

- [54] **TILT RESPONSIVE INERTIA SWITCH WITH PRINTED CIRCUIT AND MOVABLE BALL CONTACT**
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- [73] Assignee: The United States of America as represented by the Secretary of the Army
- [22] Filed: Dec. 2, 1971
- [21] Appl. No.: 204,105
- [52] U.S. Cl. 200/61.52, 200/166 PC, 200/61.45 R
- [51] Int. Cl. H01h 35/02, H01h 35/14
- [58] Field of Search 200/8 R, 11 J, 11 K, 200/11 DA, 166 PC, 166 BH, 61.45 R-61.53

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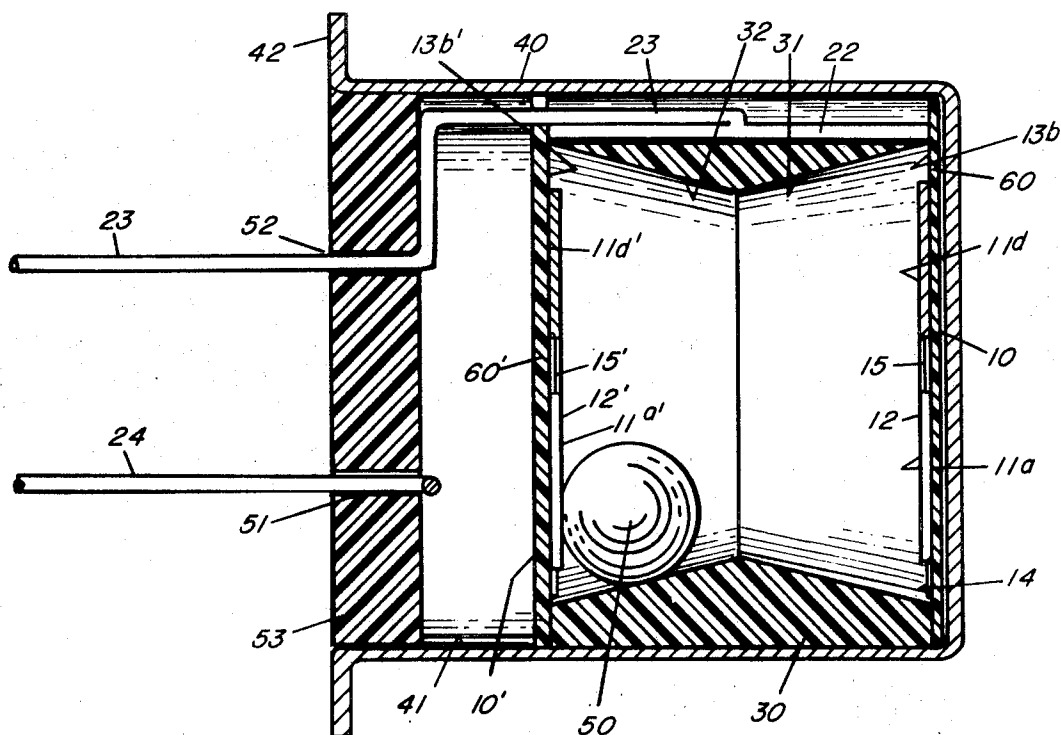
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Attorney—Harry M. Saragoritz et al.

[57] **ABSTRACT**

This invention relates to a printed circuit, intermittent, normally open, single pole electric switch designed to become operative upon the receipt of a tilt motion. The device uses a housing means, a printed circuit contact terminal means supported in the housing, a conducting ball having a first radius of curvature, operatively positioned adjacent to the contact terminal means which responsively moves when the switch is tilted, and momentarily closes the contact terminal means; an insulated track means is positioned intermediate to the printed circuit contact terminal means, insulating the housing from the contact terminal means while maintaining the conducting ball operatively adjacent to the contact terminal means.

5 Claims, 8 Drawing Figures



SHEET 1 OF 2

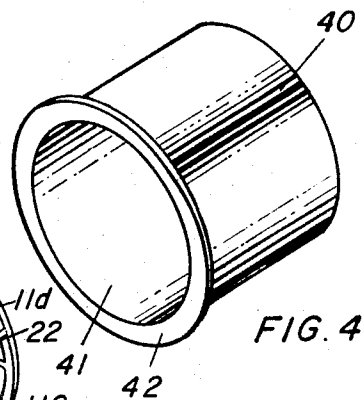
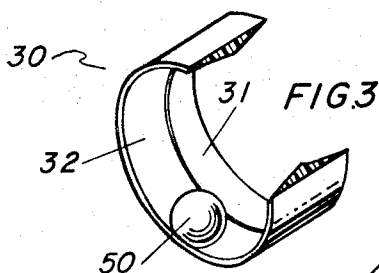
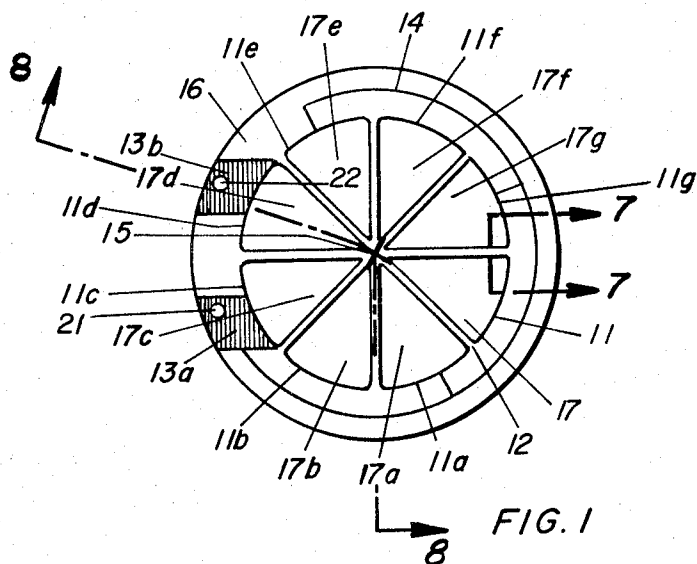
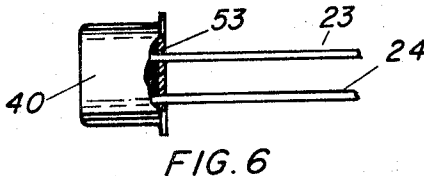
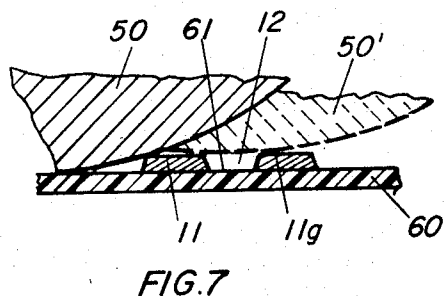
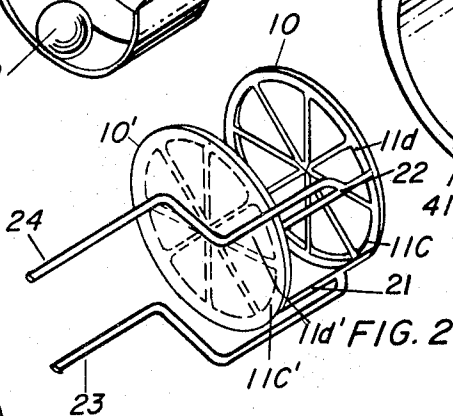
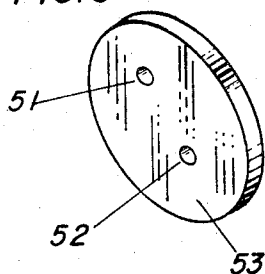


FIG. 5



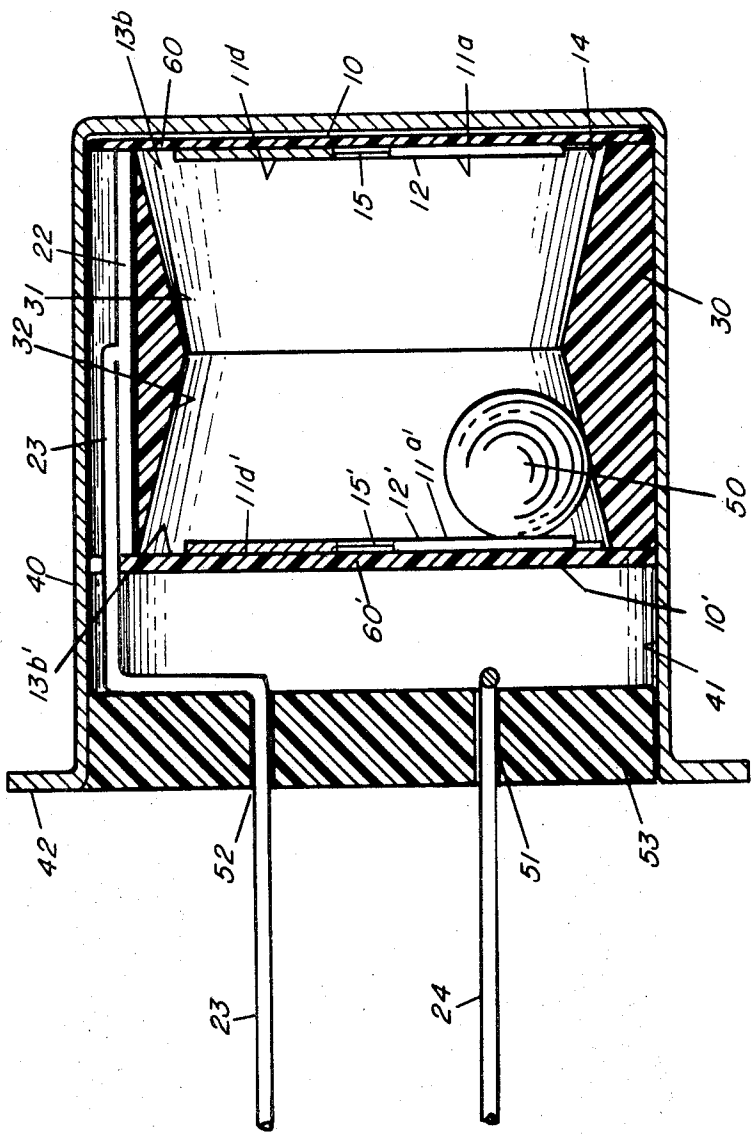


FIG. 8

TILT RESPONSIVE INERTIA SWITCH WITH PRINTED CIRCUIT AND MOVABLE BALL CONTACT

The invention described herein may be manufactured, used and licensed by or for the Government for governmental purposes without the payment to me of any royalty thereon.

BACKGROUND OF THE INVENTION

Numerous means have been used to effect the closure of an electrical circuit by prior art devices. Some of the prior art devices which are responsive to a tilting motion and/or linear and/or angular accelerations utilize a mechanical pole means such as a pendulous mass supported on a vibratory member. Other motion responsive prior art devices utilize mechanical, delicately balanced pivoted pole means members to effect the closure of the switch contact terminals. Some devices utilize a conducting fluid such as mercury or salt water to bridge the gap between the contact terminals. Other devices utilize the rolling action of a conductive ball to effect closure between two insulated machined or extruded plane surfaces or between a machined or extruded plane surface and an insulated rod. The prior art devices which utilize an inertial mass supported upon a vibratory member are generally not uniformly motion sensitive in all directions. Those prior art devices utilizing a conducting fluid have difficulty in maintaining constant switch contact resistance or container hermeticity because of the oxidizing effect of the fluid on the contacts or the amalgamizing effect with resultant structural weakness upon certain metals such as copper, copper alloys and lead.

Those prior art motion sensitive switch devices which utilize a rolling ball to effect closure between machined or extruded, insulated surfaces are limited in shape and more costly to produce than the present invention. The aforementioned prior art devices suffer from a combination of disadvantages which include, an inability to withstand high "g" loads without mechanical distortion of the switch element, a need for complex components which are heavy and/or of high cost, have low operational reliability, and an inability to maintain constant contact resistance because of oxidation and/or amalgamation of the contact surface between the pole means and the switch terminals.

The present device is not only nearly uniform motion responsive but is also simple in structure, rugged in construction, resistant to environmental oxidation, may be made small in size, and readily variable in sensitivity to tilting motions.

SUMMARY OF THE INVENTION

The present invention is an electrical switch which is designed to be utilized in an anti-disturbance device to detect the handling of an object by an intruder. The present device has been designed to respond to a motion signature of lateral acceleration or tilt that is given to an object by a person picking up the object. The present switch has been designed to provide a momentary contact or closure upon receiving the tilt motion signature. A momentary circuit closure or pulse output is made by a conductive ball rolling over a parallel pair of conductive lines; the lines being part of a pattern of similar line pairs which have been prepared in a pattern designed to facilitate ball movement and switch closure when the desired motion or tilt input is given to the de-

vice. The present device can use printed or vapor deposited conductive line pairs as the switch terminals. Patterns of such printed circuit pairs of parallel conductors switch terminals can be inexpensively and readily prepared in configurations designed to sense a wide variety of different motion signatures by varying the pattern of the line pairs, the shape of the projecting surfaces, and the size of the rolling object. The momentary pulse output from the present device is used to trigger a current sensing device such as a silicon controlled rectifier or a thyatron in an electronic circuit designed to handle larger currents, or to operate with a counter to record the number of triggering output pulses generated by each crossing by the ball of the line pairs. In the present invention a pair of pie shaped segmented printed circuit boards are connected in parallel and spaced from each other by an insulated circular track. On each of the two circuit boards electrical conductors are connected to adjacent pie shaped segments. A conductive ball is located intermediate to the two parallel segmented sections. The aforementioned switch contact segments, the circular track, and the conductive ball may be miniaturized to the extent that it may be enclosed in a cylindrical housing such as a TO-5 transistor can having a volume of approximately 0.024 cubic inches. The present device when initially emplaced will act as a normally open single pole switch. The open condition at rest is achieved in this construction by the thickness of the pie shaped segmented contact terminals, which, due to the relationship of contact terminal height, segment insulation spacing, and conductive ball diameter, causes the ball to come to rest in one of the open sectors between conductors. The present invention is exceptionally sensitive to tilt in any direction except along a radial line running from the center of the switch toward the rest position of the contact ball. Since all moving parts of the switch are hermetically sealed within a housing, oxidation effects from environmental sources of contact surfaces, which might change contact resistance as a function of shelf life, is minimized.

One of the objects of this invention is to provide an electrical intermittent normally open single pole switch which is nearly uniformly responsive to tilting motions.

Another object is to provide an electrical switch whose switching threshold level can readily be modified.

Another object is to provide an intermittent, normally open, single pole switch which because of its simplicity is inexpensive to provide.

Another object of the present invention is to insure an intermittent normally open single pole switch which will maintain nearly uniform contact resistance.

Another object of the present invention is to permit printed circuit board techniques to be used in a variety of different patterns to inexpensively form switch terminals having sensory line pairs which are specifically tailored to a particular motion signature response.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a printed circuit board switch contact terminals.

FIG. 2 is an elevational view of the parallel connections assembly of the pair of printed circuit board switch contact terminals.

FIG. 3 is an elevational view and partial cross section of the insulated dual circular tracks and conductor ball.

FIG. 4 is an elevational view of the switch housing.

FIG. 5 is an elevational view of the switch housing header cover.

FIG. 6 is an elevational view of the complete assembly of the printed circuit switch.

FIG. 7 is an enlarged detail view of FIG. 1 taken along line 7-7 of the printed circuit board and the conductor ball in the switch open and closed position.

FIG. 8 is a cross sectional view of the printed circuit switch assembly taken through line 8-8 as shown on the exploded view incorporating FIGS. 2, 3, 4 and 5.

Throughout the following description like reference numerals are used to denote like parts in the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1 a printed circuit board disc 10 has etched or deposited thereon pie shaped conductive contact terminals sections 11, 11a, 11b, 11c, 11d, 11e, 11f and 11g; these pie shaped conductors are separated and insulated from each other by radial channels 12, annular surface 16. A first solderable surface 13a is electrically connected to contact terminals 11a, 11c, 11e and 11g by connecting wire 14. A second solderable surface 13b is connected to contact terminals 11, 11b, 11d and 11f by common conductor 15.

FIG. 2 shows the parallel connection assembly of printed circuit board discs 10 and 10'. The circuit board disc 10 and 10' are positioned with respect to each other so that the contact terminals 11c and 11d are axially and rotationally aligned with conductive contact terminals 11c' and 11d'. Parallel electrical conductors 21 and 22 are soldered to solder surfaces 13a and 13b on one end and 13a' and 13b' (not shown) on the other end. Switch leads 23 and 24 are electrically connected to electrical conductors 21 and 22 respectively.

FIG. 3 shows a cylindrical insulator 30 which has an inner wall having a first partially circular concave surface 31 on one end and a second partially circular surface 32 on the other end. The cylindrical wall 33 of the cylindrical insulation 30 is straight sided and of a diameter which slidably fits into the housing bore 41 of the housing 40 shown in FIG. 4. A conductor ball 50 is of a slightly smaller radius than the partially circular channels 31 and 32 so that the former can freely roll in these channels. The cylindrical insulator 30 circumferentially encloses the parallel connection assembly shown in FIG. 2 so that neither the switch leads 23, 24 nor the parallel connectors 21, 22 will short circuit against the housing 40.

FIG. 5 shows a housing lead header disc 53 having two switch lead bores 51 and 52 for holding and hermetically sealing switch leads 23 and 24. The header disc 53, with attached parallel connection assembly of FIG. 2, the cylindrical insulator 30, and the conductor ball 50, is sealed to the housing flange 42. FIG. 6 shows the completely sealed housing 40, header 53, and the switch leads 23 and 24 of the parallel connection assembly (not shown).

FIG. 7 shows an insulator material 60 upon which has been etched or deposited switch contact terminals 11

and 11g separated by the insulator channel 12 and the insulator land surface substrate material 61. The conductor ball 50 is shown in contact with only contact terminal 11, this is the open position condition. When the switch receives a proper tilt position, ball 50 will roll momentarily into a position as shown by 50', so that the circuit connected to switch leads 23 and 24 will be closed. Whether the conductor ball 50 is in either the first circular channel 31 or in the second circular channel 32 when the device is at rest position, momentary switch closure will be effected when a tilt motion is given to the device.

FIG. 8 shows additional details of the printed circuit switch assembly in its entirety as a cross-sectional view taken along line 8-8. The conductor ball 50 is shown resting against the second partially circular surface 32 and the top, printed circuit, side of the board disc 10'. Switch leads 23 and 24 are normally insulated from each other and the housing 40 by the header disc 53 on the bottom, on the sides by cylindrical insulator 30, and on the top side of the switch by insulator land surface substrate material 60.

From the above description, it will be evident that the invention provides an intermittent normally open single pole switch which responds sensitively to lateral acceleration and tilt motion given to an object being picked up to which the device is attached.

I wish it to be understood that I do not desire to be limited to the exact detail of construction shown and described, for obvious modifications will occur to a person skilled in the art.

What is claimed is:

1. A printed circuit, intermittent, normally open, single pole electric switch for detecting tilt which comprises:
 - a housing means which includes;
 - a closed end housing cylinder having a central bore and a circular axially aligned sealing flange on the open end;
 - a housing lead header disc, sealed to said sealing flange, for operatively positioning said printed circuit contact terminal means and insulated track means within said housing cylinder;
 - a printed circuit contact terminal means supported in said housing which includes;
 - an insulator substrate;
 - a plurality of etched raised conductors on said substrate separated by insulated land surface substrate;
 - a metallic surface electrically connected to said contact terminals for electrically and mechanically holding a pair of electrical conductors thereto;
 - a conducting ball operatively positioned adjacent to said contact terminal means, responsive to tilting motions, and momentarily closing said contact terminal means; and
 - an insulated track means, positioned intermediate to said housing and said printed circuit contact terminal means, for insulating said housing from said terminal means and maintaining said conducting ball in contact with said terminal means.
2. An electric switch as recited in claim 1 wherein said insulated track means comprises:
 - a cylindrical insulator having a straight sided outer wall slidably fitting within said housing central bore, an inner wall having first and second partially

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circular concave divided surfaces, said concave surfaces having a radius of curvature larger than said first radius of curvature of said conducting ball.

3. An electric switch as recited in claim 2 wherein said conducting ball is made of steel.

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4. An electric switch as recited in claim 3 wherein said insulated track means is made of Lexan.

5. An electric switch as recited in claim 4 wherein said plurality of etched conductors have a pie-shaped configuration.

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