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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

OCT 29 1970

REPLY TO
ATTN OF: GP

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for
Patent Matters

SUBJECT: Announcement of NASA-Owned U. S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code USI, the attached NASA-owned U. S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U. S. Patent No. : 3,488,461

Government or
Corporate Employee : HUGHES AIRCRAFT COMPANY

Supplementary Corporate
Source (if applicable) :

NASA Patent Case No. : XNP-09808

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

Yes [x] No [ ]

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

Elizabeth A. Carter

Elizabeth A. Carter
Enclosure
Copy of Patent cited above

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Jan. 6, 1970 JAMES E. WEBB 3,488,461
ADMINISTRATOR OF THE NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION
DEFLECTIVE ROD SWITCH WITH ELASTIC SUPPORT AND SEALING MEANS
Filed Dec. 21, 1967

FIG. 1

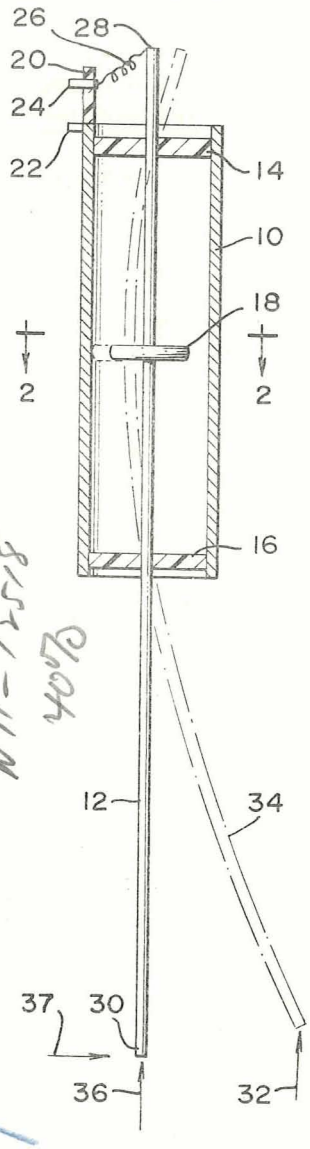


FIG. 3

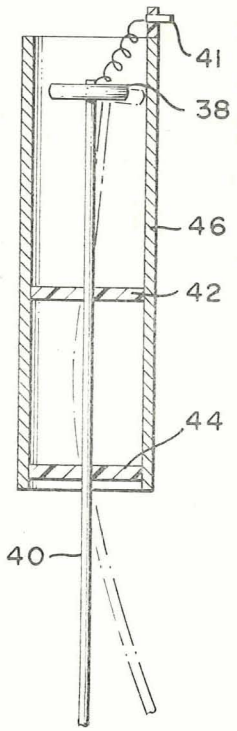


FIG. 4

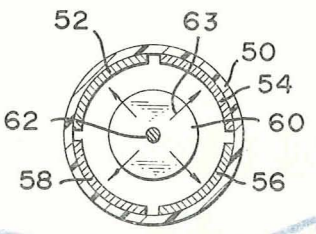
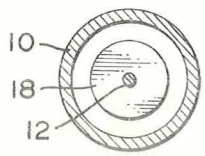


FIG. 2



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United States Patent Office

3,488,461

Patented Jan. 6, 1970

3,488,461

DEFLECTIVE ROD SWITCH WITH ELASTIC SUPPORT AND SEALING MEANS

James E. Webb, Administrator of the National Aeronautics and Space Administration, with respect to an invention of Burnham Nelson, Santa Monica, Calif.

Filed Dec. 21, 1967, Ser. No. 692,471
Int. Cl. H01h 3/16
U.S. Cl. 200—61.42 10 Claims

ABSTRACT OF THE DISCLOSURE

An hermetically sealed electric switch which can be closed by forces applied from a wide variety of directions. The switch comprises a tube connected to one electrical terminal, a flexible rod projecting axially through the tube connected to the other electrical terminal, and a contact button fixed to the flexible rod near the center of the tube for making contact between the tube and rod. Forces applied from any direction to the projecting rod cause it to bend like a column or beam, thereby moving the contact button against the inside of the tube and establishing electrical contact between the tube and rod.

ORIGIN OF INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85–568 (72 Stat. 435; 42 USC 2457).

BACKGROUND OF THE INVENTION

This invention relates to switches, and more particularly, to electrical switches which are operated by the application of force.

There are many applications where electrical switches are required which can be closed by forces applied from a wide variety of directions. For example, spacecraft require electrical limit switches for sensing the contact of the spacecraft with ground, for a wide range of orientations of the spacecraft. Heretofore, electrical switches for such applications have typically been constructed using a large number of switches arranged in a cluster. The cluster arrangement assured that at least one of the switches would be closed by a force which might be applied from any direction. However, the cluster arrangement resulted in switches of relatively high complexity and therefore high weight, high cost, and reduced reliability. A simple switch which closed upon the reception of forces from a wide range of directions, would prove useful in a wide variety of applications.

OBJECTS AND SUMMARY OF THE INVENTION

Accordingly, one object of the present invention is to provide a simple switch which is operated by forces applied from a wide range of directions.

Another object is to provide a simple switch which is hermetically sealed.

The present invention provides a simple electric switch which can be closed by forces applied from a wide variety of directions, such as any direction within a hemispheric space envelope. The switch utilizes a long flexible wire or rod which projects through a stationary capsule or switch housing. One electrical switch terminal is connected to the rod and another is connected to the walls of the housing. When the end of the rod is deflected by applied forces, the entire rod bends like a column, including that part of the rod within the switch housing. When the portion of rod within the switch housing bends, it moves an electrical contact button against the walls of the housing. This establishes an electrical connection between the rod and housing, thereby closing the switch.

In one embodiment of the invention, the switch comprises a tubular housing of conductive material with discs of insulating material at its opposite ends. A flexible rod extends through the housing, projecting through holes at the center of the discs. The insulating discs are relatively thin and of flexible material so that the wire portions extending therethrough are free to bend. A circular contact button is fixed to the rod at the rod portion between the discs. When the protruding end of the rod is deflected the entire rod bends, including the portion passing through the tube. As a result, the contact button touches the inside of the tubular housing. Electricity then flows through the flexible rod, the contact button, and the housing.

The inside of the tubular housing, where the contact button contacts the housing walls, is hermetically sealed. This is achieved by using insulating discs of elastomeric material which are sealed to the rod. While the rod must be allowed to flex with respect to the insulating discs, there is no sliding motion between rod and disc, so that a good seal is maintained and high reliability is established. Thus, the switch is both simple and reliable, yet performs a function which has heretofore required a large number of complex switch mechanisms.

The novel features of the invention are set forth with particularity in the appended claims. The invention itself will best be understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a sectional side elevation view of one embodiment of the invention;

FIGURE 2 is a sectional end view taken along the lines 2—2 of FIGURE 1;

FIGURE 3 is a sectional side elevation view of another embodiment of the invention; and

FIGURE 4 is a sectional end view of yet another embodiment of the invention.

FIGURE 1 illustrates one embodiment of the invention comprising a tubular housing **10** and a wire or rod **12** extending through the housing. Insulator discs **14** and **16** are located at opposite ends of the housing, and a contact button **18** is fixed to a portion of the rod within the housing. The housing **10** and discs **14** and **16** form a capsule through which the wire **12** extends. The housing **10**, rod **12** and button **18** are all constructed of electrically conductive material.

A bracket **20** of insulative material is fixed to the housing and holds two electrical terminals **22** and **24**. One of the terminals **22** is connected to the housing **10**. The other terminal **24** is connected to an electrical conductor **26**, which is connected to the end **28** of the flexible rod **12**. When rod **12** bends, the button **18** moves laterally relative to the stationary housing and contacts the inner walls of the housing **10**, thereby closing the switch. When the switch is closed, currents can flow from one terminal **24** through the rod **12**, button **18**, and housing **10**, to the other terminal **22**. The contact button **18** serves as one contact means and the inside walls of the housing **10** serve as another contact means, and the switch is closed when these two contact means are in physical contact.

The insulative discs **14** and **16** are constructed of an elastic material so that the portions of the flexible rod extending through them are not fixed in orientation. The rod portions extending through the discs are, however, relatively definitely fixed in position at the center of the tubular housing. Thus, the discs **14** and **16** serve together with the housing as flexible fulcrums, or supporting and

position fixing means. When the free end 30 of the flexible rod is deflected while the housing 10 is held relatively stationary, the elastic discs allow bending of the entire flexible rod. The nodes of the bending rod are located at the discs 14 and 16. However, the encapsulated portion of the flexible rod between the discs 14 and 16 bends as the free end 30 is deflected. The point on the encapsulated portion of the rod which has the greatest lateral displacement is the part approximately midway between the discs. The contact button 18 is fixed to the flexible rod near this point so that it moves against the housing 10 for even moderate deflections of the free end 30 of the rod. For any given configuration, switching sensitivity can be adjusted by changing the position of the contact button along the encapsulated portion of the rod, or by changing the size of the button 18.

The switch is closed when the flexible rod 12 is deflected. This can be accomplished by a force applied from a wide range of directions. A force, such as that shown by the arrow 32, bends the flexible rod into the configuration shown by the phantom lines at 34. The portion of the flexible rod between the insulator disc 16 and the free end 30 can act as a beam or a column or a combination of them. Forces applied in the direction of the arrow 36 cause the rod to buckle like a narrow column while forces applied in an orthogonal direction 37 cause the rod 12 to bend like a beam. The rod may be considered as a beam means, and like all beams can also function as a column. Either mode of bending can cause the contact button 18 to touch the housing 10 and close the switch. It can be appreciated that forces applied to the free end 30 from any direction within a hemisphere can close the switch. Even forces applied with a component opposite to the arrow 36 can close the switch if the object imparting the forces does not slide off the rod before the switch is closed.

The embodiment of the invention shown in FIGURES 1 and 2 provides a switch wherein the contacts can be readily sealed from the environment. The flexible rod 12 does not slide relative to the insulator discs 14 and 16 but only bends slightly relatively to them. (It may be noted that points on the rod that contact the discs 14 and 16 also move toward each other by a small amount when the rod bends.) Accordingly, insulative materials with only a low degree of flexibility can be used to construct the insulator discs 14 and 16, and the insulators can be sealed to the wire. This is important in assuring reliable switching characteristics, inasmuch as the inside of the housing 10 and the rim of the contact button 18 are thereby protected from corrosive or other deleterious atmospheres.

To provide good switching characteristics, the contact button 18 and the inside of the housing 10 may be coated with gold, palladium or other good contact materials. The flexible rod 12 may be constructed of a spring steel composition or any of a number of other stiff but flexible materials. The insulator discs can be constructed of an elastomeric material such as rubber.

FIGURE 3 is a side sectional view of another embodiment of the invention. In this embodiment the contact button 38 is positioned on one end of the flexible rod 40 opposite the area between the insulator discs 42 and 44. The bending of any portion of the flexible rod 40 will result in the bending of every other portion of the rod. The bending of every portion will occur because the insulators 42 and 44 do not fix the orientation of the rod portion passing through them. Accordingly, the contact button 38 could be placed anywhere on the flexible rod, so long as sideward movement will bring it in contact with another electrical contacting surface, such as the inside of the housing 46.

In the switch of FIGURE 3, the rod 40 is constructed of an essentially non-electrically conductive material such as glass fiber, and an electrical terminal 41 is connected directly to the contact button 38. The use of a non-conductive rod helps to insulate the electrical circuit from the object which deflects the rod. The outside of the housing may similarly be insulated from the environment by covering it with an insulative material. The embodiment of FIGURE 1 may also be constructed with a non-conductive rod and an insulated housing.

FIGURE 4 is a sectional end view of another embodiment of the invention which is useful for determining from which of four directions a force has been applied, for forces with a substantial component in the plane of the figure. This embodiment of the invention comprises a housing 50 of insulative material, with four segments 52, 54, 56, and 58 therein. Each of the segments 52 through 58 is constructed of electrically conductive material and is connected to a different output terminal of the switch. A contact button 60 fixed to a flexible rod 62 can flex so as to contact any one of the four segments. The particular segment which is contacted by the button, and through which electrical contact is made between the rod 62 and the segment, indicates the particular direction from which forces have been applied to the flexible rod 62. For example, forces in the direction of the arrow 63 will cause the contact button 60 to make contact with the segment 54.

While the figures show three different embodiments of the invention, a wide range of embodiments can be utilized. For example, forces applied from any direction of a sphere can be detected by constructing a switch of the type shown in FIGURE 1 with both ends of the rod exposed. It should also be noted that both of the insulative discs do not have to be flexible. For example, if the disc 14 in FIGURE 1 is rigid so that the rod cannot change orientation at that point, the switch will still operate; in fact, the switch will then operate even without the second disc 16.

Although particular embodiments of the invention have been described and illustrated herein, it is recognized that modifications and variations may readily occur to those skilled in the art and consequently it is intended that the claims be interpreted to cover such modifications and equivalents.

What is claimed is:

1. An electric switch comprising:

a flexible rod beam means for receiving deflecting forces, said beam means having first and second ends;

position fixing means comprising a substantially tubular housing and supporting means disposed between said housing means and said beam means for establishing the position of said beam means at a plurality of points spaced along said beam means, said housing and said supporting means forming fulcrums enabling said beam means to bend and move laterally between fulcrums relative to said housing, at least one exposed free end of said beam means projecting from said housing;

first electrical contact means disposed on said beam means for substantially lateral movement when said beam means bends; and

second electrical contact means positioned within said housing adjacent to said first electrical contact means, for contact with said first contact means when said beam means bends, whereby on application of touch forces to said free end of said beam, the beam bends between the fulcrums and brings the contacts into engagement.

2. An electric switch as defined in claim 1 wherein:

said first electrical contact means comprising a contact button of electrically conductive material fixed to said beam means between at least two of said spaced points at which the position of said beam means is established.

3. An electric switch as defined in claim 1 wherein:

said supporting means comprises a plurality of sealing means for forming a seal between said beam means and said housing means, whereby to provide an her-

metically sealed contact region where electrical contact is made and broken.

4. An electric switch as defined in claim 1 wherein:

said beam means comprises a length of electrically conductive material; and including

a switch terminal electrically connected to said beam means at said length of conductive material.

5. An electric switch as defined in claim 1 wherein:

said beam means is substantially nonconductive; and including

switch terminal means connected to said first electrical contact means.

6. An electric switch as defined in claim 3 wherein:

said supporting and sealing means comprise discs disposed at said spaced points constructed of elastomeric material, whereby to substantially fix the position of the rod portion passing through the center holes thereof while enabling said rod portion to bend relative to said discs.

7. An electric switch as defined in claim 6 wherein:

said discs are constructed of elastomeric material and the center holes thereof are formed of walls which are sealed to said rod, for forming a chamber within said housing between said discs which is sealed from the ambient atmosphere.

8. An electric switch as defined in claim 2 wherein:

said contact button means has a circular perimeter, whereby to close said switch by a given force applied from any direction of a circle.

9. An electric switch as defined in claim 2 including:

a plurality of electrical contacts disposed within said housing about said contact button means; and

a plurality of switch terminals, each connected to one of said plurality of contacts, whereby to enable the determination of the direction of forces applied to said rod.

10. A touch-sensitive, hermetically-sealed electrical switch comprising:

a substantially, tubular, stationary housing having an electrically conductive portion along the interior thereof;

a flexible rod having a portion extending axially at least

partially through said housing and an exposed, free-end portion projecting from said housing;

at least two discs of an insulating elastomeric material sealed to said housing at space points and having center holes sealed to said rod to form a hermetically-sealed capsule and to substantially fix the position of rod within said capsule, said discs and housing forming flexible fulcrums enabling said rod to bend and move laterally between fulcrums relative to said housing;

contact button means having a circular perimeter fixed to said rod within said capsule adjacent the conductive portion of said housing;

a first switch terminal electrically connected to said contact button;

a second switch terminal electrically connected to the conductive portion of said housing; and

means for supporting said housing whereby on application of touch forces to the free end of said rod, said rod bends at said fulcrums relative to said housing and moves said contact button into contact with the conductive portion of said housing.

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U.S. Cl. X.R.

200—61.44, 168