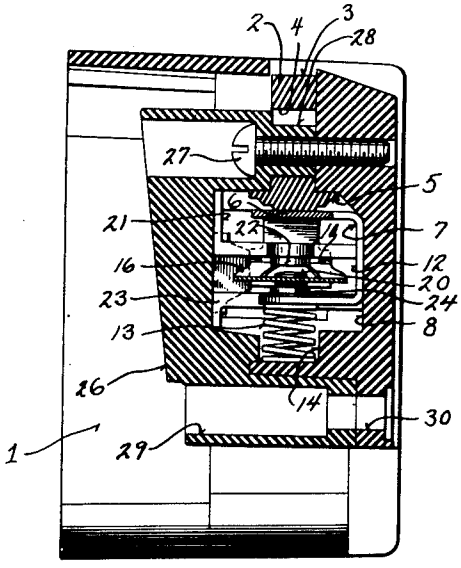


Fig. 2.

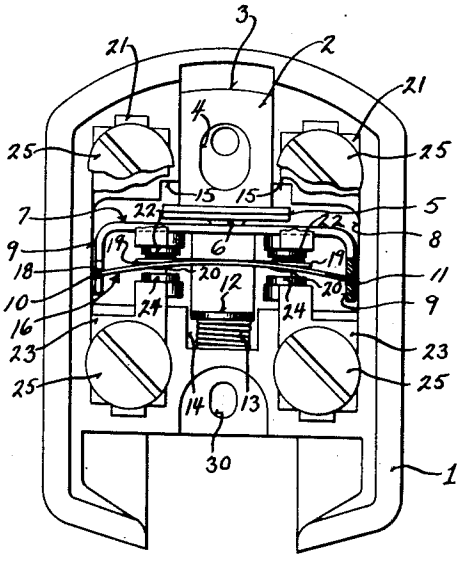
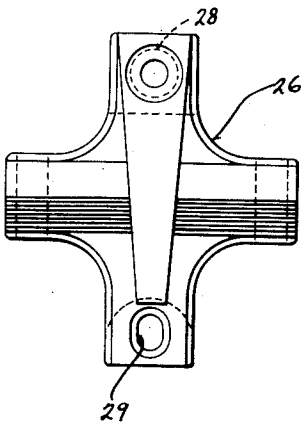


Fig. 4.



INVENTORS
William F. Dehn
Roy E. Wilson
BY
Arthur H. Seidel
ATTORNEY

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2 Sheets-Sheet 2

Fig. 5.

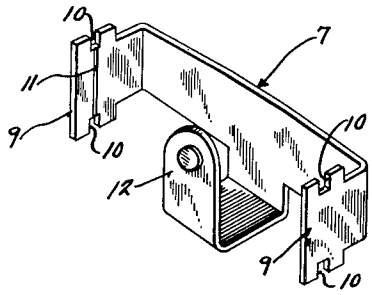


Fig. 6.

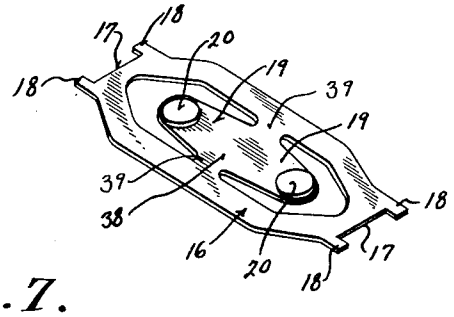


Fig. 7.

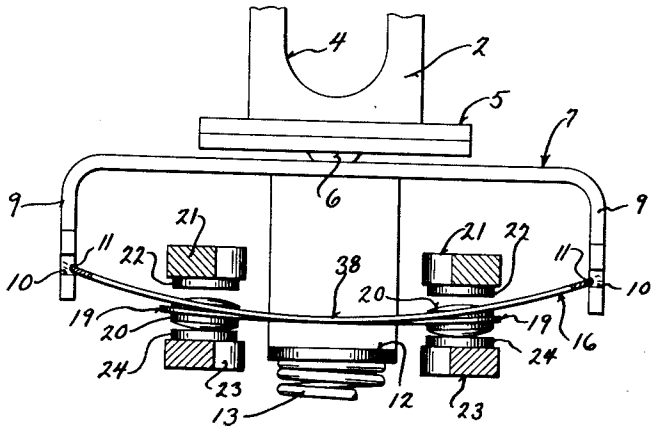


Fig. 8.

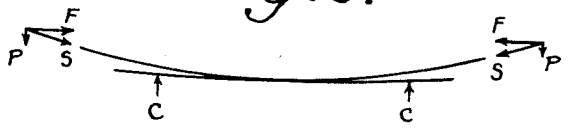


Fig. 10.

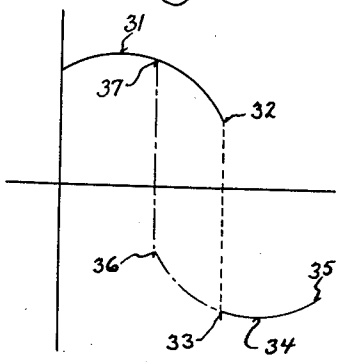


Fig. 9.



INVENTORS
William F. Dehn
Roy E. Wilson
BY Arthur H. Seidel
ATTORNEY

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CONTACT ACTUATING QUICK ACTION SWITCH

William F. Dehn, Wauwatosa, and Roy E. Wilson, Milwaukee, Wis., assignors to Allen-Bradley Company, Milwaukee, Wis., a corporation of Wisconsin

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13 Claims. (Cl. 200—67)

This invention relates to snap action electrical switches having substantial contact force for all stable positions and suitable for use with slowly advancing actuators, and it more specifically resides in a switch having a toggle carrier with a pair of spaced supports resiliently inwardly acting through a range of limited deflection, between which is inserted and held thereby under compression a resilient thin flat easily buckled column normally bowed by such compression to act as an equivalent toggle, the invention in one form including a resilient blade integral with the column having a deflectable end that is pressed against a reaction abutment as the carrier is moved in the direction of the bow of the column for storage of spring energy, which energy causes a snap over of the toggle column to an inverted position to occur before the straightened dead center position of the column is reached, the snap over throwing the blade into engagement with an opposite abutment.

In many snap action toggle operated switches contact force is dependent upon the toggle occupying a position a substantial distance away from dead center. When contact throw does not occur until the toggle system has passed or is nearly aligned in a straightened central position contact forces will diminish to small value, or vanish altogether. Detrimental heating and welding of the contacts may then occur if the switch is permitted to hover near the snap over position of the toggle. Consequently, such switches are not satisfactory for use with slowly or incrementally advancing actuators.

To retain sufficient contact force some switches have been employed in which members of the toggle itself have been utilized to provide a storage of energy that causes snap over of the toggle well in advance of the aligned position. Thus, transverse components of contact engagement force will remain adequate up to the point of contact throw. A compression spring or its equivalent is commonly provided in such form as to furnish one toggle arm and a resilient transversely deflectable member constituting the other arm is acted upon by the actuator to cause it to oppose the spring while storing energy to cause snap over to occur in advance of dead center.

The switch of this invention avoids vanishing contact force but the toggle members themselves are not deflectable to store throwing energy. In one form of the invention both arms of the toggle take the form of a single resilient leaf, rather than a multiplicity of parts, which leaf is normally bowed in response to endwise loading, and is passed through a central aligned position with a snap action to cause contact throw. Storage of energy to initiate snap over well in advance of the aligned dead center position is provided for in a resilient blade extending from and integral with the leaf but not functioning as a part of the toggle; the extending blade being deflectable to store energy at the output of the toggle rather than at the input.

It is an object of this invention to provide a snap action switch having substantial contact force for all stable positions of the switch elements.

It is another object of this invention to provide a toggle actuated snap action switch suitable for use with slowly advancing actuators in which snap over of the toggle is initiated before an aligned dead center of the toggle is assumed.

It is another object of this invention to provide a snap action switch in which the response to actuating forces will be uniform over an extended period of use.

It is another object of this invention to provide a snap action switch having a single element toggle adapted for ease of assembly and efficient manufacture.

It is still another object of this invention to provide a snap action switch in which contact rebound occurring upon throw of the movable contact into contact closed position is dampened to promote contact life.

These and other objects and advantages of this invention will appear in the description to follow. In the description reference is made to the accompanying drawings which form a part hereof, and in which there is shown by way of illustration, and not of limitation, a specific form in which this invention may be embodied.

In the drawings:

Fig. 1 is a front view in elevation with the cover removed of a switch embodying this invention,

Fig. 2 is a front view in elevation with parts broken away and in section of the switch in Fig. 1 showing the contacts in an alternate position,

Fig. 3 is a view in elevation and in cross section of the switch with the cover in place viewed through the plane 3—3 designated in Fig. 1,

Fig. 4 is a front view in elevation of the cover for the switch,

Fig. 5 is a view in perspective of the movable contact carrier employed in the switch,

Fig. 6 is a view in perspective of the resilient toggle leaf member employed in the switch,

Fig. 7 is a fragmentary front view in elevation showing a number of parts of the switch,

Fig. 8 is a vector diagram showing forces that act upon the resilient toggle leaf,

Fig. 9 is a vector diagram showing forces that act upon the resilient toggle leaf for another position of the switch elements, and

Fig. 10 is a graphical representation of contact pressure with displacement of the movable contact carrier.

Referring now to the drawings, there is shown a molded housing 1 formed of a suitable insulating material with an interior configuration adapted to receive the elements of the switch and to guide the movement of the actuating members. A vertically movable plunger 2 is received within the upper central portion of the housing 1 and is closely surrounded at its sides and back. The plunger 2 is provided with an upper face 3, exposed for engagement by an external actuator, not shown, and also with an elongated central opening 4 to receive fastening means, as hereinafter described. The lower end of the plunger 2 is formed with a horizontal rectangular flange 5 and protruding from the underside of the flange 5 is a thrust imparting button 6.

The button 6 rests upon a resilient toggle carrier 7 disposed within a central cavity 8 in the housing 1. As is shown more clearly in Fig. 5 the carrier 7 is a bracket with a depending supporting abutment 9 at each end. Each abutment 9 is notched as at 10 on opposite sides and extending between the notches 10 and across the inner faces of the abutments 9 is a transverse groove 11 terminating at the notches 10. A spring seat 12 extends downwardly from the back of the midsection of the carrier 7 to retain the upper end of a biasing spring

13 held in place within a recess 14 in the housing 1. The carrier 7 is urged upwardly by the action of the spring 13 into the position shown in Fig. 1. Upward travel of the carrier 7, in response to the bias of the spring 13, is limited by stops 15 that form a part of the housing 1 and which engage the rectangular flange 5 of the plunger 2.

Inserted between the abutments 9 of the contact carrier 7 is a thin resilient leaf 16 having the configuration more clearly shown in Fig. 6. The leaf 16 is of a length slightly greater than the distance between the valleys of the grooves 11 in the abutments 9 when the carrier 7 is unstressed. An edge 17 at each end of the leaf 16 is received within a groove 11 in the carrier 7 and a pair of ears 18 flanking the edges 17 are received within the respective notches 10 in the support abutments 9. Upon inserting the leaf 16, the abutments 9 are deflected slightly outwardly and the resilient leaf 16 is placed under compression as a hinged end column stressed beyond the point where bending occurs and assumes a bowed configuration as shown in Figs. 1, 2 and 7. The leaf 16 is equivalent to a toggle with a knee 38 at the center of bending. The extent of the toggle bow will depend upon the dimensions and spring rates of both the resilient carrier 9 and the leaf 16. Portions of the leaf 16 are cut away to form a pair of movable contact blades 19 that merge with the knee portion 38 and the knee 38 includes a pair of narrow necks 39 connecting the blades 19 with the remaining portions of the leaf 16. Thus, the blades 19 form a unitary whole with the leaf 16 and each is deflectable at its free end which mounts a movable contact 20.

A pair of upper stationary contact terminals 21 are mounted in the housing 1 on either side of the plunger 2. Each contact terminal 21 supports a stationary contact 22 disposed above one of the movable contacts 20. A pair of lower stationary contact terminals 23 are likewise mounted in the housing 1 and are disposed on either side of the spring cavity 14. Each lower contact terminal 23 mounts a stationary contact 24 disposed beneath one of the movable contacts 20. Terminal screws 25 are received by each contact terminal 21, 23 for convenient connection with electrical conductors.

To retain the plunger 2 and the spring 13 in position, as well as the carrier 7, a four armed cover 26, shown in Figs. 3 and 4, is secured by means of a screw 27 to the housing 1. The cover 26 has a boss 28 that extends within the elongated opening 4 of the plunger 2 and the screw 27 passes through the boss 28 into the housing 1. To provide for mounting the complete switch assembly an opening 29 at the bottom of the cover 26 is aligned with an opening 30 in the housing 1 to receive a suitable mounting screw, not shown.

Referring now more specifically to Fig. 7, there is shown therein the plunger 2 and carrier 7 in upper position to which they are urged by the spring 13. In this position the leaf 16 is bowed downwardly and the movable contacts 20 press upon the lower stationary contacts 24 with the contact blades 19 deflected to provide contact force. In Fig. 8 there is shown a vector diagram of the forces acting upon the leaf 16 for this position of the switch. The support abutments 9 of the resilient carrier 7 are deflected slightly outward and exert an inwardly directed force F at each end of the leaf 16. Leaf 16 consequently is placed under endwise compression and reacts as a column member. Lateral deflection forming the bow of the leaf 16 is restricted by reason of the contacts 20 bearing against the fixed contacts 24. The force at each contact 20 is represented in Fig. 8 by the force C and the deflected blades 19 react with opposite and equal downward forces. The blades 19 in turn each exert an upwardly acting force, corresponding to contact forces C, upon the knee 38 of the toggle leaf 16. For all stable switch positions the leaf 16 exerts at the knee 38 an equal and opposite downward force component resisting the

blades 19, and the deflection of the blades 19 represents an accumulation of storage of spring energy. Forces P acting downwardly at each end of the leaf 16 are a reaction external of the leaf 16 that balance the contact forces C for stable toggle positions. The bow of the leaf 16 is thus materially lessened by the lateral forces C and P from that which would occur if an endwise force F acted alone upon the toggle. The resultant force acting upon each end of the leaf 16 is represented by the force S, which is the vector addition of forces F and P.

An initial downward input thrust applied to the plunger 2 causes a downward excursion for the ends of the leaf 16. Reaction to the input thrust arises at the point of touch between the stationary contacts 24 and the contacts 20 of the blades 19, and corresponds to the forces C. Input to the toggle system is thus transmitted through the plunger 2 to the carrier 7 and hence through the toggle leaf 16 to the blades 19, at the toggle output. The reaction straightens the leaf 16 and the spread of the support abutments 9 of the carrier 7 is increased with a corresponding increase in the end forces F. The forces P and C will vary in value, but oppose one another with such values as to retain stability of the toggle leaf 16.

With continued downward travel of the carrier 7, attendant with further straightening of the leaf 16, a position will be reached at which the forces P will decrease in value at a rate greater than that of the forces C. This effects an instability for the toggle leaf 16 well in advance of a fully straightened dead center alignment. A position just preceding instability is represented in Fig. 9, and with further movement of the carrier 7 the forces C will cause the blades 19 to exert bending moments upon the leaf 16 that are no longer balanced. Snap over of the leaf 16 will commence and stored energy in the blades 19 will be released ensuring travel of the leaf 16 through aligned dead center to the inverted position shown in Fig. 2. Toggle snap over will throw the movable contact blades 19 to bring the movable contacts 20 into engagement with the upper stationary contacts 22, also as is shown in Fig. 2.

As the leaf 16 is straightened by continued travel of the carrier 7 the energy storage in the blades 19 remains substantial and contact force does not vanish or decrease to values readily permissive of contact damage from heating or welding. Upon a release of the downward input thrust acting upon the plunger 2, the carrier 7 will be returned to its upper position by the action of the spring 13. The apparatus will again assume the position shown in Figs. 1 and 7 with occurrence of a snap over of the leaf 16 and a throw of its blades 19 similarly as described for a downward excusion of the carrier 7.

Referring now to Fig. 10, there is shown a graph with the abscissa representing displacement of the carrier 7 and the ordinate representing contact force, for a particular switch embodying the invention. The position of the carrier 7, shown in Figs. 1 and 7 corresponds to a displacement of zero and for the position of the carrier 7 shown in Fig. 2 displacement is a maximum. As the carrier 7 is moved downwardly in response to input thrust contact force follows the curve 31. The value initially increases and then decreases until the position of instability, at a displacement represented by the point 32, is reached. Upon toggle snap over contact force with the upper contacts 22 is set up, as represented by the point 33. Continued downward displacement of the carrier 7 will trace out the lower curve 34 to the point 35. For upward travel of the carrier 7 the curve 34 is retraced to the point 36, at which throw occurs, and a contact force designated at 37 is then set up with the lower contacts 24.

In a measurement of contact force of a switch embodying this invention the total force on the contacts was found to be approximately .25 lb. just before the position of instability was reached and the maximum contact force was approximately .5 lb. This switch had a maximum

displacement for the carrier of approximately .07 inch and the point **32** corresponded to a displacement of approximately .045 inch and the point **36** to a displacement of approximately .026 inch. The carrier of the switch had a dimension of approximately 1.012 inches between the valleys of the grooves **11** in the inner faces of the support abutments **9** when not stressed, and the spring rate of the carrier was 715 lbs. per inch. The toggle leaf **16** for the switch had a length between the edges **17** of approximately 1.022 inches and was formed from a beryllium copper alloy with a thickness of approximately .008 inch. An endwise compression loading of approximately 2.55 lbs. was required to cause an initial bow in the leaf **16**.

Upon the contacts **20** at the deflectable ends of the blades **19** being moved into engagement with either set of stationary contacts the forces C at the contacts will be substantially equal to one another. The blades **19** are joined to the major body portions of the leaf **16** through the narrow necks **39** that form a part of the knee **38**. This narrow connection allows the blades **19** to act as a unit that has a limited freedom of turning movement with respect to the leaf **16** to permit equal distribution of the forces at the contacts. Thus adequate contact force between each set of contacts is ensured to promote contact life.

It has been found that contact rebound is effectively dampened in the employment of a switch embodying the invention. Hence the chance of destructive arcing that may cause detrimental burning and pitting of the contacts is further lessened. The invention therefore provides a switch with precision response and long contact life in which the toggle and energy storing member comprise but a single flat leaf. The use of a unitary toggle leaf is made possible by an energy storage, for causing snap over in advance of dead center, that takes place in a resilient element not forming a part of either toggle arm and which is disposed at the toggle output. In this manner the energy storage affords a reaction to the input thrust imparted to the toggle to give rise to bending moments at the toggle knee inducing snap over. The reaction of the stored energy member exceeds the oppositely directed toggle force upon a partial straightening of the toggle. Snap over, accomplished by contact throw, then occurs before contact force falls to insufficient value.

We claim:

1. In a snap action switch the combination comprising a toggle carrier of resilient material having spaced mounting ends disposed in facing relation and being reciprocably movable through a stroke normal to a line extending between said ends, a resilient leaf spring inserted between and spreading said mounting ends of said contact carrier to retain said leaf spring under endwise compression normally bowing said leaf spring with a knee in the bow medial its ends, a pair of resilient movable contact blades each joined at one end to the knee of said leaf spring and extending on opposite sides of said knee with a free end of each deflectable to exert a spring force upon said leaf spring at the knee in opposition to the bow thereof, contact blade arresting means disposed on each side of the deflectable end of each contact blade to provide reaction members against which the free ends of said contact blades may be pressed, guide means confining the stroke of said carrier to a path substantially normal to the bow of said leaf spring, and actuating means cooperatively engaged with said carrier for causing reciprocal movement in the stroke whereby movement presses said blades against arresting means to one side thereof causing a deflection of said blades accompanied by an energy storage in opposition to the bow of said leaf spring that decreases the bow of said leaf spring and initiates snap over of the leaf spring into an inverted bowed position.

2. In a snap action switch the combination comprising a pair of spaced reaction abutments, a toggle relatively displaceable in the direction of spacing between said

reaction abutments held under endwise compression at its ends to be normally bowed with a toggle knee and deflectable into an inverted bowed position, and a lengthwise resilient leaf spring member pressed at one end against one of said abutments and acting at the opposite end upon said toggle at the position of the knee in opposition to said bow of the toggle, relative displacement of the ends of said toggle with respect to said reaction abutments urging said toggle against said spring member to cause a storage of energy within said spring member and a decrease in the bow of said toggle whereby decrease in the bow permits the storage of energy in said spring member to initiate snap over of said toggle into the inverted bowed position wherein said spring member is moved toward and into engagement with the opposite abutment.

3. In a snap action switch the combination comprising a leaf spring held under endwise compression to be normally bowed and deflectable into an inverted bowed position, a set of two pair of reaction abutments with the abutments of each pair being spaced from one another in the direction of bow of said leaf spring and relatively displaceable with respect to said leaf spring, and a spring blade connected at its center portion with said leaf spring at the center of said bow with deflectable ends extending therefrom each disposed between a pair of said reaction abutments and pressed against one of said abutments to apply a force upon said leaf spring in opposition to said bow, whereby a relative displacement of said leaf spring with respect to the abutments against which the deflectable ends of said spring blade are pressed deflects said leaf spring and said spring blade in opposition to one another to provide a storage of energy within said spring blade and a decrease in the bow of said leaf spring wherein decrease in the bow permits the energy storage in said spring blade to initiate snap over of said leaf spring into the inverted bowed position.

4. In a snap action switch the combination comprising a toggle carrier having spaced supports resiliently joined to permit limited increased separation, a resilient column inserted between said supports held under endwise compression to be normally bowed to form a toggle with a knee and deflectable into an inverted bowed position, two pair of fixed reaction abutments with the abutments of a pair spaced in the direction of said bow, and a pair of spring members each having one end disposed between abutments of a pair that is pressed against an abutment and each member acting at the opposite end upon the knee of said column in opposition to said bow, whereby displacement of said toggle carrier moving said column against said spring members provides for a storage of energy within said spring members and a decrease in the bow of said column wherein decrease in the bow permits the energy stored in said spring members to initiate snap over of said column into the inverted bowed position.

5. In a snap action switch the combination of a toggle having a knee portion and two arms extending therefrom terminating in a pair of toggle ends forming a toggle input, a carrier cooperatively engaged with the ends of said toggle applying endwise compression thereto bowing said toggle to assume a position to one side of the aligned dead center, two pair of reaction abutments with the abutments of a pair spaced from one another in the direction of toggle bow, and a pair of resilient means each interposed between a pair of said reaction abutments and said knee portion of said toggle to define a toggle output, whereby an input thrust applied through said carrier to the toggle input urging said toggle output against said resilient means stores energy within said resilient means and decreases the bow of said toggle to initiate snap over of said toggle to an inverted position before said toggle is straightened to dead center.

6. In a snap switch the combination comprising a toggle carrier including a pair of separated mounting supports

resiliently connected to one another for a range of limited increased separation, a resilient column member inserted between the mounting supports of said carrier expanding said supports from one another and retained under endwise compression to be normally bowed, a pair of resilient blades having inside ends connected to one another joined at the connection of said inside ends to said column member for limited turning movement with respect to said column member and each blade having an outside deflectable end extending from the connection between the blades, and two pair of reaction abutments with the abutments of a pair disposed on each side of a deflectable end of one of said blades limiting the throw of the blades and providing reaction points against which said blades may be pressed, movement of said carrier in the direction of bow of said column pressing said blades against two of said abutments for decreasing the bow of said column and for deflecting said blades with respect to said column to cause said blades to throw said column through its straightened position to a bowed position opposite that of the initial bow.

7. In a snap action switch the combination comprising a toggle carrier movable through a stroke, said carrier having a central bridging portion extending transversely of the direction of motion of the carrier and turning at its ends to form a pair of facing supports, an actuator bearing upon the bridging portion of said toggle carrier to impart motion thereto through an engagement permitting limited tilt of said carrier with respect thereto, a resilient leaf spring inserted between the facing supports of said carrier retained thereby under endwise compression normally bowing said leaf spring in either of two inverted positions of bow, a pair of resilient blades having inside ends connected to one another joined at the connection of said inside ends to the center of the bow of said leaf spring and having outside deflectable ends for deflection in a direction to either side of said leaf spring, and a set of reaction abutments disposed with an abutment to each side of the outside deflectable ends of said blades, movement of said carrier in the direction of bow of said leaf spring pressing said blades against a pair of said abutments for decreasing the bow of said leaf spring and for deflecting said blades to cause said blades to throw said spring to a bowed position opposite that of the initial bow.

8. A switch in accordance with claim 7 in which said actuator bears upon a medial portion between the turned ends of said toggle carrier, from which bearing portion said carrier extends in opposite directions toward its ends free of contact with said actuator to permit tilting movement with respect thereto.

9. A switch in accordance with claim 7 in which said toggle carrier is a spring member with said facing supports resiliently joined to permit increased separation thereof as said leaf spring is straightened in movement from one position of bow to an inverted position of bow.

10. A switch in accordance with claim 7 in which there is provided guide means confining the movement of said toggle carrier to a path substantially normal to the bow of said leaf spring.

11. In a snap action switch the combination comprising a toggle carrier movable through a stroke, said carrier having a central bridging portion extending transversely of the direction of motion of the carrier and turning at its ends to form a pair of facing supports, an actuator bearing upon the bridging portion of said toggle carrier at a point medial its ends to permit a limited tilt of said carrier with respect thereto, said actuator being movable against said carrier to move the same through its stroke, a leaf spring inserted between the facing supports of said carrier retained thereby under endwise compression normally bowing said leaf spring, a pair of resilient blades having inside ends connected to one another joined at the connection of the inside ends to the center of said leaf spring and having outer deflectable ends extending in opposite directions from the center of said leaf spring in the plane of tilt of said carrier, and a pair of reaction abutments each disposed in engagement with an outer end of one of said resilient blades at points substantially equidistant from a line passing through the bearing engagement of said actuator with said carrier in a direction of said stroke, movement of said carrier by said actuator pressing said blades against said abutments for decreasing the bow of said leaf spring and for deflecting said blades to cause said blades to throw said spring to a bowed position opposite that of the initial bow.

12. In a switch in accordance with claim 11 in which there is a bias spring acting upon said carrier urging the carrier against said actuator, said bias spring acting in a direction substantially parallel to the stroke of said carrier with a point of application substantially aligned with the engagement of said actuator and carrier.

13. In a snap action switch the combination comprising a toggle carrier movable through a stroke, said carrier having a central bridging portion extending transversely of the direction of motion of the carrier and turning at its ends to form a pair of facing supports, an actuator bearing upon the bridging portion of said toggle carrier to impart motion thereto through an engagement permitting limited tilt of said carrier with respect thereto, a bias spring acting against said toggle carrier to urge the same toward said actuator to retain the bearing relation of said actuator and toggle carrier, a resilient leaf spring inserted between the facing supports of said carrier retained thereby under endwise compression normally bowing said leaf spring in either of two inverted positions of bow, a pair of resilient blades having inside ends connected to one another joined at the connection of said inside ends to said leaf spring and having outside deflectable ends for deflection in a direction to either side of said leaf spring, and a set of reaction abutments disposed with an abutment to each side of the outside deflectable ends of said blades, movement of said carrier in the direction of bow of said leaf spring pressing said blades against a pair of said abutments for decreasing the bow of said leaf spring and for deflecting said blades to cause said blades to throw said spring to a bowed position opposite that of the initial bow.

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