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3,484,571

INERTIA SWITCH

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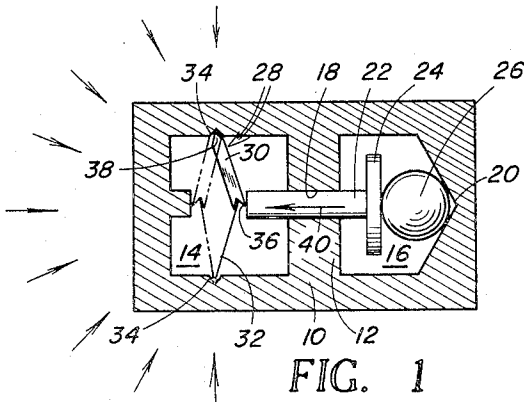


FIG. 1

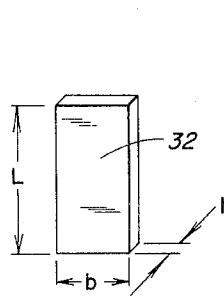


FIG. 2

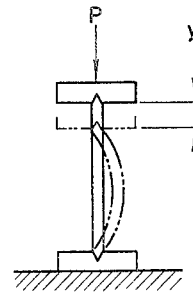


FIG. 3

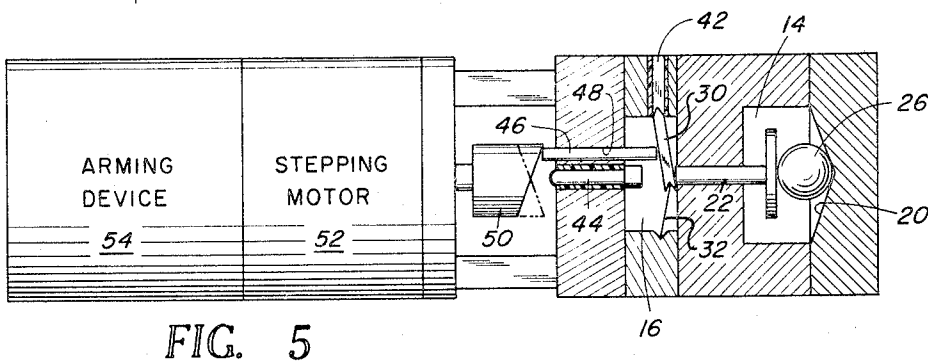


FIG. 5

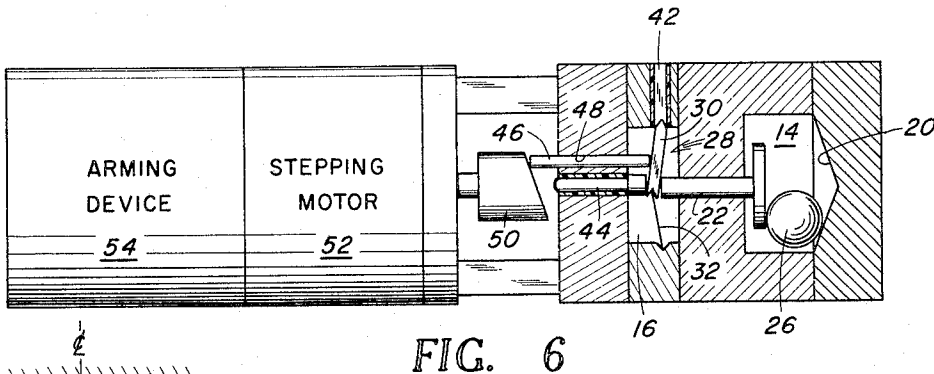


FIG. 6

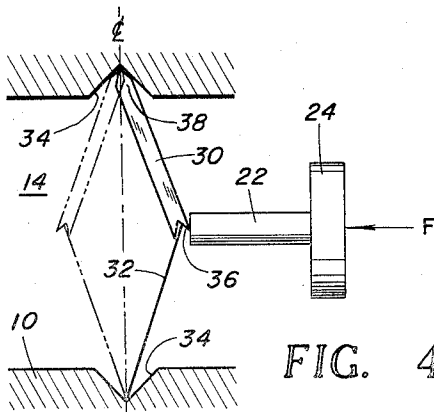


FIG. 4

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INERTIA SWITCH

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5 Claims

ABSTRACT OF THE DISCLOSURE

A buckling column inertia switch having a two column toggle system of rectangular cross-section, a plunger bearing against the toggle system, a ball and cone arrangement for exerting a force on the plunger and the toggle system proportional to deceleration, a cocking and safing cam mechanism operatively connected to the toggle system, and a pair of electrical contacts which may be selectively short circuited by said toggle system.

BACKGROUND OF THE INVENTION

This invention relates generally to inertia responsive devices, and more particularly to an inertia responsive switching device suitable for use in an ordnance fuse.

Inertia responsive or impact actuated switching devices have been used in conjunction with a variety of devices for a wide range of reasons. For example, inertia responsive electrical switches have been used on motor vehicles so as to break the ignition circuit and close an alarm circuit in the event of a collision. Similarly, such switches have been used with aircraft crash protection systems for operating fire preventing and/or extinguishing devices in response to a predetermined deceleration. Other switches of this class have been used in the fuse of an ordnance device. Still other inertia sensitive switches have been used with automatic washing machines as a cut-off switch to be responsive to undue vibrations often encountered in the wringing cycle.

Although the prior art inertia switches have served their purpose in these and other environments, in a generally satisfactory manner, they have not proved entirely satisfactory under all conditions of service because they involve complex mechanisms which have a generally low reliability. Moreover, the complexity of the prior art switches has necessitated that very close tolerances be met in the manufacture of the various elements. Still further, the prior art inertia switches have deleterious effects when exposed to extraneous vibrations because of the complexity of their design. For example, if an inertia switch is manufactured to operate at a predetermined value of deceleration, the critical value of deceleration at which the switch will actually operate, when it is subjected to extraneous vibrations of varying frequencies and amplitudes, is often lower than the predetermined setting; consequently, inadvertent operation of the switch might be caused with disastrous results. Another shortcoming of many prior art inertia switches is that positive mechanical contact is not maintained after impact since the mechanical inertia elements return to their original positions.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is the provision of a new and improved inertia sensitive device.

Another object is to provide a new and improved inertia responsive switching device for use in an ordnance fuse.

A further object of the invention is the provision of a switch of extremely simple construction which will effectively function in response to a predetermined force of inertia occasioned by a sudden stop or impact.

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Still another object is to provide a simple and efficient device of this character which can be readily reestablished to its original condition by mechanical manipulation.

Yet another object of the present invention is the provision of an inertia responsive switch which will resist accidental actuation.

A still further object is to provide an inertia responsive switch which will reset itself in the event of an impact producing an insufficient force to actuate it.

One other object of the present invention is the provision of an inertia responsive switch having a high reliability of operation.

Another still further object is to provide an inertia responsive switch that is inexpensive and relatively tamper-proof.

One more object of the present invention is the provision of a positively acting inertia responsive switch which will positively hold itself in its actuated position upon use thereof.

Briefly, in accordance with one embodiment of this invention, these and other objects are attained by a switching device provided with a two-column toggle system wherein one of the columns buckles in response to the application of a predetermined force. A cocking and safing mechanism may operatively engage the toggle system to force the toggle system into its initial cocked position and to hold it there until utilization of the switching device is desired.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation, partly in section, of the inertia sensitive switching device of the present invention;

FIG. 2 is a perspective view of a portion of the apparatus shown in FIG. 1;

FIG. 3 is a side elevation of a portion of the apparatus shown in FIG. 1;

FIG. 4 is a side elevation of a portion of the apparatus shown in FIG. 1; and

FIGS. 5 and 6 are side elevations, partly in section, of the inertia sensitive switching device with the cocking and safing mechanism of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings wherein like reference characters designate identical or corresponding parts throughout the several views, and more particularly to FIG. 1 thereof wherein the buckling column inertia switch of the present invention is shown as being composed essentially of a generally cylindrical hollow housing 10 having a central partition 12 therein so as to divide the interior volume into a first generally cylindrical chamber 14 and a second generally cylindrical chamber 16 of like diameters. A smooth bore 18 is centrally provided in partition 12, preferably coaxial with the axis of housing 10. A generally conical recess 20 is provided in the base of second chamber 16 opposite partition 12, and preferably, is coaxially disposed with respect to the axes of housing 10 and bore 18. A generally cylindrical plunger 22 is slidably mounted within bore 18 and is of sufficient length to extend into each of first chamber 14 and second chamber 16. Plunger 22 has an enlarged disc portion 24 preferably perpendicular therewith fixedly secured thereto at the extremity thereof within second chamber 16. A spherical mass, or ball, 26 is positioned within second chamber 16 and, when the switch is in its initial cocked position as illustrated in FIG. 1, ball 26 is urged into contact with the surface of that portion of housing 10 which defines conical recess 20 by disc portion 24 of plunger 22 so that the ball assumes a position as near as possible to the vertex of the conical recess.

A toggle system 28 is positioned within first chamber 14 and includes a rigid column 30 and a buckling col-

umn 32 both being illustrated in FIG. 1 in their initial cocked positions in dark solid lines. A plurality of substantially linear V-slots 34 are provided within the side walls of first chamber 14 approximately diagonally or oppositely disposed with respect to each other. Another V-slot 36 is provided in one extremity of rigid column 30, and other extremity thereof is tapered so as to form a knife edge 38. Although the connections between knife edge 38 of rigid column 30 and V-slot 34, buckling column 32 and V-slot 34, and buckling column 32 and V-slot 36 in rigid column 30 are illustrated herein as fulcrum bearings, respectively, it should be recognized that other conventional pivotal connections, such as hinges or others, may be used. The combined length of rigid column 30 and buckling column 32 is greater than the diameter of first chamber 14 thereby forming a resilient wedge against plunger 22 when assembled as shown in the initial cocked position. Rigid column 30 is significantly stiffer than buckling column 32, and this may be accomplished by fabricating the rigid column with a substantially larger cross-sectional area and/or by using a more rigid material. When a sufficient force, such as for example as would result from the target impact of an ordnance vehicle, is exerted by plunger 22 in the direction of arrow-head 40 against columns 30 and 32, buckling column 32 will undergo a flexing movement and toggle system 28 will snap into its second or moved position as illustrated by the dotted lines in FIG. 1 in accordance with principles which will become apparent.

Referring now to FIGS. 2 and 3, buckling column 32 is shown as having a rectangular cross-section of width b and thickness h and a free length L . An axial load P required to produce a sufficient buckling of column 32 to cause the column to assume a length shortened by a distance Y can be expressed as follow

$$P = \frac{bh^3E(6\epsilon + \pi^2(1-2\epsilon))}{12L^2(1-\epsilon)^2}$$

where E is the modulus of elasticity of the column and ϵ is equal to Y/L . It should be recognized that the use of a substantially linear elongated column having a rectangular cross-section results in a comparatively simple analytical parameter determination as well as ease of manufacture of the column.

Referring now to FIG. 4, the details and operation of toggle system 28 is more clearly illustrated and understood. When a load F is applied to plunger 22, via disc portion 24, this load is axially distributed along columns 30 and 32 in accordance with conventional vector force resolutions. As F is increased to the point where the axial load P along column 32 is sufficient to cause buckling, toggle system 28 will move toward centerline LC . Because of the comparatively greater stiffness of column 30, it remains rigid throughout the operation, but it pivots about the fulcrum bearing provided between V-slot 34 and knife edge 38. After it passes through the centerline as a result of the force exerted by plunger 22, toggle system 28 will positively snap into its second, or moved, position as illustrated by the dotted line construction since there is no force to resist such movement until the toggle system engages housing 10 which serves as a stop.

Referring now to FIGS. 5 and 6, there is shown the heretofore described buckling column inertia switch including a cocking and safing mechanism illustrated in its initial cocked position before impact in FIG. 5 and in its second, or moved, position after impact in FIG. 6. The buckling column inertia switch of the present invention, which may be used as only a mechanical switch, is shown in FIGS. 5 and 6 as an electrical switch having electrical contacts 42 and 44 passing through housing 10 but electrically insulated therefrom if the housing is made of an electrically conducting material. Contact 42 is positioned so as to be in physical communication with rigid column 30 in either the initial cocked position or the second position thereof while contact 44 is positioned so as to be electrically isolated from column 30 in its initial

cocked position but in physical communication therewith in its second position. Hence, in the initial cocked position there is an open circuit between contacts 42 and 44 while in the second position a short circuit exists therebetween.

An elongate locking pin 46 is slidably mounted within a bore 48 formed in one end of housing 10 so as to extend from within first chamber 14, through housing 10, and to the exterior thereof. A rotatable locking cam 50 is mounted on the shaft of a stepping motor 52 which in turn is actuated by command mechanism which may be an arming device 54 such, for example, as an impeller. Locking cam 50 is positioned to bear against locking pin 46 when the cam is in the locked position as illustrated by the solid dark lines in FIG. 5. It is apparent that, by rotating the cam into the locked position, toggle system 28 will be urged into its initial cocked position and held there by locking pin 46 bearing against rigid column 30. It should be noted that either locking pin 46 must be electrically insulated from housing 10 if the latter is electrically conductive or the locking pin must be made of an electrically non-conductive material.

In response to predetermined conditions sensed by arming device 54, stepping motor 52 is rotated approximately 180° so that locking cam 50 assumes its unlocked position illustrated by the dotted line construction in FIG. 5. Since locking pin 46 is freely slidable in bore 48, when locking cam 50 is in its unlocked position, it offers substantially no resistance to the movement of toggle system 28 in the manner heretofore described. Hence, upon impact, ball 26 moves outwardly along the surface which defines conical recess 20 thereby exerting a force upon plunger 22 sufficient to cause column 32 to buckle and to cause the toggle system to pass through the centerline. After passing through the centerline, the toggle system positively snaps into its second, or moved, position thereby short circuiting contacts 42 and 44 as shown in FIG. 6.

It will be apparent to one skilled in the art that, if a slight impact or graze is sustained, the switch will begin to close; but if the impact force is not sufficiently great to actuate the switch completely, the toggle system will return to its initial cocked position due to the resiliency of buckling column 32. Furthermore, if the switch is actuated, it may be quickly reset by mechanical manipulation by merely pushing in on locking pin 48 as by rotating locking cam 50 approximately 180° to its locked position. Moreover, the resiliency provided by buckling column 32 in the initial cocked position tends to resist accidental actuation.

Obviously, numerous modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. An inertia switching device comprising:

a housing having a pair of aligned cavities adapted to receive respectively a buckling column in one cavity and inertia means for activating the buckling column in the other cavity;

a passage connecting said cavities; and

force transfer means disposed in said passage for transferring force from said inertia means to said buckling column;

said buckling column mounted in said one cavity substantially transverse to the longitudinal axis of said shaft,

said buckling column including two members of substantially equal length and substantially dissimilar rigidity whose combined length is substantially more than the transverse dimension of said one cavity, the buckling column member having less rigidity flexing under selected force applied through said shaft

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to move the buckling column to an actuated static position.

2. The device as defined in claim 1 wherein said buckling column members pivot at their extremities at points in said housing and pivot one with respect to the other at a point substantially along the longitudinal axis of said shaft so that an actuating force is applied in line with a common point of pivot of the buckling column.

3. The device as defined in claim 2 wherein buckling is achieved by one of said buckling column members buckling under axial pressure exerted through said shaft, the other of said buckling column members adapted to complete a circuit by making contact with one or more electrical contacts when the buckling column is in the actuated position.

4. The device as defined in claim 3 wherein the centrally positioned end of the rigid buckling column member is notched to receive and contain the centrally positioned end of the less rigid buckling column member.

5. The device as defined in claim 4 wherein said inertia means is held in place centrally by force exerted by the

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flexed buckling column member when the device is in the unactuated position;

said inertia means generally spherical in shape and said other cavity dimensioned to permit peripheral movement of said inertia means thereabout so that the inertia means will block return of said shaft to the unactuated position so long as the device is in a horizontal attitude.

References Cited

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U.S. Cl. X.R.

74—100; 200—61.45, 67, 76