

[54] **VIBRATION-SENSITIVE ELECTRIC SWITCH**

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[57] **ABSTRACT**

A vibration-sensitive electric switch comprising a housing and two contacts disposed therein, one of the contacts being a vibrating contact and coming into contact by vibrational movement with the other contact which is fixedly arranged in said housing, at least one of the contacts being deformable in the area of contact with the other contact, wherein the fixedly disposed contact and the vibrating contact overlap without contact at at least two points along their axial extension when the switch is in the armed position and wherein the fixedly disposed contact is continuously bent laterally by the vibrating contact when a predetermined accelerative force has been exceeded, whereby the vibrating contact in the deflected condition is in constant contact with the fixedly disposed contact.

25 Claims, 2 Drawing Figures

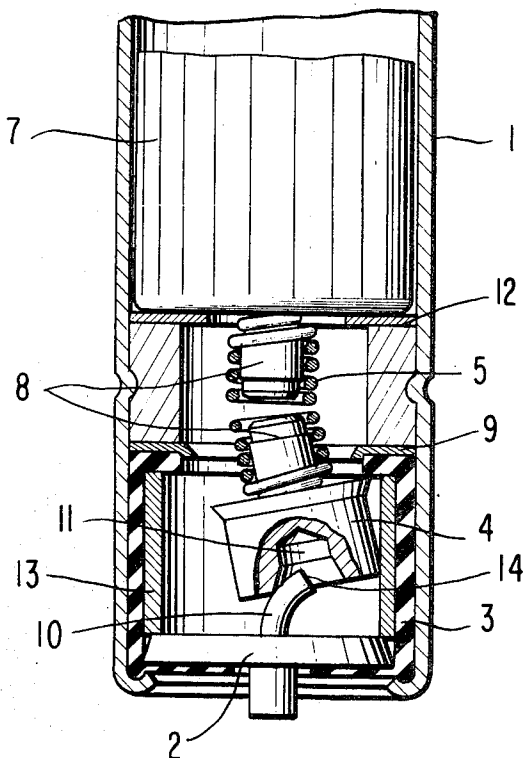


FIG. 1

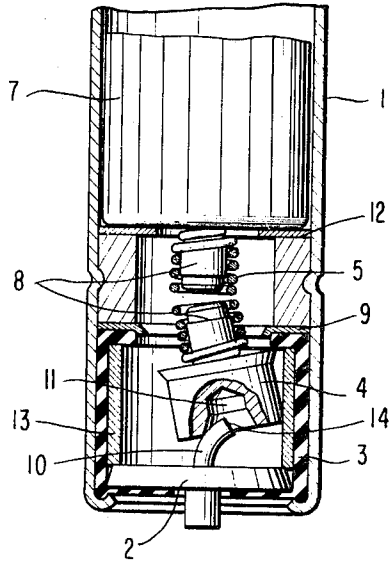
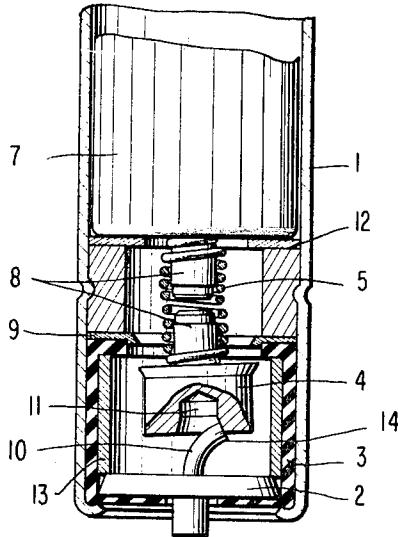


FIG. 2



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VIBRATION-SENSITIVE ELECTRIC SWITCH

This application is a continuation-in-part of copending application, Ser. No. 6,219, filed on Jan. 27, 1970.

This invention relates to a vibration-sensitive electric switch. More particularly, it relates to a vibration-sensitive electric switch having a housing and two contacts disposed therein, one of the contacts being fashioned as a vibrating contact and coming into contact, upon vibration, with the other contact which is fixedly arranged in the housing. Even more particularly, the invention relates to said vibration-sensitive electric switch wherein the flawless functioning of the switch is safely ensured in as large a range as possible of differently large accelerative forces.

The parent application, Ser. No. 6,219 is directed to a vibration-sensitive electric switch having a housing and two contacts disposed therein, one of the contacts being movably arranged in the housing and, upon a vibration, coming into contact with the other contact which is fixedly connected with the housing. One of the primary features of the development described therein resides in the provision of manufacturing at least one of the two contacts, at least in the common contact range, from an electrically conductive material which is readily, plastically and/or elastically deformable.

This switch has proven to be advantageous for devices which are to be operated electrically, which devices, for reasons of safety, compactness, expenses, etc., are designed to be less sensitive so that they require, for the flawless triggering thereof, an electric current of a relatively long duration. The effect of this switch is based on the feature that the kinetic energy of the movable contact is converted, in the contact zone of the two impinging contacts, into heat in the plastically deformed material and/or is stored in the elastically deformed material for a certain period of time. This creates the result that the duration of touching the two contacts and, thus, also the duration of current flow are prolonged to the required extent.

Since, in this conventional switch, the contact period extended in this fashion becomes the shorter, the higher the kinetic energy of the movable contact, this switch operates flawlessly even under unfavorable conditions only up to a certain upper limit of the accelerative force effective on the movable contact. Once this threshold value — depending on the properties of the material making up the contacts, the shape and the mass of the contacts, and the restoring force of the spring effective on the movable contact — is exceeded, there occurs either a more or less frequent successive collision of the contacts before the minimum contact period has been reached, with the result that the instant of triggering is shifted in an uncontrollable manner or, under unfavorable circumstances, there is no triggering at all. Obviously, these situations, particularly the latter, cannot be tolerated, especially in military applications.

One of the objects of the present invention is to provide a vibration-sensitive electric switch which overcomes the disadvantages and deficiencies of the prior art devices.

Another object of the present invention is to provide a vibration-sensitive electric switch which permits the flawless functioning of the switch in as large a range as possible of different accelerative forces.

A further object of the invention is to provide a vibration-sensitive electric switch having the advantages present in the switch described in said earlier copending application, and adding the advantage of providing more flawless operation and control on the triggering operation.

These and objects, features and advantages of the present invention will become more apparent from the following detailed description thereof, when taken in conjunction with the accompanying drawing, which illustrates one exemplary embodiment for use in a percussion or vibration fuse or primer, and wherein:

FIG. 1 is a partial sectional view of a switch according to the present invention with a maximally deflected vibrating contact; and

FIG. 2 is a partial sectional view of the switch of FIG. 1 with engaging contacts.

In accordance with the present invention, it has been found that the above problems are solved and the described objective are attained by providing that the fixedly disposed contact and the vibrating contact overlap non-contactually in the ready position of the switch — as seen in cross-section — at at least two opposed points, but preferably along the entire periphery, on a part of their axial extension, and by providing that the fixedly disposed contact, when a predetermined accelerative force has been exceeded, can be consistently or permanently bent toward the side by the vibrating contact, so that the vibrating contact in the deflected condition is in constant contact with the fixedly disposed contact.

This embodiment accomplished the purpose that the switch operates flawlessly below as well as above the threshold value of the accelerative force characteristic for the switch. If the actual accelerative force is smaller or equal to the threshold value, the required minimum contact period is already reached upon the first collision of the two contacts, as in said earlier copending application. However, if the actual accelerative force is above the threshold value, the fixedly arranged contact is constantly bent toward the side by the vibrating contact deflected from the ready or rest position, upon the first collision, during which procedure a part of the kinetic energy is converted into heat. If the vibrating contact then recedes, i.e., moves toward its rest position, it impinges once again from the opposite side on the fixedly disposed contact and is thereby prevented by the latter from returning into the rest position. Consequently, this has the effect that the vibrating contact is pressed, by the constantly restorative effect of the spring, against the fixedly disposed contact, resulting in the required flawless functioning of the switch. Of course, in this connection, the maximally possible deflection of the vibrating contact is limited, so that the vibrating contact cannot under any circumstances bend the stationary contact to such an extent that the two contacts do not touch each other during the return movement of the vibrating contact.

If it is desired, in special cases, that the switch respond preferably only to accelerative forces of a certain direction, the contacts can be formed so that they overlap only at two opposed points and, thus, touch each other only when the vibrating contact moves in the direction of the connecting line of these two points. This directional effect can be further enhanced by mounting the vibrating contact, instead of by means of a helical spring which is equally mobile in all radial directions, by means of a leaf spring, for example, so that the vibrating contact can move substantially only in one plane.

In a further suitable embodiment of the invention, the provision is made to equip the stationary contact with a pin-like extension which projects, in the ready position of the switch, without any contact into a recess formed in the vibrating contact with the result that the vibrating contact is in permanent contact with the front face of the constantly laterally bent extension. This means that the pin-like extension, which is bent toward the side, is substantially under a compressive load, rather than under a bending stress, exerted by the vibrating contact impinging on its front or end face. Since any material exhibits a higher compressive strength than bending strength, such a design has the advantageous result that, although the extension produced from a readily, plastically deformable material can easily be bent toward the side of the vibrating contact, this extension is not straightened again by the returning vibrating contact impinging on the front face of the extension. In other words, the vibrating contact is assuredly prevented from reaching the rest position.

In accordance with a further embodiment of the invention, an additional broadening of the functional range of the switch toward even greater accelerative forces can be obtained by limiting the deflection of the vibrating contact by means of a readily, plastically deformable element disposed, in the ready position of the switch, at a spacing therefrom. Depending on the material and the form of the limiting element, a more or less large part of the kinetic energy of the vibrating contact can be converted into heat because of the plastic deformation of the limiting element and, optionally, also the vibrating con-

tact occurring during the impingement of the vibrating contact on the limiting element. Consequently, the movement of the vibrating contact can be damped to such an extent that even in case of very large initial accelerative forces the required minimum contact period of the two contacts or, in certain cases, even their constant engagement, is already attained during the first movement of the vibrating contact, i.e., upon the second collision with the fixedly arranged contact.

In the simplest case, the limiting element can be fashioned as a cylindrical sleeve of a constant wall thickness concentrically surrounding the vibrating contact in the ready position. For the purpose of increasing the energy conversion, it is also possible to employ instead a sleeve having defined thinner wall portions, or a limiting element shaped in some other manner, as long as the shape thereof enhances its ready plastic deformability. If the switch is only designed for accelerative forces of a specific direction, i.e., if the switching function is to be triggered by the movement of the vibrating contact in only one specific plane, the limiting element can, of course, also be confined to substantially this plane, i.e., it can be designed, for example, as two opposed strips.

Referring now to the drawing, the safety and armed positions of the switch are described in detail in said earlier copending application in FIGS. 1 and 2 therein, identical reference numerals having been employed for the same parts. Consequently, the disclosure therein is hereby expressly incorporated by reference as necessary.

Briefly, according to FIG. 1, the contact 2, fixedly disposed in the electrically conductive housing 1, is electrically insulated from the housing 1 by means of the insulation 3. The other contact 4, designed as a vibrating contact, is connected by means of the coil spring 5 electrically and mechanically with one pole of the battery 7, the other pole of which is in electrically conductive connection with the housing 1 in a conventional manner. One or both of the contacts 2 and 4 may be made of tin and at least one of metal such as antimony, silver or gold. The coil spring 5 is held at the contact 4 and at the pole of battery 7, respectively, by means of individual extension members 8, formed at the contact 4 and at the pole of the battery 7. The extension members 8 are optionally additionally provided with an appropriate thread for safer connection with the coil spring 5 and the contacting surfaces thereof are rounded or contoured to permit free pivoting of the member connected to the contact 4 with respect to the member connected to the pole of the battery, as can be seen in FIG. 2.

The contact 2 is provided, on the side facing the contact 4, with an axial extension 10, which latter is made, for example, of a readily plastically and/or elastically deformable, electrically conductive material. This extension can be manufactured integrally with the contact 2, or also separately therefrom, and in the latter case can be also made of a different material. If the last-mentioned mode is employed, care must only be taken that both components can be connected with each other sufficiently firmly, so that a flawless electrical connection is ensured even under the shock effect produced during contact with the other contact 4. The contact 4, on the side facing the extension 10, is provided with an axial recess 11.

The battery 7 is at zero voltage in the safe position and is activated only in the armed position by means of, for example, a potassium hydroxide solution fed from a separate container, which latter is not shown. In order to take into account the possibility that, under certain circumstances, potassium hydroxide solution passes unintentionally into the battery even in the safe position, the poles of the battery 7 are short-circuited by means of the electrically conductive ring 9, which ring connects the contact 4 with the housing 1 and simultaneously also holds the contact 4 at a spacing from contact 2.

To achieve the armed position of the switch shown in FIG. 2, the battery 7 is moved, under an appropriate pressure, in the direction toward the contact 2 up to the stop 12 so that, due to that fact that the extensions 8 rest against each other in

the safe position, the contact 4 is pushed through the ring 9 and thus is made freely movable. The individual components of the switch are positioned with respect to one another in such a manner that the extension 10 of the contact 2, in the rest position of contact 4, extends into the recess 11 thereof without touching the contact. Simultaneously with being actually advanced, the battery 7 is activated, creating a difference in electric potential of a corresponding magnitude between the housing 1 and the contact 4.

If, in the armed position of the switch, also called the ready position, an accelerative force is effective on the housing 1, the radial component of which force is large than the threshold value characteristic for the switch, the vibrating contact 4 connected with the battery 7 via the two extensions 8 and the coil or helical spring 5 is accelerated to such an extent that it constantly and permanently bends the pin-like extension 10 toward the side, as can be seen in FIG. 1. The extension 10, as noted above, is a part of the contact 2 which is fixedly disposed in the housing 1 and is electrically insulated therefrom by means of the insulating materials 3. The maximum possible deflection of the extension 10 protruding into the recess 11 of the vibrating contact 4 is determined by means of the limiting or stop element 13, which is, in the case shown, a cylindrical spacer sleeve of, for example, soft aluminum, copper or a synthetic resinous material. In this manner, the vibrating contact 4, upon its return movement, contacts the extension 10 at its front or end face 14.

In case the limiting element 13 is electrically conductively connected with the contact 2, as illustrated, the switching function can be triggered at correspondingly small accelerative forces upon the impingement of the vibrating contact 4 on the limiting element 13, if the predetermined minimum contact period is reached. This effect, of course, does not occur when the limiting element 13 consists of an electrically non-conductive material, or when it is electrically insulated with respect to one or both of the contacts.

The vibrating contact 4 which returns, i.e., moves back toward its rest position free from the effect of the spring force, engages, as shown in FIG. 2, the extension 10 at the front face 14 thereof. Accordingly, the extension 10 is essentially under a compressive load and, hence, in spite of the fact that it is actually easily deformable plastically, is deformed by the repeated collision with the vibrating contact 4 either practically not at all or only with difficulty. In this connection, the dimensions of the vibrating contact 4 with the recess 11 and those of the extension 10 are adapted to each other in such a manner that the vibrating contact 4 is prevented from reaching its rest position. However, this means that the coil spring 5 constantly exerts a restoring force on the vibrating contact 4, which force presses the latter against the extension 10 so that, at the latest, during the second collision of the two contacts — except for extremely large accelerative forces — the required minimum contact time or, in certain cases, even a constant contact, is attained, and the bridge fuse, not shown, which is connected with the housing 1 and the contact 2 is ignited.

The pressure needed to actuate the switch is produced, for example, by means of a primer charge, not shown, burning with the evolution of gas, which primer charge is itself ignited by a delay charge, likewise not shown. The charge, not shown, connected to the bridge primer is ignited when the circuit is closed by way of said bridge primer, the two poles of which are connected to the housing 1 and the contact 2. Utilizing the embodiments described above, the switch operates flawlessly in the case of differently large accelerative forces to trigger the charge as desired.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included herein.

It is claimed:

1. A vibration-sensitive electric switch comprising a housing containing first and second contacts disposed therein, the first

contact being a vibrating contact and the second contact being fixedly disposed in said housing, means for supporting said first contact for vibratory movement within said housing to contact said second contact in response to forces applied thereto, at least the area of contact on one of said first and said second contacts being formed of a plastically deformable, electrically conductive material, wherein the fixedly disposed contact and the vibrating contact overlap without contact at at least two opposed points on a part of their extensions along a common axis when the switch is in the armed position and wherein the fixedly disposed contact is adapted to be bent by the vibrating contact when a predetermined accelerative force has been exceeded, and means whereby the vibrating contact when the accelerative force is exceeded moves to a deflected position and remains in constant contact with the fixedly disposed contact.

2. A vibration-sensitive electric switch as defined in claim 1, wherein the fixedly disposed contact and the vibrating contact overlap without contact along the entire periphery on said part of the extensions along a common axis when the switch is in the armed position.

3. A vibration-sensitive electric switch as defined in claim 1, wherein said fixedly disposed contact is continuously bent laterally by said vibrating contact.

4. A vibration-sensitive electric switch as defined in claim 1, wherein the fixedly disposed contact is provided with a pin-like extension which extends without contact into a recess disposed in the vibrating contact when the switch is in the armed position, whereby the vibrating contact is in continuous contact with the end face of said pin-like extension.

5. A vibration-sensitive electric switch as defined in claim 4, wherein said pin-like extension is continuously bent laterally by said vibrating contact.

6. A vibration-sensitive electric switch as defined in claim 1 further including a limiting element which is plastically deformable and wherein the deflection of the vibrating contact is limited by said limiting element which is spaced therefrom when the switch is in the armed position.

7. A vibration-sensitive electric switch as defined in claim 1, wherein the fixedly disposed contact and the vibrating contact overlap without contact at two opposed points on a part of their extensions along a common axis whereby contact is made only when the vibrating contact moves in the direction of the connecting line of said two points.

8. A vibration-sensitive electric switch as defined in claim 7, further including a leaf spring on which said vibrating contact is mounted whereby said vibrating contact moves substantially only in one plane.

9. A vibration-sensitive electric switch as defined in claim 6, wherein the limiting element comprises a cylindrical sleeve concentrically surrounding the vibrating contact.

10. A vibration-sensitive electric switch as defined in claim 9, wherein said limiting element has a constant wall thickness.

11. A vibration-sensitive electric switch as defined in claim 6, wherein the limiting element comprises two opposed strips.

12. A vibration-sensitive electric switch as defined in claim 6, wherein the limiting element comprises aluminum or copper.

13. A vibration-sensitive electric switch as defined in claim

6, wherein the limiting element comprises a synthetic resin.

14. A vibration-sensitive electric switch as defined in claim 6, wherein the limiting element is electrically conductively connected to the fixedly disposed contact.

15. A vibration-sensitive electric switch as defined in claim 6, wherein the limiting element comprises an electrically non-conductive material.

16. A vibration-sensitive electric switch as defined in claim 6, wherein the limiting element is electrically insulated with respect to at least one of said first and second contacts.

17. A vibration-sensitive electric switch as defined in claim 4, wherein the dimensions of said vibrating contact with respect to said recess and said pin-like extension are adapted to each other such that the vibrating contact is prevented from reaching its rest position when the switch is in the armed position.

18. A vibration-sensitive electric switch as defined in claim 1, wherein at least the area of contact on one or both of said first and second contacts is formed of tin and a metal selected from the group consisting of antimony, silver and gold.

19. A vibration-sensitive electric switch according to claim 1, wherein said second contact which is fixedly disposed in said housing is made of a plastically deformable material.

20. A vibration-sensitive electric switch according to claim 6, wherein said second contact which is fixedly disposed in said housing is made of a plastically deformable material.

21. A vibration-sensitive electric switch according to claim 1, wherein said means for supporting said first contact for vibratory movement within said housing comprising a first extension member affixed to said first contact on the side thereof opposite the side which is adapted to contact said second contact, a second extension member separated from said first extension member and affixed within said housing, and a coil spring means attached at each end thereof to said first and second extension members, so as to permit said first contact to be vibrationally suspended within said housing.

22. A vibration-sensitive electric switch according to claim 21, further including a limiting element which is plastically deformable and wherein the deflection of the vibrating contact is limited by said limiting element which is spaced therefrom when the switch is in the armed position.

23. A vibration-sensitive electric switch according to claim 22, further including a battery supported within said housing adjacent said second extension member, so as to be in contact therewith, a stop member supported above said limiting element to affix the position of said battery within said housing with respect to said first and second contacts and a conductive ring disposed between said limiting element and said stop member through which said first contact is suspended.

24. A vibration-sensitive electric switch according to claim 23, wherein said housing is electrically conductive and has an insulating member disposed on the interior portion thereof between the inner wall of said housing and said limiting element and between the interior of said housing and said second contact.

25. A vibration-sensitive electric switch according to claim 24, wherein said conductive ring is supported on said insulating member while contacting said inner wall of said electrically conductive housing.

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