United States Patent

[11] 3,600,537

[72] Inventor **Robert H. Twyford**
Falls Church, Va.

[21] Appl. No. **816,322**
[22] Filed **Apr. 15, 1969**
[45] Patented **Aug. 17, 1971**
[73] Assignee **Mechanical Enterprises Incorporated**

[54] **SWITCH**
6 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** **200/152, 200/67**
[51] **Int. Cl.** **H01h 29/00**
[50] **Field of Search** ..... 200/67 MS, 67 D, 152.9, 152

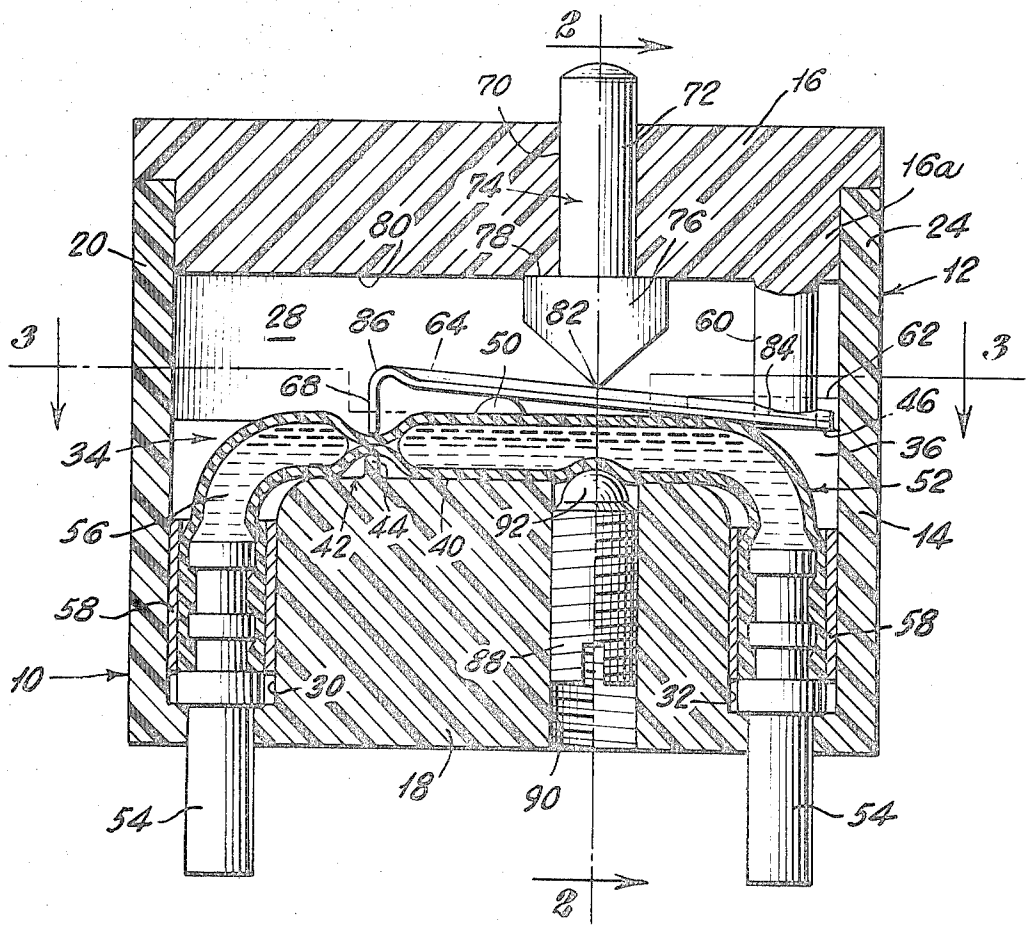
[56] **References Cited**

UNITED STATES PATENTS

2,420,880	5/1947	Hetherington	200/67 D
2,720,562	10/1955	McLaughlin	200/152.9
3,177,327	4/1965	Weiss	200/152.9
1,795,907	3/1931	Thomas	73/378.3
2,024,362	12/1935	Hoopes	74/100
2,332,883	10/1943	Abrahamson	74/100
2,374,435	4/1945	Jordan	200/67
2,512,306	6/1950	Clark et al.	200/67
2,574,869	11/1951	Green	337/88
3,133,170	5/1964	Nanninga	200/67

Primary Examiner—Robert K. Schaefer
Assistant Examiner—H. J. Hohauser
Attorney—Birch, Swindler, McKie & Beckett

ABSTRACT: An electrical switch including a resilient deformable tube filled with an electrically conductive liquid and a pair of relatively movable pinching elements disposed on opposite sides of the tube. The elements are mounted for movement between tube pinching and tube releasing positions, whereby in the tube pinching position the liquid in the tube is parted to open an electrical circuit. The switch also includes a spring-loaded snap-action mechanism operably connected to at least one of the elements for snapping the same from one of its positions to the other.

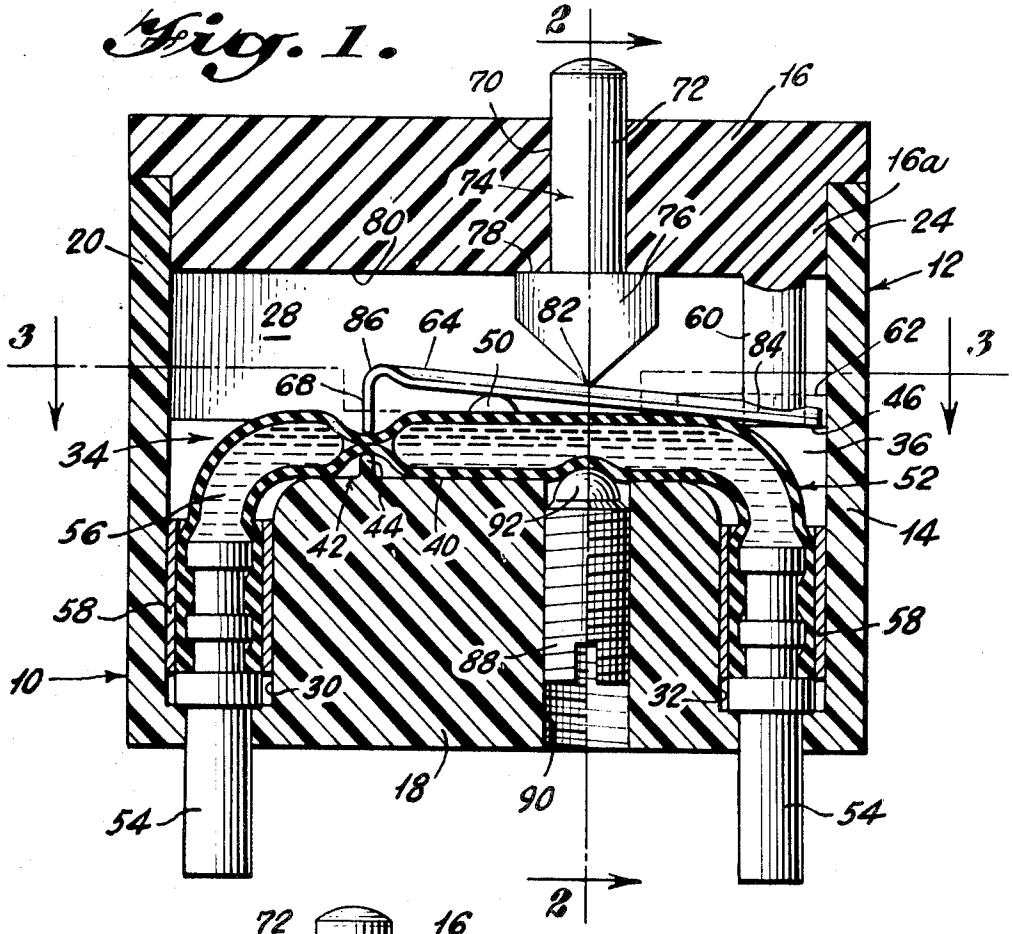


PATENTED AUG 17 1971

3,600,537

SHEET 1 OF 4

Fig. 1.



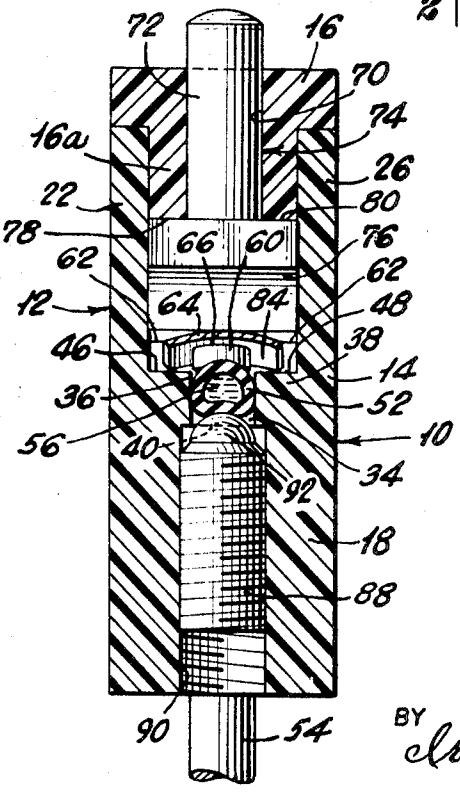
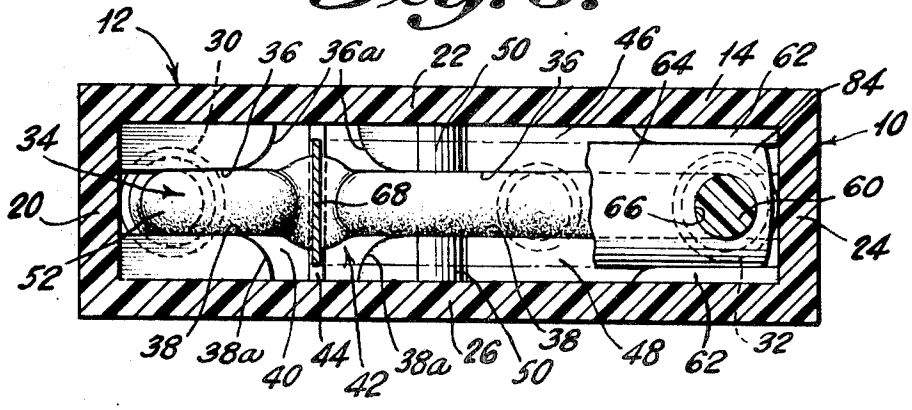


Fig. 2.

INVENTOR
ROBERT H. TWYFORD

BY Irons, Birch, Swindler & McKie
ATTORNEYS

Fig. 3.



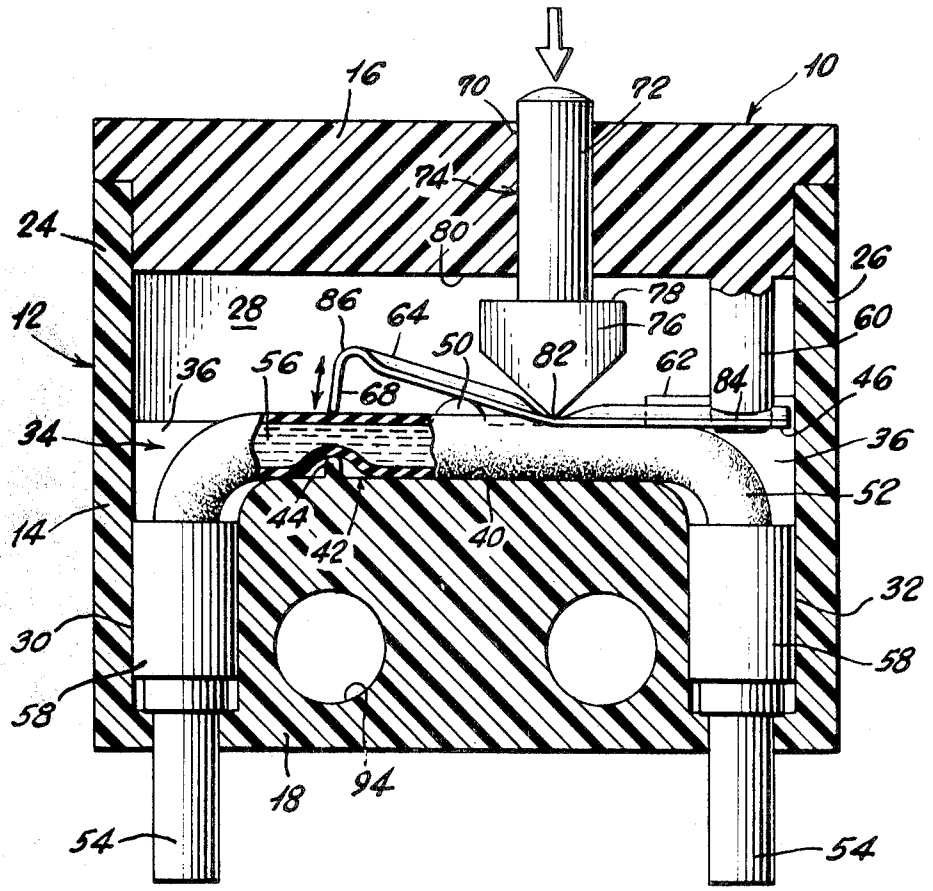


Fig. 4.

INVENTOR
ROBERT H. TWYFORD

BY
Irons, Birch, Swindler & McKie
ATTORNEYS

PATENTED AUG 17 1971

3,600,537

SHEET 3 OF 4

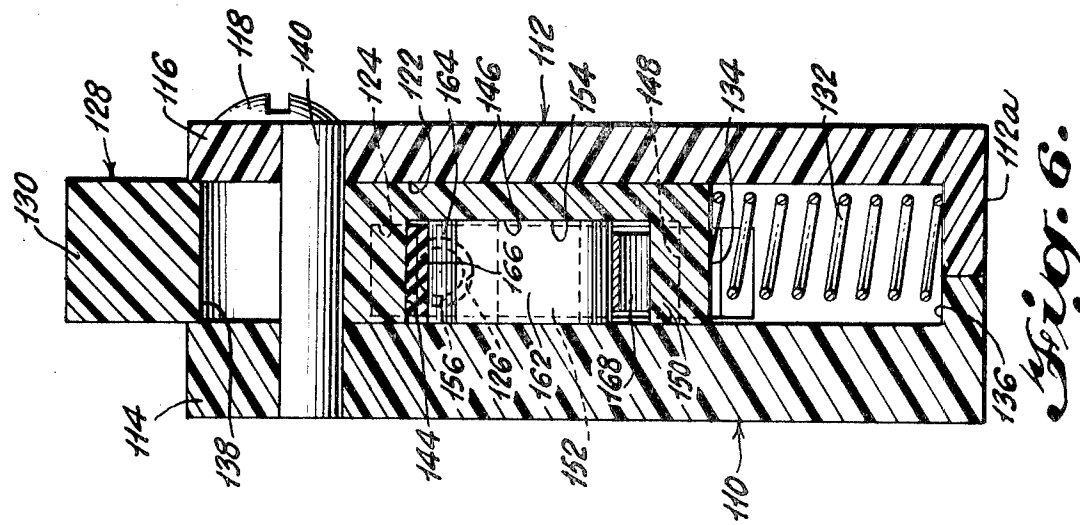


Fig. 6.

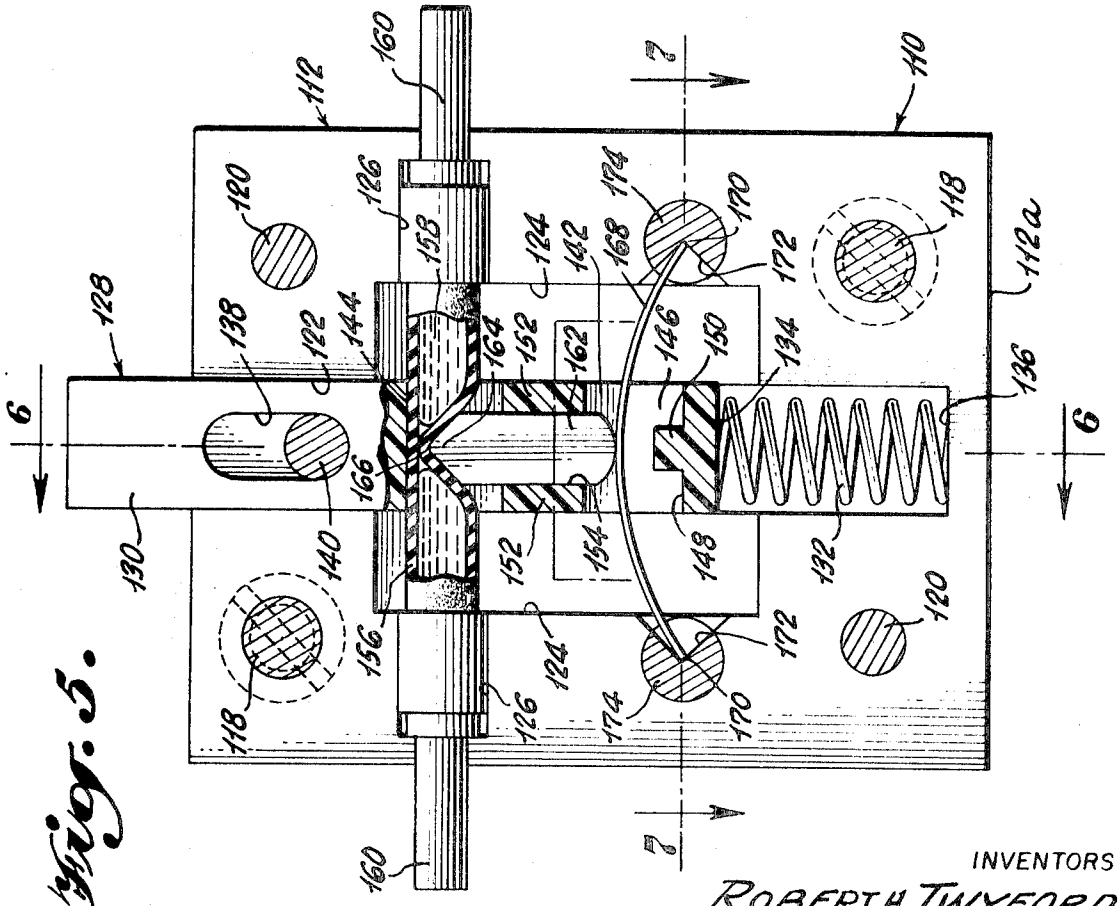


Fig. 5.

INVENTORS

ROBERT H. TWYFORD

BY

Irons, Birch, Swindler & McKie

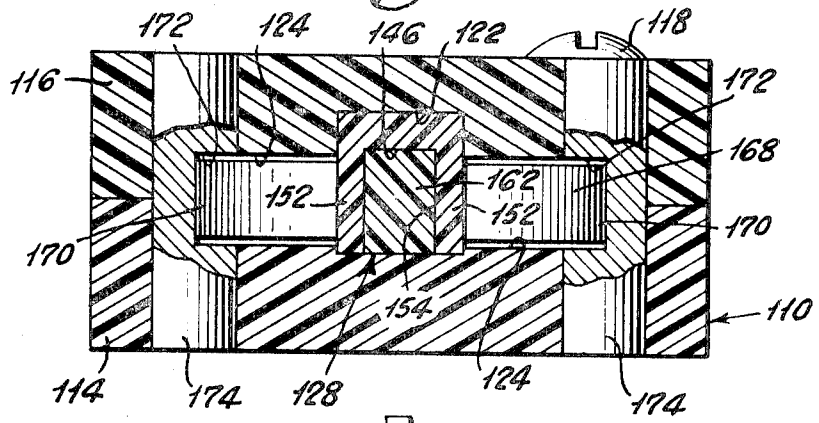
ATTORNEYS

PATENTED AUG 17 1971

3,600,537

SHEET 4 OF 4

Fig. 7.



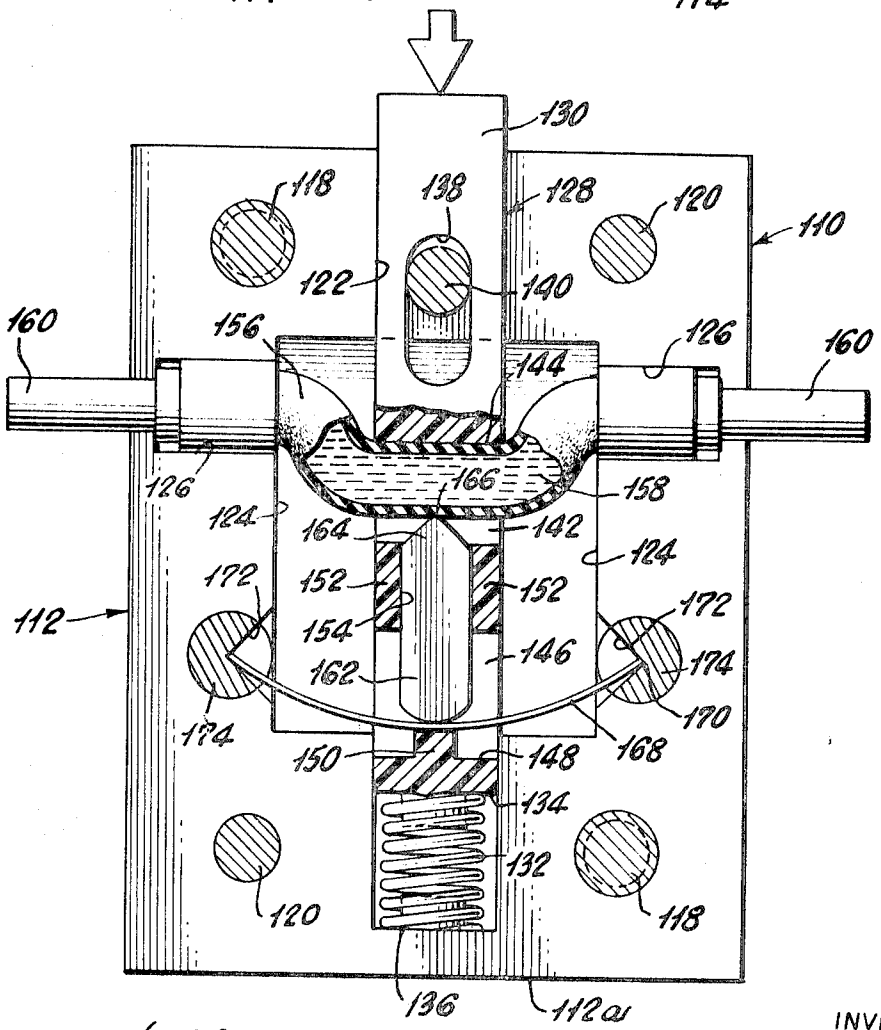


Fig. 8.

INVENTORS
ROBERT H. TWYFORD

BY
Arons, Birch, Swindler & McKie
ATTORNEYS

SWITCH

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to electrical switches and particularly to switches which include a pinchable tube filled with an electrically conductive fluid.

Description of the Prior Art

Various switches of the general type described above (which are typified for example, in U.S. Pat. No. 2,195,199) have been proposed in the past in an attempt to deal with certain problems which have particularly plagued the electrical communications and computer industries. These problems include, for example, the fact that certain prior art switches which have hard metal contact points as well as certain mercury switches have been found to be position sensitive and subject to contact oscillation requiring bounce gates in the circuitry. Further, because of certain arcing and contamination problems hard contacts are subject to pitting and the like which impedes proper timing and imposes undesirable voltage drop characteristics.

However, even the previous mercury switches having structures which include a pinchable tube filled with an electrically conductive liquid have experienced certain difficulties, such as, unpredictable responses in making or breaking the circuit.

SUMMARY OF THE INVENTION

The shortcomings inherent in the prior art switches are substantially overcome by the novel switch of the instant invention which combines the mechanical advantages of a snap-action switch with the electrical properties of a mercury switch. This is particularly accomplished in a switch which includes a tube filled with an electrically conductive liquid and structure operable for pinching the tube to part the liquid and open an electrical circuit. The structure comprises a pair of spaced pinching elements disposed on opposite sides of the tube, said elements being movable relatively in a direction toward and away from one another between tube pinching and tube releasing positions. Further, the structure also comprises a spring-loaded snap-action mechanism operably connected to at least one of the elements and actuatable for snapping said one element from one of said positions to the other. More specifically, the invention includes an overcenter device to provide the snap-action operation.

The invention is particularly directed to the provision of a switch of the kind described which is electrically normally open (that is to say, the tube is normally pinched and the liquid is normally parted). In this regard, the invention also includes, in its more specific aspects, means for pumping the liquid to momentarily increase its pressure at the instant of the snap-action release of the pinching elements whereby to cause the liquid to flow in a direction to form a continuous column to thereby close the electric circuit controlled by the switch.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view, partly in cross section, of an electrical switch embodying the principles and concepts of the instant invention;

FIG. 2 is a cross-sectional view of the switch taken substantially along line 2–2 of FIG. 1;

FIG. 3 is a cross-sectional view of the switch taken substantially along line 3–3 of FIG. 1;

FIG. 4 is a side elevational view, partly in cross section, illustrating the tube-pinching elements of the switch in their tube-releasing position;

FIG. 5 is a side elevational view, partly in cross section, of another electrical switch which embodies the principles and concepts of the instant invention;

FIG. 6 is a cross-sectional view of the embodiment of FIG. 5 taken substantially along lines 6–6 of FIG. 5;

FIG. 7 is a cross-sectional view of the embodiment of FIG. 5 taken substantially along lines 7–7 of FIG. 5; and

FIG. 8 is a side elevational view, partly in cross section, illustrating the two pinching elements of the switch embodiment of FIG. 5 in their tube-releasing position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

One form of an electrical switch, which embodies the concepts and principles of the instant invention is illustrated in FIGS. 1 –4 and is designated therein by the numeral 10. Switch 10 is of the type which is conventionally designated as being "normally open." That is to say, in its normal, or at rest condition, the switch does not permit flow of electrical current between its contacts.

In its preferred form, switch 10 includes a housing 12 which consists of a main body portion 14 and a lid portion 16. Portions 14 and 16 may be each formed in one piece from a moldable, thermoplastic resin such as, for example, polycarbonate resin. It is to be appreciated, however, that the material of construction of portions 14 and 16 is not critical and other operable materials are well known to the routineer in this art.

Portion 14 includes a block segment 18 and four walls 20, 22, 24 and 26 defining a cavity 28. Lid portion 16 has a section 16*a* of reduced size which is completely surrounded by walls 20 –26 and forms a boundary for cavity 28 such that the latter is substantially completely enclosed.

A pair of spaced openings 30 and 32 extend through block segment 18 to provide external access to cavity 28. A channel 34, defined by a plurality of walls 36, 38 and 40 (see particularly FIG. 2), extends between openings 30 and 32.

Viewing Flg. 3, it can be seen that walls 36 and 38 are each flared outwardly as at 36*a* and 38*a* to present a wide spot 42 in channel 34 disposed between openings 32 and 30 and somewhat closer to the latter. A rib 44 extends transversely across channel 34 at wide spot 42 for substantially the entire distance between walls 22 and 26. Lateral walls 46 and 48 extend outwardly from channel 34 to walls 22 and 26 respectively and each includes an upwardly bowed segment 50 disposed between wide spot 42 and opening 32. The segments 50 are preferably transversely hemispherical as can best be seen in FIG. 1.

A tube 52 constructed of deformable and resilient material is positioned within channel 34. Tube 52 is preferably greater in diameter than the depth of channel 34 so that it protrudes slightly into cavity 28. Tube 52 is provided with an electrical connector 54 at each end thereof and is filled with an electrically conductive, nonwetting liquid 56, such as, for example, mercury. Connectors 54 may be substantially as shown in FIG. 1 to provide convenient means for electrically connecting the switch in a circuit and are well known in the art. Connectors 54 are disposed within openings 30 and 32 as shown, and a sleeve 58 or the like may be provided for fastening tube 52 to each connector 54 and to substantially seal openings 30 and 32 to thereby preclude entry of foreign materials into cavity 28.

A post 60 extends inwardly of cavity 28 from section 16*a* of lid portion 16. Post 60 is located adjacent opening 32 and the free end thereof protrudes slightly into channel 34. A pair of opposed abutments 62 are provided adjacent post 60. One of the abutments 62 extends inwardly from wall 22 and upwardly from wall 46, while the other abutment 62 extends inwardly from wall 26 and upwardly from wall 48.

An elongated, transversely bowed, cricket-type spring 64 has an opening 66 at one end thereof and a lateral extension 68 disposed at the opposite end thereof. Spring 64 has a lateral width which is greater than the width of channel 34, but which is less than the width of wide spot 42. Spring 64 is normally disposed with opening 66 receiving post 60 therein and with extension 68 adjacent rib 44 as shown in FIG. 1. It is to be particularly noted that the end of spring 64 adjacent post 60 is supported by walls 46 and 48 and is positioned laterally between abutments 62 which operate to position spring 64 centrally with respect to channel 34.

An opening **70** is provided in lid portion **16** and receives the shaft **72** of a shiftable pushbutton actuator **74** therethrough. Actuator **74** includes a head portion **76** disposed within cavity **28**. Head portion **76** includes a shoulder **78** which is normally disposed against the internal wall **80** of lid portion **16** to thereby limit the movement of actuator **74** in a direction away from tube **52**. Head **76** is shaped to present an apex **82** which extends transversely of spring **64** and normally contacts the same in transverse line contact.

As can be seen viewing FIG. **1**, head portion **76** is of a size such that when shoulder **78** is in contact with wall **80**, tube **52** is pinched between extension **68** and rib **44**. Thus, it can be said that the movable pinching element presented by extension **68** and the stationary pinching element presented by **44** are disposed in a tube-pinching position (or condition). With the switch in this condition, it can be seen that the same is "-normally open" relative to flow of current between connections **54**. Also, in this condition, the force applied to spring **64** by apex **82** at the point of contact therebetween is sufficient to maintain extension **68** and rib **44** in their tube-pinching relationship, but is insufficient to flatten the transverse curvature of spring **64** beyond its center, which would result in collapse of the spring. Further, in the condition illustrated in FIG. **1** the segments **50** are preferably disposed in very slightly spaced relationship relative to spring **64**, such that they can operate as fixed fulcrums immediately upon collapse of spring **64** but do not interfere with the pinching of the tube when the switch is in its normally open position. Thus, it can be seen that switch **10** includes structure operable for pinching tube **52** to part the liquid **56** therein and open an electrical circuit.

Viewing FIG. **4**, it can be seen that when actuator **74** is pushed inwardly of switch **10**, apex **82** will act on spring **64** to flatten the same beyond the center point of its transverse curvature whereupon spring **64** will collapse adjacent apex **82**. Immediately, the relatively fixed end **84** of spring **64** will flatten against walls **46** and **48** while the opposite end **86** of spring **64** will be pivoted about the fixed fulcrum presented by the segments **50**. Thus, the elements **44** and **68** will be rapidly shifted into a tube-releasing position.

Tube **52** is preferably constructed of a resilient and easily deformable material, such as latex rubber, neoprene rubber or butyl rubber or, for that matter, any type of rubber or elasticized material. More generally, any creep resistant material is satisfactory, so long as the same has good temperature resisting characteristics.

The spring **64** and actuator **74** present a spring-loaded, snap-action mechanism for snapping elements **68** and **44** from their tube-pinching position into their tube-releasing position. The resiliency of the tube, which is provided by the material from which the same is constructed, assists in spreading elements **68** and **44** apart. Thus, it can be said that tube **52** acts like a spring which is normally overpowered by spring **64** so long as the same is in its uncollapsed condition; however, the resiliency of tube **52** overpowers spring **64** after the same has been flattened beyond its overcenter or collapse point.

In addition to the normal operation of the switch **10** as described above, switch **10** includes an additional capability which tends even more so to increase its responsiveness. Viewing FIG. **4**, it can be seen that actuator **74** has moved spring **64** into close contact with walls **46** and **48**. As discussed above, tube **52** has an outer diameter which is slightly greater than the depth of channel **34**. Thus, when spring **64** collapses, portion **84** of spring **64** will pump liquid **56** toward elements **44** and **68** by exerting an instantaneous pressure on tube **52** along the entire length of portion **84**. This is best illustrated in FIG. **4** wherein it can be seen that portion **84** has deflected the upper wall of tube **52**.

It has been found with switches of this type that when actuator **74** collapses spring **64** and simultaneously pumps the fluid **56** within tube **52**, an extremely fast response with no circuit bounce is achieved. In this regard, it has been found that the switch **10** is capable of being cycled at a rate of 200 Hz. and has a contact rise time of less than one nanosecond. Switch **10** also provides operation with a mechanical movement of as little as 0.005 inch and with an actuation force of 3.2 ounces. Further, the switch has been found capable of handling a current of 50 milliamps at 24 volts DC with a contact resistance of 35 milliohms, whereby the switch is ideal for low energy circuits such as are found in digital computers and control applications.

Viewing FIG. **1**, it can be seen that switch **10** may be provided with an adjustable screw **88** threadably engaged in an aperture **90**. Screw **88** is provided with a rounded head **92** disposed for compressing tube **52**. Thus, the pressure within tube **52** may be increased whereby to "tune" the switch for particular operations. It is to be understood that the screw **88** is normally not required even for extremely closely controlled operations. However, in applications which require the most extreme sensitivity, the screw **88** may be included.

VIewing FIG. **4** Viewing FIG. **4**, it can be seen that switch **10** may be provided with mounting holes **94** which extend through block segment **18**. Holes **94** may preferably be of standardized size and disposition.

Another electrical switch which embodies the principles and concepts of the invention is illustrated in FIGS. **5**–**8** and is designated therein broadly by the numeral **110**. Switch **110**, like switch **10**, is illustrated as being of the electrically "normally open" type. However, as will be explained later, switch **110** may very simply be converted into an electrically "normally closed" type switch.

Switch **110** includes a housing **112** consisting of front and back portions **114** and **116**, respectively, portions **114** and **116** are assembled, as illustrated particularly in FIGS. **6** and **7** and are rigidly held in mated relationship by screw means **118** and guide pins **120**.

Housing **112** will generally be constructed of a thermoplastic material, such as polycarbonate resin, or the like. On the other hand, housing **112** could well be constructed of any material known in the art and could, for example, be machined from metal or even wood. In this regard, thermoplastic materials are generally utilized because they may be easily formed into intricate patterns.

When portions **114** and **116** are assembled as shown, housing **112** presents a vertical, rectangularly configured channel **122** which extends substantially entirely therethrough, except that it terminates in closely spaced relationship to the end **112***a* of housing **112**. At approximately the center of housing **112**, a pair of opposed laterally extending cavities **124** communicate with channel **122**. The width of cavities **124** is substantially less than the width of channel **122** as can best be seen by viewing FIG. **6**. A laterally extending opening **126** extends from each cavity **124** to the outside of housing **112**.

An elongated shiftable actuator **128** is disposed within channel **122**. Actuator **128** includes an upper extremity **130**, which extends outwardly of housing **112** and a coil spring **132** is disposed between the lowermost surface **134** of actuator **128** and the bottom **136** of channel **122**.

A vertically elongated slot **138** extends through actuator **128** and a pin **140**, which is anchored in housing **112** is disposed within slot **138**. Thus, the vertical movement of actuator **128** is limited by the interaction between slot **138** and pin **140**.

Actuator **128** is provided with a hollowed out portion **142** defined by an upper wall **144**, a backwall **146** and a lower wall **148**. A rib **150** extends upwardly from wall **148** for a purpose to be described hereinbelow. A pair of opposed extensions **152** extend forwardly from wall **146** defining a central groove **154** within hollowed out portion **142**.

A deformable resilient tube **156** extends through hollowed out portion **142** above extensions **152**. Tube **156** also extends laterally across cavities **124** as can best be seen in FIGS. **5** and **8**. Tube **156** is preferably constructed of latex rubber, however neoprene rubber and butyl rubber or any type of rubber or elasticized material may also be used. Also, other deformable and resilient materials might also be utilized, so long as the same are substantially creep resistant and have good tempera-

ture resisting characteristics. Tube **56** is filled with an electrically conductive, nonwetting liquid **158**, such as mercury or the like. An electrical connector **160** is provided at each end of tube **156**. Connectors **160** are of the type well known to the routineer in this art and are shaped to substantially completely fill openings **126** to preclude entry of foreign materials into the internals of housing **112**. Manifestly, connectors **160** are in electrically conducting contact with liquid **158**.

A pinching element **162** is disposed between extensions **152** within groove **154**, and is slidable therein in a direction longitudinally of actuator **128**. Element **162** includes a wedge shaped pinching segment or head **164** which presents an apex **166** disposed for contacting tube **156** in transverse line contact.

An elongated longitudinally bowed leaf spring **168** extends through hollowed out portion **142** beneath element **162**. As can be seen viewing FIGS. **5** and **8**, spring **168** extends transversely of channel **122** and through each of the cavities **124**. The ends **170** of spring **168** are each anchored in a V-shaped notch **172** extending longitudinally of a rod **174** anchored in housing **112**. Thus, each of the ends **170** is relatively free to pivot at the apex of its corresponding notch **172**.

Viewing FIG. **5**, it can be seen that spring **168** urges element **162** toward tube **156** and surface **144** of actuator **128**. Thus, actuator **128** provides a pinching element leaving a pinching surface **144** which operates in cooperation with pinching element **162** for pinching tube **156** therebetween to part liquid **158** and open an electric circuit. Thus, as illustrated in FIG. **5**, the tube-pinching elements are in a tube-pinching position. When an external force is applied to the upper extremity **130** of actuator **128**, the same is forced downwardly against the bias of spring **132**. Wall surface **144** pushes on tube **156**, which in turn moves element **162** downwardly against the bias of spring **168**. When spring **168** passes its overcenter point, the same will snap into an oppositely bowed condition to permit element **162** to move away from wall **144** and tube **156** to thereby assume a tube releasing position as illustrated in FIG. **8**. Thus, switch **110** includes a spring-loaded, snap-action mechanism in the nature of an overcenter device for moving the pinching elements from their tube-pinching position into their tube-releasing position.

Upon release of the downward pressure on the extremity **130**, spring **132** will urge actuator **128** upwardly. Rib **150** will move spring **168** upwardly until the latter passes its overcenter point, at which time it will snap upwardly into its upwardly bowed position. This will also snap elements **162** upwardly toward wall surface **144** to thereby snappingly pinch tube **156** and open the electrical circuit.

It can be seen that if the relative positions of spring **132** and extremity **130** were reversed, the switch could be made to operate as a normally closed switch which snaps open, rather than a normally open switch which snaps closed as illustrated.

It is to be noted that channel **122** provides a path of travel for the pinching elements of switch **110** along which the elements are reciprocable. Further, the extensions **152** provide a guide structure for guiding the movement of element **162** along this path of travel.

It is to be particularly noted that the downward movement of the wall surface **144**, which results from the application of an external force to extremity **130**, exerts a pumping action on tube **156** which instantaneously slightly increases the pressure within tube **156** such that the fluid pressure within fluid **158** will assist in the opening of tube **156** when spring **168** snaps downwardly to move the elements into their tube-releasing position. This pumping action is caused by the pushing of the relatively large area surface **144** against the outer periphery of tube **156** to force the same downwardly into its U-shaped configuration as illustrated in FIG. **8**.

Both of the switches described above provide a pumping action of the tube at the instant the pinching elements snap apart to thereby instantaneously increase the pressure of the electrically conductive fluid to assist the fluid in becoming a continuous column, so that the electrical circuit is thereby closed. With this type of operation it is possible to obtain the benefits of a pressurized liquid system without the necessity for having the liquid maintained under pressure at all times while the switch is not in operation. That is to say, switches which embody the concepts and principles of this invention include tubes filled with electrically conductive fluid wherein the fluid is generally maintained at very nearly atmospheric pressure even during periods when the tube is pinched. On the other hand all of the benefits of a pressurized system are achieved since the elements act to pump the tube at the instant that the pinching elements snap apart.

Having thus described in detail several electrical switches which embody the concepts and principles of the invention, it should be appreciated and will be apparent to those skilled in the art that many physical changes could be made in the physical characteristics of the switches without altering the inventive principles and concepts embodied therein. Hence, it is intended that the scope of the invention be limited only to the extent indicated in the appended claims.

I claim:

1. A normally open circuit switch comprising:

a deformable tube filled with an electrically conductive liquid;

an actuator element having a pinching surface disposed adjacent said tube, said element being reciprocable along a path extending transversely of the tube and having a manually engageable portion remote from the tube and a guide on the opposite side of the tube from said manually engageable portion;

a pinching head disposed on the opposite side of the tube from said pinching surface, said head being slideably mounted in said guide to be reciprocable along said path, said head including a pinching segment presenting an apex extending transversely of the tube for engaging the tube in transverse line contact;

an elongated longitudinally bowed leaf spring operably engaged with said head and extending transversely of said path, said spring extending adjacent the guide on the opposite side of the head from said tube, said spring being normally bowed in one direction along the path for urging the head in said direction to pinch said tube against said pinching surface and being bowed in the opposite direction along said path in response to movement of said pinching surface for permitting movement of said head in the opposite direction; and

return spring means operably engaging the actuator element and urging said actuator element in said one direction.

2. A switch comprising:

a deformable tube filled with an electrically conductive liquid;

a stationary pinching element disposed adjacent said tube;

an elongated cricket spring member which is normally transversely bowed throughout its length, said spring member including a second pinching element located at one end thereof, said spring member being disposed with said second pinching element located adjacent said tube on the opposite side thereof from said stationary pinching element, the opposite end of said spring member being relatively fixed in a position urging the second pinching element toward the stationary pinching element to pinch the tube therebetween and part said liquid;

a pushbutton actuator having an apex engageable with the transverse bow of said spring member for collapsing the same to permit separation of the pinching elements and release said tube; and

fulcrum means disposed between said second pinching element and said apex of said pushbutton actuator in a position supporting said spring member and causing said second pinching element to rapidly pivot about said fulcrum means upon collapse of said spring member.

3. Structure as set forth in claim **2**, wherein is included tube-compressing mechanism for changing the pressure of the liquid in the tube to obtain different operation in response to movement of said actuator.

4. Structure as set forth in claim 3, wherein said compressing mechanism includes an adjustable screw device.

5. A switch as set forth in claim 2, wherein a portion of the spring is movable into pressure-applying relationship relative to said tube after collapse of said spring whereby to increase the pressure of the fluid in the tube to assist the opening of the same after it is released by the elements.

6. A switch comprising:

a housing;

a deformable tube filled with an electrically conductive liquid mounted within said housing;

structure operable to pinch said tube to part the liquid and open an electrical circuit including a pair of spaced pinching elements disposed on opposite sides of the tube, said elements being movable relatively in a direction toward and away from one another between tube pinching and tube-releasing positions;

spring-loaded snap-action mechanism operably connected to at least one of the elements and actuatable to snap said one element from one of said positions to the other;

an overcenter device forming a part of said mechanism including an elongated bowed spring having at least one end fixed relative to said housing and a portion of said spring remote from said fixed end engaging said one element with said tube in said tube-pinching position;

an actuator movably mounted relative to said housing and disposed relative to the bow of said spring to engage and deflect said bow upon movement of said actuator and thereby snap said one element from one of said positions to the other; and

means for instantaneously increasing the pressure of the liquid in the tube at the moment the one element is shifted into said releasing position.