

[54] **ACCELERATION SWITCH WITH
MAGNETIC PERMEABLE METAL
SLEEVE FOR SHUNTING MAGNETIC
FIELD**

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[58] Field of Search **200/61.45 R, 61.45 M, 200/61.52, 61.53; 335/205**

[56] **References Cited**

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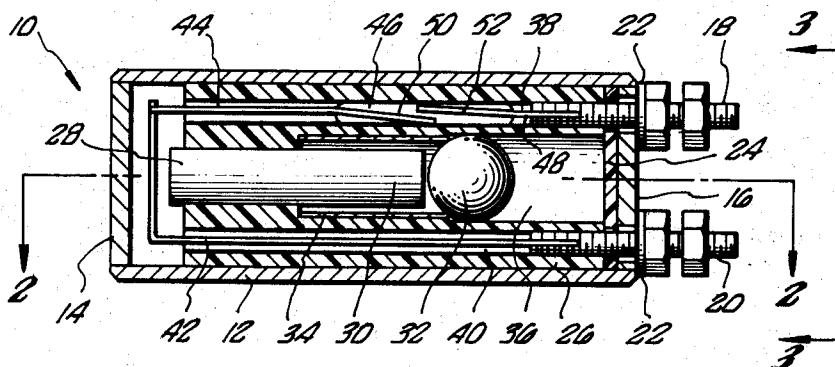
Primary Examiner—J. R. Scott

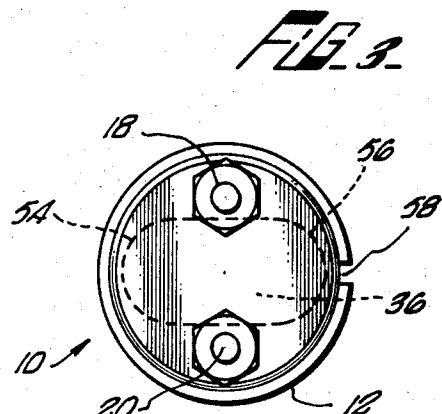
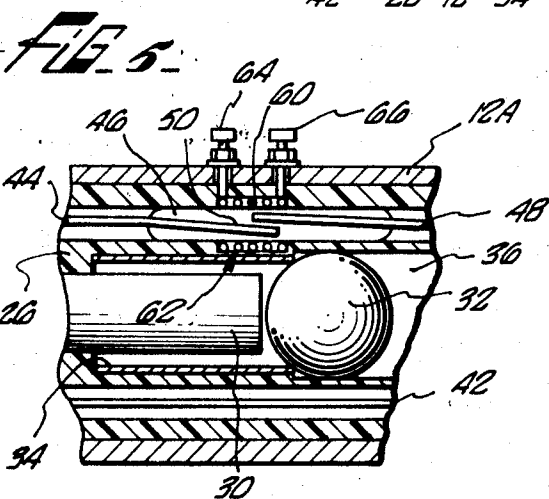
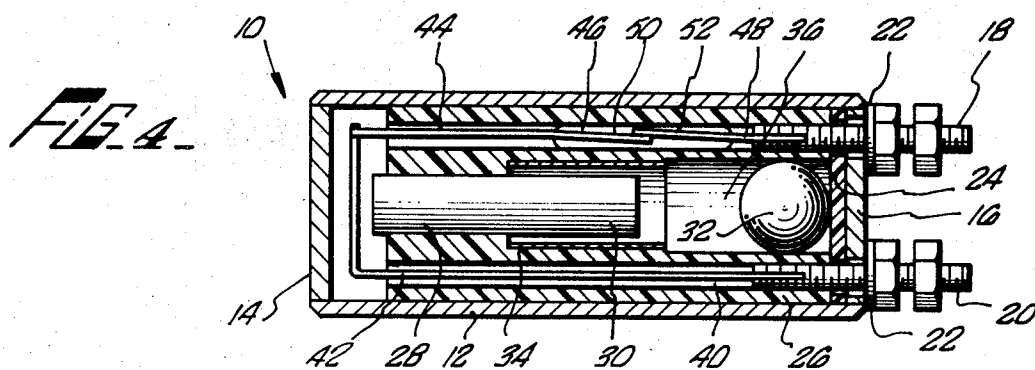
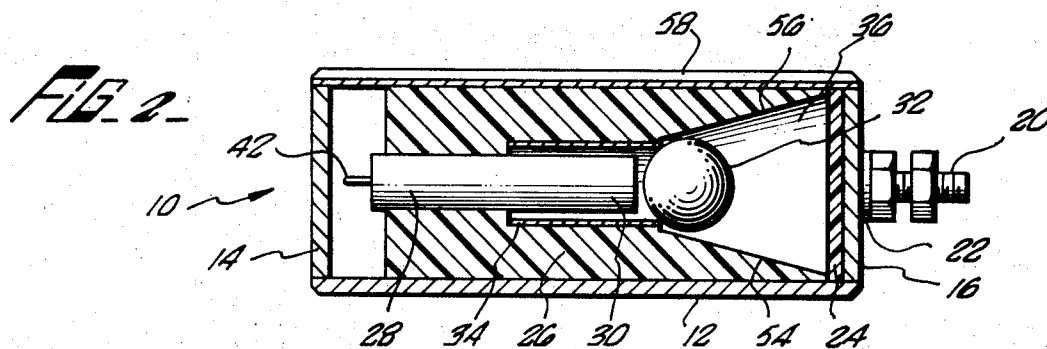
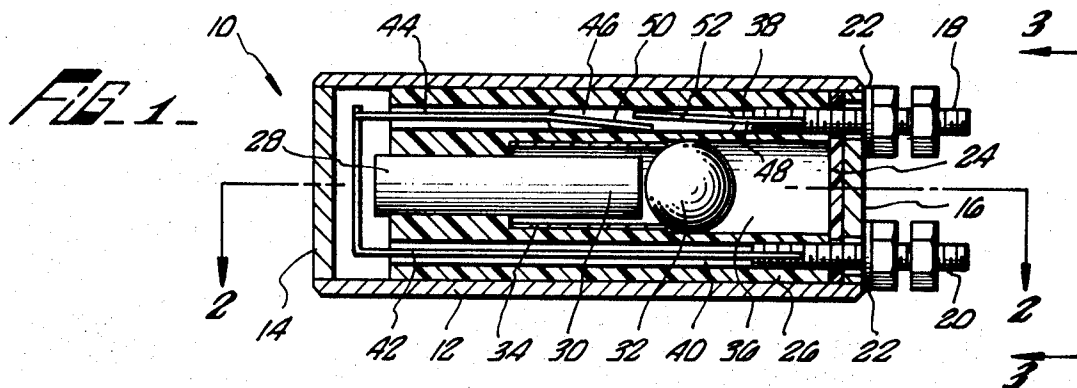
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[57] **ABSTRACT**

An acceleration switch utilizes a permanent magnet with a pole enclosing a magnetically permeable shield and a magnetically permeable ball. The field of the magnet is normally shunted by the shield and ball to weaken the magnetic field existing at a magnetic reed switch. In response to the acceleration, the ball leaves the sleeve and diminishes the shunting effect of the sleeve, so that the field at the reed switch increases and actuates the switch. Directional sensitivity of the acceleration switch is provided by the shape of the cavity within which the ball moves. A winding may be provided about the reed switch for testing switch operation or selectively inhibiting the actuation of the switch.

6 Claims, 5 Drawing Figures





ACCELERATION SWITCH WITH MAGNETIC PERMEABLE METAL SLEEVE FOR SHUNTING MAGNETIC FIELD

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to acceleration sensitive switches of the type using a permanent bar magnet, whose field is shunted by ball movement to actuate or deactuate a magnetic reed switch.

2. Description of the Prior Art

Acceleration switches of the type which utilize a permanent magnet, a moving ball, and a magnetic reed switch, are well known in the art and are shown, for example, in U.S. Pat. No. 3,459,911. Such switches have, conventionally, utilized the shunting effect of the ball to apply a magnetic field to the magnetic reed switch, so as to hold the switch in its normal position. Upon movement of the ball away from the permanent magnet, induced by acceleration, the shunting effect of the ball on the magnetic field is eliminated, so that the magnetic field at the reed switch diminishes or disappears, and the reed switch is actuated in response to its inherent spring bias. Because of the gradual change in flux at the switch which occurs with ball movement in such devices, switching is not abrupt, and reed switches with fairly low drop out to pull in ratios can be used. Furthermore, such devices have been sensitive only unidirectionally, so that lateral acceleration, in any amount, would not actuate the switch.

SUMMARY

According to the present invention, an acceleration switch utilizes a nonmagnetic housing having a longitudinal passage extending therethrough, within which a permanent magnet is fixed. A magnetically permeable ball is disposed within the longitudinal passage so as to be movable toward and away from one of the poles of the permanent magnet. A magnetically permeable sleeve encloses that portion of the permanent magnet adjacent the ball. A magnetic reed switch is disposed adjacent the sleeve so as to be shielded thereby from the permanent magnet. The reed switch is positioned so that, when the ball is in its normal position immediately adjacent the permanent magnet pole, the magnetic field produced by the permanent magnet is shunted through the sleeve and ball and so is insufficient in intensity at the reed switch to actuate it. When the ball moves away from the permanent magnet pole by reason of acceleration, the magnetic field produced by the permanent magnet is no longer shunted through the ball, and so extends through the sleeve and magnetic switch so as to actuate the switch. A rapid rate of change of flux for small displacements of the ball then occurs at the reed switch, producing an abrupt switching action.

BRIEF DESCRIPTION OF THE DRAWING

The invention may be more readily understood by referring to the accompanying drawing in which:

FIG. 1 is a side elevation, partially in section, of an acceleration switch according to the present invention;

FIG. 2 is a view taken along lines 2—2 of FIG. 1;

FIG. 3 is an end view of the acceleration switch of FIG. 1 taken generally along lines 3—3 of FIG. 1 but not in section;

FIG. 4 is a view of the device as shown in FIG. 1 in its actuated condition; and

FIG. 5 is a partial sectional view of an alternate embodiment of the device of FIG. 1, illustrating circuitry for testing or inhibiting the action of the magnetic reed switch.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, an acceleration switch 10 according to the present invention is shown in side elevation, partially in section. The acceleration switch 10 includes a cylindrical outer housing 12 and a first end cap 14. A second end cap 16, at the opposite end of the housing 12 from the first cap has a pair of electrical terminals 18, 20 extending therethrough and insulated therefrom by insulating washers 22. The second end cap 16 has an insulating housing 24 which abuts an inner insulating housing 26 within the cylindrical outer housing 12. The inner insulating housing 26, end cap 14, 16, and insulating housing 24 may be made of any suitable insulating material, such as methyl methacrylate. The housing 12 and end caps 14, 16 preferably are constructed of material such as to magnetically shield the components contained therewithin. If magnetic shielding is not required, these components can be made of any suitable material, either metallic or non-metallic, or they can be eliminated entirely.

The inner insulating housing 26 has a longitudinal passage extending therethrough. Disposed in the longitudinal passage is a permanent magnet 28. Adjacent one pole 30 of the permanent magnet 28 is a magnetically permeable ball 32. The ball 32 is held from the permanent magnet 30 by a sleeve 34, constructed of magnetically permeable material, and located so as to enclose the pole 30 of the magnet 28, adjacent to which is the ball 32. As is seen in FIG. 1, the ball 32 is located in an enlarged portion 36 of the passage extending through the inner insulating housing 26.

The terminals 18, 20 each extend into passages 38, 40, respectively, formed in the inner insulating housing 26. Attached to the terminal 20 within the passage 40 is an electrical connector 42 which extends around the inner housing 26 adjacent the first end cap 14 and is attached to a second electrical conductor 44. A magnetic reed switch 46 is connected, at one end, to the second electrical conductor 44, and at its opposite end, to a third electrical conductor 48, which extends to the terminal 18. The magnetic reed switch 46 has a pair of contact arms 50, 52 which are inherently spring biased so as to be normally open. Upon actuation, the pair of contact arms 50, 52, closes. Alternatively, magnetic reed switches may be used which are of the type in which the contacts are connected so as to be normally closed and open upon switch actuation. Therefore, as used herein, the term actuation, with respect to magnetic reed switch, is to be understood to refer to the change in switch state in response to a change in magnetic field intensity at the switch.

FIG. 2 is a view, partially in section, of the acceleration switch of FIG. 1, taken generally along lines 2—2 of FIG. 1. FIG. 2 illustrates a particular embodiment of enlarged portion 36 of the longitudinal passageway extending through the inner insulating housing 26. In the particular embodiment of enlarged portion 36 shown in FIG. 2, the enlarged portion tapers inwardly toward the pole 30 of the magnet 28 adjacent to which the ball 32

is normally positioned. However, this taper is in one dimension only. Thus, whereas the switch shown in the aforesaid U.S. Pat. No. 3,459,911 is sensitive to acceleration only in a longitudinal direction, the switch of the present invention is also sensitive to a limited degree to acceleration in a lateral direction, but not in a vertical direction. The terms lateral and vertical are used relative to the disposition shown in the Figures. By using the inwardly tapering enlarged portion 36, it will be seen that limited additional acceleration sensitivity is provided in the dimension which includes the taper. Of course, if limited lateral sensitivity to acceleration is not desired, the enlarged portion 36, rather than tapering so as to be oval in cross sectional configuration, does not taper and closely encloses the ball 32 throughout, so as to be circular in cross section configuration. The degree of lateral sensitivity of the acceleration switch utilizing taper in the enlarged section 36 is determined by the degree of taper. As will be apparent from FIGS. 2 and 3, the taper of the enlarged portion 36 is provided by a pair of inclined shoulders 54, 56 formed opposite one another in the housing 26. If lateral sensitivity in only one direction is to be provided, only one of the shoulders 54, 56 is formed at an inclination to the axis, the other shoulder conforming to the configuration for the enlarged portion 36 shown in FIG. 1. While the shoulders are shown as tapering linearly, the taper may be arcuate, if desired. For linearly tapering shoulders, the sensitivity of the switch to lateral acceleration of an angle greater than the angle of inclination of the shoulder is approximated by the equation

$$|\bar{a}_\beta| = \frac{a_{\beta_0}}{\cos(\beta - \alpha)}$$

where $|\bar{a}_\beta|$ is the magnitude of acceleration in a given direction required to actuate the switch;

α is the angle of inclination of the shoulder and is less than 90° ;

β defines the direction of $|\bar{a}_\beta|$, $\beta \geq \alpha$ and $\beta - \alpha \leq 90^\circ$ and

a_{β_0} is the magnitude of longitudinal acceleration required to actuate the switch.

As will be apparent, if β is less than α , the magnitude of acceleration required to actuate the switch is a_{β_0} .

FIG. 3 is an end view of the acceleration switch of the present invention, and illustrates the oval cross sectional configuration of the enlarged portion 36 in the preferred embodiment. Also apparent in FIG. 3 is a longitudinal groove 58 formed in the cylindrical outer housing 12 and utilized as an alignment groove so as to assure that the acceleration switch is positioned to measure lateral acceleration in the desired direction.

In operation, the device of FIGS. 1 through 3 is sensitive to longitudinal acceleration and, to a limited extent, to lateral acceleration. Normally, the contacts 50, 52 of the magnetic reed switch 46 are open. Upon closure, the contacts complete any desired electrical circuit. In the open position, the magnetic field intensity of the magnetic reed switch 46 is insufficient to actuate the switch. The field intensity produced by the perma-

nent magnet 28 of the switch 46 is such that, absent the sleeve 34, the switch 46 would be actuated regardless of ball position. By enclosing the pole 30 of the magnet 28 with the magnetically permeable sleeve 34, the magnetic field from the pole 30 is shunted through the sleeve 34 and ball 32 when the ball is adjacent the pole 30. Upon movement of the ball 32 away from the pole 30, a rapid, increase in magnetic flux occurs at the switch 46, by reason of the rapid decrease in shunting as the distance between the ball and the sleeve increases. Therefore, the switch is subjected to an abrupt change in field intensity, providing abrupt switching action.

The relative position of the switch components, when the switch is in its actuated condition, is illustrated in FIG. 4, which is a view in section of the switch, corresponding to FIG. 1, but showing the ball in its second position, remote from the pole 30, and the contacts 50, 52 closed, indicating that the switch 46 has been actuated.

FIG. 5 illustrates an alternate embodiment of the acceleration switch of the present invention, which provides for testing the operation of the magnetic switch 46 or for selectively inhibiting the closure of the switch contacts 50, 52. In FIG. 5 there is shown, in section, a portion of an acceleration switch generally corresponding to a portion of the switch shown in FIG. 1. However, in FIG. 5, the magnetic reed switch 46 is enclosed by a number of turns of an electrical conductor 60 so as to form a winding 62. A pair of signal input terminals 64, 66 extend through an outer housing 12A and are connected to the conductor 60 and are utilized to apply an electrical potential to the winding 62. When the embodiment of FIG. 5 is to be utilized to test the operation of the switch 46 in order to assure that it is operating satisfactorily, a test input signal is applied across the terminals 64, 66. The test input signal is such that the current flow through the winding 62 produces a magnetic field sufficient to actuate the switch 46.

The embodiment of FIG. 5 may also be used to inhibit the operation of the acceleration switch. For example, an input signal may be applied to the terminals 64, 66 of the same magnitude as the test signal heretofore referred to, but of opposite polarity. Such a signal will then override the magnetic field change which occurs upon ball movement away from the pole 30, so that the contacts 50, 52 will remain open, even though the ball 32 may have moved to the insulating housing 24. Thus, the winding 62 may be used not only to test the operation of the switch 46, but also to inhibit the operation of the switch 46.

The invention claimed is:

1. An improved acceleration switch having
 - a housing with a permanent magnet fixed within a passage therein,
 - a magnetically permeable ball disposed in said passage so as to be moveable between a first position adjacent one pole of said magnet and a second position remote from said magnet pole, and
 - a magnetic reed switch actuated by a change in magnetic flux occurring upon movement of said ball away from said magnet pole,
 wherein the improvement comprises
 - a magnetically permeable sleeve disposed within said passage which encloses said magnet pole to shunt the magnetic field of the permanent magnet through said sleeve and ball when said ball is in its

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first position whereby, when said ball is in its said first position, the magnetic field intensity at said reed switch is insufficient to actuate said reed switch and, when said ball moves toward its said second position, said magnetic field intensity at said reed switch increases to actuate said reed switch.

2. An acceleration switch according to claim 1, and including a winding about said reed switch operable, upon the application thereto of the first input signal, to actuate said reed switch and operable, upon the application thereto of a second input signal, opposite the first, to inhibit switch actuation upon ball movement toward its said second position.

3. Apparatus according to claim 1, and in which said passageway portion within which said ball is disposed is laterally tapered inwardly toward said magnet pole and is oval in cross section.

4. Apparatus according to claim 2, and in which the passageway portion within which said ball is disposed is tapered inwardly toward said magnet pole and is oval in cross section.

5. An improved acceleration switch having longitudinal and selectively limited lateral but not vertical sensitivity including

a housing with a permanent magnet fixed within a passage therein,

a magnetically permeable ball disposed in said passage so as to be moveable between a first position

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adjacent one pole of said magnet and a second position remote from said magnet pole, and a magnetic reed switch actuated by a change in magnetic flux occurring upon movement of said ball away from said magnet pole,

where the improvement comprises

a passageway portion within which said ball is disposed and which is laterally tapered inwardly toward said magnet pole and is oval in cross section.

6. In an acceleration switch having a housing with a permanent magnet fixed within a passage therein,

a magnetically permeable ball disposed in said passage so as to be moveable between a first position adjacent one pole of said magnet and a second position remote from said magnet pole, and a magnetic reed switch actuated by a change in magnetic flux occurring upon movement of said ball away from said magnet pole,

the method of increasing the rate of change of magnetic flux at said reed switch with ball movement comprising

enclosing said magnet pole with a magnetically permeable sleeve disposed in said passage so as to decrease the magnetic field intensity at said reed switch when said ball is in its first position by shunting said magnetic field through said sleeve and said ball.

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