United States Patent

Wilkes

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[45] **Jan. 18, 1972**

[54] **ELECTRICAL SNAP ACTION SWITCH APPARATUS**

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[21] Appl. No.: **84,534**

Related U.S. Application Data

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[52] **U.S. Cl.** ....**200/67 DA,** 74/100

[51] **Int. Cl.** **H01h 13/48**

[58] **Field of Search** ....200/67 D, 67 DA, 67 DB, 76; 74/100 P

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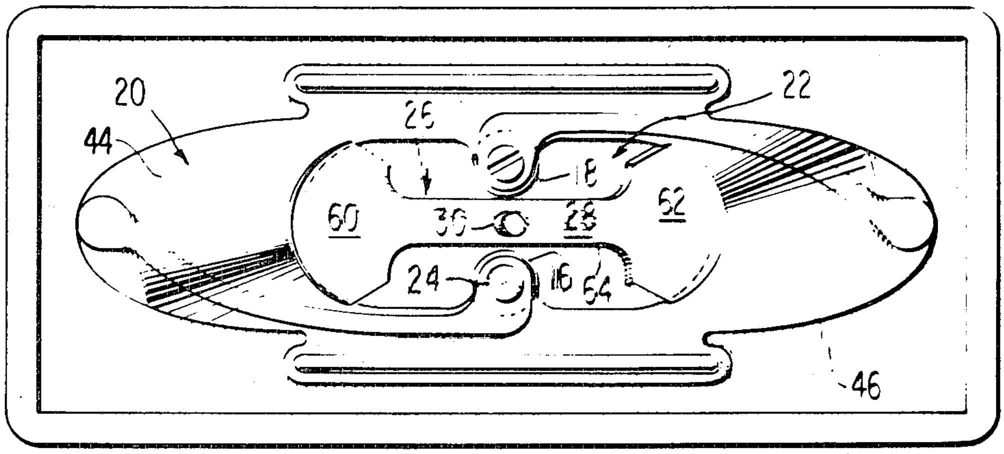
[57] **ABSTRACT**

An elastically coned bistable blade carries electrical contact surfaces at its outer free end and is caused to snap back and forth between opposed spaced-apart stationary contacts in response to movements of an inner portion of the blade. In one of its contacting positions, the blade is coned in one direction and, in the other, it is coned in the opposite direction.

22 Claims, 14 Drawing Figures



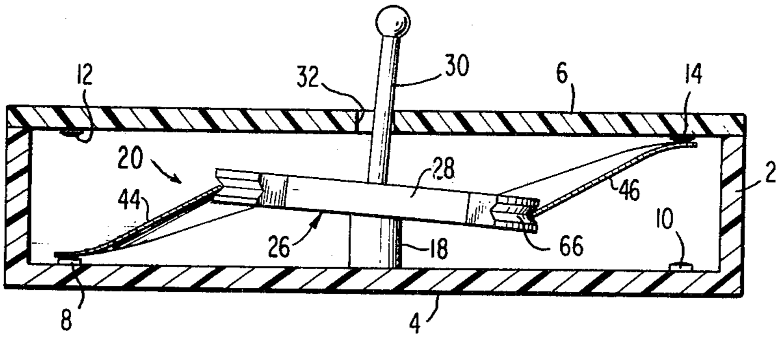


FIG.1

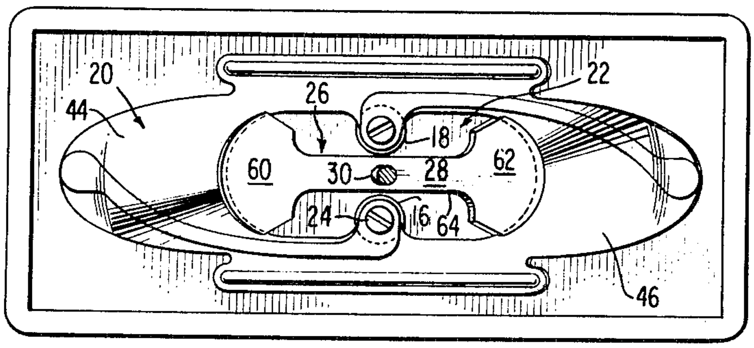


FIG.2

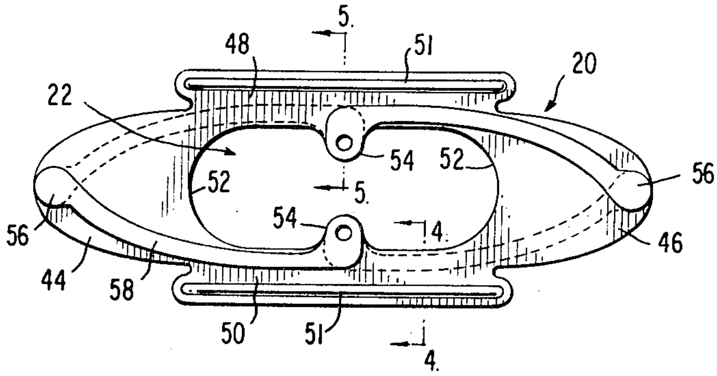


FIG.3

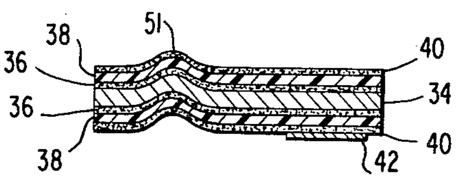


FIG.4

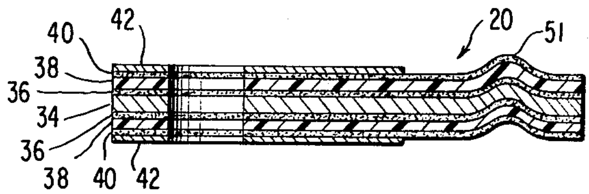


FIG.5

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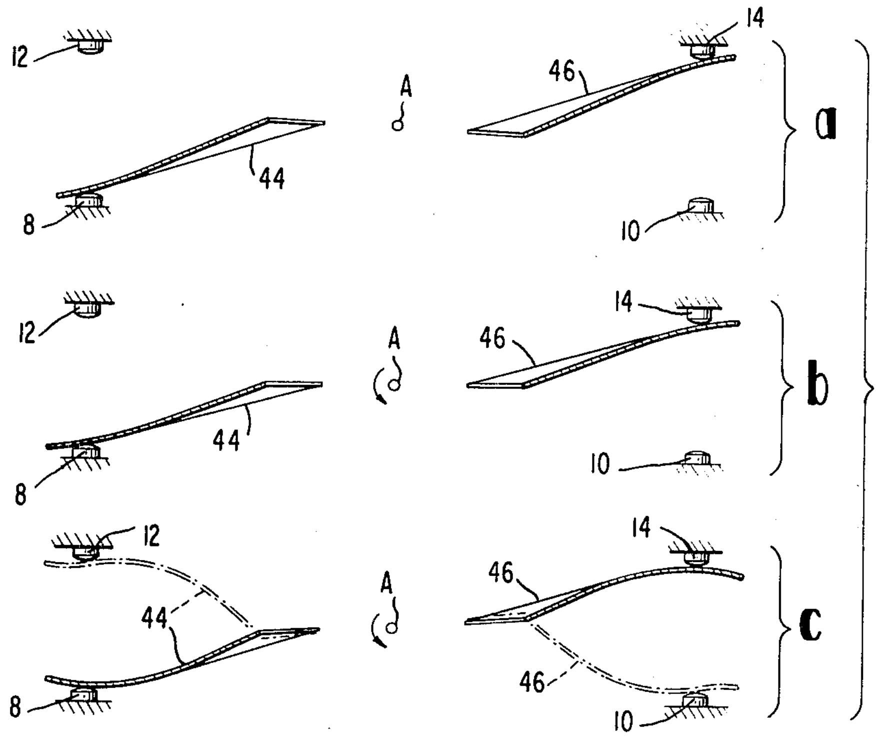


FIG.6

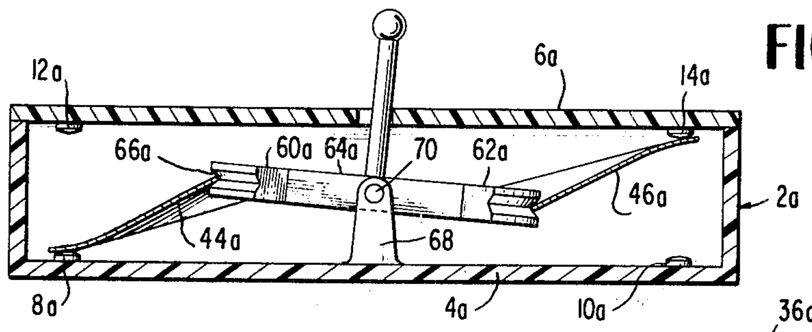


FIG.7

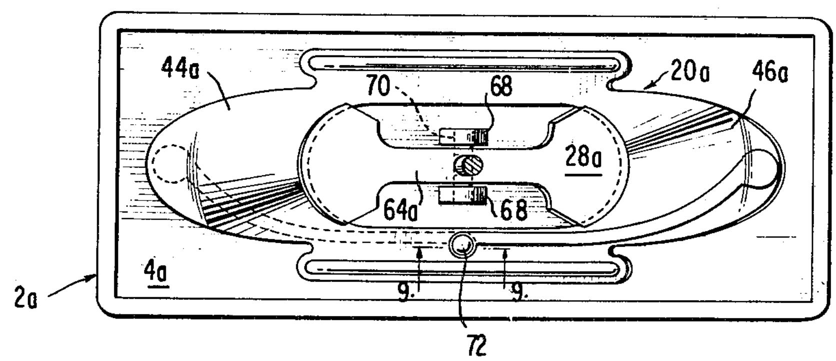


FIG.8

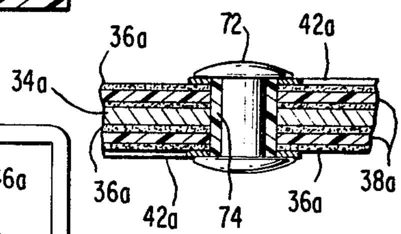
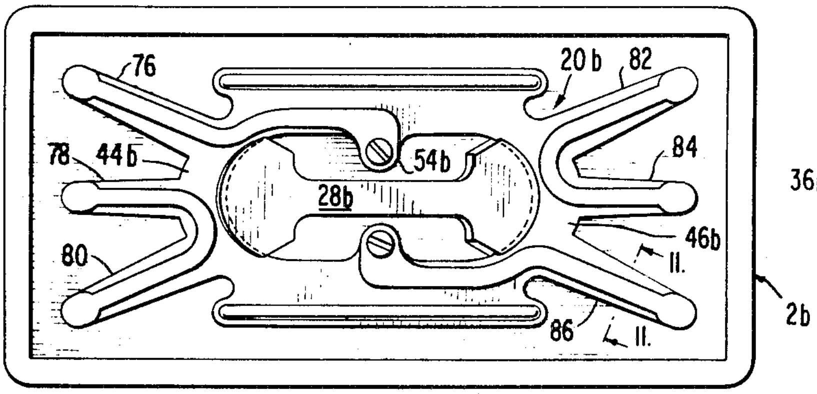


FIG.9

FIG.10



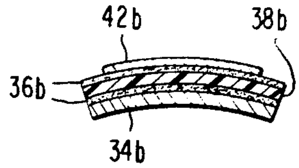
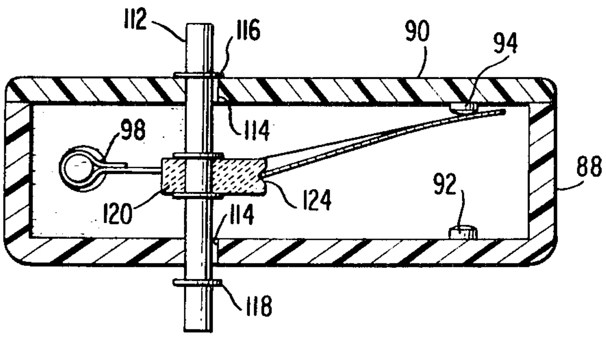


FIG.11

FIG.12



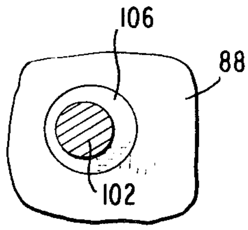


FIG.14

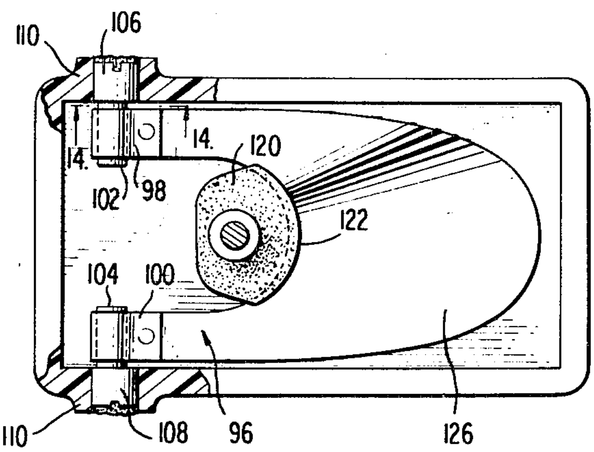


FIG.13

ELECTRICAL SNAP ACTION SWITCH APPARATUS

This application is a continuation of application Ser. No. 717,090, filed Mar. 29, 1968, now abandoned.

CROSS-REFERENCES TO RELATED APPLICATIONS

Two related applications of Donald F. Wilkes entitled respectively "Snap Action Apparatus" Ser. No. 717,114, filed Mar. 29, 1968 and "Magnetically Operable Switching Apparatus," Ser. No. 717,113, filed Mar. 29, 1968 now U.S. Pat. No. 3,543,595 are being filed concurrently herewith. Both disclose related subject matter, and the disclosures thereof are incorporated herein by reference.

BACKGROUND OF THE INVENTION

This invention relates to electrical contact making and breaking apparatus of the snap-action type. It is concerned particularly with apparatus in which movable contacts are provided on elements of thin resilient sheet material and in which the sheet material is deformed elastically in effecting the snap-actions desired for contact making and breaking.

Many different forms of snap-acting blades have been employed heretofore in various types of contact making and breaking apparatus. Insofar as I am aware, however, none of these has been entirely satisfactory for use in devices which must be mass produced and in which such qualities as effective contact wipe, high-contact pressures, minimum contact bounce, and high speeds of operation are required. The difficulties experienced heretofore may be traced largely to a failure on the part of prior workers in the field either to appreciate fully the structural properties of very thin resilient sheet materials or to provide assemblies in which these properties may be utilized to best advantage.

In most of the prior art proposals where elements of thin resilient material, such as spring metal, are relied upon to provide the desired snap-actions, the assemblies in which these elements are used are not arranged so as to load the elements properly. One result has been that the elements generally used in commercial devices of this type are relatively thick and have substantial masses that give them undesired inertia characteristics which restrict the speed with which contact actuations may take place and enhance the contact bouncing tendencies of the device.

SUMMARY OF THE INVENTION

Objects of this invention are to provide improved contact making and breaking apparatus which can be manufactured economically on a mass production basis and which will function to provide high-contact forces, quick contact actuation sequences, and effective contact wiping actions for cleaning the contact surfaces.

These and other objectives are obtained, in accordance with certain embodiments of the invention, by utilizing transversely curved segments of thin resilient sheet material as the movable blade elements of contact making and breaking apparatus. One end of each such segment is connected to an actuator, and the opposite end is free and extends into the space between two opposed reaction surfaces. The actuator is movable in a direction having a component extending in the same direction as the spacing between the two opposed reaction surfaces.

Each of the blades preferably has two stable configurations. In one of these the blade is transversely curved so that its front face is concave and its front face engages one of the reaction surfaces at the outer end of the blade. In the other stable position of the blade, the blade is transversely curved so that its back face is concave, and in this position, the outer end portion of the back face of the blade engages the other of the opposed reaction surfaces.

In each of the stable positions of a blade, the curvature thereof preferably conforms generally to the curvature of a segment of the surface of a cone. Some transverse tapering of the blade from its inner to its outer ends also is ordinarily desirable.

With this arrangement, movement of the actuator toward the level of the reaction surface against which the blade is pressing will serve first to increase the pressure of the blade against the reaction surface. Then, as the motion of the actuator is continued, a point will be reached where the blade suddenly snaps over its highly unstable center position and moves rapidly into engagement with the opposite reaction surface. Either or both of the opposed reaction surfaces may take the form of electrical contacts, and either or both of the faces of the blades may constitute or carry electrical contacts. Therefore, the pressure effects of the blade against the reaction surfaces have corresponding electrical effects.

During contact breaking sequences, for example, the contact pressure will be maintained, and even increased, right up to the moment when the blade snaps. As a result, there will be no increase in contact resistance during such sequences. Contact heating will be minimized and this, in turn, will prevent degradation of the contacts.

The blade also is arranged to scrape along the contact surfaces during portions of the actuation sequences. Since such scraping movements take place while substantial contact pressures are being applied, a cleaning effect is produced which further minimizes contact degradation.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of these and other features and advantages of the invention will be gained from the following detailed description of certain embodiments illustrated in the accompanying drawings in which:

FIG. 1 is a longitudinal cross-sectional view of a switching assembly in accordance with the invention;

FIG. 2 is a plan view of the switching assembly of FIG. 1, with the top casing member of the assembly being removed so as to reveal the configurations of the internally located elements of the assembly;

FIG. 3 is a plan view of a thin resilient element employed in the switching assembly of FIGS. 1 and 2 and it shows this element in the natural unstressed configuration assumed thereby prior to its incorporation into the assembly;

FIG. 4 is a transverse cross-sectional view taken along the line 4—4 in FIG. 3;

FIG. 5 is a transverse cross-sectional view taken along the line 5—5 in FIG. 3;

FIG. 6 is a sequence of diagrams designated *a*, *b* and *c*, illustrating the relative positions of the blades and the stationary contacts of the assembly of FIGS. 1 and 2 during a contact breaking sequence;

FIG. 7 is a longitudinal cross-sectional view of another embodiment of the invention;

FIG. 8 is a plan view of the embodiment of FIG. 7 with the top cover member of the device removed so as to reveal the configurations of the interiorly located elements;

FIG. 9 is a vertical cross-sectional view taken along the line 9—9 of FIG. 8;

FIG. 10 is a plan view similar to FIGS. 2 and 8 but illustrating another embodiment of the invention;

FIG. 11 is a vertical cross-sectional view of one of the contact fingers of the embodiment of FIG. 10, and this view is taken along the line 11—11 in FIG. 10;

FIG. 12 is a longitudinal cross-sectional view illustrating yet another embodiment of the invention;

FIG. 13 is a plan view of the device of FIG. 12 with the top cover element of the device removed so as to reveal the configurations of the interiorly located parts; and

FIG. 14 is a detail, cross-sectional, view taken along the line 14—14 in FIG. 13.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiment of the invention illustrated in FIGS. 1–5 includes a housing 2 having a base 4 and a top member or cover 6. Stationary means 8 and 10, preferably in the form of electrical contacts, are carried by the base 4 at locations spaced apart along the longitudinal axis of the device and provide upwardly facing reaction surfaces. Similar means 12 and 14 are carried by the cover 6, and these provide downwardly facing reaction surfaces disposed in opposing relation to the reaction surfaces of the respective means 8 and 10. The housing components should be insulated electrically from the various conductive reaction surfaces, and to this end, the housing base 4 and cover 6 may be formed from plastic or other suitable insulating materials.

At a location approximately midway between the means 8 and 10, the base 4 is provided with upwardly extending, transversely spaced apart, mounting posts 16 and 18, the upper ends of which are disposed approximately midway between the base 4 and the cover 6. A thin resilient element 20 having an elongated central opening 22 therein is positioned upon the upper ends of the mounting posts 16 and 18 and affixed thereto by screws or other means 24. An actuator 26 is mounted within the central opening 22 in the thin resilient element 20. It includes a body 28 extending generally along the plane of the central opening 22 and an upwardly extending handle or lever 30 protruding upwardly through a longitudinally elongated opening 32 in the cover 6.

As best illustrated at the left hand portion of FIG. 5, the thin resilient element 20 is formed from a laminate which includes a central layer 34 of spring metal sheet material, layers 36 of sheet adhesive material adhered to opposite surfaces of the layer 34, layers 38 of insulating material such as sheets of polyester plastic adhered to the adhesive layers, additional layers 40 of sheet adhesive material, and outer layers 42 of electrically conductive material such as copper adhered to the sheet adhesive material 40. Such laminated constructions are often desirable from the standpoint of providing suitable electrical characteristics to the element 20. Additionally, interlamina shear actions produce damping effects which may be useful in minimizing contact bounce and in instances where the apparatus is to be used in severe environments.

The overall thickness of the laminate illustrated in FIG. 5 is of course greatly exaggerated. In practice, the thickness of the laminate would be gauged in hundredths or even thousandths of an inch. For example, excellent results may be obtained through the use of a laminate in which the central layer 34 is formed from stainless steel sheet material only 0.0015 inch thick and in which the overall thickness of the laminate is in the order of 0.0065 inch.

The thin resilient element 20 is illustrated in FIG. 3 in its natural unstressed condition. The element is generally flat. The outlines of the edges of the central opening 22 and the external edges of the element are such that the element can be considered generally to be subdivided into oppositely directed, outwardly tapering, blade portions 44 and 46 connected together by longitudinal side strips or portions 48 and 50. The blades 44 and 46 are bounded interiorly by concavely curved end edge portions 52 and 54 of the central opening 22. Each of the side strips 48 and 50 is provided with a longitudinally extending stiffening rib 56, produced for example by conventional stamping operations which serve to permanently deform the material of the element 20 from its naturally flat shape in the limited zones where the ribs 52 are desired. The side strips 48 and 50 also are provided with inwardly protruding mounting tabs 54 at a midportion of the element.

The layers 42 of electrically conductive material at the upper and lower surfaces of the element 20 normally are subjected to controlled etching operations of the type customarily employed in chemically milling operations and in the fabrication of printed circuits so that, in the completed component, the layers 42 will occupy only portions of the surfaces of the element 20. These portions of the layer 42 form contact areas 56 and electrical circuit segments 58 which preferably extend to the zones to the mounting tabs 54 where they may be connected electrically to circuit elements carried by or forming parts of the mounting posts 16 and 18.

The body 28 of the actuator 26 illustrated in FIGS. 1 and 2 is shaped so as to cooperate with the edges of the central opening 22 in a predetermined manner. This body 28 includes enlarged end portions 60 and 62 connected together by an elongated center portion 64. The ends of the end portions 60 and 62 are curved convexly (FIG. 2) at radii of curvature substantially less than the corresponding radii of curvature of the end edge portions 52 and 54 of the central opening 22 in the thin resilient element 20. Each of these ends is provided with a correspondingly curved notch 66 in its edge for receiving the end edge portions 52 and 54. The distance between the bases of the notches 66 in the two end portions 60 and 62 of the actuator is somewhat greater than the length of the central opening 22 in the resilient element 20.

Hence, when the central opening 22 is brought into position over the body 28 of the actuator, the actuator will hold the resilient element 20 in a deformed configuration in which the radii of curvature of the curved edge portions 52 and 54 of the central opening 22 are shortened to conform to the radii of curvature of the convex ends of the actuator. This deformation of the inner boundaries of the blades 44 and 46 imposes internal stresses on the material of the blades and causes each of them to aggressively seek a coned configuration extending out of the plane of the central opening 22. The angle of inclination of each blade with respect to the plane should be at least 5°, and more preferably, at least 10°.

Each of the blades 44 and 46 may be coned upwardly or downwardly from the plane of the central opening 22. In a preferred assembly illustrated in FIGS. 1 and 2, the blades 44 and 46 are out of phase with each other in the sense that when the blade 44 cones downwardly, the blade 46 curves upwardly. This assembly is balanced with respect to linear acceleration inputs. Additionally, the arrangement is such that the designer may, by properly proportioning the actuator and the resilient element, provide an assembly which is substantially balanced with respect to rotary acceleration inputs.

A typical switching sequence may be carried out by shifting the handle 30 counterclockwise as viewed in FIG. 1 to tilt the actuator 26 about a transverse axis defined by the points of attachment of the flexible mounting tabs 54 of the resilient element 20 to the upper ends of the mounting posts 16 and 18. The tilting of the body 28 of the actuator shifts the inner boundaries of the blades 44 and 46 in opposite directions and, as this shifting is continued, a point will be reached at which each of the blades is caused to snap across the plane of the central opening 22 of the resilient element 20 and assume a coned configuration on the opposite side of that plane.

These effects can perhaps be best explained by reference to the sequence of diagrams illustrated in FIG. 6. In these simplified diagrams the support structures have been omitted and the actuator has been replaced by an indication A of the axis about which it tilts. Also, the blades 44 and 46 have been shown in isolation and as they would appear in a longitudinal cross-sectional view.

Diagram *a* in FIG. 6 illustrates the relationship between the blades and the stationary contacts when the actuator is in the extreme position thereof illustrated in FIG. 1. In this position the actuator is tilted clockwise far enough to bring the handle 30 into contact with the right end of the opening 32 in the cover 6. In order that adequate preload forces may be applied through the blades 44 and 46 to the contacts 8 and 14, the angle of actuator tilt permitted by the opening 32 is somewhat less than that which would be required if the blades 44 and 46 were allowed to cone freely away from the plane of the central opening 22 of the resilient element 20. Hence, the outer end portions of the blades 44 and 46 will be elastically stressed and flattened somewhat. Note in this connection that the background lines defining the remote edges of the blades 44 and 46 in diagram *a* of FIG. 6 join with the cross-hatched portions of the blades at locations spaced just inwardly from the stationary contacts 8 and 14.

The initial movements of the actuator about the transverse axis A serve to increase the bearing forces between the blades 44 and 46 and the respective stationary contacts 8 and 14. In diagram *b*, of FIG. 6, this effect is reflected by an increase in the lengths of the flattened outer end portions of the blades.

It should be observed also that this motion produces some sliding of the contact surfaces of the blades 44 and 46 with respect to the stationary contacts. In moving from the positions shown in diagram *a* to the positions of diagram *b*, the extreme ends of the blades move longitudinally relative to the adjacent contacts. Since this sliding motion takes place while substantial bearing forces are being exerted between the contacting surfaces, a particularly effective contact cleaning action is achieved.

Continued tilting of the actuator in a counterclockwise direction about the transverse axis A results in a further increase in the loading on the blades 44 and 46, and the buckling of the outer end portions of the blades from their curved to their flattened conditions progresses inwardly as indicated in full lines in diagram *c* of FIG. 6. This progressive flattening continues until, at a point after that depicted by the full line showing in diagram *c*, the flattened portions extend substantially all the way to the roots of the conical segments. At this point, the blades will no longer be able to maintain their orientation toward the contacts 8 and 14 and the blades will snap suddenly into reversely coned configurations which bring their outer end portions into engagement with the opposing contacts 12 and 10, as suggested by the broken lines in diagram *c*.

In considering this sequence, it should be kept in mind that the masses of the blades 44 and 46 are exceedingly small. The blades have low inertia characteristics, and the snap-action suggested in diagram *c* takes place very quickly. The low inertia of the blades 44 and 46 also tends to minimize contact bounce as the blades move into position with respect to the stationary contacts 10 and 12. Moreover, a substantial portion of whatever inertial energy the blades have will be dissipated in useful contact wiping effects as the surfaces of the blades drag against the contacts 10 and 12 in seeking their minimum energy positions.

It is of interest to note also that the contact forces between the blades and the contacts 8 and 14 continue to increase right up until the moment when the blades snap over. Much difficulty has been experienced heretofore in obtaining sharp contact breaking actions which do not involve reductions in contact pressure prior to break. Similarly, the impacting of the low inertia blades against the contacts 10 and 12 causes the initial pressures between the blades and the contacts in the make sequence to be somewhat greater than the contact pressures normally exerted after the circuits through these contacts have been established. This latter effect helps to insure low initial contact resistance by effectively penetrating oxide, organic and other films on the contact surfaces and it may be particularly beneficial in connection with the handling of contacting surges such as those experienced when closing circuits containing substantial capacitively stored energy.

Another embodiment of the invention is illustrated in FIGS. 7 through 9. This embodiment is similar in most respects to the embodiment described above and corresponding reference character, with the letter "*a*" added, have been applied to the various elements. In this embodiment, however, an alternative form of support for the resilient element-actuator assembly has been employed. Referring to FIGS. 7 and 8, it will be seen that the base 4*a* is provided with upwardly extending bracket members 68 on opposite sides of the center portion 64*a* of the body 28*a* of the actuator means and that a pivot pin 70 extends through the upper end portions of the brackets and through the midportion of the actuator body so as to provide a fixed pivot for the actuator.

In some applications the mounting arrangement illustrated in FIGS. 7 and 8 will be found to be somewhat less desirable than that illustrated in FIGS. 1 and 2. This is so because the location of the pivot axis is fixed in FIGS. 7 and 8 by the location of the pivot pin 70. With this arrangement, variations in the locations or dimensions of the various parts of the device may result in some variations in performance. Such variations in performance are minimized in constructions such as that shown in FIGS. 1 and 2, because the flexible mounting tabs 54 permit minor shifting movements of the tilt axis so as to accommodate dimensional irregularities which may result from the manufacturing techniques employed.

The circuit arrangements illustrated in FIGS. 8 and 9 also differ somewhat from those illustrated in FIGS. 3–5. In the embodiment of FIGS. 7–9, the blade 46*a* carries circuit components only on its upper surface and the blade 44*a* carries circuit components only on its lower surface. The two circuits are connected together, as indicated in FIG. 9, by a rivet 72 passing through an insulating sleeve 74 disposed in a hole extending through the laminate which forms the thin resilient element. Hence, when the parts are in the positions illustrated in FIG. 7, a circuit will be completed from the stationary contact 8*a* to the stationary contact 14*a*. The other stable position of the parts is an idle position in the electrical sense, because the faces of the blades which contact the means 10*a* and 12*a* are electrically nonconductive.

FIGS. 10 and 11 show another embodiment of the invention which is similar in most respects to that illustrated in FIGS. 1 and 2. Parts of the embodiment shown in FIG. 10 which correspond to parts illustrated in other views have been designated by similar reference characters to which the letter "*b*" has been added.

The coned bistable blades 44*b* and 46*b* in FIG. 10 have external outlines which subdivide the outer ends of each of the blades into three distinct contact fingers. The finger portions on the blade 44*b* are designated 76, 78 and 80. The finger portions on the blade 46*b* are designated 82, 84 and 86. Each of these finger portions is an integral part of one of the snap acting blades 44*b* and 46*b*. The coning of each blade persists through the finger portions thereof, and all of the finger portions participate in the snap actions of the blades.

Configurations such as that illustrated in FIG. 10 are particularly useful in applications where a large number of electrical circuits must be opened or closed in response to a single movement of the actuator. It will be understood, of course, that the number of contact fingers depicted in FIG. 10 is illustrative only and that persons skilled in the art will select the number of contact fingers to be included in a particular design on the basis of the needs to be served by that design.

The designer should understand also that the relative contact finger lengths and shapes illustrated in FIG. 10 are exemplary only. A wide variety of useful effects may be obtained through variations in contact finger shapes. For example, one can provide for essentially equal or substantially unequal contact forces and/or sequential making and breaking operations by a proper selection of contact finger lengths and shapes. Such relationships may be established as between contact fingers on a single coned blade and/or as between contact fingers on different blades of the same assembly.

FIGS. 10 and 11 also illustrate yet another circuit arrangement. In this embodiment the thin resilient element 20*b* is a laminate which includes circuit elements only on the top face thereof. In some instances these circuit elements connect contact surfaces on a single snap acting blade. In others, these circuit elements extend from the contact surfaces over portions of the side strips of the resilient element and into the zones of the mounting tabs so that the circuits may be completed through connections extending through the mounting posts of the device.

Still another embodiment of the invention is illustrated in FIGS. 12 through 14. This embodiment differs in many respects from those which have been described heretofore and no attempt will be made to relate the reference numerals applied to the parts of this embodiment with those which have been used in connection with the other embodiments.

The device illustrated in FIGS. 12 through 14 is suitable for very simple switching operations. It includes a housing 88 having a cover or top member 90. Stationary contacts 92 and 94 are disposed in opposing relation to each other and are fixed respectively to the base of the housing 88 and the cover 90. A generally U-shaped, thin resilient element 96 is disposed within the housing 88 and includes looped end portions 98 and 100 which surround eccentric elements 102 and 104 protruding into the interior of the housing from rotatable members 106 and 108 mounted in boss portions 110 of the housing.

Actuator means for cooperation with the thin resilient element **96** includes a vertical rod **112** extending loosely through enlarged holes **114** in the cover **90** and the base of the housing **88**. The rod is vertically shiftable with respect to the housing **88**, but the extent of its shifting movement is limited by stop elements **116** and **118** affixed to its protruding end portions. A central portion of the rod **112** carries an actuator body **120** having a convexly curved front end **122**. A notch **124** in the edge of the curved front end **122** of the body member **120** received a curved edge of the thin resilient element **96** and cooperates therewith in much the same manner as has been described heretofore in connection with other embodiments of the invention.

The natural radius of curvature of the edge portion of the resilient element **96** disposed within the notch **124** is somewhat greater than the radius of curvature of the base of the notch **124**. When the resilient element **96** is stressed, however, by rotating the eccentric elements **102** and **104** to the positions illustrated in the drawings, the curvature of the edge of the sheet is made to conform to the curvature of the end of the member **120** and the protruding end portion **126** of the thin resilient element **96** assumes a coned configuration extending either above or below the plane of the notch **124**. This end portion **126** of the resilient element **96** has the characteristics of bistability which have been discussed above in connection with other embodiments.

When it is desired to snap the blade **126** out of engagement with stationary contact **94** and into engagement with stationary contact **94**, the actuator rod **112** may be moved upwardly by pressing against its lower end. The locations of the stops **116** and **118** are chosen so that the amount of rod motion permitted thereby will be sufficient to produce the desired snap actions of the blade **126**.

The resilient element **96** need not be a laminate. It may be formed from a single layer of electrically conductive sheet metal material. In this instance, the resilient element **96** will serve to complete circuits extending from the eccentric elements **102** and **104** to the contacts **92** and **94**. If desired, the body element **120** of the actuator means may be formed from some suitable insulator such as a ceramic material.

The use of a single layer of electrically conductive sheet material as the thin resilient element of the assembly is of course a feature which may be applied if desired in embodiments other than that illustrated in FIGS. **12** to **14**. For example, in a device similar to that illustrated in FIG. **1**, the upper reaction surfaces on the cover might be nonconductive and a single layer resilient element might be employed as a common to electrically connect either of the contacts on the base to circuits extending through the center posts.

Although the illustrated embodiments include symmetrically arranged stationary contacts or reaction surfaces, various asymmetrical arrangements may be used. For example, if it were desired that the actuator-movable contact assembly of a device such as that shown in FIG. **1** should exhibit a preference for a particular one of its two basic positions, this effect could easily be achieved by changing the relative levels of the reaction surfaces. Such an arrangement may be visualized readily by referring to FIG. **1** and picturing the contact **10** as being elevated to a position above the pivot axis of the actuator-movable contact assembly. In this device, the spring forces developed within the blade **46** when the handle **30** is positioned at the left end of the slot **32** would be sufficient to flip the assembly back to the illustration position upon release of the handle.

Similarly, it will be evident that the invention is not restricted to devices embodying manually operable handles such as those illustrated for moving the actuator elements. The forces for effecting actuator movement may be supplied by whatever means best suit the particular application of the invention.

Still other variations and modifications will be apparent to persons skilled in the art. It is intended therefore that the foregoing detailed description of the embodiments illustrated in the drawings be considered as exemplary only, and that the scope of the invention be ascertained from the following claims.

I claim:

1. Electrical contact making and breaking apparatus comprising:

means providing opposed, spaced apart, reaction surfaces at least one of which is electrically conductive;

a thin, resilient element including a longitudinally extending blade having opposite longitudinal edges and an interior edge that is spaced from said reaction surfaces and from said longitudinal edges, an outer end portion of said blade being movable alternately into engagement with said surfaces;

means stressing said blade to be positionally unstable in a central position thereof and to be biased toward a transversely curved configuration extending longitudinally at an angle on either side of said central position, said blade including an inner portion adjacent said interior edge, said outer end portion having an electrically conductive front face portion engaging an electrically conductive one of said reaction surfaces in one position of the blade and a back face engaging the opposite reaction surface in another position of the blade;

actuator means for moving said inner portion of said blade back and forth relative to said reaction surfaces, said actuator means cooperating with said blade to urge said outer end portion against the engaged reaction surface with increasing contact force upon movement of said actuator means in one direction and to progressively buckle successive transverse cross sections of said blade from adjacent said outer end portion toward said inner portion upon continued movement of said actuator means and thereby to increase contact force until said blade reaches its unstable central position and snaps so as to make and break electrical contact between said electrically conductive front face portion of said blade and an electrically conductive one of said reaction surfaces.

2. Electrical contact making and breaking apparatus according to claim **1**, wherein said angle is at least 5°.

3. Electrical contact making and breaking apparatus according to claim **1**, wherein said angle is at least 10°.

4. Electrical contact making and breaking apparatus according to claim **1** wherein movement of said actuator means in one direction causes said free outer end portion of said blade to snap in an opposite direction, whereby the initial motion of said actuator means in a contact breaking sequence serves to increase contact pressure.

5. Electrical contact making and breaking apparatus according to claim **4**, wherein the extent of movement of said actuator means is so restricted relative to the locations of said reaction surfaces as to prevent said blade in said one of its stable positions from extending outwardly at a uniform angle throughout its length, whereby an outer end portion of said blade is elastically bent to maintain a substantial contact pressure between said electrically conductive front face portion of said blade and an electrically conductive one of said reaction surfaces when said actuator means is at one end of its path of movement.

6. Electrical contact making and breaking apparatus according to claim **5**, wherein said actuator means during the final motion of a contact making sequence cooperates with said blade to change the linear distance along said front face of said blade from said actuator means to said electrically conductive one of said reaction surfaces, whereby said electrically conductive front face portion of said blade wipes against such reaction surface while contact pressure is being applied to effect a contact cleaning action.

7. Electrical contact making and breaking apparatus according to claim **4**, wherein said actuator means during the initial motion of a contact breaking sequence cooperates with said blade to change the linear distance along said front face of said blade from said actuator means to said electrically conductive one of said reaction surfaces, whereby said electrically conductive front face portion of said blade wipes under pressure against such reaction surface while contact pressure is being applied to effect a contact cleaning action.

8. Electrical contact making and breaking apparatus according to claim 1 wherein said thin resilient element is a laminate comprising an electrically insulating layer of sheet material having adhered to the front surface thereof a partial layer of electrically conductive material for forming a portion of a circuit when the front face of said blade is in contact with an electrically conductive one of said reaction surfaces.

9. Electrical contact making and breaking apparatus according to claim 8, wherein said laminate includes a thin layer of spring metal sheet material adhered to the back surface of said electrically insulating layer.

10. Electrical contact making and breaking apparatus according to claim 9, wherein opposed reaction surfaces are both electrically conductive; and wherein said laminate includes a second electrically insulating layer of sheet material adhered to the back surface of said spring metal layer, and a second partial layer of electrically conductive material adhered to the back surface of said second electrically insulating layer.

11. Electrical contact making and breaking apparatus comprising:

means providing a first set of opposed spaced-apart reaction surfaces at least one of which is electrically conductive;

means providing a second set of opposed spaced-apart reaction surfaces spaced longitudinally from said first set;

a thin resilient element having a longitudinal axis and an intersecting transverse axis located between said sets of reaction surfaces and including blades at its ends spaced apart by a middle portion,

said middle portion being oriented along the plane of said axes and being tiltable about said transverse axis,

means stressing said element, said stressing means biasing said blades toward a transversely curved cone configuration with the curvature of each blade increasing progressively from adjacent the respective ends toward said middle portion,

each of said blades being positionally unstable when extending flat in the plane of said axes but being positionally stable when allowed to assume a coned configuration extending at an angle on either side of said plane,

a first one of said blades extending at an angle on one side of said plane and including a free outer end portion protruding into the space between said reaction surfaces of said first set, said free end portion including an electrically conductive face portion for engaging an electrically conductive one of said reaction surfaces and an opposite face for engaging an opposite one of said reaction surfaces,

a second one of said blades extending at an angle on the opposite side of said plane and including a free outer end portion protruding into the space between the said reaction surfaces of said second set, said free end portion including opposite faces for engaging opposite ones of said reaction surfaces, and

actuator means for tilting said middle portion about said transverse axis and simultaneously moving inner portions of said blades relative to said sets of reaction surfaces, said actuator means cooperating with said element to urge said blade end portions against said reaction surfaces with increasing contact force upon tilting movement of said actuator means in one direction and to progressively buckle successive transverse cross section of said blades from adjacent said end portions toward said middle portion upon continued movement of said actuator means and thereby to increase contact force until said blades snap through their unstable central positions.

12. Electrical contact making and breaking apparatus according to claim 11, wherein the spacings between said opposed reaction surface of said first set and between said opposed reaction surfaces of said second set are so restricted that said blades bend longitudinally at their outer end portions in the stable positions thereof to yieldingly press against said reaction surfaces.

13. Electrical contact making and breaking apparatus according to claim 12, wherein said middle portion of said thin resilient element is provided with an elongated central opening therethrough, and wherein said actuator means includes an element extending longitudinally across said opening and being connected to edge portions of said opening only at the inner marginal ends of said bistable blades.

14. Electrical contact making and breaking apparatus according to claim 13, wherein said middle portion of said thin resilient element includes flexible mounting tabs protruding into said opening at the location of said transverse axis, and in which stationary mounting means are connected to said tabs for supporting said resilient element and said actuator means.

15. Electrical contact making and breaking apparatus according to claim 13, wherein mounting means are provided and wherein said element of said actuator means is pivotally connected to said mounting means for movement about said transverse axis.

16. Electrical contact making and breaking apparatus according to claim 11 wherein said first set of reaction surfaces includes a plurality of spaced-apart reaction surfaces at one level and a plurality of opposing, spaced-apart reaction surfaces at another level, and wherein said free outer end portion of said first blade includes a plurality of spaced apart contact fingers positioned for cooperation with opposed ones of said reaction surfaces of said first set.

17. Electrical contact making and breaking apparatus according to claim 16 wherein all of said reaction surfaces of said first set are electrically conductive, and wherein said thin resilient element is a laminate of electrically conducting and nonconducting layers arranged so as to expose electrically conductive material on opposite faces of said contact fingers.

18. Electrical contact making and breaking apparatus according to claim 17 further characterized by mounting means connected to said middle portion of said thin resilient element, and wherein said electrically conductive material on the faces of said contact fingers is connected electrically to said mounting means.

19. Electrical switch apparatus comprising:

means providing a pair of opposed reaction surfaces spaced apart from each other, at least one of said reaction surfaces being electrically conductive,

a thin resilient elongated element having opposite longitudinal edges and a pair of transverse edges spaced longitudinally of said element, one of said transverse edges including a concavely curved portion, said one transverse edge being spaced from said reaction surfaces, a portion of said element adjacent the other of said transverse edges being movable alternately into engagement with said surfaces,

an actuator, said actuator having an arcuate notch, said curved transverse edge of said element being received in said notch, said notch having a radius of curvature that is less than the corresponding radius of curvature of said curved transverse edge, said element including leg portions extending on opposite sides of said actuator in a direction away from said other transverse edge, means for applying tension to said leg portions, thereby causing said curved transverse edge to conform to the curvature of said notch and stressing said element to assume a transversely curved cross-sectional configuration that is convex on one face of said element, said element including electrical conductor means in position for contacting said electrically conductive reaction surface when said element engages said conductive reaction surface, and

means for displacing said actuator relative to said reaction surfaces in a direction causing said element portion adjacent said other transverse edge to deflect while in engagement with one of said reaction surfaces and to flatten said element from adjacent said member progressively toward said notch until the element snaps over into engagement with the other reaction surface.

20. The apparatus according to claim **19** wherein said tension means includes means for holding said element at a substantially fixed distance from said notch while said element snaps over between said reaction surfaces.

21. The apparatus according to claim **19** wherein said displacing means includes bearing means defining a transverse pivot axis for said actuator, said pivot axis being spaced from said notch, whereby swinging said actuator about said transverse axis causes said element portion that is adjacent said other transverse edge to deflect.

22. The apparatus according to claim **19** including means for maintaining a portion of said element stationary during operation of said displacing means, said element including electrical conductive means extending between said stationary portion and said element portion adjacent said other transverse edge.

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