Oct. 25, 1966

E. F. PIERCE

3,281,545

TOGGLE SWITCHES

Filed Dec. 20, 1965

Fig. 1.

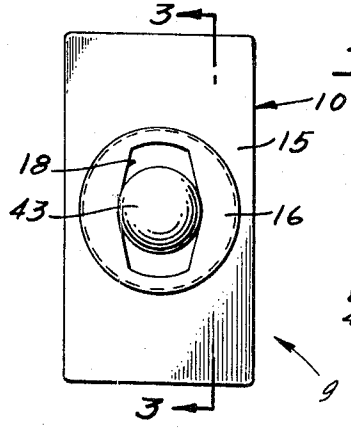


Fig. 6.

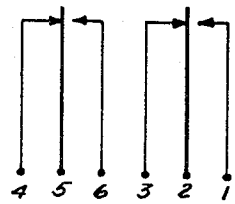


Fig. 2.

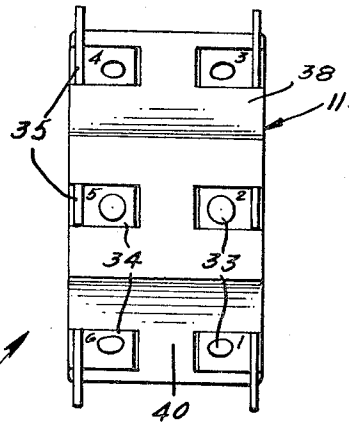


Fig. 3.

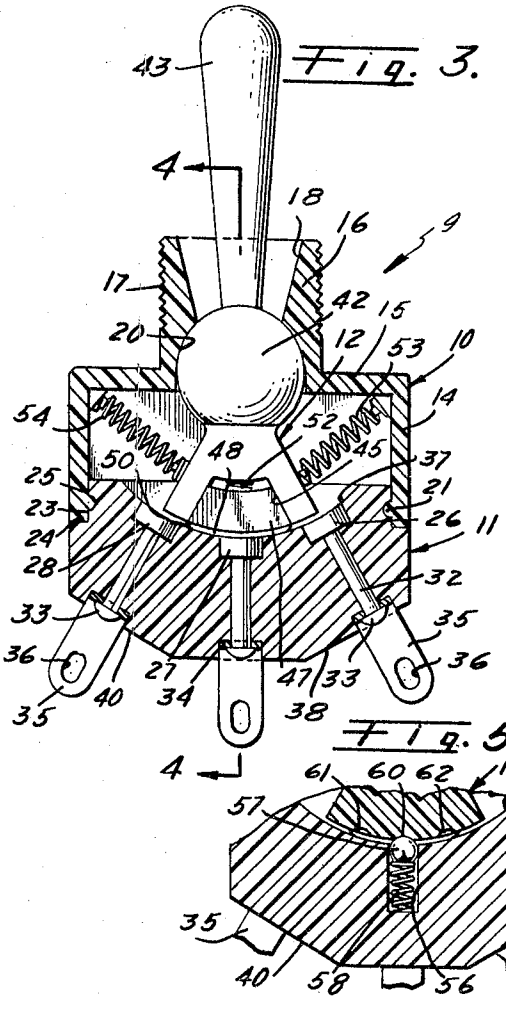


Fig. 4.

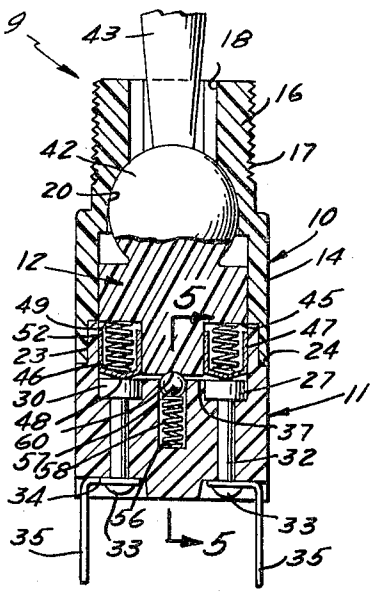


Fig. 5

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TOGGLE SWITCHES

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11 Claims. (Cl. 200—6)

This invention relates generally to electromechanical switches and particularly relates to a toggle switch of the sliding contact type.

Toggle switches of the sliding contact type are well known. In order to minimize problems due to wear, the contact pressure between the contacting surfaces must be maintained relatively low. Due to the low contact pressure, there may be bouncing of the movable contact element with respect to the fixed contacts. This bouncing in turn results in erratic switching voltages and may cause a build-up of voltages as well as arcing between the contact elements. The arcing in turn causes pitting and erosion of the contacts and may also oxidize the contact surfaces. The contact surfaces may further be coated with a film of oxide or other chemical compounds due to oxidation or chemical reaction with the atmosphere. These oxide films or films of chemical compounds in turn raise the contact resistance in an unpredictable manner.

If a high contact pressure is used with a toggle switch of the sliding contact type the films of oxide or other chemical compounds which may form on the contact surfaces can be worn or scraped off. However, this high contact pressure in turn increases the wear. The metal particles worn off the contacts may be plated over the insulating surface to cause undesirable short circuits and to shorten the life of the toggle switch.

This invention provides an improved toggle switch of the sliding contact type wherein high contact pressure can be used without detrimental effects. The switch is so constructed that the high contact pressure is maintained through an extended number of switching operations. Further, with nominal modifications, a basic switch structure can be used to single-pole, or double pole switching, as well as single-throw or double-throw operation. The switch includes an insulating lubricant on the contact surfaces for encapsulating and insulating from each other metal particles worn from the contacts as the switch is operated.

Generally speaking, this invention comprises a toggle which has a housing defining an internal cavity. One portion of the housing is defined by a contact holder fabricated of electrically non-conductive material. The contact holder defines a concave circularly cylindrical surface opening to the cavity. The housing also includes means substantially closing the cavity opposite from the cylindrical surface and defining a hemispherical recess open to the cavity; these means also define an opening to the exterior of the housing from the recess at a location of the recess opposite from the cylindrical surface. The center of curvature of the recess lies on the axis of curvature of the cylindrical surface. Two conductive contacts are mounted in spaced relation to each other in the contact holder. Each contact has a contact surface disposed flush with the cylindrical surface. An armature fabricated of electrically non-conductive material is disposed in the cavity adjacent the cylindrical surface. The armature carries a ball disposed in and mated intimately with the recess. An armature actuating lever is secured to the ball and extends from the ball through the opening. The lever is operable for oscillating the armature in the housing relative to the cylindrical surface. A conductive brush is carried by the armature in slidable engagement with the cylindrical surface. The brush is disposed on the armature so that the brush engages both contacts in a first position of the armature angularly relative to the contact holder and does not engage both contacts in a second position of the armature angularly relative to the contact holder. A spring is engaged between the brush and the armature for urging the brush into slidable engagement with the cylindrical surface and for urging the ball into intimate engagement with the recess.

The above-mentioned and other features of the invention are more fully set forth in the following description of a preferred embodiment of the invention, which description is presented with reference to the accompanying drawing, wherein:

FIG. 1 is a top plan view of a double-pole, double-throw toggle switch embodying the present invention;

FIG. 2 is a bottom plan view of the toggle switch of FIG. 1 and illustrating the terminal lugs thereof;

FIG. 3 is a sectional view taken on line 3—3 of FIG. 1 on enlarged scale and illustrating one row of the contacts of the switch;

FIG. 4 is a sectional view taken substantially on line 4—4 of FIG. 3 and illustrating particularly the two shorting brushes of the toggle switch and the detent mechanism;

FIG. 5 is a detail sectional view taken on line 5—5 of FIG. 4 and illustrating the detent ball with its pockets for retaining the toggle switch in any one of three different positions; and

FIG. 6 is a circuit diagram of the double-pole, double-throw contacts provided by the toggle switch of the invention.

The double-pole, double-throw toggle switch **9** includes an upper housing portion or end cap **10**, a lower housing portion serving as a contact holder **11**, and a movable armature **12**. The end cap is made of an electrically non-conductive material. It has a dependent body portion **14** of rectangular cross section. The end cap also has a flat top portion **15** and an upper cylindrical sleeve **16** which may be provided with external threads **17**. The upper sleeve defines an elongated internal recess **18** which communicates with a spherical ball socket **20** for receiving a ball. The lower end of dependent housing portion **14** is provided with an inwardly extending peripheral rib **21**.

Contact holder **11** is made from electrically non-conductive material and closes the open portion of the main housing **10**. The contact holder **11** is also of substantially rectangular cross section and is provided with an outer, circumferential recess **23** forming a shoulder **24** for engagement with the dependent portion **14** of the end cap; it is also provided with a recess **25** of semicircular cross section to form a snap lock with rib **21**. When

interconnected, the end cap and the contact holder define a substantially closed cavity within the housing.

The contact holder is provided with two rows of three contacts each. As shown in FIG. 3 the first row of contacts is comprised of conductive contacts **26**, **27** and **28**. Only one contact **30** of the other row of contacts is shown. Since the six contacts are all identical, only one of them is described. Contact **26** is formed by the substantially square head of a rivet **32** which extends through a suitable bore molded in the contact holder **11**. The outer end of each of the rivets is formed with a head **33** for securing thereto a bent-over portion **34** of a terminal lug **35**. Each of the terminal lugs is provided with a suitable aperture **36** for connecting thereto a wire conductor. In FIG. 5, the six contacts are numbered consecutively from 1 through 6.

The contact surfaces of the contacts have a concave cylindrical curvature and are flush with a concave cylindrical surface **37** of the contact holder. Surface **37** opens toward spherical recess **20**; the center of curvature of the spherical recess lies on the axis of curvature of surface **37**. The bottom of the contact holder **11** is chamfered at **38** and **40** so that all the rivets are of equal length.

Armature **12**, also made from an electrically non-conductive material, has secured to it (preferably by an integral molding process) a ball **42** which is rotatably received in spherical ball socket **20**. Integral with the ball is an operating lever or handle **43** which projects from the ball through recess **18** to the exterior of the switch. The ball **42** permits rotation or oscillation of the handle **43**. However, due to the shape of recess **18** and the shape of armature **12**, lever **43** can only be oscillated in a plane.

Armature **12** is provided with two elongated openings **44** and **45** aligned with an opening toward the two rows of contacts. Mounted within openings **44** and **45** are two elongated conductive contact brushes **46** and **47**. As shown in FIGS. 3 and 4, each of the contact brushes **46** and **47** comprises a sheet of metal having two parallel, spaced sides interconnected by a curved contact surface **48** having rounded ends **50**. By virtue of the rounded ends of the contact brushes and by the flush mounting of the contacts in the contact holder, arcing is minimized.

A coil spring **52** is disposed in each respective opening **44** and **45** and between the parallel sides of the brushes for urging the associated contact brush into engagement with the contact holder **11**. Additional coil springs **53** and **54** are secured between the respective ends of the armature and housing **10**. Springs **53** and **54** bias the armature into its neutral position shown in FIG. 3.

Toggle switch **9** is equipped with a detent mechanism illustrated in FIGS. 4 and 5. A central cylindrical recess **56** is formed in the contact holder for mounting a detent ball **57** urged outwardly by a coil spring **58**. The armature is provided with a central detent pocket **60**. As a result, the toggle switch is maintained, by the detent ball engaging pocket **60**, in the central or neutral position shown in FIG. 3. Lever **43** may be turned to the left or right to make momentary contact between the brushes and respective pairs of contacts, such as brush **47** engaging contacts **27**, **28** or **26**, **27**. Springs **53** or **54** return the armature into its neutral position when operating force is released from the operating lever.

Preferably, however, the armature **12** is provided with two additional detent pockets **61** and **62** corresponding to the left-hand and right-hand positions of handle **43**. In this case, bias springs **53** and **54** may be omitted, if desired. The toggle switch is retained by the detent ball and a respective one of the three detent pockets in any one of three desired positions. Alternatively, only two detent pockets **60** and **61** and one bias spring **54** may be provided. There will be momentary switch contact when the handle is pulled to the right; the armature is then returned by spring **54** into its neutral position. When the handle is oscillated to the left, the armature is locked by the engagement of detent ball **57** with pocket **61**.

Armature **12**, ball **42** and lever **43** are preferably molded in one piece. Furthermore, the armature with its ball and operating lever, the main housing and the contact holder **11** preferably consist of the same insulating material which may be a plastic material. These elements may be made from an insulating plastic material having good electrical properties, including a high dielectric constant, such as, for example, a polycarbonate. A suitable polycarbonate is sold under the trade name of "Lexan" by General Electric Company. This material is inexpensive, may be readily molded, and possesses great impact strength. The detent ball **57** may be made of nylon or of polyethylene.

Contact brushes **46** and **47** preferably consist of or have their contact surfaces **48** plated with an alloy known as nickel silver which includes 81% copper and 18% nickel. However, any conducting material which has a flaking action may be used for the contact brushes. Thus, the contact brushes may be made of, or their contact surfaces **48** may be plated with, an alloy known as coin silver which consists of 92% silver and 8% copper. Furthermore, the contact brushes may consist of, or their contact surfaces **48** may be plated with, palladium, rhodium, platinum or gold. These metals have the property that they are resistant to chemical action and hence the contact surface remains clean. They also have a flaking action which helps to maintain a clean contact surface.

The contacts may be made of nickel plated copper or brass. The nickel plating has minute surface pits or depressions. Instead of nickel plating the contacts, they may be plated with, or made of, tungsten, molybdenum or stainless steel, all of which are characterized by a surface having pits or depressions.

In accordance with the present invention there is provided an insulating lubricant on the contacts and on the contact surfaces of the brushes. This insulating lubricant preferably has a high dielectric constant and a high wetting action or low surface tension. Due to the low surface tension, the lubricant is retained in the pits or depressions on the surfaces of the contacts. Since the lubricant is highly insulating, the contact pressure should be sufficiently high to break through the lubricating film. The magnitude of the contact pressure which is required to break through the insulating film will depend on the particular materials used for the contacts and brushes and on the particular lubricant.

By way of example, the insulating lubricating material may include a major proportion of mineral oil of the type used in high voltage transformers. This mineral oil withstands high and low temperatures and has a high dielectric constant. This mineral oil may be emulsified and may have a base of a tallow grease which will not carbonize out under conditions of wear. A mineral detergent may be added to increase the wetting action or to decrease the surface tension.

A suitable insulating lubricant is sold under the trade designation No. 871 Switch Lube by Lubrication Company of America. This lubricant includes at least 93% mineral oil and is of relatively high viscosity; at 100° F., the viscosity is on the order of 2,600 centistokes per second. This oil has a flash point at 550° F.

Ball **42** is urged intimately against socket **20** by the action of the brush bias spring. Furthermore, the bias spring which urges detent ball **57** against the armature also helps to press the ball against socket **20**. As a result, the toggle switch of the invention is substantially sealed and tends to keep out the atmosphere from the switch mechanism.

In the position of the toggle switch shown in FIG. 3, each of the contact brushes is only in contact with one of the contacts in the adjacent row of contacts. Thus, electric circuits connected to terminal lugs **35** are all open. When actuating lever **43** is oscillated into one

extreme position, for example, to the right of FIG. 3, brush **47** bridges the contacts **27** and **28**; the corresponding two contacts of the other row of contacts are bridged by brush **46**. The switch is now in the position illustrated in FIG. 6. Electric circuits connected between terminals **2** and **3** and between terminals **4** and **5** are closed. Electric circuits connected to terminals **1** or **6** are opened.

When the toggle switch is oscillated to its other position by moving lever **43** to the left in FIG. 3, the electric circuits between terminals **4** and **5** and terminals **2** and **3** are opened, but circuits connected between terminals **1** and **2** and terminals **5** and **6** are now closed.

The toggle switch illustrated is of the double-pole, double-throw type. It is also possible to provide a double-pole, single-throw toggle switch. In that case, only the contacts corresponding to terminals **2**, **3** and **4**, **5** are required. There are two rows of contacts each consisting of two individual contacts. In that case, the toggle switch only has two positions.

In order to obtain a single-pole, double-throw toggle switch, only the contacts corresponding to terminals **1**, **2** and **3** are required. Thus, there is only a single row of three contacts. In that case, the contacts are preferably disposed in the center of the switch armature so that the pressure exerted by the single contact brush is properly balanced. Furthermore, a single-pole single-throw toggle switch is readily obtained by utilizing, for example, only the contacts corresponding to terminals **2** and **3**. In that case, the toggle switch only has two positions.

It will also be understood that instead of providing only two rows of contacts, three or more rows of contacts may readily be provided with a corresponding number of shorting brushes.

There has thus been disclosed an improved toggle switch characterized by an insulating lubricant provided over the cooperating contact surfaces. As a result, the switch will withstand even high wear due to the high contact pressure because worn off metal particles are encapsulated and insulated from each other. Thus, it is possible to provide high contact pressure where this may be desired. The toggle switch is disposed in a housing which is substantially sealed and hence is not subject to the deleterious effects of the atmosphere. The toggle switch may readily be modified to provide single-throw or double-throw, single-pole or double-pole operation. It is further feasible to provide momentary contact from an "off" position or to lock the toggle switch by a detent mechanism in either one or both of its "on" positions.

The invention and its attendant advantages will be understood from the foregoing description. It will be apparent that various changes may be made in the form, construction and arrangement of the parts of the invention without departing from the spirit and scope thereof or sacrificing its material advantages, the arrangement hereinbefore described being merely by way of example. Accordingly, the foregoing description is not to be regarded as limiting the scope of this invention.

What is claimed is:

1. A toggle switch comprising:

(a) a housing defining an internal cavity,

(b) a non-conductive contact holder carried by the housing and defining a concave circularly cylindrical surface opening to the cavity,

(c) means substantially closing the cavity opposite from said surface and defining a hemispherical recess concave to the cylindrical surface and an opening to the exterior of the housing from the hemispherical recess at a location on the recess opposite from the cylindrical surface,

the center of curvature of the hemispherical recess lying on the axis of curvature of said cylindrical surface,

(d) two fixed spaced conductive contacts mounted in the contact holder,

each of said contacts having a contact surface disposed flush with said cylindrical surface,

(e) a non-conductive armature disposed in the cavity adjacent the cylindrical surface,

(f) a ball curved to mate intimately with the hemispherical recess secured to the armature and engaged in the recess to close said opening,

(g) an armature actuating lever secured to the ball and extending therefrom through the opening to the exterior of the housing operable for oscillating the armature in the housing relative to the cylindrical surface,

(h) a conductive brush carried by the armature in slidable engagement with the cylindrical surface and disposed so that the brush engages both contacts in a first position of the armature angularly relative to the contact holder and does not engage both contacts in a second position of the armature angularly relative to the contact holder, and

(i) a spring engaged between the armature and the brush urging the brush into slidable engagement with the contact holder and urging the ball into intimate engagement with the recess.

2. A switch according to claim **1** wherein the contact surfaces have minute pits therein and the surface of the brush engaged with the cylindrical surface is defined by a metal which flakes when abraded, and an insulating lubricant disposed on the contact and brush surfaces for encapsulating and insulating from each other particles of metal worn from the brush during operation of the switch.

3. A switch according to claim **1** including detent means engaged between the housing and the armature for retaining the armature in at least one of said positions relative to the contact holder.

4. A switch according to claim **1** including spring means engaged with the armature for urging the armature into one of the first and second positions relative to the contact holder.

5. A switch according to claim **1** including detent means retaining the armature in one of the first and second positions of the armature relative to the contact holder, and spring means engaged with armature for engaging the armature into the other one of said positions.

6. A switch according to claim **1** including means limiting oscillatory movement of the armature to movement in a plane normal to the axis of curvature of the cylindrical surface.

7. A switch according to claim **6** wherein the means limiting oscillatory movement of the armature comprise opposite parallel walls of the cavity.

8. A switch according to claim **6** wherein the contacts are spaced apart from each other in a row parallel to the plane, and the brush is elongated in a direction parallel to said plane and has a cylindrical surface conforming to the curvature of the contact holder concave surface slidably engaged with the contact holder concave surface.

9. A switch according to claim **8** including a third contact spaced from the two contacts along said row, the brush engaging the third and one of the other contacts in its second position relative to the contact holder.

10. A switch according to claim **8** including a second pair of spaced contacts fixed in the contact holder and having contact surfaces flush with the contact holder cylindrical surface, the second pair of contacts being spaced from said two contacts and arranged in a row parallel to said plane, a second brush carried by the armature in a manner like the first brush, and a spring engaged between the second brush and the armature urging the second brush into slidable engagement with the contact holder cylindrical surface.

11. A switch according to claim **10** including a third contact in each row of contacts spaced from the other contacts in said each row, each brush engaging the third contact and one of the other two contacts in the adjacent

row in the second position of the armature relative to the contact holder.

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