United States Patent

Burch et al.

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[54] **SNAP ACTION SWITCH WITH FREE-FLOATING ROLLER AND CAM SHAPED ACTUATOR**

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[21] Appl. No.: **877,959**

[52] **U.S. Cl.**.....**200/68**, 200/77, 200/166 BB

[51] **Int. Cl.**.....**H01h 13/32**, H01h 13/28

[58] **Field of Search**.....200/68, 73, 166 B, 52, 6, 77

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Primary Examiner—Robert K. Schaefer
Assistant Examiner—Robert A. Vanderhye
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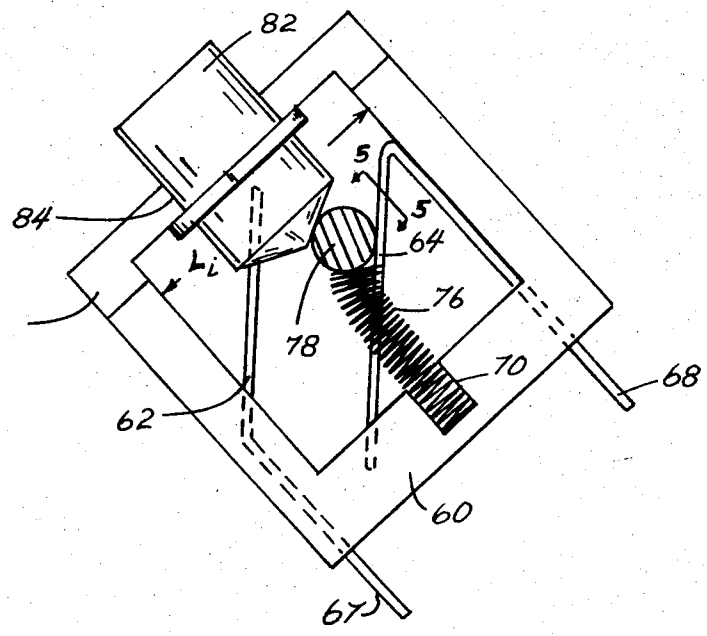
[57] **ABSTRACT**

Principles of switching are disclosed which variously enable achievement of simplicity, high current for size, long life and automated production. The principles are applicable to most switching situations.

Conductor elements which are discrete, loosely confined by casing, dropped into operating position during assembly, circular, rigid, rotatable, elongated, in the form of a laterally moving rod, serving as a snap action bus, and capable of double make and break are variously shown.

Directing assemblies move the conductor elements along a first surface until a release region is reached. Resilient energy stored during that movement then propels the conductor element away from the first surface, against an opposed surface. Assemblies are shown which are movable and self adjustable so as to constrain the conductor element against either opposed surface. Directing assemblies featured have faces that constrain the conductor, wedge it forward and, after release, divert it to the opposed surface. Projecting members that define these faces are shown as actuators movable relative toward the contact surfaces. Resilient members are shown on the opposite side of the conductor element, confined between the latter and a formation of the housing. The resilient members are arranged to propel the conductor along a path lying at an acute angle to the path the conductor element followed earlier as it approached the release region.

3 Claims, 27 Drawing Figures



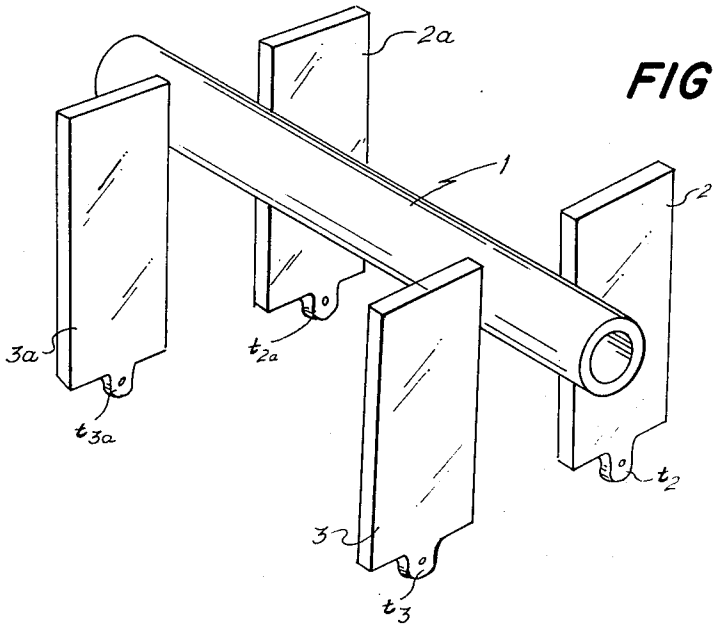


FIG 1

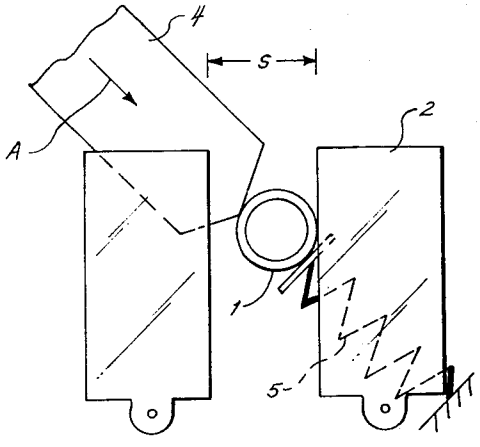


FIG 2

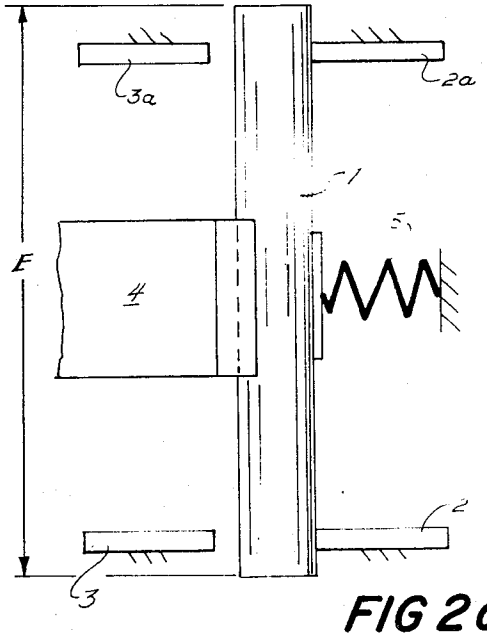


FIG 2a

FIG 3

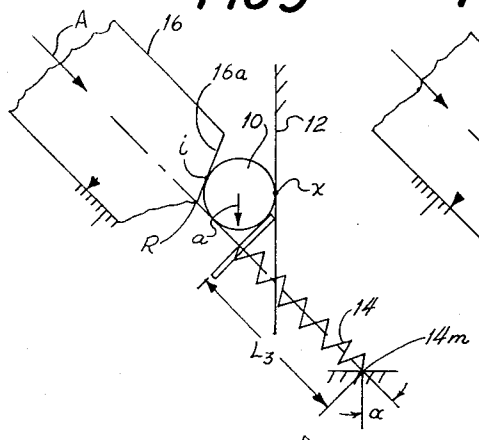


FIG 3a

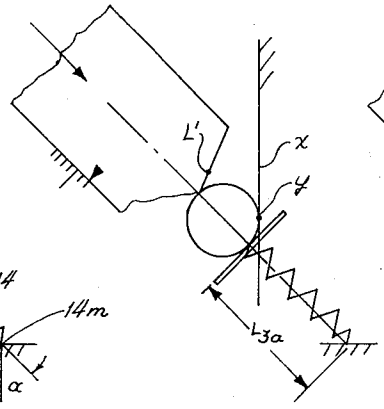
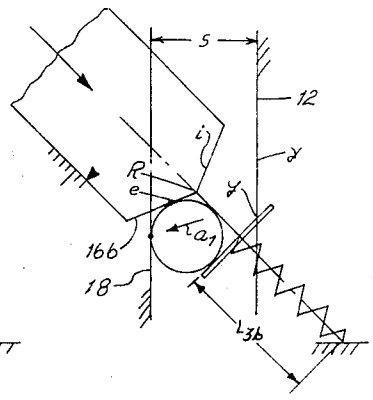


FIG 3b



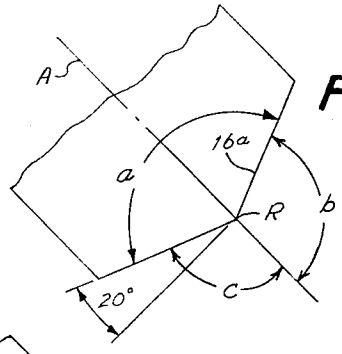


FIG 3d

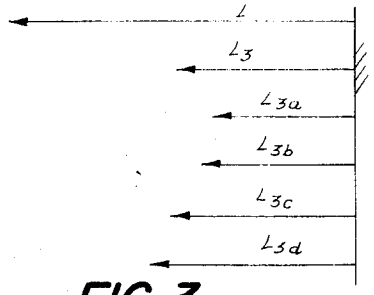


FIG 3e

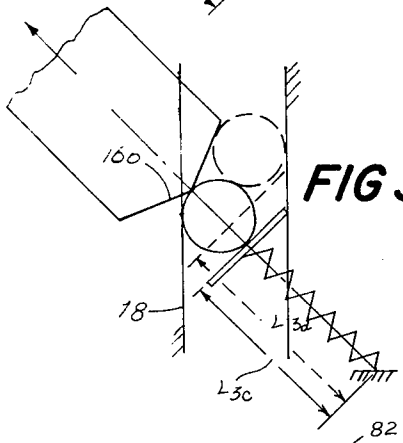


FIG 3c

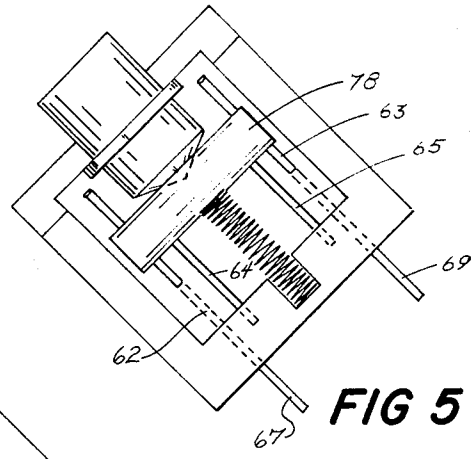


FIG 5

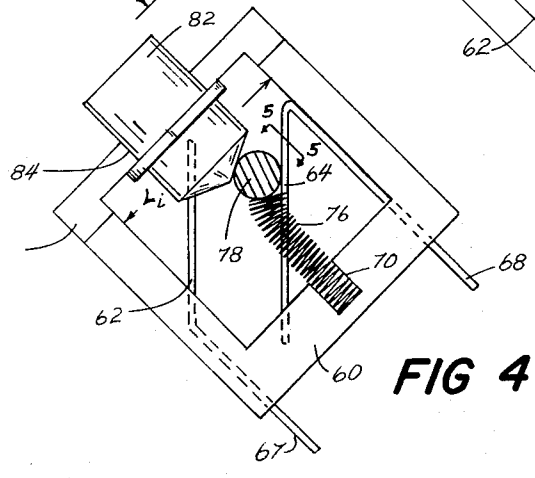


FIG 4

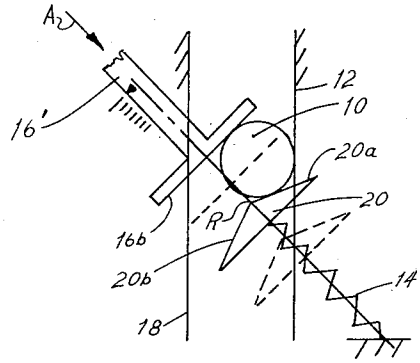


FIG 6

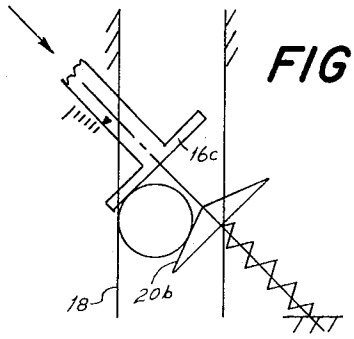


FIG 6a

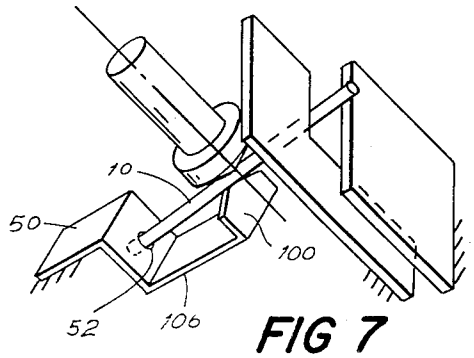


FIG 7

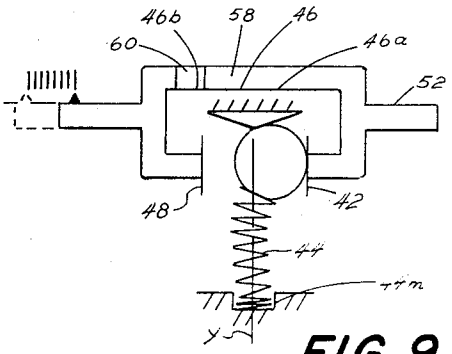


FIG 9

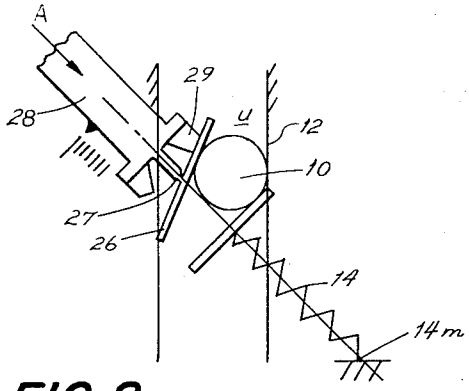


FIG 8

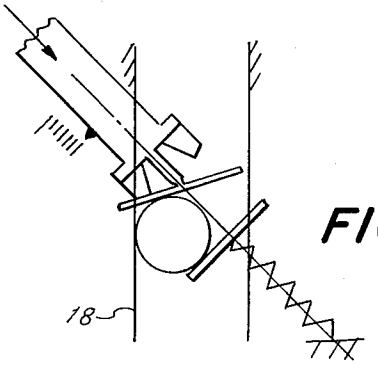


FIG 8a

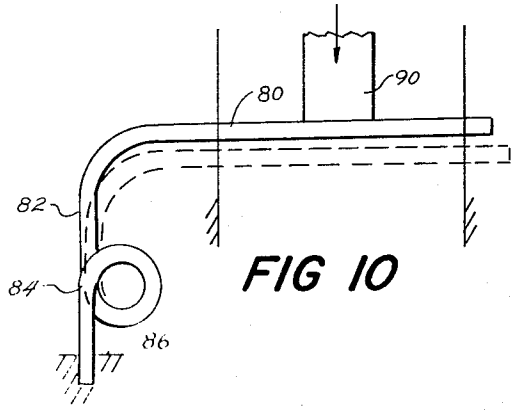


FIG 10

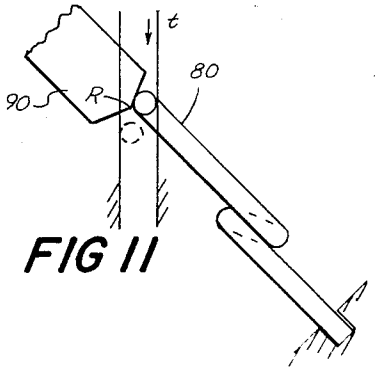


FIG 11

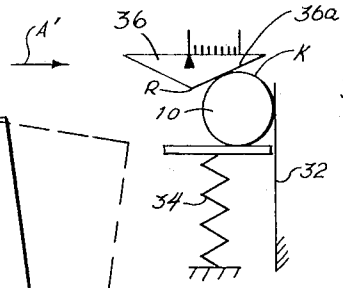


FIG 12

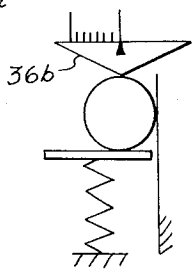


FIG 12a

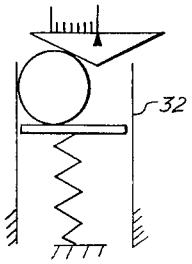


FIG 12b

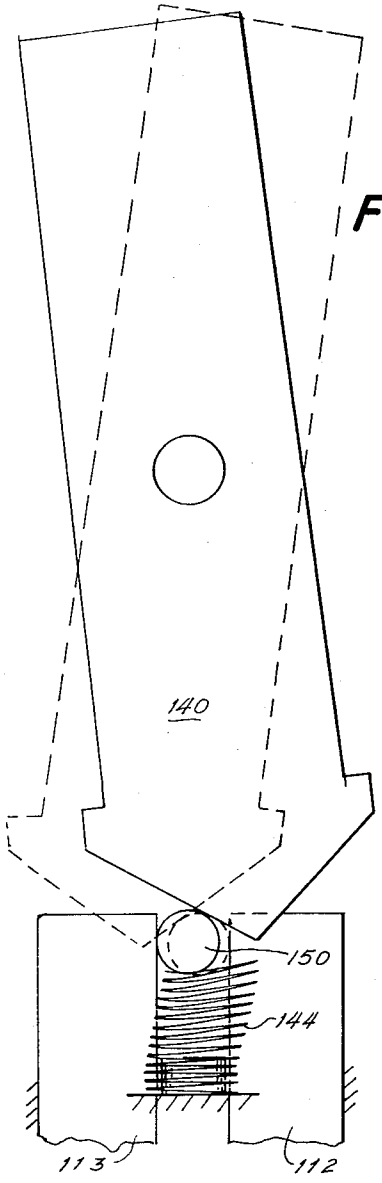


FIG 14

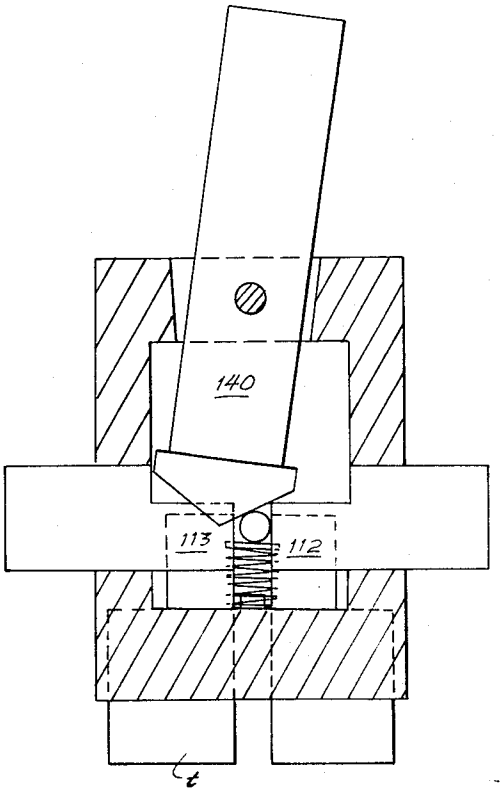


FIG 13

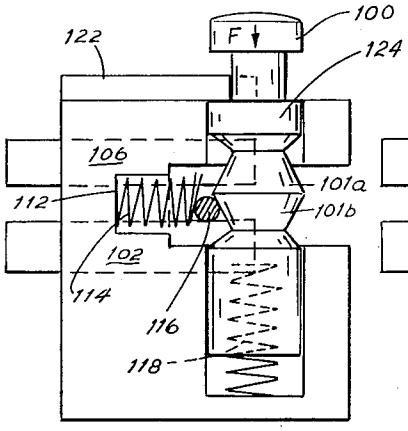


FIG 15

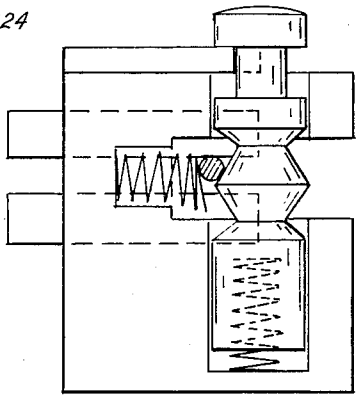


FIG 15a

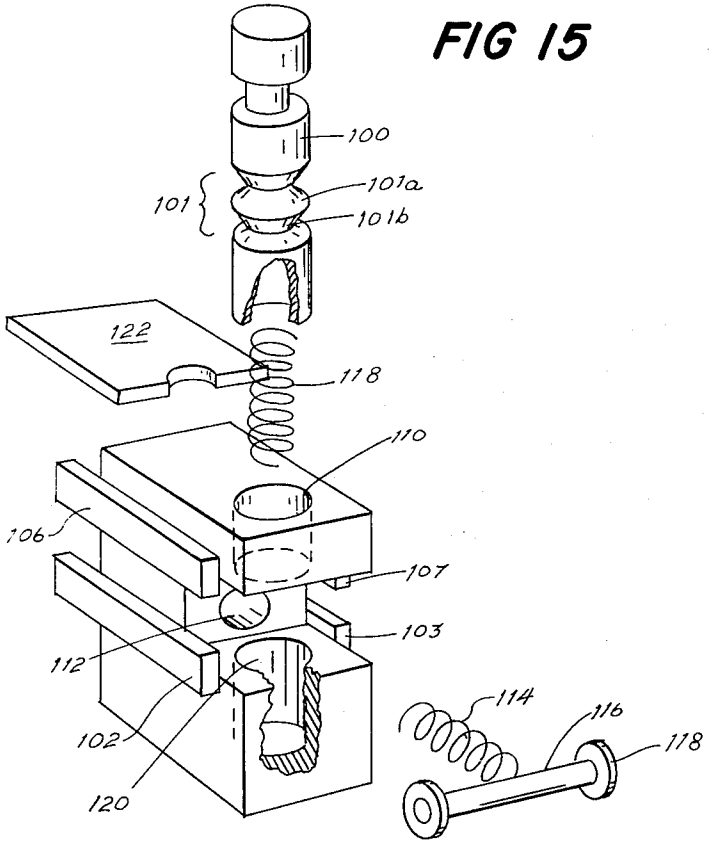


FIG 16

SNAP ACTION SWITCH WITH FREE-FLOATING ROLLER AND CAM SHAPED ACTUATOR

This invention relates to switches and their manufacture.

It is the object of the invention to provide principles which may be employed for reducing the number of parts of a switch and their complexity, for enabling mass production of the parts and their automated assembly, for obtaining improved snap action characteristics such as improved life and greater switching capacity, and for performing a wide variety of switching function with the same parts.

In one important aspect the invention features a discrete conductor element, e.g., a rod or a free-floating bar or cylinder, which is constrained to move relative to a contact surface while a resilient member, e.g. a compression spring, is stressed. When a release region is reached the conductor element is urged to move through space, away from the contact surface at an angle to its earlier path. According to one important aspect of the invention a snap action switch is achieved in which the snap acting conductor element forms a bridging current path between a pair of electrical contacts, the snap acting bridging element comprising a smooth surface of revolution in the region where a biasing means directly engages it, the biasing means applying radial force without restraint against lateral relative movement.

These and other objects and features of the invention will be understood from the abstract and claims and the following description of preferred embodiments with reference to the drawings wherein:

FIG. 1 is a perspective view of the arrangement of contacts and discrete, rod-form conductor element of a specific embodiment of the invention while FIGS. 2 and 2*a* are end and top views of the operating portions of that embodiment;

FIG. 3 is a diagrammatic representation of a general embodiment of the invention;

FIGS. 3*a*, 3*b*, and 3*c* are views similar to FIG. 3 showing the switch at various points during its operation while FIG. 3*d* is a magnified view of the actuator of FIG. 3; and FIG. 3*e* is a vector representation of the lengths of the spring of the embodiment of FIG. 3 occurring in the various FIGS. 3, 3*a* and 3*b*;

FIG. 4 is a vertical cross-section of a third embodiment according to the invention while FIG. 5 is a cross-section of that embodiment along lines 5—5;

FIG. 6 is a diagrammatic representation of another embodiment while FIG. 6*a* is a view similar to FIG. 6 showing the elements in a different position during switch operation;

FIG. 7 is a diagrammatic view of another embodiment in which a spring and directing surface for the conductor element are formed as an extension of a holder for that element;

FIGS. 8 and 8*a* show another embodiment employing a tilting surface for releasing the conductor element;

FIG. 9 shows a switch construction in which movable contacts roll a free conductor element through the release region;

FIGS. 10 and 11 are side and end diagrammatic views of another embodiment of the invention employing a conductor element of rod form;

FIGS. 12, 12*a* and 12*b*, show diagrammatically an actuator moving transversely relative to a stationary contact;

FIGS. 13 and 14 are similar cross-sections but on different scale of another embodiment of the invention;

FIG. 15 is a cross-section of still another embodiment of the invention while FIG. 15*a* is a view similar to FIG. 15 with the parts in another position and FIG. 16 is an exploded view thereof.

The embodiment of FIGS. 1–2 comprises a conductor element 1 in the form of an elongated cylinder bar of rigid conductive material. It spans between two stationary members 2, 2*a*, which together form a pair of first contacts, having terminals t. Two other members 3, 3*a*, are opposed to members 2, 2*a*, forming a second pair of contacts. The pairs of contacts are spaced apart a distance *s* greater than the thickness of conductor element *l*, and the length E of the conductor element is greater than the spacing *p* between members of the contact pairs.

Referring to FIGS. 2 and 2*a* a directing assembly is formed by actuator 4 on one side of conductor element 1 and spring 5 on the other side. The conductor element 1 is thus not carried by any other member but is rather resiliently constrained against the contact 2 by three-point slidable engagement of parts upon its periphery.

With two leads completing a circuit connected to terminals t_2 and t_{2a}, the current flows through the bar 1 of rigid material. When the actuator 4 moves down, the bar moves, usually rolling but sliding also permitted, relative to the two stationary contact members, 2, 2*a*. Transverse relative motion of the bar also occurs with reference to axis A of actuator 4. When the release point R formed by the actuator is reached, the bar moves abruptly from the two contact members 2 and 2*a*, across the space s and into engagement with contact members 3 and 3*a*. This action constitutes a double break of the circuit through terminals t_2, t_{2a}, and double make between t_3 and t_{3a}, with the inherent advantage of added capacity that this gives. Also to be noted are the facts that current is carried only through rigid members, and that relative movement of the conductor element with the engaged contacts occurs up to the very point of snap action.

The snap action will be better understood in light of discussion of the more general embodiment of FIG. 3. There a conductor element 10 of rigid material and circular form is adapted to move in the direction of arrow *a* along the surface of stationary contact 12 as seen in the perspective view of FIG. 1 the conductor bridges a spaced pair of members. The conductor element 10 is constrained against this contact by a spring 14 and an actuator 16, these engaging conductor 10 on opposite sides on a line making an angle α of e.g. 45° to the surface of stationary contact 12. The actuator moves straight along this line, axis A, and the spring is arranged to be compressed in the direction of this line. The uncompressed length L of spring 14 is shown in FIG. 3e.

The conductor 10 is free to move with respect to each member. While it moves in direction *a* rolling along the second contact 12 it also rotates relative to spring 14 and actuator 16 as well as moving laterally relative to axis A.

The actuator face 16*a* which engages conductor 10, is set at an obtuse angle b (e.g., 110°, FIG. 3*d*) to the direction of movement of the actuator and this face 16*a* has an end release point R. Face 16*a* and contact 12 thus form an acute angle crotch in which conductor 10 resides in stable position. Referring to FIG. 3, it engages contact 12 at point *x* and actuator face 16*a* at point i, the latter point being spaced from release point R. In FIG. 3 the spring is compressed to length L_3. In FIG. 3a actuator 16 has moved along its axis closer to contact 12. Conductor 10 has travelled along contact L_{3a} to point y, spring 14 has compressed to length La ($La<L_3$ see FIG. 3e) and conductor 10 has moved transversely relative to actuator 16 so that it is passing the release point R. This is an unstable position. When the center of conductor 10 passes a line projected between release point R and mount 14m of the far end of the spring, then face 16*a* is no longer effective to constrain conductor 10 against contact 12. The conductor 10 is released and moves abruptly away from contact 12 under the influence of stored energy of the spring, which expands.

Referring to FIGS. 3*b* and 3*c* the actuator 16 is provided with a second face 16b extending from release point R at an obtuse angle *c* (e.g. 110°) to actuator axis A, in the opposite direction from face 16*a*. Thus faces 16*a* and 16*b* define an included angle d less than 180°, e.g., 140°, having a projecting point at R. The angle of face 16*b* provides a relief space into which the conductor 10 is urged. During expansion of the spring 14 conductor escapes from release point R along path a_1, at an acute angle to earlier path *a*. Face 16*b* may be engaged by the conductor 10 during this movement, and after conductor 10 has moved away from second contact 12 it engages face 16*b* at point *e*.

Referring to FIG. 3*e* it will be seen that the assembly has acted to compress the spring 14 to a minimum length L_{3a} at the point where conductor 10 reaches a position of release or instability, from which the conductor moves with expansion of the spring. Once the position of instability is reached (FIG. 3*a*) no further movement of the actuator is theoretically needed to cause the abrupt movement to the position depicted at FIG. 3*b*.

Second contact 18 extends parallel to contact 12, spaced from it a distance greater than D, the diameter of conductor 10. This second contact is shown being engaged by conductor 10 while the latter engages the actuator at point e. It is seen that conductor 10 is again constrained and expansion of spring 14 is limited to length L_{3b}. The directing assembly has thus been self adjustable, effective to constrain the conductor against either of the opposed surfaces of contacts 12 and 10.

Upon return movement of the actuator (in the direction opposite of arrow A in FIG. 1) conductor 10 moves upwardly along contact 18 while moving relatively along face 16*b* of actuator 16 from point e toward point R — where face 16*b* ends. With conductor 10 still engaging contact 18, as the center of conductor 10 passes the line projected between spring mount 14_m and release point R, an unstable condition is again reached. Conductor 10 springs into the open space beyond point R, travelling laterally along actuator face 16*a* until it reaches contact 12, in the dotted line position shown in FIG. 3*c*, spring length L_{3d}. A suitable stop is provided to prevent much further release movement of the actuator.

It is quite conceivable that the action here described with reference to FIGS. 3 and 3*a* would be useful without an opposed contact, with other form of retaining member acting to hold the conductor. Another form of return is also conceivable if return is required. A zig-zag path between successive contacts in a multiple action switch, progressing generally in the same direction would eliminate return in certain switches. Here the last contact for instance could complete the loop with the first contact. In important instances, however, return movement as illustrated in FIGS. 3*b* and 3*c* is desired. Then the path of the conductor element is a closed loop, between the two pairs of contacts. With the particular arrangement shown it will be seen that this loop is in the form of a parallelogram.

This general embodiment can be employed in numerous ways to accomplish switching. For instance either the actuator 16 of the spring 14 could be connected to a terminal to create a circuit through conductor 10 to the engaged contact 12 or 18, or even flexible "pigtail" connections to the conductor 10 could be employed. The advantage of all current carrying elements being of rigid material (hence thick and of high capacity) is obtained when the conductor serves as a shunt between a pair of members forming one of the sides of the switch. Where the conductor 10 is a spherical ball this could be accomplished with a track formed by two spaced members, along which the ball rolls.

In the preferred embodiment of FIGS. 4 and 5, the conductor 10 is a rod and it is loosely disposed in the casing, spanning pairs of contacts, and confined against end-wise movement by walls of the casing.

Here the switch comprises a casing 60 e.g., of plastic into which are molded four rigid contact members, formed surfaces of which define contacts 62, 63, 64 and 65, and projecting ends of which define terminal 67, 68, 69 and another not shown. (To establish a common terminal for instance contacts 62 and 64 may be formed integrally in the same rigid conductive member, and connected to a common terminal.) In the base of casing 60 a hole formation 70 is provided having a bottom surface. Into this hole is inserted a resilient member, here, coil spring 76. The parts are constructed to permit reciprocatory motion with contraction and expansion of the spring. A rigid bar 78 of a length slightly less than the inside dimension *Li* of casing 60 is dropped into this construction, rests on contacts 64 and 65 and against the surface of the resilient member found at the bottom end of the space between the opposed contact pairs. Conductor 78 is shown engaging the spring directly, as is also true in certain following embodiments.

An actuator 82 is inserted in hole 84 in the cover 62 and the cover is then secured to the base of casing 60 completing the switch. Reciprocal plunger movement of the actuator 82 is effective to cause the conductor 78 to roll, mutually engaging, alternately, pairs of contacts 62, 63 and 64, 65.

The spring 76 is effective to cause return movement of the plunger acting through the conductor 78, as well as to impart snap action to the conductor 78 itself.

The reader should note that the conductor 78 is unattached to other parts. The resilient member is first

dropped into its hole and is confined against the housing by the conductor which is then dropped in. An operative switch is obtained by supplying the last part, the actuator, and affixing the cover without post assembly adjustments. These assembly operations can be performed entirely automatically, without need of skilled labor.

Initial work employing the invention resulted in the preferred embodiments just described and other embodiments of certain features, to be described now referring to FIGS. 6–11. Other presently preferred embodiments will then be described in connection with FIGS. 13–16. The reader will understand, however, that all of these embodiments are the result of only a limited period of work, and with more time, and when different switching requirements, size requirements, etc., are examined, numerous other embodiments of features of the invention are expected to occur to those skilled in the art.

Referring to FIG. 6, this embodiment is similar to FIG. 3b except that the actuator face 16*c* engaging conductor 10 is at right angles to actuator axis A and a member 20 having faces like those of the actuator in FIG. 3 is supported on the end of spring 14 and defines the constraining faces 20a and 20b with release point R. Movement of the actuator 16' in the direction of the arrow causes conductor 10 to roll down contact 12 until it reaches point R. There the contact is released and under the combined effect of the relieved face 20*b* and spring 14 conductor 10 escapes from contact 12 and is directed into a crotch formed by contact 18 and actuator surface 16*c*. From this position, reverse movement can occur similarly to that as described in connection with FIG. 3*c*.

Referring to the embodiment of FIG. 7 an extension of common terminal 50 has a cutout 52 which confines one end of the conductor rod. Where this confinement is a loose hole holding the rod, swivel movement of the rod would occur with actuation. Snap action would occur at one end of the rod only. On the other hand the shaping and spacing of the confinement surfaces could be identical to the shape of the space between the contacts and snap action would occur as previously described, with transverse motion bodily of the rod.

A further cantilever spring extension 106 of common terminal 50 extends under conductor 10. The end 100 of this extension forms an angular member for constraining the conductor 10 in the manner of member 20 of FIG. 6.

Referring to the embodiment of FIG. 8, the conductor and spring arrangement is the same as FIG. 3 but the actuator has a tiltable surface 26 pivoted at 27 to the actuator rod 28. The rod moves in a straight line along axis A. As shown in FIG. 8 the surface 26 is tilted to form an acute angle crotch K with contact 12, into which crotch conductor 10 is pressed by compression spring 14. A stop 29 prevents further counterclockwise rotation of tilt surface 26. As the actuator moves downwardly unstable position or release region is reached when the center of conductor 10 reaches the point coinciding with a line projected between the spring mount 14m and pivot 27. Thereupon tilt surface 26 turns clockwise, conductor 10 is released and moves abruptly to contact 18, see FIG. 8*a*.

Referring to FIG. 9 a conductor 10 is constrained against contact 42 by stationary surface 46 and compression spring 44. Stationary surface 46 defines faces 46*a* and 46*b* similar to the faces of the actuator of FIG. 3. Contact 42 is movable by an actuator 52 transversely to the line Y projected from spring mounting point 44m to release point R. When contact 42 moves to the left the conductor 10 rolls upwardly against contact 42. When the conductor reaches a point corresponding with the line Y, it is released and moves abruptly from contact 42 with expansion of spring 44. Here again, the conductor 10 reaches the release region, defined by the point R, still in electrical continuity with the contact 42 with which it started, and a torque or relative rotation occurs continually between the two to break incipient welds. Reaching point R conductor 10 can then jump to opposite contact 48. Contact 48 is linked to contact 42 by bridge 58 which includes insulating material 60, and the entire assembly is moved by actuator 52. As with the other embodiments, electrical connections can be made with terminal members by flexible pigtails connected to the various contacts.

In the embodiment of FIGS. 10 and 11 the rod 80 is formed integrally with a leg 82 which incorporates a spring loop 84 in the nature of a safety pin. The remote end of this leg is captured loosely in an opening 86 in the base of the switch. Movement of the actuator 90 downwardly against the bar 80, causing the bar to travel in the direction t along stationary contact 12, is effective to stress the spring. When the conductor 80 reaches release point R of the actuator the conductor springs away in the manner heretofore described. In place of actuator 90 a toggle type actuator, see e.g., FIG. 8, may be employed.

Referring first to the diagram of FIG. 12, an actuator 36 is shown moving transversely relative to the stationary contact 32, in a straight path A'. The conductor 10 is forced by spring 34 into an acute angle crotch *k* formed between contact 32 and face 36*a* of the actuator. As the actuator moves in the direction of the arrow A', a point of release R is reached (FIG. 12*a*) and the conductor 10 moves abruptly from surface 32, guided by face 36*b* which permits expansion of the spring as the conductor 10 moves away from contact 32.

Referring to FIGS. 13 and 14 the motion just described is incorporated in a toggle switch in which the toggle member 140 is held in either of its stable positions by the same spring 144 that serves to constrain the conductor member 150 and cause its snap movement. Contacts 112,113 are integral with terminals *t*.

Referring to FIGS. 15, 15*a* and 16, the actuator 100 of this embodiment is constrained for straight line movement at a right angle to opposed pairs of contact surfaces 102, 103 and 106, 107. This is achieved simply by a hollow bore 110 in the molded casing.

At the bottom of the space between the pairs of contacts a hole 112 is formed, into which is dropped spring 114. Conductor element 116, having end retaining flanges 118 is dropped into the assembly, resting upon spring 114.

The actuator 100 has a formed portion 101 presenting two faces 101*a* and 101*b* analagous to surfaces 36*a* and 36*b* of FIG. 2. The actuator is inserted into bore 110, with portion 101 lining up with the space between

the contacts, with face 101*b* engaging the conductor 116, and constraining the latter against contact 102. A spring 118 is inserted into bore 110 preceding the actuator, and seats in hole 120 beyond the contacts. In this position retainer 122 is fixed in position, engaging flange 124 of the actuator, to hold the parts in operating relation.

With further plunger movement of actuator 100, while spring 118 is compressed, the release point passes over the conductor 116 and the latter is snapped against contact 106 in the manner previously described. Upon release of actuating force F, spring 118 returns the actuator to its original position, and conductor 116 to contact 102.

To achieve a push pull switch or relay the spring 118 may be omitted and the switch will remain in either position until a push or pull actuating force is applied.

These and numerous other embodiments will occur to those skilled in the art.

What is claimed is:

1. A snap action switch having a bridging bar of electrically conductive material, the bar having a circular cross-section taken perpendicular to the longitudinal axis, a pair of electrical contacts across which said bar bridges to complete a circuit, and a snap action assembly including a cam and spring for snapping said bar toward or away from said electrical contacts, said bar being free floating and said snap action assembly comprising a resilient surface pressing against one side of said bar, urging the opposite side of said bar against said cam, said bar being free to move across and change its position on said resilient surface during said snap action, said switch including a moving device defining opposed push surfaces and adapted to push said bar back and forth, said cam being incorporated in stationary structure engaged by said bar during said movement, said push surfaces being adapted to move in unison and being spaced apart a distance greater than the diameter of said bar, enabling one push surface to push said bar as it moves over said cam until the bar reaches an over-center position whereupon said bar may snap over-center while free of said push surfaces, the bar then moving into a position to be engaged by said other push surface for return movement.

2. A snap action switch having a bridging bar of electrically conductive material, the bar having a circular cross-section taken perpendicular to the longitudinal axis, a pair of electrical contacts across which said bar bridges to complete a circuit, and a snap action assembly including a cam and spring for snapping said bar toward or away from said electrical contacts, said bar being free floating and said snap action assembly comprising a resilient surface pressing against one side of said bar, urging the opposite side of said bar against said cam, said bar being free to move across and change its position on said resilient surface during said snap action, said switch including an actuator and a single spring provides the resiliency for said resilient surface and is arranged to apply return forces to said actuator, whereby upon release of actuating forces said actuator returns to its initial position.

3. The snap action switch according to claim 2 wherein said spring comprises a coil spring and said actuator comprises a plunger having a cam-shaped end surface and a straight line of travel generally parallel to and toward the axis of said spring.

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