May 12, 1964 R. N. NANNINGA 3,133,170

SNAP SWITCH HAVING A CANCAVO-CONVEX DIAPHRAGM

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Fig. 1

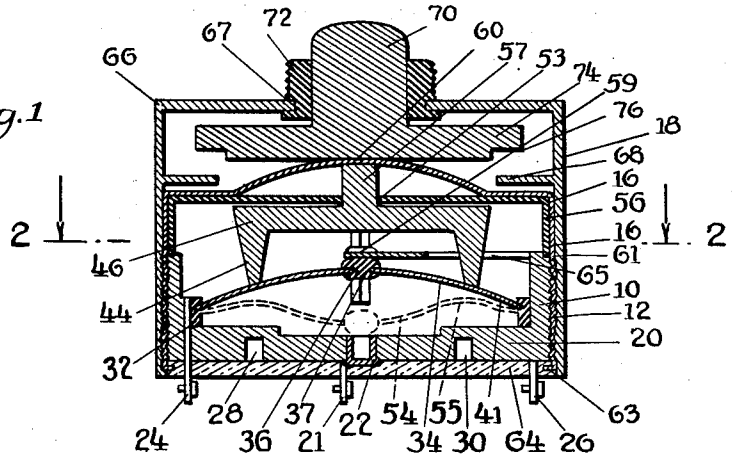


Fig. 2

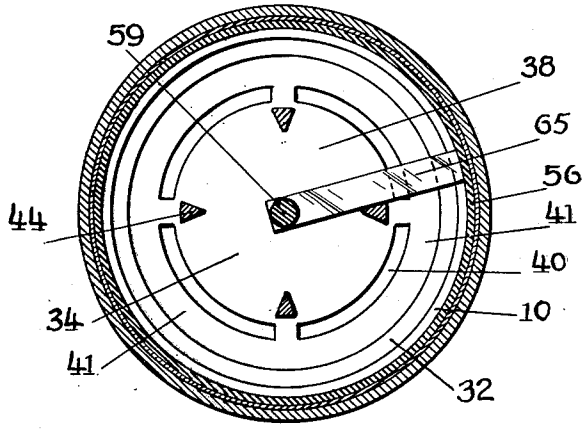


Fig. 3

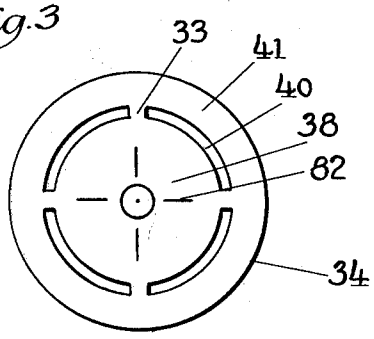
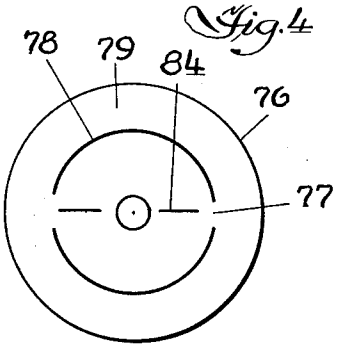


Fig. 4



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SNAP SWITCH HAVING A CONCAVO-CONVEX DIAPHRAGM

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This invention relates to a switch and more particularly to a new and improved snap-acting switch for electrical circuits.

This application is a continuation-in-part of an application filed in the name of Robert N. Nanninga in the United States Patent Office on October 11, 1957, Serial No. 689,642, which application, subsequently abandoned, was assigned to the assignee of the present invention.

The particular type of switch with which the present invention is concerned is known in the trade as a cylindrical switch inasmuch as the body or case for the switch is of a cylindrical configuration and the moving element carrying the movable contact of the switch is disc-shaped. Disc elements for switches incorporating this invention are preferably resilient devices and are so arranged and constructed that they are subject to integrated multiple springs or complex spring operation. In general, the disc element has a concavo-convex configuration and is arranged to have regions defining separation of concentrically arranged spring portions preferably with the inner springs being weaker or more subject to stressed movement than the outer spring areas.

Proper selection of the manner of applying actuating force to the spring and coordinated with a particular manner of spring area definition results in an action in springs embodying this invention, such that the innermost spring area will snap rapidly to an overcenter position while the outermost spring area will substantially retain its original position. Additionally, the outer spring area will be so cooperatively arranged with the inner spring area that the stress patterns therein will be effective to return the inner spring area to its original position.

The definition for operation of the spring areas is an important phase of the instant invention. This definition may be effected by employing annular slots in the spring disc at the boundaries of the inner and outer springs. While these slots have a stress relief effect on the inner spring, they more importantly serve to directionalize and concentrate the stresses occurring in the spring disc from forces applied by the actuator to cause the above described multiple or complex spring action. The definition may be effected in a number of other ways, such as by selection of different spring alloys for the different areas of the spring, selection of different thicknesses for the different areas of the spring and selection of different configurations and dimensions for the different areas of the spring.

In any event, it is important in the present invention that the spring be so arranged and coordinated with the manner of imparting stresses thereto for movement of the inner portion of the spring that the inner spring be more subject to movement than the outer spring within the single spring disc and that the outer spring refrains from going over center while the inner spring moves over center during spring operation. Exemplifying the foregoing, if the force applied to the spring is uniform over its entire area, then the inner spring should be weaker than the outer spring. On the other hand, when the spring moving forces are applied at selected areas, the stress patterns should be so directionalized as to effect the desired movement. The stress direction control becomes more important as the definition line for separation of the springs becomes less clear and absolute and/or as the stress application areas are more outwardly positioned on the spring disc.

An illustrative embodiment of this invention is shown in the drawings and described in detail hereinbelow. In that embodiment of the invention, the concavo-convex spring member is divided into a central spring area and an outer or rim spring area separated by annular slots. An actuator comprising a radially extending body having peripheral transverse subtending projections which engage the diaphragm at areas just inward of said slots between said central area with said rim area applies an actuating force to the spring to produce a snap operation thereof with rapid engagement and disengagement of the movable contact element with the opposing fixed contact elements.

The actuating force is provided by a switch actuator which is disposed for axial movement within the switch enclosure and is in operative relationship with the two-area diaphragm. The legs may either abut against the top dome surface of the diaphragm or project through appropriately shaped openings in the diaphragm. In the latter instance, the legs act as stops against the application of an undue amount of force to the actuator and thereby prevent deformation of the diaphragm, by bearing against the base.

The cross-sectional shape of the legs of the actuator is also significant in providing the desired multiple or complex manner of spring action. By utilizing triangular legs with one apex of the triangle pointed toward the center of the diaphragm, stress concentration and direction control may be effected to provide the desired inner spring over center action with outer spring stress retaining action for return of the inner or center spring. It should be understood, of course, that radial location of the actuator legs may play a significant role in this regard inasmuch as more inwardly disposed specific areas of force application result in less requirement for stress direction of control.

Moreover, it will be appreciated that proper selection of stress area location and direction control affects the desirability of peripheral confinement to the outer spring. In addition to the foregoing requirements for the spring diaphragm, it should be appreciated in connection with this invention that there is no requirement for a prestressed condition in the diaphragm. The diaphragm may be of annealed, unstressed material which is unstressed in its normal position, if desired.

The foregoing and other features and advantages of this invention will be more readily apparent and understood from the following detailed description of an illustrative embodiment of the invention and from the drawing in which each and every detail shown is incorporated herein as a part of this specification, in which like references normally refer to like parts, and in which:

FIGURE 1 is a cross-sectional view of an illustrative embodiment of the snap switch utilizing the movable contact member of the invention;

FIGURE 2 is a top cross-sectional view of the snap switch taken along the line 2—2 of FIGURE 1;

FIGURE 3 is a detail top view of the movable contact assembly; and

FIGURE 4 is a detail top view of an alternate embodiment of a movable contact member of the invention.

Referring particularly to the drawing, the illustrated embodiment of the snap switch of this invention consists of an annular enclosure formed in two sections. The lower section comprises a base member 10 formed of insulating material, such as a thermosetting resin with a threaded peripheral surface 12 for securing it within a tapped opening in a seal enclosure member 16, or alternatively or additionally, as desired, in a switch operator housing 18.

The switch base 10 has a bottom 20 which supports a centrally disposed contact element 22 and peripherally disposed terminal assemblies 24 and 26. Transverse span-

ner wrench holes 28 and 30 are shown in the sectional view of the base 10. These are used to grip the base 10 when the seal enclosure or switch operator housing described hereinafter is being secured thereto.

Along the inside of the annular surface of the base 10 is a retainer ring 32 having an annular V-shaped groove which provides a seat for the edges of the novel resilient concavo-convex member or diaphragm 34. The retainer ring 32 may be eliminated for a flat support surface for the lips of the diaphragm 34. Only such a support surface is actually necessary for proper functioning of the diaphragm. The diaphragm 34 contains a movable contact 36 in an axial opening 37 of the concavo-convex member. The two zones of the diaphragm, namely, the central area 38 and the outer or rim area 41 or 79 in FIGURES 3 and 4 respectively, are separated by the arcuate slots 40 of the embodiment shown in FIGURE 3 or the arcuate slits 78 of the embodiment shown in FIGURE 4, but joined together by tabs 33.

An actuator 46, which comprises a radially extending body member having subtending legs 44, contacts the diaphragm on or inwardly of the tabs 33 forming the stress junction between the two spring areas. The legs 44 of the actuator are tapered to their lower end portions and triangularly shaped so as to form stress directing and force applying contact with the diaphragm. Alternatively, they may extend through appropriately shaped openings in the diaphragm. Thus, when actuating forces are applied to the actuator, the central area 38 of the diaphragm 34 is caused to snap downwardly by reason of the force applied by the legs 44. Where the legs extend through the diaphragm, they may by reason of the limited clearance around the legs, act as stops to limit the amount of "snap-over" of the concavo-convex member and to prevent undue actuating force by bearing against the bottom 20 of the base 10. In both instances of actuated condition, the diaphragm 34 is in the position approximately as illustrated by the dotted line 54. The humps 55 in this dotted line illustration indicate the boundary between the central area and the rim area of the diaphragm.

During the period of actuation, the movable contact 36 engages the stationary contact 22 in the base 14 to complete a normally open circuit between terminals 21 and 24.

The enclosure 12 is completed by a cover member 56 having a lower annular portion seating in an annular undercut portion 61 along the upper periphery of the base 10. Such additional means as found necessary such as adhesive material or gasket material may be used to insure retention of the cover 56 to the base 10.

As shown, a central opening 53 is provided in the top of the cover 56 for passing a center vertical abutment 57 of the actuator 46. This abutment provides for the coupling of actuating forces applied thereto to the actuator legs 44 and the movable switch elements inside the enclosure 12.

The terminal assembly 26 includes a conductive strap 65 passing through the bottom 20 and vertically along the inner periphery past the retainer ring 32, separated from the strap by a layer of insulation, to the upper annular edge. The strap 65 then projects radially towards the central area of the snap switch enclosure terminating in a contact secton to form a stationary contact assembly 59 for engaging the movable contact 36 while in its inactuated or normal position as shown. It should be noted that this contact is instantaneously broken upon activation of the movable contact assembly.

The conductive strap portion of terminal assembly 24 projects vertically through the bottom of the base 10 and inside the switch enclosure 12 where the strap may be secured to the annular retainer ring 32. Since the annular edge of the diaphragm seats in the V groove of the retainer ring 32, or on the surface thereof, the entire diaphragm acts as a conductor to complete the circuit from terminal 24 to the movable contact element 36. It will be appreciated, of course, that any desired conductive connection to the diaphragm may be made if the diaphragm is not held. A flexible wire connection may be made thereto in any desired manner.

The snap switch, as illustrated in the preferred embodiment, is enclosed by a fluid-sealing domed stainless steel or similar metallic enclosure member 16. It has an upper section 60 formed to provide a flexible dome over the actuator abutment 57. Its side portions thread onto the threaded peripheral surfaces 12 of the base 10. The ends 63 of the threaded portion may be flanged inwardly and sealed over a bottom plate 64. A hermetic seal can be formed about the ends 63 and terminals 22, 24, 26 to completely seal off the snap switch elements from the outside atmosphere.

A push-button type switch operator including an annular housing 66 threaded on its inner surface for securing to the annular threaded side portion of the sealing enclosure member 16 complete the outer surface of the snap switch.

The switch operator push-button 70 is slidably mounted for reciprocation in a sleeve 72 secured to the housing 66 in a top opening 67 of the annular housing 66. The radially extending disc portion 74 of the push-button 70 rests on the dome of the sealing enclosure and the actuator 46. The resiliency of the diaphragm 34 and the dome return the push-button to its normal position upon the removal of operating pressure on the push-button 70. Operating pressure exerted on the push-button 70 moves the push-button down thereby operating the actuator 46 and the diaphragm 34. The travel of the push-button downwardly is limited by an annular flange 68 which engages an undercut annular portion 76 of the push-button disc 74.

For small snap switches, a simpler actuator having but two legs instead of four may be desirable. An alternate diaphragm member for use with a two-legged actuator is shown in FIGURE 4. And although slits 78 are shown, slots such as shown in FIGURE 3 could be utilized.

Preferably, the diaphragm is cut or stamped from annealed stock, formed concavo-convex and tempered to retain its preformed condition. The arcuate openings 40 and 78 in the diaphragm, whether of the slot or slit type, provide a boundary between the two zones of spring action in the diaphragm. They may also provide for some compression relief upon the axial movement of the central area. Radially extending compression relief slits 82 and 84 may also be utilized to decrease the pressure required to deform the diaphragm and actuate the movable contact assembly. The same definition of the two portions of the spring may be obtained by proper alloy control, thickness control or configuration control.

In operation, the switch contacts are closed through the snap action of the movable contact assembly including the diaphragm 34 having its central area disposed for axial movement within the snap switch. In the normal unoperated position of the diaphragm 34, the circuit through the terminals 24 and 26, is closed via the opposed contact assembly 59 and the movable contact 36. Upon applying an actuating force to the push-button 70, the actuator 46 is depressed to move and deform the central area of the diaphragm 34 to the position indicated by the dotted line 54. Since only the central portion 38 (or 77 in the embodiment of FIG. 4) of the diaphragm 34 has travelled over center while the rim 41 (or 79 if the embodiment of FIG. 4 is used) remains substantially in an unstressed condition except possibly at its upper lip area, adjacent the slot 40 (or slit 78), the rim by the force of its resistance to deformation acts, through tabs 33 (or 77 if the embodiment of FIG. 4 is used), to return the diaphragm to its normal and unoperated position. During the interval that the snap switch is operated, a circuit connecting termnials 22 and 24 is completed through the movable contact 36, diaphragm 34 and retainer ring 32.

The radially disposed arcuate slots or slits **40** and **78** in the diaphragms **34** and **76**, respectively, separate the two zones of spring force and also, incidentally, provide some relief for the compression of the central area of the diaphragm during operation. Flex grooves **82** and **84** are included to povide uniform bending of the diaphragm.

If the openings are provided in the concavo-convex diaphragm, and the actuator legs permitted to extend therethrough, the openings should conform to the cross-sectional shapes of the legs with a slight clearance between the leg and the openings. As the diaphragm is activated, or snapped over, a binding action betwen the legs and the openings occurs, thus affecting a stop against complete snap over. This adds in return of the central area of the spring to its unsnapped position.

While a detailed description has been provided of several embodiments, it is realized that alternative designs or modifications in the embodiments shown can be made, without departing from the true spirit and scope of this invention.

I claim:

1. In a snap switch including an enclosure and a contact element affixed thereto, the improvement comprising a movable contact assembly comprising a resilient concavo-convex diaphragm mounted within said enclosure and having a central area with a movable contact element affixed to the axial portion of the central area of said diaphragm for engaging said fixed contact element and a rim area separated by arcuate openings therein, said central area being disposed for axial movement, an actuator disposed for axial movement in the enclosure and in operative engagement with the central area of said diaphragm, said actuator including a radially extending body with peripheral subtending legs projecting therefrom and engaging the peripheral zone of the central area of the diaphragm for applying actuating forces to the central area of the diaphragm to produce a snap action operation of the central area and rapid engagement and disengagement of the movable contact element with said enclosure-affixed contact element.

2. In a snap switch including an actuator and a switch enclosure, a movable contact assembly supported in the enclosure comprising a concavo-convex diaphragm formed of resilient conductive material having a centrally disposed movable contact element for engaging at least one other switch contact element, flex grooves in the diaphragm extending radially from the movable contact, a plurality of openings in the diaphragm disposed radially about the center contact, said openings including spaced pressure relief openings providing for compression of the diaphragm during axial movement of the movable contact element and adjacent diaphragm area relative to the outer edges of the diaphragm and openings for receiving and coupling the actuator to the diaphragm whereby a complete operation of the actuator produces a snap movement of the movable contact element to engage and disengage the movable contact element with at least one other contact element.

3. In a snap switch including an actuator and an annular switch enclosure, a movable contact assembly comprising a resilient preformed concavo-convex annular diaphragm in which the annular edge of the diaphragm is seated in an annular V-shaped groove in the inner periphery of the switch enclosure and a movable contact element mounted in the center of the diaphragm for engaging at least one other switch contact, a plurality of openings in the diaphragm spaced radially about the movable contact, said openings including spaced arcuate pressure relief openings providing for compression of the diaphragm during axial movement of the movable contact element and the inner area of the diaphragm relative to the edges of the diaphragm and openings for receiving and retaining at least a portion of the actuator in the diaphragm whereby operation of the actuator produces a snap operation of the diaphragm for quick engagement and disengagement of the movable contact element and the other contact element.

4. A snap switch including an annular enclosure member for housing the switch elements, a movable contact assembly comprising a resilient concavo-convex diaphragm mounted in the enclosure, a movable contact element supported in the central area of the diaphragm, a plurality of openings in the diaphragm radially disposed about the movable contact element to provide pressure relief within the diaphragm for axial movement of the contact element and central area of the diaphragm, an actuator disposed for axial movement in the enclosure and in operative relationship with the diaphragm comprising a radially extending body member having subtending legs disposed annularly about the body member and projecting transversely therefrom, radial openings in the diaphragm about the contact element individual to the actuator legs receiving and passing a portion of the legs for releasably securing the legs to the diaphragm, said switch being responsive to actuating forces exerted on the actuator to operate the movable contact assembly in a snap action for rapid engagement and disengagement of the movable contact element and an opposing contact element.

5. The snap switch of claim 4 in which the outer periphery of the annular enclosure is threaded for threading into a switch operator.

6. In a snap switch, a movable contact assembly comprising a resilient concavo-convex diaphragm of conductive material supported in an enclosure and having a central area disposed for axial movement, a movable contact element centrally disposed in the diaphragm for engaging an opposing contact element, radially disposed arcuate compression relief openings in the diaphragm for reducing the actuating force of the diaphragm, an actuator disposed for axial movement on one side of the diaphragm and in operative relationship therewith, said actuator including a radially extending body and subtending legs engaging the diaphragm on opposing sides of the movable contact element, radially disposed openings for receiving the respective end portions of the actuator legs, and means for limiting the travel of the diaphragm, whereby the switch is returned to its initial position upon withdrawing the actuating pressure to the actuator.

7. The movable contact assembly as defined in claim 6 wherein the portion of each of the legs of the actuator that engage the diaphragm is generally triangular in shape with the apex formed by two sides thereof projecting toward the center of the diaphragm.

8. In a snap switch including an enclosure and a contact element affixed thereto, the improvement comprising a movable contact assembly comprising a resilient concavo-convex diaphragm of conductive material supported within said enclosure and having a central area and a rim area separated by arcuate slots therein, which define tab portions between the central and rim areas, said central area being disposed for axial movement and having a movable contact element centrally affixed therein for engaging said enclosure affixed contact element, an actuator disposed for axial movement on one side of the diaphragm and in operative relationship therewith, said actuator including a radially extending body with peripheral subtending legs engaging the diaphragm adjacent said tab portions to produce a snap action operation of the central area and rapid engagement and disengagement of the movable contact element with said enclosure affixed contact element.

9. In a snap switch including an actuator and a switch enclosure, a movable contact assembly supported in the enclosure comprising a concavo-convex diaphragm formed of resilient conductive material having a centrally disposed movable contact element for engaging at least one other switch contact element, flex grooves in the diaphragm extending radially from the movable contact element, a plurality of spaced pressure relief openings in the dia-

phragm disposed about the center contact providing for compression of the diaphragm during axial movement of the movable contact element and adjacent diaphragm area relative to the outer edges of the diaphragm whereby a complete operation of the actuator produces a snap movement of the movable contact element to engage and disengage the movable contact element with at least one other contact element.

10. In a snap switch, a movable contact assembly comprising a resilient concavo-convex diaphragm of conductive material supported in an enclosure and having a central area disposed for axial movement, a movable contact element centrally disposed in the diaphragm for engaging an opposing contact element, arcuate compression relief openings in the diaphragm for reducing the actuating force of the diaphragm, an actuator disposed for axial movement on one side of the diaphragm and in operative relationship therewith, said actuator including a radially extending body and subtending legs engaging the diaphragm on opposing sides of the movable contact element, each of the legs of the actuator that engages the diaphragm being generally triangular in shape with the apex formed by two sides thereof projecting toward the center of the diaphragm whereby the switch is responsive to actuating forces exerted on the actuator to operate the movable contact element in a snap action for rapid engagement and disengagement of the movable contact element and an opposing contact element.

11. In a snap switch, a movable contact assembly comprising a resilient concavo-convex diaphragm of conductive material supported in an enclosure and having a central area disposed for axial movement, a movable contact element centrally disposed in the diaphragm for engaging an opposing contact element, radially disposed arcuate compression relief openings in the diaphragm for reducing the actuating force of the diaphragm, an actuator disposed for axial movement on one side of the diaphragm and in operative relationship therewith, said actuator including a radially extending body and subtending legs engaging the diaphragm on opposing sides of the movable contact element, radially disposed openings for receiving the respective end portions of the actuator legs, and limiting means engaging the legs of the actuator to prevent travel of the outer portion of the diaphragm over center whereby the switch is returned to its initial position upon withdrawing the actuating pressure to the actuator.

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