Jan. 23, 1962 W. H. MITCHELL 3,018,353

CURRENT CARRYING SPRING MEMBER

Filed Jan. 19, 1959 2 Sheets-Sheet 1

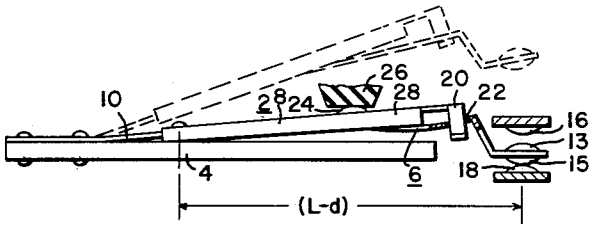



Fig. 1

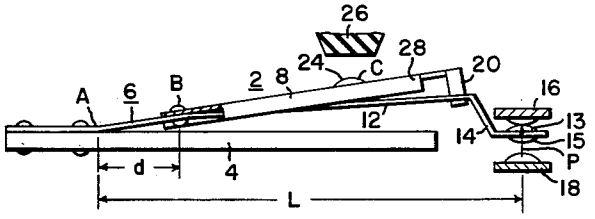



Fig. 2

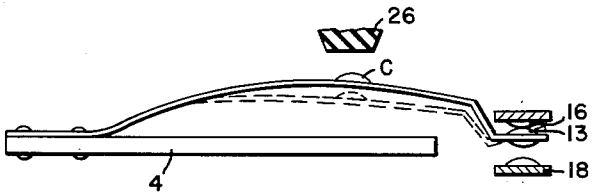



Fig. 3

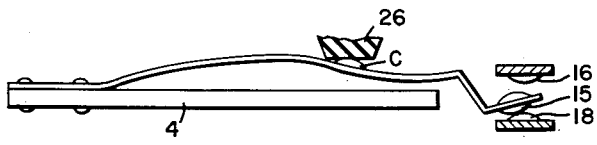



Fig. 4

WITNESSES

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CURRENT CARRYING SPRING MEMBER

Filed Jan. 19, 1959 2 Sheets-Sheet 2

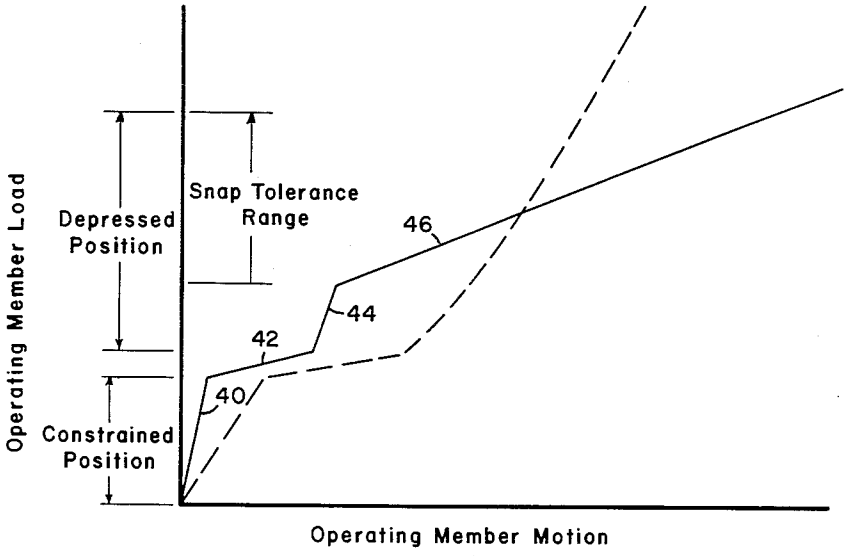



Fig. 5

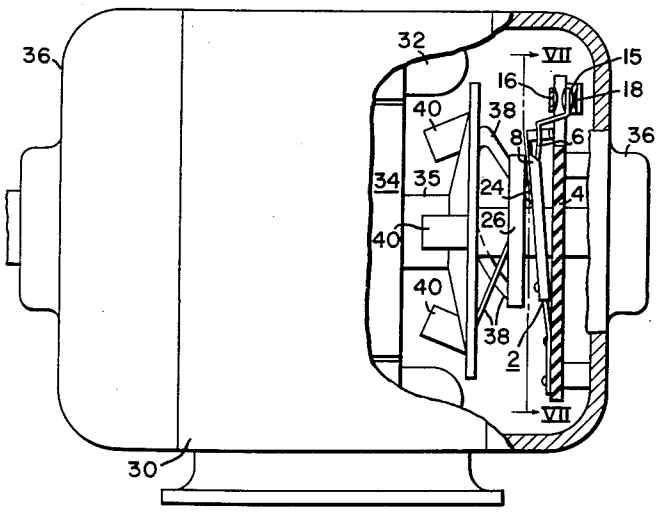



Fig. 6

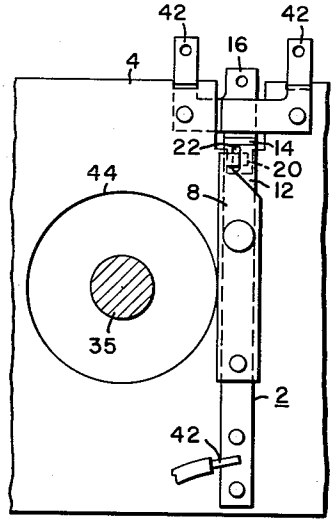



Fig. 7

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3,018,353

# CURRENT CARRYING SPRING MEMBER

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6 Claims. (Cl. 200—166)

The present invention relates generally to current carrying spring members, and more particularly to a bi-cantilever spring blade for use in switching devices.

Switching devices quite often employ a current carrying spring blade which is resiliently urged or biased in its position to make electrical connection with an appropriately positioned contact button. The spring blade is moved from its biased position into electrical engagement with another contact button by an operating member controlled by means external to the switching device. The operating member is usually a snap-acting member in which transfer occurs during the snap action of the operating member. The external means provides a control force acting upon the operating member which will result in a snap action when the control force exceeds the inherent constant force of the operating member opposing the snap action plus the biasing force of the spring blade. It is desirable to design the spring blade with a minimum but adequate bias force to obtain the least amount of change per unit deflection. In this manner, a "soft" spring can be had. The minimum proper operating force, the extent of travel, the "softness" of the spring, the resulting deflection of the spring blade, the proper contact pressure, and constant free height are all important factors in the proper functioning of such a switch. At the same time, it is desirable to maintain or even reduce the overall dimensions of the switching device. Increased life for the switching device through reduction in wear and fatigue of the spring blade is also desirable.

The principal object of my invention is to provide a current carrying member for a switching device which is capable of movement as a cantilever of two different lengths.

Another object of my invention is to provide a current carrying member requiring very little space for its proper operation.

Another object of my invention is to provide a current carrying member which is substantially free from fatigue and wear.

Further objects and advantages of my invention will be more readily apparent from the following detailed description, taken in connection with the drawings, in which:

FIG. 1 is a side elevation view of an illustrative embodiment of my invention, partly in section, in its depressed position as shown by the solid lines and further shows my invention, indicated with dotted lines, if allowed to assume its "free" position;

FIG. 2 is a view similar to FIG. 1 showing my invention partly in section and in a non-depressed position;

FIG. 3 is a side elevation view of a simple cantilever spring of prior art with the spring indicated in solid lines in a non-depressed position and further shows, by dotted lines, the extent of pre-travel necessary for a simple cantilever spring;

FIG. 4 is a view similar to FIG. 3 but with the simple cantilever spring in a depressed position;

FIG. 5 is a graphical comparison of the characteristics of my invention to a simple cantilever spring;

FIG. 6 is a single phase electric motor partly in section showing an illustrative embodiment of my invention in a speed sensitive switching device; and

FIG. 7 is a partial section view, taken along the lines VII—VII in FIG. 6.



The invention is illustrated in FIGS. 1 and 2, as embodied in a switch device including a bi-cantilever spring 2 of any suitable conducting resilient material secured to a supporting base 4. The term bi-cantilever is applied to my invention in that it functions as a cantilever of one length when it is in its non-depressed position and functions as a cantilever of another length when in its depressed position. It can be seen that the bi-cantilever spring 2 comprises a spring blade 6 and a rigid member 8 rigidly secured in piggy-back fashion on the spring blade 6.

The configuration of the spring blade 6 can be most readily seen from FIG. 2 where a portion of the rigid member 8 has been cut away. From that figure, it can be seen that the spring blade 6 is rigidly secured at one end to the supporting base 4. The spring blade 6 has a first portion designated as reference 10 which lies in a plane forming an angle with the supporting base 4. The spring blade 6 also has a second portion 12 which lies in a plane angularly disposed from the first portion 10 and which makes a smaller angle with respect to the supporting base 4 than the first portion 10. The spring blade 6 has an end portion 14 which is freely movable between a first stationary electric contact 16 and a second stationary electric contact 18, spaced apart by an appropriate gap distance. Secured to the side of the end portion 14 facing the first stationary contact 16 is an electrical contact 13 while an electrical contact 15 is secured to the other side of the end portion 14.

The rigid member 8 is disposed in a plane parallel with the first portion 10 on the same side of the spring blade as the first stationary electric contact 16. The rigid member 8 is secured at one end to a position intermediate the ends of the first portion 10. As can be more clearly seen from FIG. 7, the free end of the rigid member 8 is formed as a hook 20 which is inserted through an opening 22 close to the end of the second portion 12 adjacent the free portion 14. The hook 20 is positioned to engage the opposite side of the blade 6 when the blade is in the non-depressed condition. In such a manner, the hook 20 limits the maximum separation between the free end of the rigid member 8 and the spring blade 6. A lesser amount of separation is possible, however, when the bi-cantilever spring 2 is in its depressed position shown in FIG. 1. The rigid member 8 is adapted to be depressed by means of an operating member indicated diagrammatically by the reference number 26 engaging a raised knob portion 24 on the rigid member. The point of application of the operating force has been designated as point "C" on the drawings.

The first portion 10 of the spring blade 6 forms an angle with the supporting base 4 at a point designated as "A" which angle is sufficient to urge the spring blade in the direction of the first stationary contact 16. The maximum fiber stress within the spring blade 6 due to its movement will occur at the point "A." The broken line outline shown in FIG. 1 indicates the "free" position which the bi-cantilever spring 2 will assume due to the bias provided by its first section 10. Referring to Fig. 2, however, the spring blade 6 is constrained from its "free" position by the first stationary contact 16. A proper contact pressure, "P," between the first stationary contact 16 and the contact 13, is provided by a moment acting about the point "A." The moment is equal to the contact pressure "P" multiplied by the cantilever length "L" shown as the distance between the point "A" and the contact 13. The active spring portion in the non-depressed condition is shown to be of length "*d*" since the rigid member 8 and its hook 20 restrains the resiliency of the remaining length. The length "*d*" is chosen to be a minimum without losing control of the desired contact pressure "P" within allow-

able contact pressure tolerances. It is to be noted that the fiber stress at point "A" will remain unchanged for a given active spring portion as supplied by the first portion **10** and a fixed moment of value "PL," regardless of the configuration of the members within the length "L." In the non-depressed condition as shown in FIG. 2, restrained by the first stationary contact **16**, the bi-cantilever spring **2** functions as a cantilever of length "L."

The bi-cantilever spring behaves as a soft simple cantilever of length "L" from the aforementioned non-depressed condition, throughout the interval of crossing the gap and to initial contact with contact **18**. At this point a simple cantilever spring would change from a soft cantilever to a very stiff redundant beam. The bi-cantilever spring on the other hand changes from a soft cantilever of length "L" essentially to a slightly less soft cantilever of length "*L—d*." When contact **15** and stationary contact **18** touch, portion "*d*" and rigid member **8** are in the depressed position and may be thought of as locked in that position in space. The portion "*L—d*" of the spring blade **6** is then a simple canitlever anchored at "B" with contact **15** at its free end, and the free end may be visualized as moving back essentially counter-clockwise about point "B" until in its proper position on contact **18**. Thus, all necessary motion beyond initial contact with contact **18** is essentially that of a soft simple cantilever of length "*L—d*" rather than as a stiff redundant member.

When in a depressed condition, the bi-cantilever spring **2** functions as a cantilever of shorter length. At that time, the operating member **26** forces the bi-cantilever spring to assume a position as shown in FIG. 1 with the contact **15** engaging the second stationary contact **18**. Maximum fiber stress occurs at point "A," while at the same time the rigid member **8** causes the bi-cantilever spring to function as a cantilever of length equivalent to "*L—d*." The limits of the effective cantilever length (*L—d*) are at a point B where the first portion **10** joins the second portion **12** at one end, and the contact **15** on the opposite end.

Hence, the bi-cantilever spring **2** operates with a first cantilever length equivalent to "L" in its undepressed and partially depressed positions and acts with a cantilever length equivalent to "*L—d*" when in its depressed position.

The advantages of my invention can be readily appreciated by considering FIGS. 3 and 4 in which a simple cantilever spring has an end freely movable between the same stationary first contact **16** and second stationary contact **18**. In a constrained position between the stationary contacts **16** and **18**, the simple cantilever spring would assume a position as shown in the solid lines. Considering FIG. 3 further, it will be noted that to disengage the free end of the simple cantilever spring from the first stationary contact **16**, it is necessary that the force supplied by the operating member **26** undergo an appreciable pre-travel distance before the free end of the simple cantilever spring departs from the first stationary contact **16**. Not only is the necessary pre-travel distance undesirable, but the variation in the free height of "C" is related to the amount of pre-travel which, in turn, limits the control sensitivity; further, the pre-travel also results in a large counterclockwise rotation of the electrical contact pad **13** about the first stationary contact **16**.

Pre-travel has been virtually eliminated by my invention. The hook **20** is located very close to the contacts **13** and **15** on the end portion **14** of the spring blade so that the deformation of the spring blade **6** in the area opposite the hook **20** due to the contact pressure "P" is very small. The operating member **26** need move the knob **24** only a negligible amount to transfer the load "P" to itself and initiate separation of the contacts 13 and **16**. The bi-cantilever spring contact **13** rotates a negligible amount counterclockwise in leaving the first stationary contact **16** because no pre-travel is required.

From FIG. 4, it can be seen that the simple cantilever spring would assume a position as shown in FIG. 4 when the external force is applied to depress the simple spring. Here again, the contact **15** on the free end of the spring is forced to rotate in a counterclockwise direction through a rather large angle about the second stationary contact **18**. Should rotation become overly excessive the free end of the spring blade **6** may extend across the entire gap and short-circuit the stationary contacts **16** and **18**. The excessive counterclockwise rotation is caused by the relatively short distance between the contacts **15** and the point of application "C" of the external force **26**. In order to obtain the proper contact pressure between the contact **15** and the second stationary contact **18**, it is necessary for the simple cantilever spring to overtravel an appreciable distance which requires added motion by the external member **26** applying force to the spring.

In comparison, when the bi-cantilever spring **2** leaves the stationary contact **16**, the end portion **14** will undergo a small clockwise rotation while crossing the gap between the contacts **16** and **18**. This rotation is compensated for, however, by a small counterclockwise rotation allowed by the bi-cantilever spring when the rigid member moves relative to the spring blade **6** at the completion of its movement across the gap. The counterclockwise rotation of the end portion **14** is inversely proportional to the cantilever length (*L—d*) and is a minimum because (*L—d*) is maximum since "*d*" was chosen to be a minimum without losing control of the contact pressure "P" as described previously. The net result is negligible rotation of the contact **15** relative to the second stationary contact **18**. The bi-cantilever spring **2** permits good contact alignment and a minimum gap between the stationary contacts **16** and **18**.

In the depressed position, the simple cantilever spring is subjected to a much greater fiber stress with the possibility of metal fatigue in a much shorter time of operation. The greater fiber stress condition can be partly compensated for by providing the simple cantilever spring with a relatively higher stress metal content than required of the bi-cantilever spring **2**. A further disadvantage results however in that the electrical conductivity of the current carrying member is reduced.

At the same time, the actuating or closing member **26** may have motion relative to the simple cantilever spring and if the operating force is applied directly to the spring, friction and wear of the spring will result even if a wear pad is provided for the application of the force. With the bicantilever spring **2**, the rigid member **8** separates the operating member **26** from the spring blade **6** thereby protecting the spring blade **6** from friction wear. This arrangement preserves the resilient characteristics of the spring blade. The rigid member has a wear pad, namely, the knob **24**, which renders the friction wear on the rigid member **8** to inconsequential proportions.

It can be seen from my invention that very small motion of the operating member **26** is required to separate the spring blade **6** from the first stationary contact **16**. Over-travel is reduced to a minimum since the rigid member **8** forces the bi-cantilever spring **2** to operate as a cantilever of length (*L—d*) about point B. The distance required to be traveled by the external closing element **26** is small and the overtravel required to attain a proper contact pressure "P" between the contact **15** of the second stationary contact **18** is negligible compared to a plain cantilever spring. The maximum fiber stress at "A" which increases with the motion of point "B" for a given overtravel is reduced substantially by the cantilever spring after proper contact pressure is attained. The rigid member **8** is formed to have side portions **28** located perpendicular to the spring blade **6**. When the

rigid member 8 is depressed, the side portions 28 engage the supporting base 4 limiting further application of the operating force on the blade 6 and protecting the spring blade 6 from overstressing. Minimum overtravel for proper contact pressure is required of the bi-cantilever spring 2 since the cantilever length acting when the bi-cantilever spring is in its depressed position is equivalent to $(L-d)$. The cantilever length $(L-d)$ is considerably larger than the lever arm distance between the point of application "C" of the external force and the contact 15. The two cantilever lengths "L" and "$(L-d)$" provide a moment of sufficient magnitude in the non-depressed and depressed positions respectively to obtain proper contact pressure "P" upon initial engagement of the proper contacts.

FIG. 5 shows the operating characteristics of my bi-cantilever spring as a solid line, while the operating characteristics of a simple cantilever spring is shown in dotted lines for comparison purposes.

The necessary travel motion of the operating member 26 is plotted against the load on the operating member as the bi-cantilever spring travels from its constrained position at one extreme to the depressed position in the opposite extreme.

The first portion 40 of the solid line shows the relatively short pretravel distance which the operating member 26 must travel to reduce the contact pressure between the contact 13 and the first stationary conact 16 to zero. The second portion 42 of the solid line is the distance required for the operating member to travel in crossing the spaced gap between the first stationary contact 16 and the second stationary contact 18. The third portion 44 of the solid line illustrates the small overtravel distance necessary on the part of the operating member 26 to obtain the proper contact pressure "P" between the contact 15 and the second stationary contact 18. The remainder 46 of the solid line shows the large working range secured by the "soft" spring effect of my invention. As illustrated by the gentle slope of the solid line 46, a well regulated snap action can be assured to the operating member 26 in this range. Quite often, the operating member 26 will be designed to have a snap action in a speed sensitive or pressure sensitive manner as FIGS. 6 and 7 will illustrate. The bi-cantilever spring allows snap action to take place within very close tolerances in either the depressed or the non-depressed position and in either direction.

At the same time, it can be seen that the pretravel distance required of the operating member 26 when used with a simple cantilever spring is considerably larger and the overtravel distance is also considerably larger in order to obtain the proper desired contact pressure. The working range of the simple cantilever spring is quite limited in comparison with the bi-cantilever spring.

The characteristic curve in FIG. 5 shows the great reduction in pre-travel distance, the minimum gap between the stationary contacts, and the minimum overtravel distance required of the bi-cantilever spring. These, in turn, permit proper switching in a minimum distance meaning less space required for the current carrying elements. A reduction in size of the switching device is accomplished while at the same time its sensitivity is increased and performance improved.

FIG. 6 illustrates an embodiment of my invention in a single-phase electric motor 30 having a stator 32 rotatably supporting a rotor 34 by suitable means within end brackets 36. For purposes of clarity, like reference characters have been used to designate like or corresponding parts discussed previously. The bi-cantilever spring 2 is embodied in a speed sensitive switching device used to disconnect an auxiliary or starting winding (not shown) from the power circuit upon the motor reaching or accelerating to a predetermined rotational speed. At that time, more satisfactory motor performance is realized by allowing the motor to attain its full load speed with only the main or running winding connected to the power circuit.

The chosen illustration is an application whereby the bi-cantilever spring 2 is initially in its depressed position thereby connecting the auxiliary winding circuit to the power circuit. Upon the motor reaching a predetermined rotational speed, the spring is allowed to assume its non-depressed condition, thereby opening the engaged contacts 15 and 18 and disconnecting the auxiliary winding from the power circuit. The stationary contact 16 is not connected into the electrical circuit and serves merely as a stop limiting further travel of the bi-cantilever spring. The stationary contact 16 may be utilized where desired in a particular circuit such as a two speed motor. It will be understood that an arrangement whereby the bi-cantilever spring is initially in its non-depressed position could also be used. Such an arrangement was outlined with FIGS. 1, 2 and 5. It is not necessary that a contact be located on each side of the free end of the bi-cantilever spring nor is it necessary that two spaced stationary contacts be used. A single stationary contact may be used with one contact on the spring blade or any other contact arrangement may be had with my invention.

From FIG. 6, it can be seen that a supporting base 4 of suitable insulating material be secured to the end bracket 36 in any suitable manner with the bi-cantilever spring 2 mounted to the base 4 as previously described. An operating mechanism 38 is mounted on the shaft 35 of the rotor 34 and adapted to rotate therewith. The operating mechanism 38 has weights 40 mounted thereon. The weights 40 will be forced radially outward by centrifugal force upon attainment of a predetermined rotational speed, thereby initiating the mechanical linkage 33 to move the operating member 26 axially away from the rigid member 8 of the bi-cantilever spring 2. In other words, when the constant biasing force of the spring blade 6 plus the control force provided by the rotating weights 40 exceeds the inherent constant force opposing snap action of the operating mechanism 38, transfer will occur away from the stationary contact 18. Should the rotational speed of the rotor be reduced to a level below which the weights 40 can be maintained in their radially outward position, the weights 40 return to the position shown in FIG. 6, thereby moving the operating member 26 back into engagement with the rigid member 8. The operating member 26 is chosen of suitable material having electrical insulating properties. The spring blade 6 has a free end freely movable between the stationary contacts 16 and 18 for purposes of clarity with respect to the foregoing discussion. The first stationary contact 16, as well as the second stationary contact 18, is secured to the supporting base 4. Terminals 42 provide means for electrical connection from the stationary contacts 16 and 18 as well as from the stationary end of the current carrying spring blade 6 to the proper connections on the auxiliary winding and power supply lines. The terminals 42 can be more readily seen from FIG. 7 which provides a top view of the bi-cantilever spring 2 mounted on the supporting base 4, partially shown. From that figure, it can be seen that the supporting base 4 is provided with a large circular opening 44 for the insertion of the shaft 35 of the rotor 34 of the single-phase electric motor.

It can be seen that the axial motion of the operating member 26 can be made to have speed sensitive or pressure sensitive snap action, usually present in centrifugal type switches. The built-in pressure control of the bi-cantilever spring 2 allows the snap action to take place within very close tolerances in both directions.

A bi-cantilever spring operative as a cantilever of two different lengths, has been provided for a switching device in a single-phase electric motor. Factors contributing to the reduced size of the switch as compared to the conventional construction are the virtual elimination of the pre-travel required of the operating member 26; the

minimum air gap; and the small overtravel necessary to obtain proper contact pressure. The use of a rigid member in the bi-cantilever spring serves to locate the friction wear on a wear pad that is built onto the rigid member. By lowering the maximum fiber stress within by bi-cantilever spring as compared to the conventional cantilever spring, a much greater number of cycles of operation will result before fatigue occurs in the switching device for such an application as a speed sensitive switching device. A single operating member may be used to actuate more than one bi-cantilever spring when a number of events are desirable. In such cases the advantages of the bi-cantilever spring are cumulative and therefore substantially more significant.

While my invention has been described with a certain degree of particularity for the purposes of illustration, it is to be understood that all equivalents, modifications and alterations within the spirit and scope of my invention are herein meant to be included.

I claim as my invention:

1. In a switching device, a support member, a conducting spring member secured at one end to the support member, contact means at the free end of the spring member, a rigid member extending longitudinally of the spring member and secured thereto adjacent said one end of the spring member, the rigid member overlying the spring member and being shorter than the spring member so that the rigid member is longitudinally spaced from the free end of the spring member, said spring member being formed to bias the free end thereof away from the rigid member, and means for limiting the maximum separation between the rigid member and the free end of the spring member.

2. In a switching device, a support member, a conducting spring member secured at one end to the support member, contact means at the free end of the spring member, a rigid member extending longitudinally of the spring member and secured thereto adjacent said one end of the spring member, the rigid member overlying the spring member and being shorter than the spring member so that the rigid member is longitudinally spaced from the free end of the spring member, said spring member being formed to bias the free end thereof away from the rigid member, and the rigid member having a hook portion adapted to engage the spring member adjacent the free end thereof to limit the maximum separation between the rigid member and the spring member.

3. In a switching device, a support member, a conducting spring member secured at one end to the support member, contact means at the free end of the spring member, a rigid member extending longitudinally of the spring member and secured thereto adjacent said one end of the spring member, the rigid member overlying the spring member and being shorter than the spring member so that the rigid member is longitudinally spaced from the free end of the spring member, said spring member being formed to bias the free end thereof away from the rigid member, the rigid member being adapted to be engaged by an actuating member to move the spring member toward the support member to actuate said contact means, and means for limiting the maximum separation between the rigid member and the free end of the spring member when the spring member is in non-actuated position.

4. In a switching device, a support member, a conducting spring member secured at one end to the support member, contact means at the free end of the spring member, a rigid member extending longitudinally of the spring member and secured thereto adjacent said one end of the spring member, the rigid member overlying the spring member and being shorter than the spring member so that the rigid member is longitudinally spaced from the free end of the spring member, said spring member being formed to bias the free end thereof away from the rigid member, the rigid member being adapted to be engaged by an actuating member to move the spring member toward the support member to actuate said contact means, and the rigid member having a hook portion in position to engage the spring member in the non-actuated position to limit the maximum separation between the rigid member and the free end of the spring member.

5. A switch device comprising a support member, a stationary contact, a conducting spring member secured at one end to the support member, a contact on the free end of the spring member in position to engage said stationary contact, the spring member being biased away from the stationary contact, a rigid member extending longitudinally of the spring member on the side thereof away from the stationary contact, the rigid member being secured to the spring member adjacent said one end thereof, the rigid member overlying the spring member and being shorter than the spring member so that the rigid member is longitudinally spaced from the free end of the spring member, the spring member being formed to bias the free end thereof away from the rigid member, and means on the rigid member for engaging the spring member to limit the separation between the rigid member and the free end of the spring member.

6. A switch device comprising a support member, a stationary contact, a conducting spring member secured at one end to the support member, a contact on the free end of the spring member in position to engage said stationary contact, the spring member being biased away from the stationary contact, a rigid member extending longitudinally of the spring member on the side thereof away from the stationary contact, the rigid member being secured to the spring member adjacent said one end thereof, the rigid member overlying the spring member and being shorter than the spring member so that the rigid member is longitudinally spaced from the free end of the spring member, the spring member being formed to bias the free end thereof away from the rigid member, the rigid member having a portion adapted to be engaged by an actuating member to move the spring member to bring said contacts into engagement, and the rigid member having a hook portion in position to engage the spring member to limit the separation between the rigid member and the free end of the spring member.

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