Jan. 27, 1970 B. J. STOCKDALE ET AL 3,492,450

INERTIA SWITCH

Filed Jan. 22, 1969

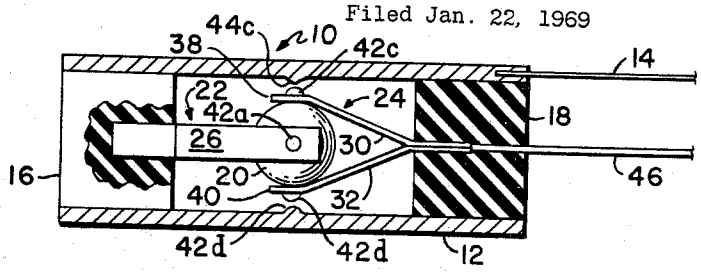


Fig 1

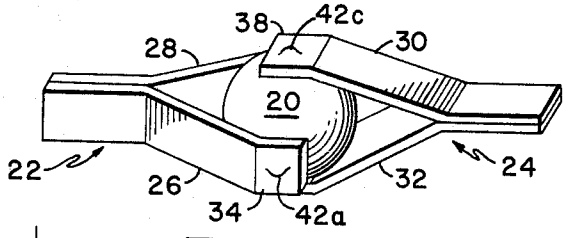


Fig 2

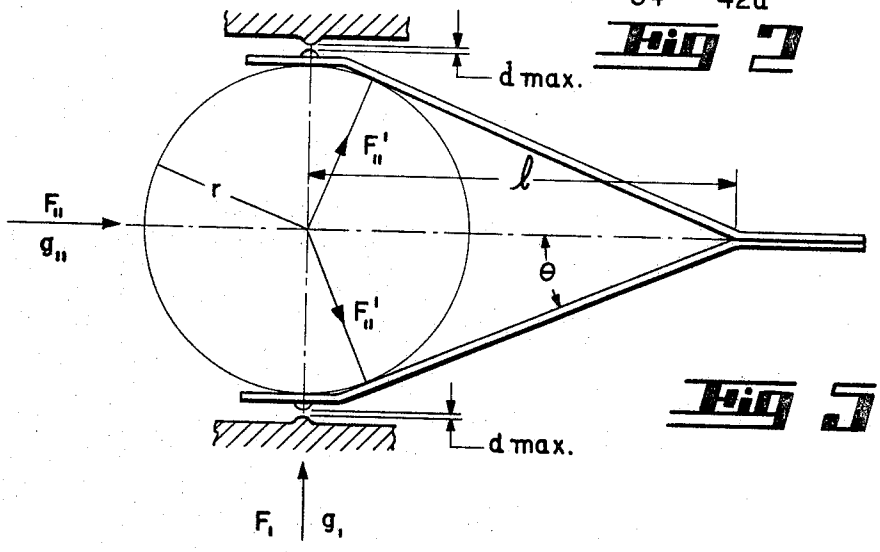


Fig 3

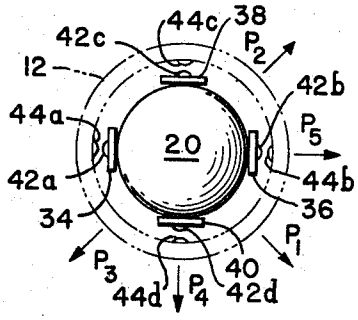


Fig 4

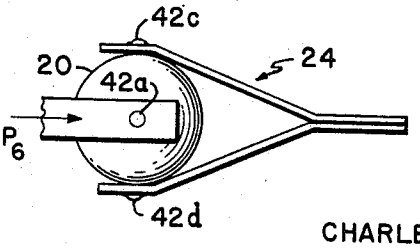


Fig 5

INVENTORS.
CHARLES V. FRUZZETTI
BY BILLY J. STOCKDALE
Charles M. Hogan
Eugene C. Stockdale
ATTORNEYS.

United States Patent Office 3,492,450
Patented Jan. 27, 1970

3,492,450

INERTIA SWITCH

Billy J. Stockdale and Charles V. Fruzzetti, Richmond, Ind., assignors to Avco Corporation, Richmond, Ind., a corporation of Delaware

Filed Jan. 22, 1969, Ser. No. 793,086
Int. Cl. H01h 35/02
U.S. Cl. 200—61.45
6 Claims

ABSTRACT OF THE DISCLOSURE

An inertia switch is disclosed in which a pair of spring contacts, encompassing an inertia member, is mounted within a conducting housing. The contacts are orthogonally arranged to hold the inertia member in equipoise and movement of the inertia member in any direction relative to the housing will cause at least one of the contacts to engage the housing and close the switch.

BACKGROUND OF THE INVENTION

This invention relates generally to inertia switches and more particulraly to an omnidirectional inertia switch.

An inertia switch is one which will respond to a sudden acceleration or deceleration of a predetermined magnitude. One common application of such devices is in the field of munitions fuzing, especially in those applications in which the munition must be armed or detonated upon impact with an object. It is noted, however, that inertia switches of this type have other applications, such as being placed in vehicles to deenergize the ignition system whenever a collision occurred.

The prior art discloses that the usual inertia or impact switch includes a movable mass, mounted in a housing, which is generally biased to a normal or off position by compressed springs or magnetic means. The application of the forces causing the sudden acceleration or deceleration will cause the movable mass to move relative to the housing and against the biasing elements. Means are provided to sense this movement of the mass from the normal position and thus perform the function of the switch.

In munitions applications, it is often necessary that the switch be omnidirectionally responsive since many munitions are not oriented to strike the target in any specified position. Omnidirectional switches have been developed in the prior art. These devices have been a combination of several unidirectional impact switches mounted in a single casing. As such, the switch is redundant in form and does not utilize each component to its fullest capacity. In a field where miniaturization is required, a plurality of working components increases the problems involved in manufacture and assembly of the switch. The resulting complex structure is inherently less reliable than a switch of fewer components.

The present invention provides an inertia switch which has a minimum of components, is easy to manufacture and assemble and has a high degree of reliability.

This invention further provides for a more accurate and uniform response to forces applied from any direction.

SUMMARY OF THE INVENTION

An inertia switch is provided in which an inertia member is so mounted in a conducting housing that forces of a predetermined amount from any direction will cause relative movement between the inertia member and the housing. The mounting means encompasses the inertia member and also provides the contact elements which are forced outward into engagement with the housing in response to the relative movement of the inertia member to function the switch.

DESCRIPTION OF THE DRAWINGS

An illustrative embodiment of the present invention is shown in the following drawings, in which:

FIG. 1 is a partial longitudinal sectional view showing the preferred embodiment of this invention;

FIG. 2 is a perspective view of the inertia member and contact-mounting members; and

FIGS. 3, 4 and 5 are schematic representations of the invention showing various applications of external forces to the inertia member.

DETAILED DESCRIPTION OF THE INVENTION

In the illustrative embodiment of the invention illustrated in FIG. 1, there is generally shown an inertia switch **10** in its normally open position. A housing **12** composed of a conducting material, such as a thin walled aluminum tube, forms the body of the switch. The housing, as shown in phantom in FIG. 4, is seen to be cylindrical; however, the housing **12** can be square or any other desired configuration. Lead **14** connects housing **12** with a desired external electric circuit, not shown.

Each end of housing **12** is filled with a non-conducting material **16** and **18**, respectively, which serves as a filler means for that end and also as a mounting base for the switch enabling means to be described herebelow.

As seen best in FIG. 2, the enabling means includes an inertia member **20** held in equipoise by a pair of spring contacts **22** and **24**. The spring contacts are respectively mounted in the non-conducing material **16** and **18**, thus forming cantilever supports for the inertia member.

In the illustrative embodiment shown, each spring contact **22** and **24** comprises a pair of leaf spring elements **26–28** and **30–32**, respectively.

Each, for example, spring **24**, is formed as a fork or bifurcated member terminating in opposing flat surfaces **38** and **40** which engage, in tangent relationship, the 180° displaced polar points of the inertia member **20**. The bifurcations converge at the other end to provide a single terminal in electrical and mechanical continuity with lead **46**. The leaf spring **22** is similarly formed but it is oriented orthogonally with respect to leaf spring **24** and mounted perpendicular to the plane of leaf spring **24** so that its flat surfaces **34** and **36** are tangent to 180° displaced equatorial points on inertia member **20**. Thus, the flat surfaces **34**, **36**, **38** and **40** constitute a pair of orthogonally arranged members which snugly hold the inertia member **20** at 90 degree displaced points on the periphery thereof. The inertial member **20** is wedged against the convergent bearing surfaces of **30**, **32**, **26** and **28** which hold the inertia member immobile.

Each of the flat surfaces has a small rounded protuberance or dimple **42***a* to **42***d* thereon and similar protuberances **44***a* and **44***d* are placed on the inner surface of housing **12** to cooperate with respective ones of the protuberances **42** on the flat surfaces of the contact members **22** and **24**. The spring contacts **22** and **24** are so mounted that the protuberances **42***a*–**42***d* are all spaced an equal distance from the corresponding protuberances **44***a*–**44***d*.

A lead **46** connects contact member **24** with the external circuitry not shown. In the illustrative embodiment shown, inertia member **20** is a small conducting ball. Thus, when a shock, acceleration or deceleration force of preselected magnitude is applied to the switch assembly **10**, regardless of direction, the inertia member **20** is made to move relative to the housing **12** and forces one or more of the spring elements apart. The spreading of the spring elements will cause one or more of the protuberances **42***a*–**42***d* to make contact with the cooperating protuberances **44***a*–**44***d* on the inner surface of housing **12** thereby completing the electrical circuit and functioning the fuze.

As shown in FIGS. 3 and 4, a transverse force, such as P_4 or P_5, on inertia member **20** will urge the corresponding flat surface and protuberance **42***d* or **42***b* outward into engagement with cooperating protuberance **44***d* or **44***b*. Forces, as represented by forces P_1, P_2, P_3, or P_6, result in the inertia member **20** urging the angled connecting surfaces apart to cause one or more of the protuberances to make contact with the conducting housing **12** and complete the circuit.

It can be seen that either or both sets of protuberances may be eliminated if desired. If this is done, the flat surface of the spring contacts could engage the inner wall of housing **12** directly to make the necessary contact to complete the circuit. In addition, if it were desired to make the inertia member **20** of a non-conducting material, it would only be necessary to have an additional lead connecting spring contact **22** with the external electrical circuitry to maintain the omnidirectional utility of the inertia switch.

It has been found that by designing the contact springs with an included angle of approximately 46 degrees, the same force may be made to deflect the contacts nearly the same distances regardless of whether the force is axial or perpendicular to the axis, thus providing an omnidirectional inertia switch which will exhibit almost the same sensitivity in all directions.

Referencing FIG. 5, which shows a schematic of the inertia switch detailed in FIGS. 1 and 2, the relatively simple calculations, which follow, will demonstrate the correctness of the above statement.

For the purposes of computation the nomenclature in the computations is:

g_I=acceleration perpendicular to axis
g_{II}=acceleration along axis
m=mass of inertia member
r=radius of inertia member
F_I=force perpendicular to axis
F_{II}=force along axis
l=length of suspension
2θ=included angle between springs
J=moment of inertia of cross section of the springs
E=modulus of elasticity
b=width of springs
h=thickness of springs
d_{max_I}=maximum deflection resulting from F_I
$d_{max_{II}}$=maximum deflection resulting from F_{II}

Using conventional mechanics we can establish the following equations for the deflection of the cantilever springs resulting from the application of gravitational forces F_I and F_{II}

$$d_{max_I}=\frac{F_I l^3}{3EJ}=\frac{F}{3EJ}\left(\frac{r}{\sin\theta}\right)^3 \quad (1)$$

since

$$l=\frac{r}{\sin\theta}$$

$$d_{max_{II}}=\frac{F_{II}'}{3EJ}\cdot(1\cos\theta)^3\cos\theta\cdot\frac{1}{\cos\theta}$$

where:

$$\frac{F_{II}'}{3EJ}\cdot(1\cos\theta)^3$$

is the deflexion in the direction of the force F_{II}' at the point where this force is applied. The factor $\cos\theta$ establishes the deflexion in the direction of the contact point. The factor $1/\cos\theta$ transfers the motion from the point where F_{II}' is applied to the contact point.

$$F_{II}'=\frac{F_{II}}{2\sin\theta}$$

$$d_{max_{II}}=\frac{F_{II}}{6EJ}\cdot\frac{r^3\cos^3\theta}{\sin^4\theta} \quad (2)$$

Since it is desired that $d_{max_I}=d_{max_{II}}$ for $F_I=F_{II}$ Equations 1 and 2 may be combined to provide Equation 3

$$2\sin\theta=\cos^3\theta \quad (3)$$

This equation can quickly be solved by successive approximations which indicate that

$$\theta=22.97°$$

will satisfy the equation.

Since $J=bh^3/12$ all desired constants can be determined from the equation to provide the required deflexion.

It is thus seen that an inertia switch has been provided for use in omnidirectional applications. The switch has a minimum of components and a high degree of reliability. The components of the switch lend themselves for ease in manufacture and assembly and provide for a uniform response to forces applied from any direction. The compactness of the switch and component parts make the inertia switch easily adaptable for use where miniaturization is required.

While the forms of inertia switch herein described constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to these precise forms of apparatus.

What is claimed is:

1. A normally open inertia switch comprising:
a conducting housing having an inner contact surface;
an inertia member;
and a pair of bifurcated spring contacts having contacting portions and other portions orthogonally arranged and holding said inertia member in equipoise within said housing, each of said spring contacts being fixed to said housing by said other portions so that each of said contacting portions is normally spaced an equal distance from the inner surface of said housing; said housing, inertia member and pair of bifurcated spring contacts being so constructed and arranged as to constitute means whereby movement of said inertia member relative to said housing will cause at least one of said contacting portions to move into engagement with said housing inner contact surface and thereby close the switch.

2. A normally open inertia switch comprising:
a conducting housing having an inner contact surface;
an inertia member;
a first pair of spring contact members having contacting portions holding said inertia member on opposite faces thereof and terminating in a single first lead at one end of said housing;
a second pair of spring contact members having contacting portions holding said inertia member at 90 degrees displacement points from said first contact members, said second pair of spring contact members terminating in a single second lead at the opposite end of said housing;
and said first and second leads being mounted in a non-conducting material within said housing so that each of said contacting portions is normally spaced an equal distance from the inner surface of said housing; said housing, inertia member, first and second pair of contact members being so constructed and arranged as to constitute means whereby movement of said inertia member relative to said housing will cause at least one of said contact members to move into engagement with said housing inner contact surface and thereby close the switch.

3. A normally open inertia switch comprising:
a conducting housing having an inner contact surface;
an inertia member;
a first spring member mounted at one end of said housing and bifurcated to provide a pair of contact elements;

a second spring member mounted at the other end of said housing and bifurcated to provide a pair of contact elements;

each spring member terminating in a parallel surface and snugly holding said inertia member in equipoise at 90 degree displaced points on the periphery thereof;

and each of said contact elements is normally spaced an equal distance from the inner surface of said housing; said housing, inertia member, first and second spring members being so constructed and arranged as to constitute means whereby movement of said inertia member relative to said housing will cause at least one of said contact elements to move into engagement with said housing inner contact surface and thereby close the switch.

4. A normally open inertia switch as set forth in claim 3 in which each spring member is formed to provide a single lead portion; an intermediate divergent portion; and a terminating flat portion; the flat portions bearing against the inertia member so that transverse movement of the inertia member urges a flat portion into engagement with the housing contact surface, the diverging portions providing bearing surfaces against which the inertia member wedges, whereby axial movement of the inertia member against any of said divergent portions will cause one of the terminating flat portions to engage the housing and thereby provide an omnidirectional inertia switch.

5. A normally open inertia switch as set forth in claim 4 in which the included angle between the intermediate connecting divergent portions is approximately 46 degrees wherein the same force acting on said inertia member will deflect the flat surfaces of said spring member the same distance regardless of the direction of application of the force and thereby providing an omnidirectional inertia switch which exhibits the same sensitivity in all directions.

6. A normally open inertia switch as set forth in claim 3 in which said inertia member is a spherical ball;

each of said contact elements is a rounded protuberance;

and said conducting housing includes corresponding protuberances on the inner contact surface wherein said protuberances form the switch contact points.

References Cited

UNITED STATES PATENTS

2,679,819	6/1954	Torcheux	200—61.45
3,001,039	9/1961	Johnson	200—61.45
3,156,794	11/1964	Vold	200—61.45

ROBERT K. SCHAEFER, Primary Examiner

M. GINSBURG, Assistant Examiner

U.S. Cl. X.R.

102—70.2