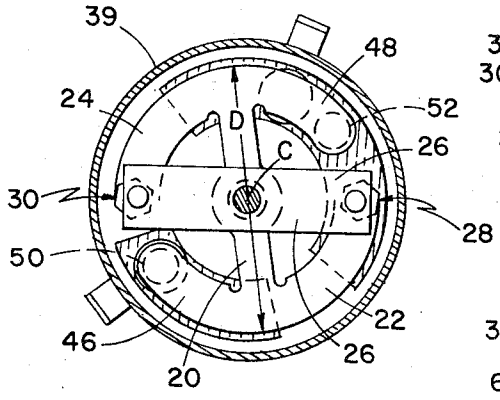
March 5, 1968 H. K. BURCH ET AL 3,372,254

SNAP-ACTING SWITCH MEANS

Filed Sept. 22, 1966 3 Sheets-Sheet 1

FIG 1



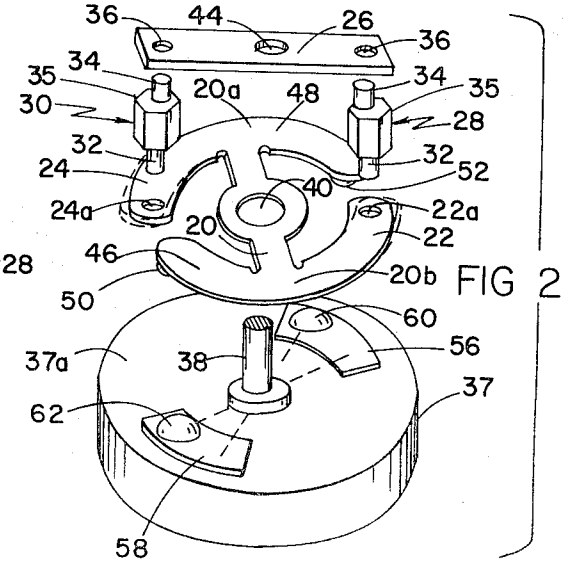


FIG 2

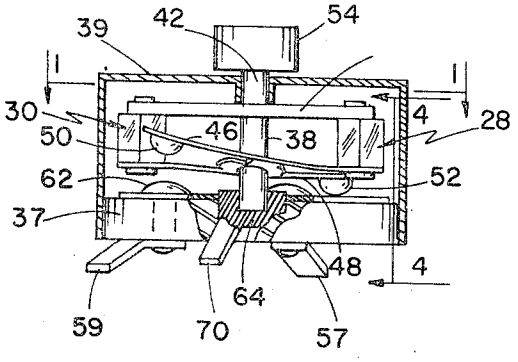


FIG 3

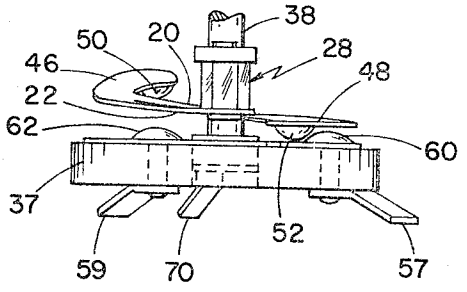


FIG 4

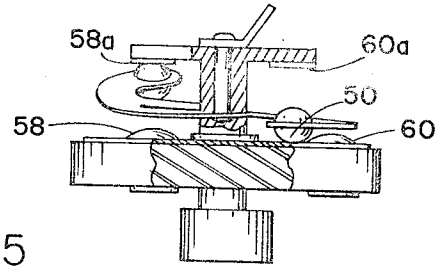
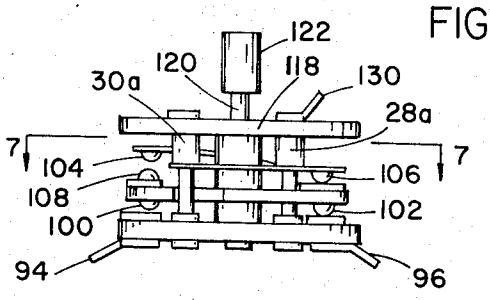


FIG 5

FIG 6



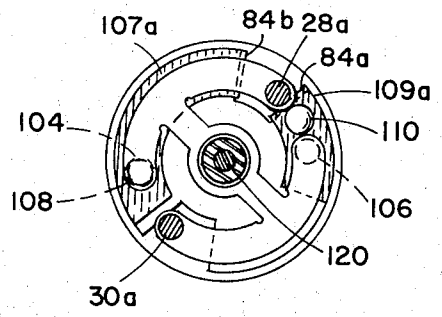
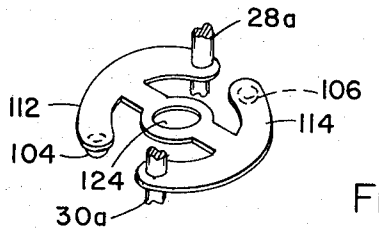


FIG 7



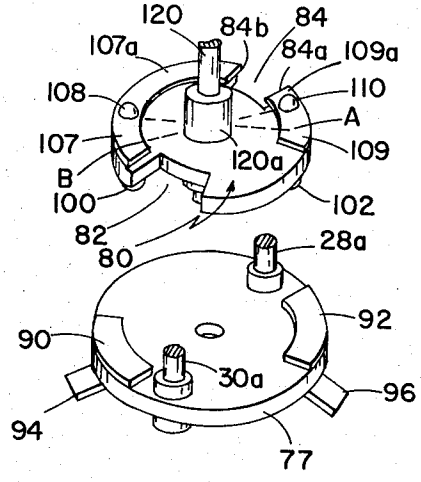


FIG 8

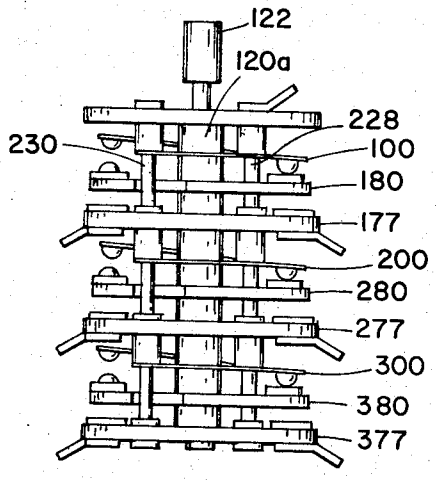


FIG 9

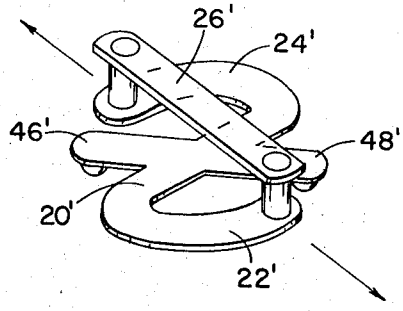


FIG 10

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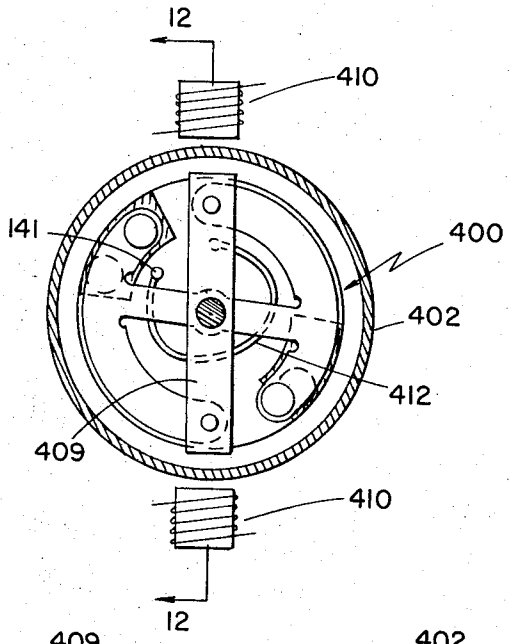


FIG 11

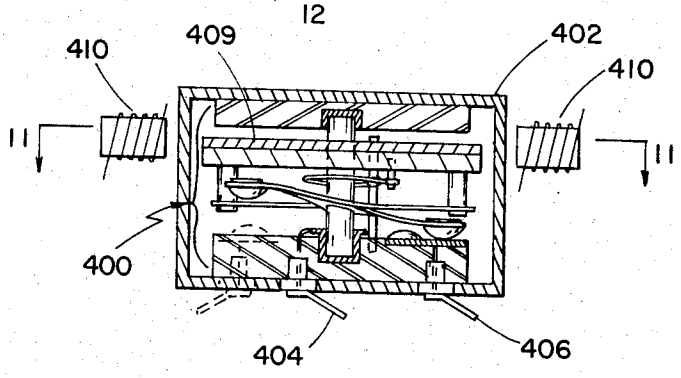


FIG 12

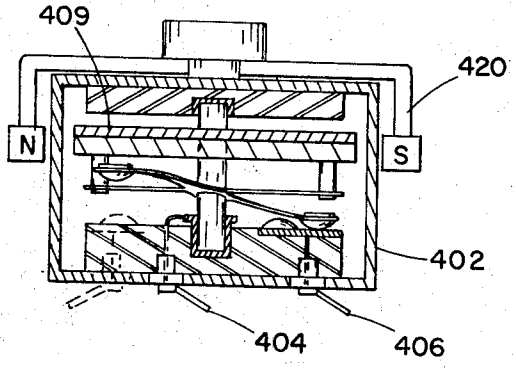


FIG 13

United States Patent Office 3,372,254
Patented Mar. 5, 1968

3,372,254

SNAP-ACTING SWITCH MEANS

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Filed Sept. 22, 1966, Ser. No. 583,492
21 Claims. (Cl. 200—63)

This invention relates to snap-action electrical switches and the like.

A principal object of the invention is to provide improved snap-action blade elements and switch constructions, especially rotary switches, which are simple and economical to manufacture, while demonstrating other desirable features such as compactness, high current switching capacity relative to size, resistance to acceleration and vibration effects, durability, immunity to harmful effects due to over-travel, and ability to maintain its electrical properties despite such factors as contact welding, contamination of contacts and presence of foreign matter.

Among the other objects of the invention are to provide improved hermetically sealed rotary switches and relays, and multiple contact switches, and an improved modular stressed blade construction and means of assembly.

The invention in one respect features a snap acting blade having a central leg, two tension legs for stressing the blade, and two amplifier legs connected to move in opposite directions with warpage of the blade, in which both the tension legs and the amplifier legs are so connected and shaped as to lie within a circle projected through the ends of the central leg. It is found that such a blade can achieve fast over-center motion and strong contact pressure. The blade also can be immune to the effects of vibration and acceleration forces due to its compactness and opposite motion of the amplifier legs, as well as the ability to construct the blade with dynamic balance.

Preferred embodiments of the invention feature tension legs which are curved and amplifier legs which extend in opposite directions from the central leg to ends which lie closely adjacent the mounting points of the tension legs. Preferred embodiments also feature the amplifier legs connected to the ends of the central leg.

Preferred embodiments further feature each end portion of the central leg and the respective tension and amplifier legs forming together a single semicircular arc, the two resulting arcs joined together by the central leg.

Preferred embodiments of the invention also feature a bifurcated central leg, and in particular a central leg with a central opening through which a mounting shaft can extend.

The invention also features any of the blades as just described, combined together with a stressing bar which prestresses the blade to provide a stressed snap blade module for incorporation into switches of differing characteristics. Such a module can be incorporated into a novel rotary switch, with the stressing bar mounted on the rotary shaft, and the blade rotating in a plane parallel to the general plane of the blade, with the cooperating contacts stationary. In such rotary switches, as well as in novel rotary switches in which the blade is stationary and the cooperating contacts rotate, actuation of the blade can be effected by a relative off-setting of a portion of the cooperating contacts, to apply actuating stress through the blade contacts themselves and through the amplifying arms upon which the blade contacts are mounted. Preferred embodiments of such switches feature the mounting of the cooperating contacts upon a single mounting surface, which thereby avoids some of

the critical tolerance problems encountered with certain prior switches.

The invention also features the combination of a rotary snap action blade associated with a magnetically attractable member, hermetically sealed into a casing, with an actuating member such as a movable magnet or an electromagnet coil located outside the casing. Advantageously the blade is here again actuated by relative rotation of the contacts, by force applied through the amplifying legs upon which the blade contacts are mounted. The blades which have been mentioned above, when employed in rotary switches, require little actuation force, and therefore enable the construction of very effective electrical relays.

These and numerous other features and advantages will be understood from the following description and claims, and the accompanying drawings, wherein:

FIG. 1 is a plan view taken on line 1—1 of FIG. 3 of one preferred embodiment of the invention;

FIG. 2 is a partially exploded perspective view of the switch of FIGS. 1 and 3;

FIG. 3 is a side view, with parts partially broken away, of the embodiment of FIG. 1;

FIG. 4 is a side view taken on line 4—4 of FIG. 3;

FIG. 5 is a vertical cross-sectional view of another preferred embodiment according to the invention taken through the center of the embodiment;

FIG. 6 is a side view of another preferred embodiment according to the invention;

FIG. 7 is a horizontal cross-sectional view taken on line 7—7 of FIG. 6;

FIG. 8 is an exploded perspective view of the embodiment of FIGS. 6 and 7;

FIG. 9 is a side view of another preferred embodiment of the invention;

FIG. 10 is a perspective view of a blade module for use according to the invention;

FIG. 11 is a horizontal cross-sectional view of a preferred embodiment according to the invention;

FIG. 12 is a vertical cross-sectional view taken on line 12—12 of FIG. 11; and

FIG. 13 is a view similar to FIG. 12 of another preferred embodiment of the invention.

Referring to FIGURE 1–4 there is shown a novel snap-acting blade comprising an elongated central leg 20 having a length D. Connected to one end of the central leg 20, along one side, is tension leg 22, and connected to the other end, along the other side, is tension leg 24. Near the ends of these tension legs are provided mounting points, here holes 22*a* and 24*a* respectively. The blade thus defined can be warped under the application of tension to the tension points 22*a* and 24*a*. To accomplish this effect in this embodiment, a stressing member 26 is provided, extending between the two mounting points, and connected thereto by means of adjustable eccentric rivets, 28 and 30. Each rivet has a lower pin 32 for fastening to the tension leg, an upper pin 34, eccentric to pin 32, for fastening to the stressing member, and a nut-shaped portion 35. By turning these rivets, tension can be applied to the tension legs, to force them apart relative to their unstressed position, to place the blade under tension and the stressing bar under compression. Accordingly, it can be seen that the blade and stressing bar comprise a prestressed blade module which can be incorporated into various switches. For a similar module see FIG. 10.

Two amplifier legs 46 and 48 are connected to the blade for amplifying the warping action of the blade in such manner that one leg (shown as 46) is in the up position while the other leg (shown as leg 48) is in the down position. When the blade is snapped the legs move to opposite positions, and vice versa.

In this embodiment it will be seen that the amplifier legs **46**, **48**, as well as the tension legs **22**, **24**, reside entirely within the circle of diameter D centered on the center C, the diameter D corresponding to the length of the central leg **20** and the center C corresponding to the center of that leg. It will also be seen that the tension legs **22** and **24** are curved and that the amplifier legs **46** and **48** extend from opposite sides of the central leg **20** to ends which lie adjacent the mounting points **22***a*, **24***a* of the tension legs. (See also FIG. 10.) With such an arrangement a substantial amplification of the warping movement of the blade is obtained with all components lying within the limits of the circle of D diameter.

Still referring to the FIGURES 1–4, each end **20***a* and **20***b* of the central leg **20**, together with the corresponding tension and amplifying legs, legs **24** and **48** with respect to end **20***a*, legs **22** and **46** with respect to end **20***b*, form a circular strip of substantially semi-circular extent. This provides a highly effective and durable snap action blade with efficient use of spring material and space occupied.

Advantageously, as shown, the central leg **20** is bifurcated in its central region. This is found to increase the flexibility of the blade and permit the use of less force for actuation, substantial advantage for certain uses. Further advantage is taken of this bifurcation in the present embodiment by the formation of a central opening **40** in the center leg **20** of sufficient size for a rotary shaft to pass through the blade. As will be discussed below, this permits improved mounting and actuation of the movable component of the switches.

Referring in particular to FIGS. 2 and 3, in this embodiment an insulative base member **37** is provided upon which is rotatably mounted shaft **38**, which extends through the opening of the switch blade, and mounts the stressing bar **26**, this bar in turn mounting the blade to the shaft. The shaft and the central opening of the blade are so sized with respect to one another that the sides of the opening do not contact the shaft during actuation. The end portion of shaft extends through a stationary cross-support **39**, and on its outer end is shown an actuating knob **54**. The blade and stressing bar can thus be turned.

Electrical contact members, **50** and **52**, are mounted on the ends of the amplifying legs, **46** and **48** respectively. In this embodiment these contacts are connected electrically to terminal **70** at the base by means of the conductive, stationary bushing **64**, which mounts the shaft **38**, and the shaft **38**, stressing bar **26**, mounting rivets **28**, **30**, and the snap blade, all of which are conductive.

The base **37** is provided with a base surface **37***a* extending perpendicular to the shaft axis, parallel to the plane of the blade. A feature of this embodiment is that all of the stationary contacts, here a pair of contacts **56** and **58**, are fixed to this surface, connected to separate terminals, **57** and **59** respectively. Integral with these contacts are upwardly raised portions **60** and **62** respectively, positioned to be engaged by a blade contact **50** or **52**, and to wedge that contact upwardly past the region of instability, and thus cause the blade to snap. The blade contact and amplifier leg, e.g. **52** and **48** respectively, engaged with a stationary contact, e.g. **56**, are thus snapped to the up position, out of engagement with contact **56**, and the opposite amplifier leg **46** is snapped downward, carrying contact **50** into engagement with the other stationary contact **58**.

In this preferred embodiment the entire blade is constructed of uniform thickness spring metal, e.g. Phosphor bronze, the tension legs are of equal length, weight and shape and the blade is substantially dynamically balanced about a line through the mounting points. The offset portions **60** and **62** are each diametrically aligned with a flat portion of the opposite contact, to permit the down-moving contact to reach a stable normally closed condition. Further rotation of the blade causes the closed contacts to wipe until a raised portion, **60** or **62**, is again reached, and then again the closed contacts are snapped open, and the open contacts snapped closed.

Referring to the embodiment of FIG. 5 it is seen that it is possible, albeit with the introduction of another dimensional tolerance to maintain, to also locate stationary contacts on the other side of the blade, **58***a* and **60***a*, facing contacts **58** and **60** respectively, to provide a double pole, double throw switch.

Referring to the embodiment of FIGS. 6–8, in this case the blade, which may be identical to the one of the preceding embodiment, is mounted on stationary stressing pins **28***a*, **30***a*, which are secured by eccentric pins to the base **77**, and can be adjusted during manufacture to stress the blade.

Between the base **77** and the blade is positioned an intermediate member **80** of insulative material having notches **82**, **84**, through which the mounting pins **28***a*, **30***a* extend. The sides of one of these notches can serve as stops in a manner to be described later.

Two planar contacts, **90**, **92** are secured to the upper surface of the base **77**, and connected to terminals **94**, **96**. The intermediate member **80**, on its bottom surface, has a pair of contacts **100**, **102**, which wipe upon the contacts **90**, **92** of the base **77**. The intermediate member **80** also has a pair of upper planar contacts **107**, **109**, arranged to be wiped by blade contacts **104** and **106** on the amplifying arms **112**, **114**, of the blade. The contacts **107** and **109** have raised portions, of the form, for example, of rounded heads **108** and **110** respectively, which are positioned and adapted to acutate the blade.

The switch includes an upper cross-arm **118** to which the upper ends of the posts **28***a* and **30***a* are attached. A central shaft **120** is rotatably mounted to this cross-arm and to the base **77**, and extends outwardly of the cross-arm, to knob **122**. As with the previous embodiment the shaft **120** extends through an opening **124** in the central leg of the blade.

The notch **84**, on one side of the intermediate member is of shorter arcuate extent than the other and is arranged to engage post **28***a* as a limit stop for rotation in either direction.

For actuation, the shaft **120** is turned, turning the intermediate member **80**. Assume that the edge **84***a* of the notch is engaged with the stop post **28***a* and that rotation occurs clockwise as viewed looking down in FIG. 8. In this position the blade contact **106** engages contact **109** at A. After a slight amount of rotation with blade contact **106** wiping against contact **109** in the direction of the arrow, the head **110** which protrudes from contact **109** engages blade contact **106** and forces it upwardly. This moves amplifying arm **114** upwardly, until the unstable region is reached and the blade snaps blade contact **106** upwardly, out of contact with the intermediate member, and snaps leg **112** and blade contact **104** down into engagement at B. After further slight clockwise rotation edge **84***b* of the notch engages the stop post **28***a*.

With counter-clockwise rotation from this position the blade contact **104** wipes upon the intermediate contact **107** until head **108** passes under contact **104**, lifting it and actuating the blade, snapping contact **104** up and contact **106** down.

Electrical energy can be introduced to the blade contacts through either mounting post. By introducing it through terminal **130** to the mounting post **28***a* which also serves as the stop for the switch, it is possible to employ the shorting-out principle disclosed in the copending application S.N. 567,633, entitled, Snap-Action Switch, inventor Lyndon W. Burch, one of the applicants herein, to which reference is made. To attain this effect both of the contacts **107** and **109** on the intermediate member are extended to the edge of the notch **84** and arranged to engage the stop post **28***a*. Thus, as with the clockwise rotation described above, after the blade contact **104** snaps down to engage intermediate contact **107** (connecting terminal **130** and post **28***a* to terminal **94**,

through contact surfaces **100** and **90**), then with overtravel movement, the extension **107***a* of the intermediate contact engages the stop **28***a*, shunting the blade. In reverse rotation extension **109***a* shunts the blade.

Referring to FIG. 9 a plurality of snap action blades **100, 200, 300**, as described above are each mounted as in the embodiment of FIGS. 6–8, and provided with cooperating intermediate members **180, 280, 380**, and terminal bases **177, 277, 377**. All blades are mounted on common posts **228, 230**, and the intermediate members **180, 280, 380**, are mounted for rotation upon a common shaft **120***a*, whereby a large number of circuits can be controlled.

Referring to FIG. 10, in this embodiment the tension legs **22′, 24′** are curved to substantially match the circle of a diameter corresponding to the length of the central leg, but the amplifier legs **46′** and **48′** are connected substantially to the mid-point of the central leg, for the purpose of acting in opposite directions to amplify the warpage movement of the blade. As with the blades previously discussed, the amplifier legs are substantially confined to the circle defined by the length of the central leg, and the amplifier legs extend to end portions lying closely adjacent mounting points of the tension legs.

The stressing member **26′** is connected to the mounting points of the tension legs, to provide a prestressed module.

Referring to the embodiment of FIGS. 11 and 12, a rotary switch **400** similar to one of the switches described above, in this case the switch of FIGS. 1–4, is enclosed within a heremetic casing **402**, with nothing protruding from the casing except the terminals **404** or **406**, which may for instance protrude through glass-to-metal seals. Besides the omission of the knob assembly of the previous embodiment, a magnetically attractable member **409**, e.g. a bar of soft iron, is secured to the stressing bar. The casing **402** is made of magnetically permeable material, e.g. copper, and a means **410** outside the casing to produce a magnetic field is provided to actuate the member. The rotatable switch is biased by spring **412** against the stop **141**. Upon energization of the electromagnet the field, acting upon member **409**, rotates the switch to actuate it to one position, and de-energization of the electromagnet enables the spring **412** to return the blade to its initial position, reactuating the switch with the return movement. The low forces required to actuate the blade enables economical manufacture of electrical relays employing this general concept, and the ability of making them with dynamic balance and immune to vibration and gravitational effects provides a very reliable and rugged construction.

Referring to FIG. 13, the same casing and switch assembly is shown in combination with an exterior rotary magnet **420** by which the switch can be actuated.

It will be appreciated that the two preceding embodiments seal the contacts from exposure to contaminants, such as vaporized varnishes used upon electrical windings, to further increase their reliability and ability to be stored for exceedingly long periods without danger of contamination.

It will be appreciated that numerous variations may be made in the specific details, within the spirit and scope of the invention.

What is claimed is:

1. A snap-acting blade formed of thin resilient material and comprising a central leg, two tension legs each having means thereon forming a mounting point for a stress producing element, and two amplifier legs, one of said tension legs connected to one side, near one end of the central leg, the other tension leg connected to the other side and near the other end of the central leg, the mounting points of said tension legs so located with respect to said blade as to permit the application of tensional stress to said blade to cause it to warp, each amplifier leg connected to the blade in a location to permit amplification of the warpage of said blade, and so connected that when one amplifier leg is warped to one side of the blade, the other leg is warped to the other side, and vice versa, said tension legs and said amplifier legs substantially disposed within a circle centered on the middle of said central leg, projected through the ends of said central leg.

2. The snap-acting blade of claim **1** wherein the two amplifier legs are located one on each side of the central leg, and connected thereto, each extending to a point closely adjacent the mounting point of one of said tension legs.

3. The snap-acting blade of claim **1** wherein said tension legs are of the same length, said amplifier legs are of the same length, and said blade having substantial dynamic balance about a line projected through said two mountings points.

4. The snap-acting blade of claim **1** wherein all of said tension and amplifier legs are of curved form to substantially conform to said circle.

5. The snap-acting blade of claim **1** wherein said amplifier legs are connected to the ends of said central leg, extending in opposite directions relative to said tension legs.

6. The snap-acting blade of claim **5** wherein each end of the central leg, the respective tension leg and the respective amplifier leg together form a substantially continuous circular arc of substantial extent.

7. The snap-acting blade of claim **1** incorporated in a prestressed snap acting blade module for use in snap action switches, including a substantially rigid stressing bar, said bar connected to said two mounting points on said tension legs, said stressing bar being under compression, said mounting points positioned further apart by said bar than the spacing of said points when the blade is in unstressed condition.

8. The snap-acting blade of claim **1** incorporated in a rotary switch, including means applying tension to said tension legs to place said blade under stress and to warp said blade, at least one raised surface against which the ends of said amplifier legs may react for actuation of said blade, at least one electrical contact surface which the end of one amplifier arm can engage upon actuation and rotational mounting means to produce relative rotational movement about the center of said central leg between said blade and said surfaces, at least one of said amplifier legs carrying an electrical contact to engage said electrical contact surface when the other amplifier leg is actuated by said raised surface.

9. The snap-acting switch of claim **8** wherein said surfaces are spaced arcuately about said center and are located on the same side of said blade on a single mounting member.

10. The switch of claim **9** having at least a pair of electrical contact surfaces which terminate in a pair of raised surfaces, all located on the same side of the blade and positioned so that when one raised surface actuates said blade through engagement with one amplifier leg, the other amplifier leg is snapped against the other contact surface, and vice versa.

11. The snap-acting blade of claim **1** wherein the middle portion of the length of said central leg is bifurcated with an opening between the two portions located at the center of said central leg.

12. The snap-acting switch of claim **8** wherein the means for stressing said blade comprises a substantially rigid stressing bar, said bar connected to said two mounting points on said tension legs, said stressing bar being under compression, said mounting points positioned further apart by said bar than the spacing of said points when the blade is in unstressed condition, the middle portion of the length of said central leg is bifurcated with an opening between the two portions located at the center of said central leg, and a mounting shaft extending through said opening, said shaft connected to said stressing bar and rotatably mounted on a supporting base.

13. The snap-acting blade of claim 8 including a magnetically attractable member drivingly connected to the rotational means, a hermetically sealed casing surrounding said stressed blade and magnetically attractable member, said casing being permeable to a magnetic field, and magnet means outside of said casing adapted to apply a magnetic field to rotate said magnetically attractable member, thereby to actuate said switch.

14. The snap-acting switch of claim 13 wherein said magnet means comprises an electromagnet, whereby said switch can be operated as an electrical relay switch.

15. The snap-acting switch of claim 13 wherein said magnet means is rotatable relative to said casing to actuate said switch.

16. The snap-acting switch of claim 8 in combination with at least one other switch of like configuration, the blades of said switches being mounted in a co-axial, side-by-side relationship, and the rotational means for both of said switches being joined to turn together, thus to provide a single switch having multiple blades.

17. A flat disc substantially round of thin spring material whose outer periphery is cut away to provide two semi-circular strips whose center portions are connected together by a central leg, two diametrically opposite ends of said semi-circular strips secured to a mounting means that cause said disc to be normally in tension, the remaining two ends of said strips capable of carrying electrical contacts, said remaining ends assuming normal positions of one below and one above the general plane of said disc and said ends being capable of changing their respective positions abrutply by applying a force and movement to a pre-determined point upon said disc whereby said disc can serve as the snap acting blade of a switch.

18. A switch incorporating the disc of claim 17, said two remaining ends each carrying an electrical contact, a second pair of cooperating contacts adapted to cooperate with the pair mounted on said disc, mounting means adapted to rotate one pair of electrical contacts relative to the other pair in a circular path generally parallel to the unstressed plane of the disc, and centered on the center of said disc, portions of said second pair of electrical contacts off-set toward said disc, arranged upon relative motion so that one of said off-set portions, when engaged during rotation by one of the contacts on said disc, applies an actuating force to said blade, to cause said blade to snap, and carry the other contact on said disc against the other contact of said second pair.

19. A rotary snap-action switch comprising a snap action blade formed of thin resilient material, means to stress said blade, and means to mount said blade with respect to cooperating surfaces for actuation and electrical contact, said snap action blade assembly including a central leg and a plurality of arms having a high width to thickness ratio, at least a pair of said arms providing means to receive forces in opposite directions to place the blade under stress and warp the blade into one condition, from which it can be snapped to an opposite condition, and said blade including at least one electrical contact mounted to be moved by said blade in accordance with the warped state of said blade, said stressing means for said blade comprising a stressing body extending between and connected to said stressing legs, displacing them into said stressed condition, said stressing means being secured against lateral movement relative to a rotatable shaft mounted along the center of said blade, said rotary shaft adapted, upon rotation, to produce relative rotational movement of said blade and said cooperating surfaces, said cooperating surface forming means to cause actuation of said blade.

20. The rotary snap-action switch of claim 19 wherein said blade assembly includes a pair of amplifying arms each carrying an electrical contact and located on opposite sides of the center of said blade in a substantially balanced relationship, said amplifying legs constructed and arranged with respect to the body of said blade that movement upwardly of one of said legs tends to cause the opposite amplifier leg to move downwardly.

21. The rotary snap-action switch of claim 19 wherein said blade includes a central leg having a central opening, said shaft extending through said opening, said stressing means comprising a member mounted upon said shaft, said blade rotatable with said shaft, said cooperating surfaces being stationary.

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