Nov. 10, 1970 D. F. WILKES 3,539,742

ELECTRICAL SNAP SWITCH HAVING STRESSED BLADE

Filed Dec. 4, 1968 4 Sheets-Sheet 1

FIG. 1

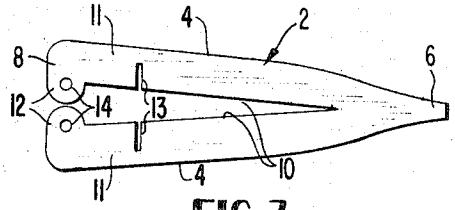


FIG. 2

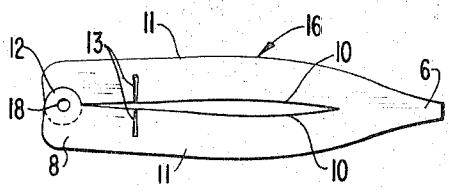


FIG. 3

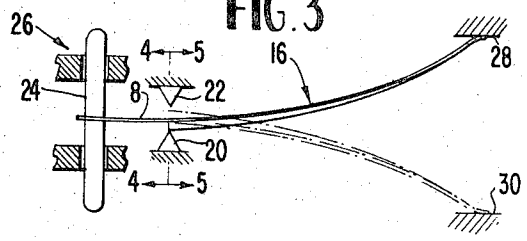
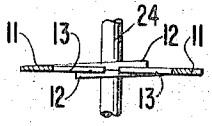


FIG. 4



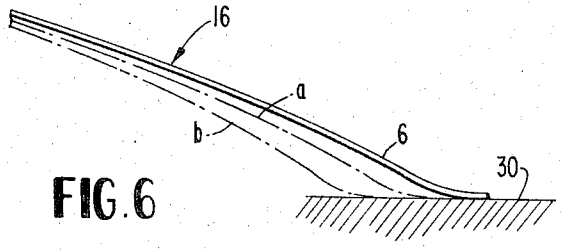


FIG. 6

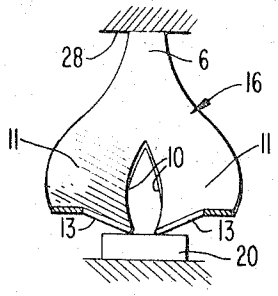


FIG. 5

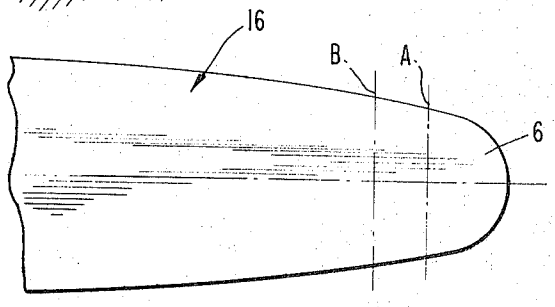


FIG. 7

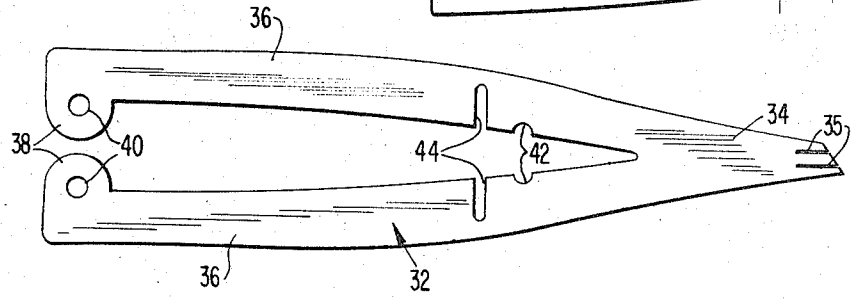


FIG. 8

INVENTOR
DONALD F. WILKES

BY

Burns, Doane, Benedict, Swecker & Mathis
ATTORNEYS

ELECTRICAL SNAP SWITCH HAVING STRESSED BLADE

Filed Dec. 4, 1968 4 Sheets-Sheet 2

FIG. 9

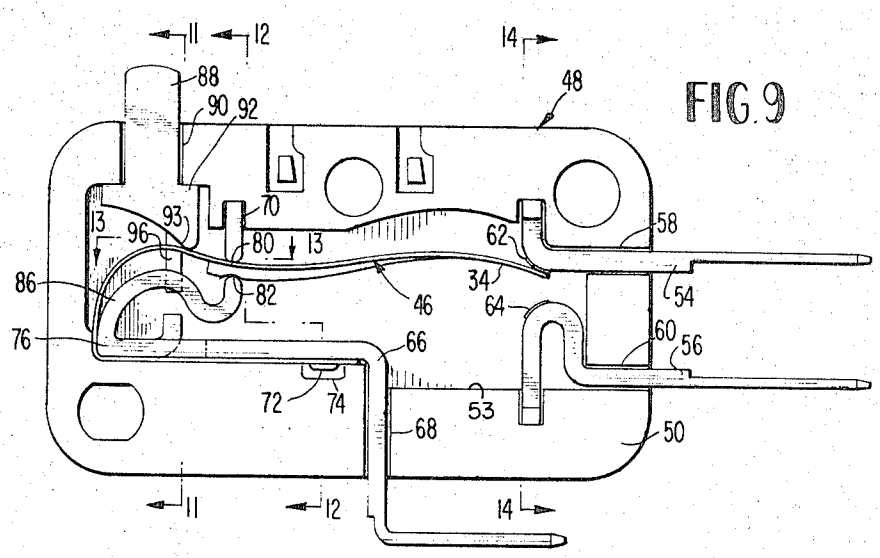


FIG. 10

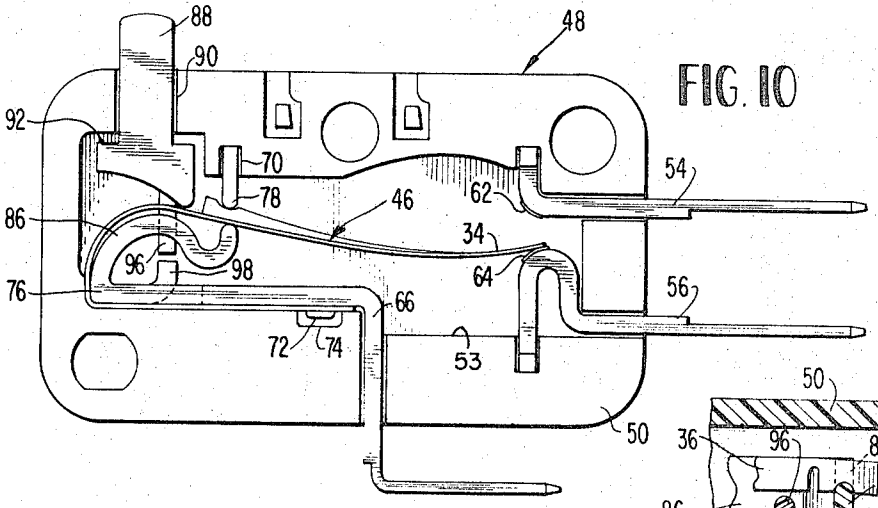


FIG. 13

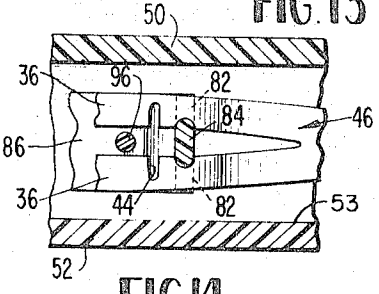


FIG. 11

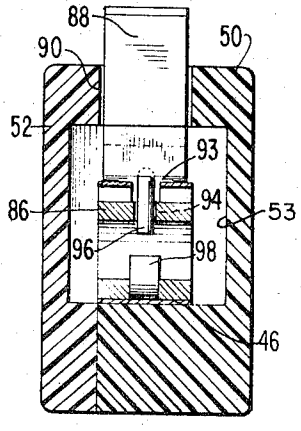


FIG. 12

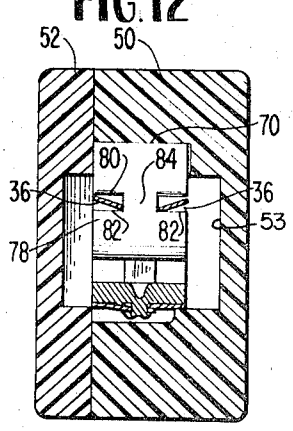
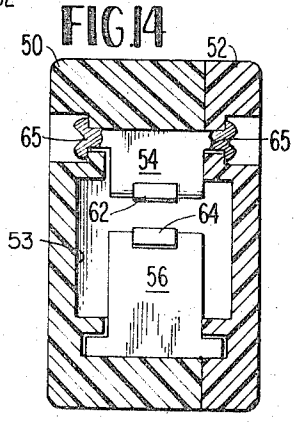


FIG. 14



Nov. 10, 1970 D. F. WILKES 3,539,742

ELECTRICAL SNAP SWITCH HAVING STRESSED BLADE

Filed Dec. 4, 1968 4 Sheets-Sheet 3

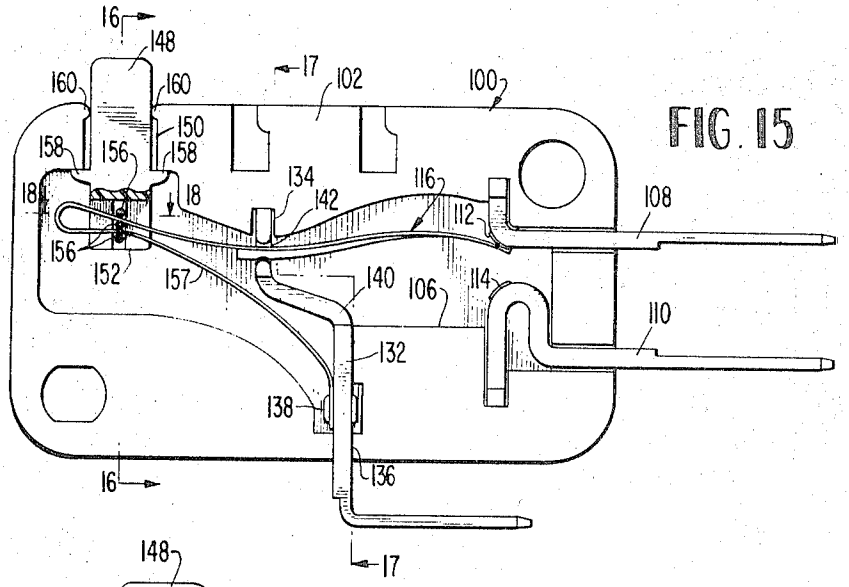


FIG. 15

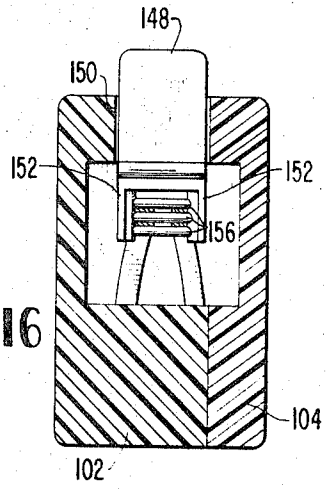


FIG. 16

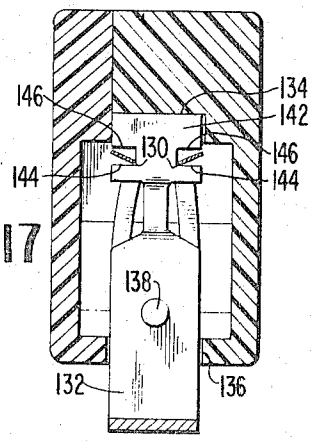


FIG. 17

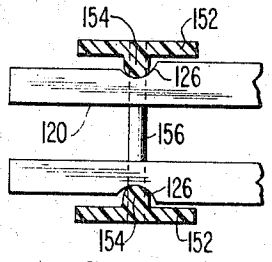


FIG. 18

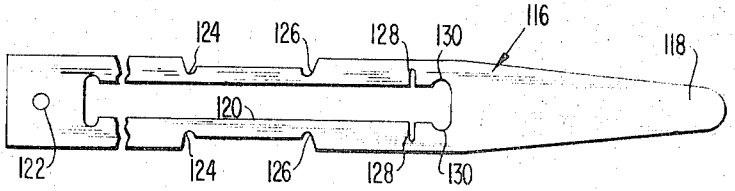


FIG. 19

INVENTOR
DONALD F. WILKES

BY

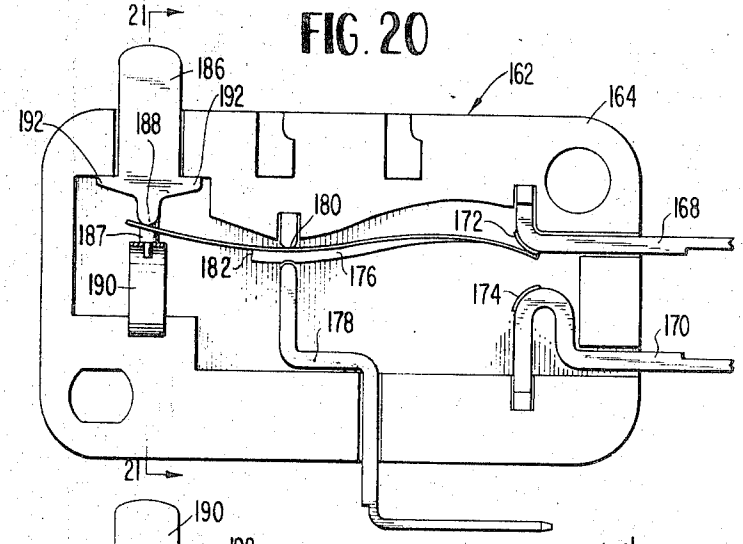
Burns, Doane, Benedict, Swecker & Mathis
ATTORNEYS

Nov. 10, 1970 D. F. WILKES 3,539,742

ELECTRICAL SNAP SWITCH HAVING STRESSED BLADE

Filed Dec. 4, 1968 4 Sheets-Sheet 4

FIG. 20



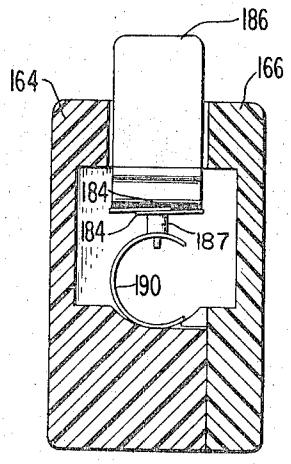


FIG. 21

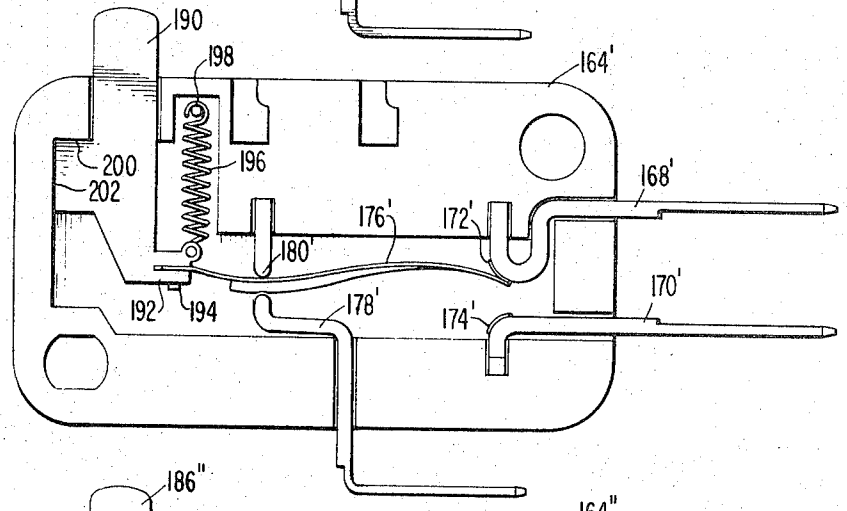


FIG. 22

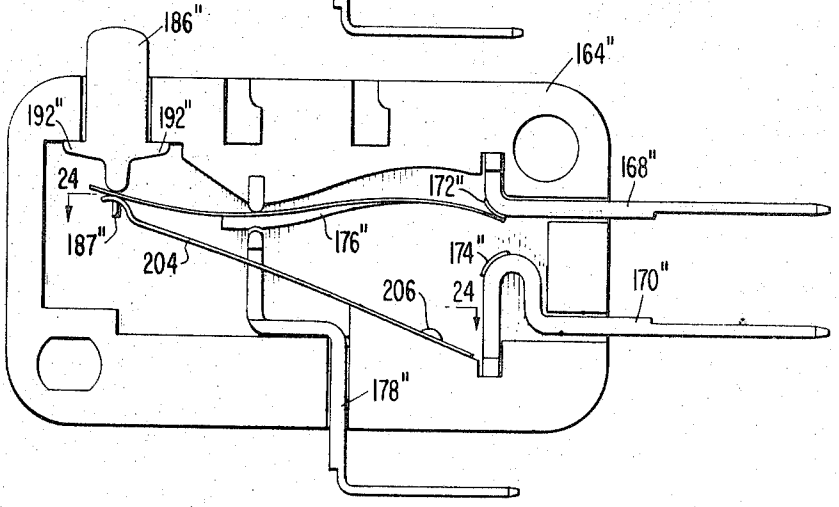


FIG. 23

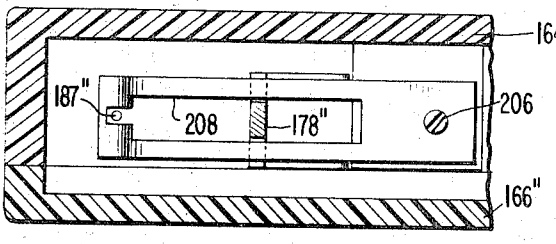


FIG. 24

INVENTOR
DONALD F. WILKES

BY
Burns, Doane, Benedict, Swecker & Mathis
ATTORNEYS

United States Patent Office

3,539,742

Patented Nov. 10, 1970

3,539,742

ELECTRICAL SNAP SWITCH HAVING STRESSED BLADE

Donald F. Wilkes, Albuquerque, N. Mex., assignor to Rolamite Technology, Incorporated, San Francisco, Calif., a corporation of California

Filed Dec. 4, 1968, Ser. No. 781,120
Int. Cl. H01h 13/36
U.S. Cl. 200—67 29 Claims

ABSTRACT OF THE DISCLOSURE

An electrical switch of the type having a switch blade movable between a pair of opposed contacts and a plunger that is spring biased for displacing the blade from engagement with one contact into engagement with the other contact. The switch has an elongated blade that is supported by a reaction surface in the switch housing so that one end of the blade is movable between the opposed electrical contacts. An actuator mounted in the housing engages the blade for effecting displacement of the blade end from one contact to the other. The blade is arranged to provide spring bias for urging the actuator toward an inactive position. When the actuator is displaced sufficiently to deflect the blade, the contact end of the blade snaps from one contact to the other and when the actuator is released, the contact end of the blade snaps back to the first contact. The various components of the switch may be modified to provide a variety of modes of operation and characteristics without altering the basic switch structure.

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of my copending applications entitled "Electrical Contact Making and Breaking Apparatus," Ser. No. 717,090, filed Mar. 29, 1968 and "Snap Action Apparatus," Ser. No. 717,114, filed Mar. 29, 1968.

BACKGROUND OF THE INVENTION

This invention relates to electrical switch apparatus and, more particularly, to electrical switches of the snap action type.

Snap action switches have a great variety of applications because they provide rapid circuit making and breaking and are moderately shock resistant. Such switches are often small in size. A microswitch may typically be about one inch long, one-half inch wide and one-quarter inch thick. The switch blade and actuating components of the switch are often required to undergo several million operations without failure and these small switches are expected to be capable of conducting as much as 15 amps current at 125 to 250 volts AC.

Present microswitches contain a large number of parts to provide the snap action of the switch blade. Most of these parts are manufactured to close tolerances, which is especially difficult due to their small size. These small parts must be accurately assembled together and installed in the housing. The cost of the switch is dependent to some extent on the number of parts and the difficulty with which the switch parts are assembled.

Another problem with conventional microswitches is that the various components are arranged in engagement with each other for relative movement. This requires accurate alignment of the components. Also, the working joints between components are sources of high stress and frictional drag. Consequently, wear at the working joints often causes failure of the switch.

The electric contacts on the blade and on the switch terminals that are engaged by the blade of conventional microswitches may be subjected to rapid wear because of arcing at the contacts that results from inadequate contact pressure. It is particularly important to have sufficient contact pressure just prior to the time that the switch blade disengages the stationary contact. Pitting and other surafce defects may cause unreliable switching characteristics. Inadequate contact pressure also renders the switch unacceptable for use where shock and vibration might cause unpredictable switching behavior. Also, unless high contact pressure is provided when the blade first engages the terminal, the blade may bounce away and momentarily make and break the circuit before finally coming to rest against the terminal.

Accordingly, it is an object of this invention to provide improved switch apparatus.

It is another object of this invention to provide switch apparatus having a minimum number of parts that are readily assembled in the switch housing.

It is a further object of this invention to provide a switch having improved contact making and breaking characteristics.

It is a still further object of this invention to provide a switch that is resistant to shock and vibration and has a minimum of frictional joints.

Another object of the invention is to provide a basic switch structure that can readily be modified to provide various modes of operation.

Another object is to provide a switch in which the movable contact element moves into engagement with the stationary contact rapidly, but with substantially less bounce than conventional switches.

SUMMARY OF THE INVENTION

These objects are accomplished in accordance with several preferred embodiments of the invention by a switch assembly having an elongated resiliently flexible, electrically conductive switch blade mounted in a housing. The switch blade is preferably constructed of thin material and has contact surfaces at one end and a slot extending longitudinally of the blade. The slot is spaced from the contact surfaces and the leg portions of the blade which are on opposite sides of the slot are displaced toward each other to stress the blade and thereby distort the blade into a shape in which the contact surfaces are displaced to one side or the other of a median plane. Opposed electrical contacts are provided in the housing in position to be engaged by the contact surfaces of the blade.

The blade is supported between a pair of transverse pivots that engage the blade at the edges of the slot. The blade extends beyond the pivots and an actuator is connected with the blade for applying a force generally perpendicular to the blade. The distortion due to stress in the blade maintains the end of the blade in engagement with one of the electrical contacts, but when the actuator applies a force to the blade which tends to flatten out the blade against the pivot, the stresses ultimately cause the blade end to snap over into engagement with the opposite contact. The blade remains in that position until a return force is applied by the actuator. The electrical circuit may be completed through the blade to either housing contact.

In another embodiment, the housing has a pair of opposed electrical contacts adjacent one end and a terminal along one side. An actuator plunger extends through the opposite side of the housing. The switch blade is formed of a thin, naturally flat material and has a longitudinal slot extending axially between points spaced from opposite ends of the blade. Opposed notches are provided in the slot and a reaction surface in the housing engages the

notches to prevent longitudinal displacement of the blade relative to the housing at the reaction surface. The blade extends outwardly from the reaction surface to the region between the opposed stationary contacts. The portion of the switch blade on the opposite side of the reaction surface is positioned to be engaged by the actuator plunger and to urge the plunger toward an outward position relative to the housing. Also, the opposite lateral edges of the slot in the remaining portion are displaced toward each other and fixed relative to each other to impose tensile stresses along the lateral edges of the blade on opposite sides of the reaction surface and to impose compressive stresses in the blade at the junction between the reaction surfaces and the blade. The stresses cause the blade to assume a generally frustoconical shape, with the outer end of the blade being generally flat due to engagement with one of the housing contacts. Snapping of the blade is accomplished by displacing the plunger against the blade. This causes the reaction force of the housing contact on the blade to increase, thereby progressively displacing the transverse bending axis of the blade contact end toward the reaction surface. Ultimately the blade snaps from one stationary contact to the other. The spring bias imposed by the blade on the actuating plunger continuously urges the plunger outwardly and when the plunger is released, the blade snaps back to its original position.

A third embodiment includes a switch blade and pivot arrangement in a housing as described with respect to the second embodiment, but the spring return force is provided by a separate spring connected with a plunger. The plunger engages the blade at the end opposite the contact end and is urged outwardly of the housing by the spring. Displacement of the plunger inwardly causes the blade to snap over from one housing contact to the other. When the plunger is released, the blade snaps back into engagement with the first contact.

DESCRIPTION OF THE DRAWINGS

These preferred embodiments of the invention are illustrated in the accompanying drawings in which:

FIG. 1 is a top plan view of switch blade preform according to this invention;

FIG. 2 is a top plan view of the completed switch blade incorporating the preform of FIG. 1;

FIG. 3 is a schematic view of a switch employing the blade of FIG. 2;

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

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

FIG. 6 is an enlarged side elevational view of the contact end of the blade in FIG. 3;

FIG. 7 is a top plan view of the blade shown in FIG. 6;

FIG. 8 is a top plan view of a modified blade preform.

FIG. 9 is a side elevational view with the cover removed of a second switch embodiment of this invention employing the preform of FIG. 8;

FIG. 10 is a side elevational view with the cover removed of the switch as in FIG. 9, but showing the blade displaced into engagement with the opposite terminal contact;

FIG. 11 is a cross-sectional view of the switch along the line 11—11 in FIG. 9;

FIG. 12 is a cross-sectional view of the switch along the line 12—12 in FIG. 9;

FIG. 13 is a cross-sectional view of the switch along the line 13—13 in FIG. 9;

FIG. 14 is a cross-sectional view of the switch along the line 14—14 in FIG. 9;

FIG. 15 is a side elevational view with the cover removed of a modified form of the second switch embodiment according to this invention;

FIG. 16 is a cross-sectional view of the switch along the line 16—16 in FIG. 15;

FIG. 17 is a cross-sectional view of the switch along the line 17—17 in FIG. 15;

FIG. 18 is a cross-sectional view of the switch along the line 18—18 in FIG. 15;

FIG. 19 is a top plan view of the switch blade preform of the blade in the switch of FIG. 15;

FIG. 20 is a side elevational view with the cover removed of a third embodiment according to this invention;

FIG. 21 is a cross-sectional view of the switch along the line 21—21 in FIG. 20;

FIG. 22 is a side elevational view with the cover removed of a modified form of the third embodiment;

FIG. 23 is a side elevational view with the cover removed of a second modified form of the third embodiment; and

FIG. 24 is a cross-sectional view of the switch along the line 24—24 in FIG. 23.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1 to 5, a sheet of thin, naturally flat, electrically conductive and resiliently flexible sheet material, such as spring metal, is cut in the shape indicated in FIG. 1, which is a preform 2 for a snap action switch blade. The preform 2 has a uniform thickness and is substantially flat. The preform has opposite lateral edges 4 extending from the contact end 6 to the actuating end 8. A longitudinal slot in the preform has opposite slot edges 10, so that a pair of legs 11 are defined by the edges 4 and 10. The legs are spaced progressively wider apart from adjacent the contact end to actuating end 8 where the legs have tabs 12 projecting toward each other. Outwardly extending decoupling slots 13 are provided in the legs 11 and a pair of holes 14 are also provided in the tabs 12.

The preform 2 of FIG. 1 is transformed into a switch blade 16 by positioning the tabs 12 in overlapping relation with the holes 14 in alignment. A rivet or pin 18 is secured in the holes 14 to maintain the blade 16 in the shape shown in FIG. 2. The blade 16 is stressed by the displacement of the free ends of the legs 11 toward each other. The blade material along the opposite lateral edges 4 of the blade 16 is stressed in tension which induces compressive stresses in the material along the slot edges 10. The material of the blade 16 is thin and is capable of sustaining tensile stresses, but the compressive stresses cause the center portion of the blade to buckle transversely. The decouplng slots 13 relieve the compressive stresses at the actuator end 8 thereby allowing the actuator end of the blade 16 to remain generally flat, allowing for the overlapping arrangement of the tabs joined by the pin or rivet 18.

The blade 16 of FIG. 2 is shown schematically in FIGS. 3, 4, and 5, as mounted in a switch assembly. The blade 16 is positioned between a pair of opposed pivot blocks 20 and 22. The actuator end 8 of the blade 16 is secured to a double acting plunger 24, which is mounted for longitudinal sliding movement between support structure indicated generally at 26. Opposed contact surfaces 28 and 30 are shown schematically in position to be engaged by the contact end 6 of the blade 16.

As shown in FIG. 5, the blade 16 is supported on the lower pivot 20 which engages the edges 10 of the slot in the blade and the decoupling slot 13 allows the center portion of the blade to buckle transversely, as shown in FIG. 5, while the rear portion of the blade remains substantially flat, as shown in FIG. 4. This distortion causes the contact end 6 of the blade to be arched upwardly as viewed in FIGS. 3 and 5 when the edges 10 of the slot are displaced downwardly. When the plunger 24 is displaced downwardly, as viewed in FIG. 3, the pivot 20 exerts an upward reaction force on the blade 16 at the slot edges 10. The sloping arrangement of the legs 11, as shown in FIG. 5, resists bending along the frustoconical center portion of the blade, and the blade initially acts like a

lever with the downward force of the plunger **24** serving to press the contact end **6** more firmly against the contact surface **28**. When the force of the pivot **20** on the blade **16** becomes so great that the blade is no longer able to resist collapsing, the center portion of the blade snaps over so that the edges **10** of the slot are in engagement with the upper pivot **22**. Now, instead of being generally concave on the upper side, the blade is concave on the lower side, so that the contact end **6** of the blade is rapidly displaced to the position shown in dotted lines in FIG. 3. The blade **16** will remain in that position until the plunger **24** is displaced upwardly to snap the blade back to the position shown in full lines in FIG. 3.

The switch blade assembly of FIGS. 3, 4 and 5, is bistable and has characteristics which are particularly advantageous in electrical switching. The switch contacts **28** and **30** and the blade contact **6** coatct to remove or reduce oxide or other material on the contacts which would otherwise increase the resistance across the contacts and would ultimately prevent current from being conducted from the blade **16** to the contact **28** or **30**. Another characteristic of this switch blade assembly is that the force holding the blade against the stationary contact increases before the blade snaps away from the contact. Also, when the blade engages the contact, considerable force is applied ot hold the blade against the stationary contact. In control circuits, for example, closing of the switch contacts must be accomplished without any ambiguity. If the blade tends to bounce away from the contact, immediately after first engagement then the resistance across the contacts changes abruptly and interferes with the accurate circuit response to operation of the switch. The switch blade shown in FIGS. 3, 4 and 5, imposes considerable force on the outer end of the blade **16**, urging the blade to remain continuously in engagement with the contact and to avoid bouncing.

The action of releasing the blade **16** from engagement with the lower switch contact **30** is illustrated schematically in FIGS. 6 and 7. As the plunger **24** is moved upwardly, displacement of the blade is resisted by the pivot **22**, and the actuating force on the plunger **24** is transmitted to the contact end of the blade. The blade **16** is shown in full lines in FIG. 6 in the position in which the blade remains when no external force is imposed on the plunger **24**. The outer end **6** bends in response to the blade force to assume a substantially flat shape that is in engagement with the contact surface **30**. As the force of the plunger **24** is transmitted to the contact end, the axis of transverse bending of the blade progresses across the surface until the axis is at the position indicated at A in FIG. 7. The blade assumes the shape shown by the line *a* in FIG. 6. Further deflection of the blade in response to the axial force on the plunger **24** displaces the bending axis rearwardly to the position marked B in FIG. 7, and the blade assumes the shape shown by the line *b* in FIG. 6. This bending of the outer end causes slight relative wiping motion between the blade end **6** and the surface **30** which dislodges any oxide or other film that might be present between the blade and the surface **30**.

It can be seen from FIGS. 6 and 7 that the bending axis A or B represents the outermost portion of the blade that is capable of sustaining tensile stresses that maintain the center portion of the blade in compression. When the blade can no longer sustain the force imposed perpendicularly by the plunger **24**, the tensile forces at the outer end of the blade initiate a buckling wave and that progresses from the outer end toward the pivot **22** which rapidly snaps the blade over to the opposite position. Since the sheet metal blade **16** is extremely thin and has a small mass, the snap action rapidly accelerates the blade away from one contact and into engagement with the other.

A second embodiment of the switch blade of this invention is illustrated in FIG. 8. The preform **32** is fabricated from a strip of electrically conductive material which is resiliently flexible and normally flat. The preform **32** has a contact end **34** which is divided into three flexible contact sections by longitudinal slots **35**. The sections are of different lengths, so that the sections engage and disengage the stationary contacts progressively, a pair of leg portions **36** in the preform **32** have inwardly extending tabs **38** at their ends. The tabs **38** are provided with holes **40**. The inner edge of each leg **36** is provided with a reactor slot **42** and a decoupling slot **44**. The preform **32** is assembled by displacing the tabs **38** into overlapping relation so that the holes **40** are in alignment and a fastener is inserted through the holes **40** to stress the preform so that it functions as a snap type switch blade, as described in relation to the blade in FIGS. 2 to 7.

The switch blade that is fabricated from the preform **32** is shown at **46** in FIGS. 9 to 13, as installed in a switch assembly **48**. The switch assembly **48** functions as a single pole double throw switch. The switch assembly **48** includes a housing **50**, which is preferably molded of insulating material. The housing has a cover **52** that is shown in FIGS. 11 and 12. In FIGS. 9 and 10, the cover has been removed to show the internal parts of the switch assembly. A pair of electrically conductive terminals **54** and **56** are mounted in grooves **58** and **60**, respectively, which extend through the wall of the housing. The terminals preferably have contact surfaces **62** and **64** that are in position to be engaged by the contact end **34** of the blade **46**. The terminal **54** also has lateral projections **65** (FIG. **14**) which extend through openings in the housing **50** and cover **52**. Similar projections may be provided on the terminal **56**. These projections are provided to serve as rivets holding the terminals in place and securing the cover on the housing.

An electrically conductive anchor bar **66** is also mounted in the housing **50**. The anchor bar extends through a groove **68** in the housing and the end of the anchor bar **66** is received in a slot **70** formed in the central cavity **53** in the housing **50**. Lateral projections similar to the projections **65** may be provided on the anchor bar **66** for securing the cover **52** to the housing **50**. The switch blade **46** is clamped between the anchor **66** and the wall of the cavity **53**, and as shown in FIGS. 10 and 12. The pin that joins together the tabs **38** of the preform (FIG. 8) is provided by an integral rivet **72**, which is formed by punching. The head of the rivet **72** is received in a slot **74** in the housing **50**. The anchor bar **66** has a right angle bend **76** which clamps an intermediate portion of the legs **36** (FIG. 8) against the end wall of the housing **50**. The snap action portion of the switch blade **46** is supported in a reactor **78** formed integrally in the anchor **66**. The reactor **78** includes upper and lower opposed reaction surfaces **80** and **82**, respectively, (FIG. 12). A mounting post **84**, formed in the anchor **66**, extends between the reaction surfaces **80** and **82**. The reactor slots **42** of the blade **46** are positioned on opposite sides of the post **84**. The post **84** has a width corresponding to the distance between the bottom of the opposed slots **42** and therefore the sides of the post **84** do not impose lateral stresses on the blade **46**, but merely serve to prevent longitudinal displacement of the blade relative to the post. The inner edges of the legs **36** engage the lower reaction surface **82**, as shown in FIG. 12. The outer edge of each leg **36** is spaced above the reaction surface **82** due to the transverse flexing induced in the blade **46**. The decoupling slots **44** are positioned between the reactor **78** and the bend **76** of the anchor. The blade **46** is flexed in an arc urging the intermediate portion of the blade away from the curved surface **86** of the anchor **66**.

A plunger **88** is mounted for reciprocating movement in a slot **90** formed in the wall of the housing **50**, as shown in FIGS. 9 and 11. The inner end of the plunger has shoulders **92** for limiting outward movement of the plunger engages the legs **36** of the blade **46** and due to the flexing of the intermediate portion of the blade **46**,

the plunger is urged outwardly to maintain the shoulders **92** in engagement with the wall of the housing. The curved portion **86** of the anchor **66** has a hole **94** (FIG. 11) to receive a pin **96** that is secured in the end of the plunger **88**. The pin **96** is in position to engage a stop **98** that projects upwardly from the anchor **66**. The pin **96** limits downward displacement of the plunger and provides overtravel protection.

In operation, the switch assembly of the embodiment shown in FIGS. 9 to 14 normally maintains an electrical circuit between the anchor **66**, and the terminal **54** through electrically conductive switch blade **46** when the blade is in the position shown in FIG. 9. When the plunger **88** is displaced inwardly relatively to the housing **50**, the legs **36** of the blade **46** are displaced downwardly, thereby increasing the reaction of the surface **82** (FIG. 12) on the snapper portion of the blade **46**. As deflection of the outer end of the blade **46** progresses in response to the displacement of the intermediate portion of the blade caused by the plunger **88**, the blade **46** snaps over to the position shown in FIG. 10. Further displacement of the plunger **88** merely causes the pin **96** to engage the stop **98** to prevent damage to the spring blade **46**. The electrical circuit is then disconnected from the terminal **54** and connected with the terminal **56**, as long as the plunger **88** remains in the postion shown in FIG. 10.

When the plunger is released, the spring bias of the curved leg portions **36** of the switch blade **46** urges the plunger outwardly until the shoulders **92** engage the wall of the housing **50**. This movement of the plunger allows the leg portion **36** of the blade **46** to return to the position shown in FIG. 9, thereby causing the blade to snap from the position shown in FIG. 10 to the position shown in FIG. 9 to re-establish the circuit with the terminal **54**.

Of course, the switch of FIGS. 9 and 10 can be readily converted to a single pole single throw switch by eliminating the terminal **56** and merely providing a shoulder or other reaction surface in the place of the contact **64**. Also, the switch can be converted to a long stroke, low force switch by reversing the plunger **88** so that the point of engagement of the plunger with the leg portions **36** is closer to the bend **76**. When the plunger is reversed in this way, the pin **96** should be removed because it is no longer in alignment with the hole **94** in the anchor **66**. In this mode of operation, the curved surface **86** of the anchor **66** provides adequate overtravel protection.

A third embodiment of the switch assembly of this invention is illustrated in FIGS. 15 to 19. The switch assembly **100** includes a housing **102** and a cover **104**. A cavity **106** is provided in the housing **102** for receiving the switch components. Electrically conductive terminals **108** and **110** are mounted in the housing **102** and generally correspond to the terminals **54** and **56** of the switch in FIG. 9. The terminals **108** and **110** are provided with contact coatings or strips **112** and **114**, respectively, for engagement by the switch blade.

The switch blade **116** is formed of thin naturally flat, sheet material that is electrically conductive, and resiliently flexible, as shown in FIG. 19. The blade **116** includes a contct portion **118** at one end and a longitudinal slot **120** extending through the central portion of the blade **116**. The anchoring end of the blade has a hole **122** and a pair of preloading grooves **124** and **126** along the outer lateral edges of the blade **116**. Also, decoupling slots **128** extend outwardly from the central slot **120**. The end of the slot **120** is enlarged to provide reaction edges **130** on opposite sides of the slot **120**. The blade **116** is secured in the housing **102** by an anchor bar **132**. The end of the bar **132** is recieved in a groove **134** formed in the wall of the housing **102** and the intermediate portion of the bar **132** extends through a slot **136** in the wall of the housing, so that it is rigidly maintained in position. The anchor end of the blade **116** is secured to the anchor bar **132** by a rivot **138**, or other suitable means, which extends through the hole **122** in the blade. The bar has a bend **140** and the blade **116** is looped between the bend **140** and the reactor **142**, provided on the anchor bar **132**. The reactor **142** has substantially the same shape as the reactor **78**, shown in FIGS. 9, 10 and 12, with the reaction edges **130** bearing against the opposed reaction surfaces **144** and **146** (FIG. 17).

The looped intermediate portion of the blade **116** is connected with a plunger **148** which is mounted for reciprocating movement in a slot **150** in the housing **102**. The plunger **148** has a pair of flanges **152** at its inner end. These flanges are spaced apart and have longitudinal ribs **154**. A plurality of rods **156** extend between the flanges **152** and the blade **116** is retained between the rods **156**. As shown in FIGS. 18 and 19, the blade has a pair of preloading grooves **124** and **126**. These grooves are positioned with respect to the ribs **154** on the plunger to retain the loop in the shape shown in FIG. 15. The preloading grooves **126** are positioned betwen the upper and middle rods **156**, while the grooves **124** are positioned between the middle and lower rods **156**. The distance between the ribs **154** is less than the width of the blade **116** at either of the grooves **124** or **126**, so that when the blade is mounted betwen the flanges **154** of the plunger, the opposite sides of the blade are displaced toward each other, thereby stressing the blade into the desired shape, as shown in FIG. 15. The grooves **124** and **126** prevent longitudinal movement of the blade relative to the ribs **154** as the plunger **148** reciprocates in the housing.

As shown in FIG. 15, the portion of the blade **116** between the plunger and the rivet **138** acts as a spring biasing the plunger **148** outwardly with respect to the housing. Shoulders **158** are provided on the plunger for engagement with the wall of the cavity **106** to restrict displacement of the plunger. Also, a pair of ribs **160** are provided on the housing on opposite sides of the plunger to allow slight pivoting movement of the plunger as it reciprocates.

In operation, the switchblade **116** is normally in the position shown in FIG. 15. In this position, an electric circuit is established between the anchor bar **132** and the terminal **108** through the blade **116** when the plunger **148** is displaced inwardly, the looped portion of the blade **116** is displaced downwardly and the lower end of the plunger swings slightly away from the reactor **142**. When the plunger has been displaced to exert sufficient force on the reaction edges **130** (FIGS. 17 and 19), the blade **116** snaps over to the opposite position where the blade end engages the contact surface **114** on the terminal **110**. The circuit is then established between the anchor bar **132** and the terminal **110**. When the plunger **148** is released, the curved portion **157** of the blade urges the plunger outwardly, thereby causing the blade to snap over to the position shown in FIG. 15 and movement of the plunger stops when the shoulders **158** engage the housing.

The curved portion **157** of the blade **116** is capable of providing a relatively strong restoring force on the plunger **148**, since the root of the curved portion is generally parallel to the direction of movement of the plunger **148**. If additional stiffness is required, the leg portions on opposite sides of the slot **120** along the curved portion **157** may be twisted to increase the effective cross-sectional area of the blade **116**.

Referring to FIGS. 20 to 24, it may be desirable to utilize spring biasing of the plunger independently of the switch blade **116**, and the third embodiment of this invention provides this variation.

The switch assembly **162** which is illustrated in FIGS. 20 and 21 include a housing **164** and a cover **166** electrically conductive terminals **168** and **170** are mounted in the housing. These terminals each have contact coatings or strips **172** and **174**. The switchblade **176** is supported on an anchor bar **178** which is rigidly mounted

in the housing **164**. The anchor bar **178** includes a reactor portion **180** which corresponds to the reactor **78** illustrated in FIGS. 9 to 14. The blade **176** corresponds generally to the shape illustrated in FIGS. 1 and 2, including decoupling slots **182** and overlapping tabs **184** which stress the blade into the shape shown in FIG. 20. A plunger **186** is mounted for reciprocating movement in the housing **164** and at its inner end is provided with a pin **187** which extends through aligned holes in the tabs **184**. The plunger also has a transverse bearing surface **188** which engages the surface of the blade **176**.

A C-shaped spring **190** is mounted between the opposite wall of the housing and the pin **187**. A projection of the pin **186** secures the spring and plunger together. The plunger also has shoulders **192** which engage the housing to limit outward movement of the plunger **186**. Of course, a coil or other appropriate spring could be substituted for the spring **190**.

When the plunger **186** is displaced inwardly relative to the housing **164**, the opposite ends of the spring **190** are compressed toward each other and the actuator end of the blade **176** is displaced downwardly until the blade snaps over into engagement with the contact strip **174**. When the plunger **186** is released, the spring **190** displaces the plunger outwardly until the shoulders **192** engage the wall of the housing. The displacement of the actuator end during movement of the plunger outwardly causes the blade **176** to snap over into engagement with the strip **172**.

A modified form of the switch is shown in FIG. 22. In this form, the housing **164'**, the terminals **168'** and **170'** are comparable to the corresponding components illustrated in FIG. 20. The anchor bar **178'** has a reactor **180'** which supports the switch blade **176'**, as shown in FIG. 22. The end of the blade **176'** is normally in engagement with the contact **172'**. A plunger **190** is mounted for reciprocating movement in the housing **164'** and is provided at its inner end with a bifurcated flange **192**. The overlapping tabs of the blade **176'** are received in the slot of the flange **192** and a pin **194** retains the tabs in the slot in overlapping relation. A coil spring **196** is attached at one end of the flange **192** and at the opposite end to a pin **198** on the housing **164'**.

The spring **196** urges the plunger **190** outwardly relative to the housing **164'**. Of course, a C-shaped, or other suitable spring, can be substituted for the coil spring **196**. Outward movement of the plunger **190** is restricted by a shoulder **200** which engages the wall of the housing **164'**. When the plunger **190** is displaced inwardly, the movement of the actuator end of the blade **176'** causes the blade to snap over into engagement with the contact **174'**. Inward movement of the plunger is limited by the engagement of the pin **194** with the opposite wall of the housing **164'**. When the plunger **190** is released, the spring **196** displaces the plunger outwardly, thereby snapping the blade over into engagement with contact **172'**. The plunger **190** has a guide surface **202** which engages the end wall of the housing **164'** in order to maintain the plunger in a straight path during reciprocating movement.

A second modified form of the switch is shown in FIGS. 23 and 24. This form of the invention includes a housing **164''** with terminals **168''** and **170''**. An anchor bar **178''** supports the switch blade **176''**. The blade is movable into engagement with the contact strip **172'** or the strip **174''**. A plunger **186''** is mounted in the housing for reciprocating movement. At the inner end, the plunger has a pin **187''** that extends through the overlapping tabs at the actuator end of the switch blade **176''**. A cantilever spring **204** is secured on a sloping portion of the housing wall by a screw or other suitable means **206**. The spring **204** has a longitudinal slot **208** through which the anchor bar **178''** extends. The free end of the spring **204** bears against the underside of the blade **176''** and the slot **208** includes a portion through which the pin **187''** extends.

When the plunger **186''** is displaced inwardly relative to the housing **164''**, the actuator end of the blade **176''** swings downwardly with the free end of the spring **204**. Ultimately, the blade **176''** snaps over into engagement with the opposite contact surface **174''**. When the plunger **186''** is released, the spring **204** urges the plunger outwardly until the shoulders **192''** on the plunger engage the wall of the housing. The free end of the spring **204** is curved transversely to provide a continuous bearing surface as the spring deflects.

An important feature of the several switch embodiments of this invention is the remarkable reduction in the number of components as compared with conventional snap action switches. This is particularly important in microswitches which are so small that it is difficult to assemble the parts. The active components of the switches of this invention can be completely assembled together before being installed in the housing. This makes adjustments relatively easy since it allows access to all sides of the components during assembly. Also, the arrangement of the components permits the use of automated assembly techniques.

The switch assembly of this invention also provides more effective switching characteristics due to the use of a snapper blade actuation that does not decrease the contact forces between the blade and the terminal contact until the instant of opening when the blade is moving away from the terminal. When the blade moves into engagement with one of the terminal contacts, bouncing does not occur because the blade is urged firmly against the contact by the spring forces in the blade. Furthermore, the wiping action that occurs at the contacts extends the life of the switch and overcomes the problems of contamination at the contact surfaces.

Unlike conventional switches, the cooperating surfaces between moving parts of the switch are substantially free of relative sliding motion, and the blade is only lightly stressed in either contact position. Consequently, frictional wear and frictional drag are substantially eliminated. This is particularly important where large spring forces are imposed for snapping the switch blade from one position to another. These switches do not have any knife edge working joints and therefore the attendant problems of parallel alignment of the knife edges and high stress, in addition to the friction and wear problems, are not present in the switches of this invention.

The switches of this invention are capable of a variety of configurations without substantial changes in the components. The switches may be made to operate as normally open or normally closed, or bistable switches which are double acting. Another important advantage is that the actuating force on the plunger of these switches is independent of the force exerted on the contact by the switch blade, and the deflection of the blade during switching, the displacement of the plunger required for switching, and the spring bias for returning the plunger can all be adjusted independently to obtain the particular characteristics desired. Thus, utilizing the same basic components, a family of switches are provided at a minimum of cost.

Since the switch blade is thin, it has a relatively low mass. The spring action therefore is capable of rapidly accelerating the blade end from one contact to the other. The large contact force in relation to the mass also makes these switches resistant to shock and vibration.

While this invention has been illustrated and described in several preferred embodiments, it is recognized that variations and changes may be made therein without departing from the invention as set forth in the claims.

What is claimed is:

1. An electrical switch comprising:

base means, a contact on said base means;

an elongated switch blade having opposite faces and opposite lateral edges and having one end adjacent said contact, said blade being thin, naturally flat and resiliently flexible and having an elongated slot therein, one end of said slot being spaced longitudinally from the contact end of said blade, means transversely displacing said opposite lateral edges toward each other in a zone coextensive with said slot and spaced longitudinally from said slot end, said transverse displacement stressing said blade in tension along said opposite lateral edges and in compression adjacent said slot end, thereby normally constraining said blade in a flexed state capable of sustaining bending moments at said slot end and at said contact end, said blade being flexed in a substantially concave shape alternatively on said opposite faces,

means mounting said blade in said base means, said mounting means including a pair of opposed pivot surfaces in position to engage said blade face adjacent the edges of said slot, said blade having a pair of decoupling slots extending outwardly from said longitudinal slot, said decoupling slots being spaced on the opposite side of said pivot surfaces from said slot end,

means for moving a portion of said switch blade in a direction substantially perpendicular to said blade faces, said blade portion being on the opposite side of said decoupling slots from said pivot surfaces, means for resiliently resisting displacement of said blade portion by said moving means,

a second contact on said base means opposite said first mentioned contact, said blade end being movable between said first and second contacts upon displacement of said blade portion, said blade engaging said contacts when in said flexed state, said blade and at least one of said contact means being electrically conductive, whereby said moving means applies leverage to said blade through one of said pivot surfaces to progressively bend said blade contact end against said contact until said blade snaps over into engagement with the other contact.

2. The electrical switch according to claim **1** wherein said transverse displacement means includes a pair of tabs formed integrally on said blade adjacent the end opposite said contact end, said tabs being displaced into overlapping relation and joined together.

3. The electrical switch according to claim **1** wherein said slot has opposite ends and said lateral blade edges are displaced toward each other midway of the length of said longitudinal slot.

4. The electrical switch according to claim **1** wherein said displacement resisting means includes a portion of said blade arranged in a loop in said base means, and means securing said opposite end of said blade against movement relative to said base means.

5. The electrical switch according to claim **4** including an anchor member, means mounting said anchor member in said base means, said pivot surfaces being provided on said anchor member and said opposite end of said blade being secured on said anchor member.

6. The electrical switch according to claim **5** wherein said anchor member has an angular bend between said blade securing means and said pivot surfaces, said blade loop extending between said pivot surfaces and said bend.

7. The electrical switch according to claim **5** wherein said moving means includes a plunger on said blade portion, said plunger being movable toward and away from said anchor member, and including means on said anchor member for limiting displacement of said plunger.

8. The electrical switch according to claim **1** wherein said moving means includes a plunger on said blade portion and said displacement resisting means includes spring means connected between said plunger and said base means.

9. An electrical switch comprising:

a housing having a hollow cavity therein, said housing having opposed reaction surfaces in said cavity;

an anchor member, means mounting said anchor member in said housing;

a thin, naturally flat, resiliently flexible switch blade in said housing cavity, said blade having a longitudinal slot therein, said blade slot having one end spaced longitudinally from one end of said blade, said one blade end extending between said housing reaction surfaces;

said blade having a pair of reactor slots extending laterally from said longitudinal slot, said anchor member having a pair of opposed pivot surfaces, said blade reactor slots being aligned with said pivot surfaces, said blade opposite end being separated by said slot and secured in overlapping relation to said anchor member, thereby stressing said blade into a normally flexed state between said slot end and said one blade end, said blade engaging one of said pivot surfaces and said one blade end engaging one of said reaction surfaces when said blade is in said flexed state;

a plunger, means mounting said plunger for reciprocating movement in said housing, said blade being arranged in a loop between said reactor slots and said opposite end, said plunger engaging said blade loop and being movable for displacing portions of said blade adjacent said reactor slot toward one of said pivot surfaces, said blade including lateral decoupling slots between said reactor slots and said plunger;

said blade being electrically conductive, whereby the spring bias of said blade loop urges said blade one end to remain in engagement with one of said housing reaction surfaces and upon longitudinal displacement of said plunger the blade snaps said one end into engagement with the other housing reaction surface.

10. The electrical switch according to claim **9** wherein said blade loop portion includes a flexible length extending between said pivot surfaces and a portion of said anchor member spaced from said pivot surfaces, said flexible length being substantially parallel to the direction of movement of said plunger at said anchor member portion and being substantially at right angles to said plunger direction at said pivot surfaces.

11. The electrical switch according to claim **9** wherein said plunger has shoulders thereon limiting outward movement of said plunger relative to said housing, said blade loop continuously urging said plunger shoulders into engagement with said housing, and stop means on said anchor member for limiting inward longitudinal movement of said plunger.

12. The electrical switch according to claim **9** wherein said plunger has an end surface in position to engage said blade, said end surface being shaped to engage said blade loop at a point closer to said reactor slots in one rotational position and to engage said blade loop at a greater distance from said reactor slots in another rotational position.

13. The electrical switch according to claim **9** including a pair of electrically conductive terminals mounted in said housing, said terminals having said reaction surfaces thereon, at least one of said terminals having projections on opposite sides, said housing including a cover on one side of said terminals, one of said terminal projections extending through said cover and said projections being deformed to secure said cover and housing together.

14. An electrical switch comprising,

a housing having a hollow cavity therein, said housing having opposed reaction surfaces in said cavity;

an anchor member, means mounting said anchor member in said housing;

a thin, naturally flat resiliently flexible switch blade in said housing cavity, said blade having opposite later-

al edges and having a longitudinal slot therein, said blade slot having one end spaced longitudinally from one end of said blade, said one blade end extending between said housing reaction surfaces;

said blade having a pair of reactor slots extending laterally from said longitudinal slot, said anchor member having a pair of opposed pivot surfaces and a post portion extending between said pivot surfaces, said blade reactor slots being aligned with said post portion, said slot opposite end being spaced from said blade opposite end, said blade opposite end being secured on said anchor member, means displacing said blade lateral edges toward each other at a location on said blade coextensive with said slot and spaced longitudinally from said pivot surfaces, thereby stressing said blade into a normally flexed state between said slot end and said reactor slots engaging one of said pivot surfaces and said blade one end engaging one of said reaction surfaces when said blade is in said flexed state,

a plunger, means mounting said plunger for reciprocating movement in said housing, said blade being arranged in a loop between said reactor slots and said opposite end, said plunger engaging said blade loop and displacing a portion of said blade adjacent said reactor slot toward one of said pivot surfaces, said blade including lateral decoupling slots between said reactor slots and said plunger, said loop being spaced from said anchor member throughout its length and arranged for biasing said plunger in one direction;

said blade being electrically conductive, whereby the spring bias of said blade loop urges said blade one end to remain in engagement with one of said housing reaction surfaces and upon longitudinal displacement of said plunger the blade snaps said one end into engagement with the other housing reaction surface.

15. The electrical switch according to claim **14** wherein said loop portion extends substantially parallel to said plunger direction adjacent said opposite blade end and extending substantially at right angles to said plunger direction at said pivot surfaces.

16. The electrical switch according to claim **15** wherein said plunger is secured on said blade at said loop portion and is movable along a path, said opposite blade end and said pivot surfaces being offset on the same side of said plunger path.

17. An electrical switch sub-assembly comprising:

an elongated anchor member, said anchor member being substantially rigid and having a pair of opposed pivot surfaces extending laterally of said member,

an elongated electrically conductive switch blade on said anchor member, said blade being naturally flat and resiliently flexible, said blade having a longitudinal slot therein and having opposite reactor slots extending laterally from said blade slot,

said blade extending outwardly on opposite sides of said anchor member, means for displacing portions of said blade on opposite sides of said slot toward each other to cause said blade to be normally flexed transversely and arched longitudinally between said anchor member and one blade end, the opposite end of said blade being secured on said anchor member,

said blade reactor slots being aligned with said pivot surfaces and in engagement with one of said pivot surfaces, said blade having a loop portion between said reactor slots and said opposite end, whereby said loop urges said blade between said reactor slots and said one end to remain flexed and arched, thereby allowing said blade and anchor member to be assembled together and adjusted prior to installation in a housing.

18. The sub-assembly according to claim **17** wherein said anchor member has opposite faces with a base portion and an intermediate portion and a reactor portion, said reactor portion extending substantially perpendicularly to the face of said base portion, said member having a bend at the junction of said intermediate portion and said base portion, said blade loop being normally spaced from said member between said bend and said reactor portion.

19. The sub-assembly according to claim **17** wherein said displacing means includes a fastener, said fastener including opposed flanges extending on opposite side of said blade at said loop portion, said flanges being spaced apart from each other a shorter distance than the natural width of said blade at said flanges, whereby said blade is stressed to provide flexing and arching said blade on the opposite side of said anchor member.

20. The sub-assembly according to claim **19** wherein said fastener includes means for forming a bight portion in said loop portion, said flanges engaging said blade at spaced intervals at opposite ends of said bight portion.

21. A snap action switch comprising:

at least one stationary contact element having an electrically conductive surface;

an elongated strip of thin, naturally flat, electrically conductive, elastic sheet material having a free front end portion extending into a space adjacent said contact surface, said strip being provided with an opening extending longitudinally thereof intermediate its lateral margins from a location rearwardly of said free front end portion;

first stationary means engaging a mid-portion of said strip adjacent the edges of said opening without contacting the lateral margins of the strip so as to fix the location of the engaged edges of said opening while permitting deflection of the adjacent lateral margins of said strip from the plane of said engaged edges;

second stationary means cooperating with a rear end portion of said strip for fixing the location of said rear end portion and for holding said rear end portion in an elastically deformed condition in which its width is reduced so as to induce longitudinal tensile stresses in the lateral margins of the strip and cause the strip to seek a transversely curved three-dimensional configuration extending rearwardly from said free front end portion;

said first and second stationary means being spaced apart from each other a distance less than the length of the portion of said strip which extends between said means, whereby said strip is longitudinally curved into a spring loop configuration intermediate said first and second stationary means; and

movable actuator means bearing against the convex side of said spring loop configuration adjacent the lateral margins of said strip and being movable against the force of said spring loop in a direction to cause said strip to undergo a transverse buckling.

22. A snap action switch comprising:

at least one stationary contact element having an electrically conductive surface;

an elongated strip of thin, naturally flat, electrically conductive, elastic sheet material having a free front end portion extending into a space adjacent said contact surface, said strip being provided with an opening extending longitudinally thereof intermediate its lateral margins from a location rearwardly of said free front end portion;

first stationary means engaging a mid-portion of said strip adjacent the edges of said opening without contacting the lateral margins of the strip so as to fix the location of the engaged edges of said opening while permitting deflection of the adjacent lateral margins of said strip from the plane of said engaged edges;

movable actuator means, said actuator means cooperating with a rear end portion of said strip for holding said rear end portion in an elastically deformed condition in which its width is reduced so as to induce longitudinal tensile stresses in the lateral margins of the strip and cause the strip to seek a transversely curved three-dimensional configuration extending rearwardly from said free front end portion; and

spring means connected with said actuator means, said spring means yieldably urging said actuator means in a direction perpendicular to the flat faces of said strip at said rear end portion, whereby said front strip end is urged to remain in engagement with said contact element.

23. The snap action switch according to claim 22 wherein said contact element and said stationary means are rigidly positioned within a housing, said actuator means including a plunger, said housing including guide means for reciprocating said plunger along a path, and said spring means being interposed between said plunger and said housing.

24. Electrical switch apparatus comprising:

a housing, a pair of electrically conductive contact terminals, means mounting said terminals in said housing, said contact terminals each including an electrically conductive contact surface, said surfaces being in opposed relation to each other,

an elongated thin switch blade having opposite faces and opposite lateral edges and having one end extending into the space between said surfaces and being movable alternately into engagement with both of said surfaces, said blade being naturally flat and resiliently flexible, means stressing said blade at a predetermined distance from said one end, said stressing means causing said blade to assume a transversely curved configuration between said stressing means and said one end when said blade one end is in engagement with either of said contact surfaces, the radius of curvature of said transverse configuration being greater adjacent said one end than adjacent said stressing means,

said blade curved configuration with respect to one of said blade faces being concave when said one end is in engagement with one of said contact surfaces and being convex when said one end is in engagement with the other of said contact surfaces,

a common terminal, means mounting said common terminal in said housing spaced from said contact terminals, said blade being in engagement with said common terminal and including means for conducting electric current along said blade between said common terminal and said one end,

a plunger in said housing, said plunger being movable inwardly and outwardly relative to said housing for displacing said one end of said blade from one contact surface to the other contact surface, means connecting said blade with said plunger for displacement of said blade upon movement of said plunger inwardly relative to said housing, said blade including a spring portion between said plunger and said common terminal, said spring portion urging said plunger outwardly relative to said housing, whereby movement of said plunger causes said blade to snap over from one contact surface to the other contact surface.

25. The electrical switch apparatus according to claim 24 wherein said blade is arranged in a loop adjacent said plunger.

26. The electrical switch apparatus according to claim 24 wherein said blade is an integral strip of material extending continuously and in sequence from said one end through said stressing means through said plunger connecting means and into engagement with said common terminal.

27. The electrical switch apparatus according to claim 24 wherein said blade has a longitudinal slot forming leg portions between said slot and said blade lateral edges, said slot terminating in a transverse edge spaced from said one end of said blade, said stressing means including means applying longitudinal tension in said leg portions relative to said transverse edge thereby urging said blade between said transverse edge and said one end to assume said transversely curved configuration.

28. The electrical switch apparatus according to claim 24 wherein the width of said blade between said opposite lateral edges progressively decreases from adjacent said stressing means to adjacent said one end of said blade.

29. The electrical switch apparatus according to claim 24 wherein said plunger is in position to deflect said one blade end against one contact surface upon initial movement relative to the housing in one direction and upon further movement of said plunger to snap over said one blade end into engagement with the other contact surface, said one blade end transmitting a progressively greater force against said one contact surface during said further plunger movement until snap over of said blade end occurs.

References Cited

UNITED STATES PATENTS

2,202,440	5/1940	Beach.
2,584,460	2/1952	Jacobs.
2,789,173	4/1957	Kaminky.
2,805,297	9/1957	Campbell.
2,806,927	9/1957	Allen.

ROBERT S. MACON, Primary Examiner

D. SMITH, JR. Assistant Examiner