

[54] SELF-ALIGNING MOTION DETECTORS

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[22] Filed: Oct. 21, 1970
[21] Appl. No.: 82,570

[52] U.S. Cl.200/61.48
[51] Int. Cl.H01h 35/14
[58] Field of Search200/61.45, 61.48, 61.49, 61.51, 200/61.52, 166 BH, 61.53; 340/261, 262

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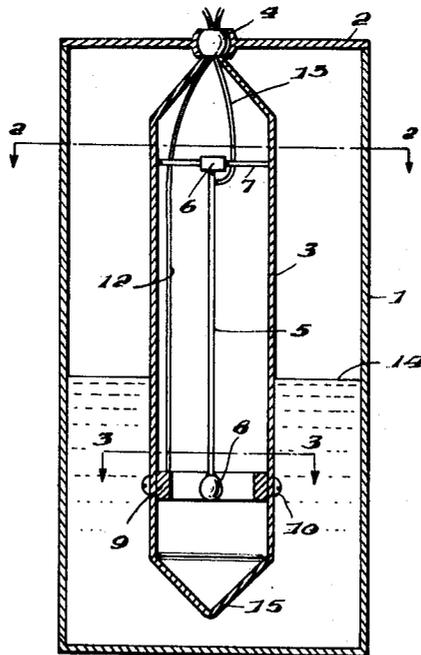
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[57] ABSTRACT

A motion detector for energizing an alarm signal at a suitable location and which is responsive to linear motion of an object on which the detector may be mounted and capable of self-alignment to the object. The detector comprises a case or suitable enclosure within which an outer pendulum or pendulum body is supported for freedom of universal but sluggish movement and within which a second pendulum or body is supported for universal and unconstrained movement with respect to the outer pendulum. Contact is made between respective pendulums or bodies upon motion of the case to transmit an electrical signal to a suitable sensor, alarm or the like. The motion of the outer pendulum is suitably constrained as by immersing it in a liquid within the case or by providing it with a greater period than the inner pendulum or body in compound pendulum aspects. A contact ring may be located on the inner wall of the outer pendulum or other suitable contact means for electrical contact between the ring and the inner pendulum or between the contact means to close a control circuit.

12 Claims, 8 Drawing Figures



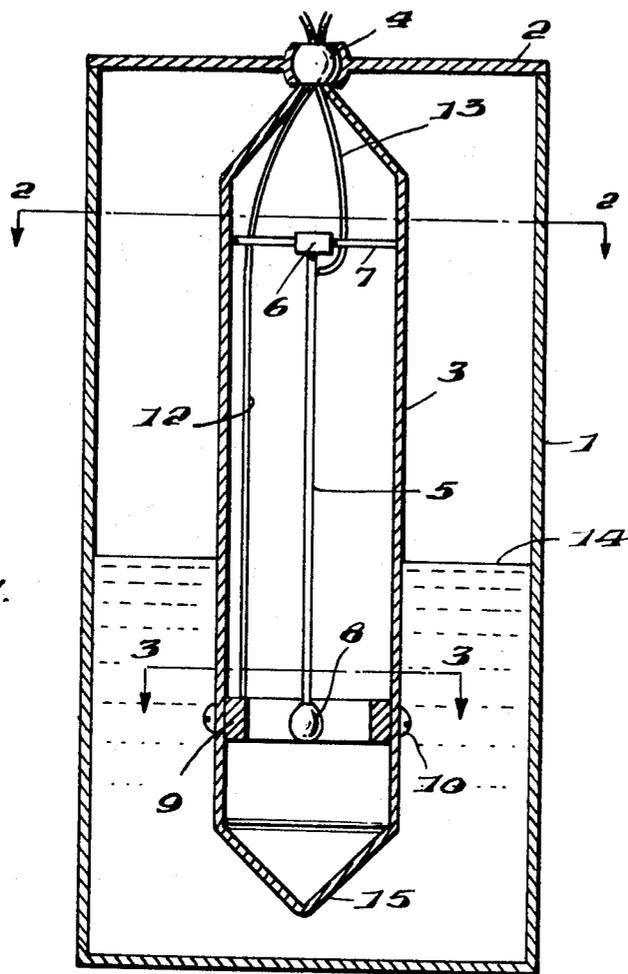


Fig. 1.

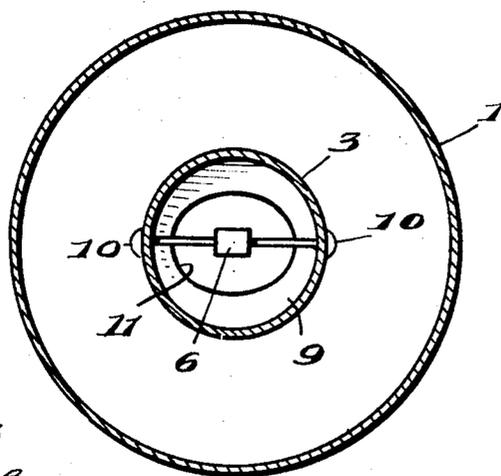


Fig. 2.

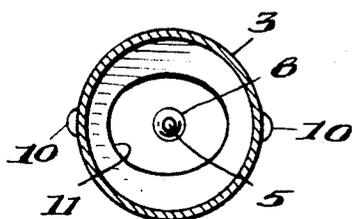


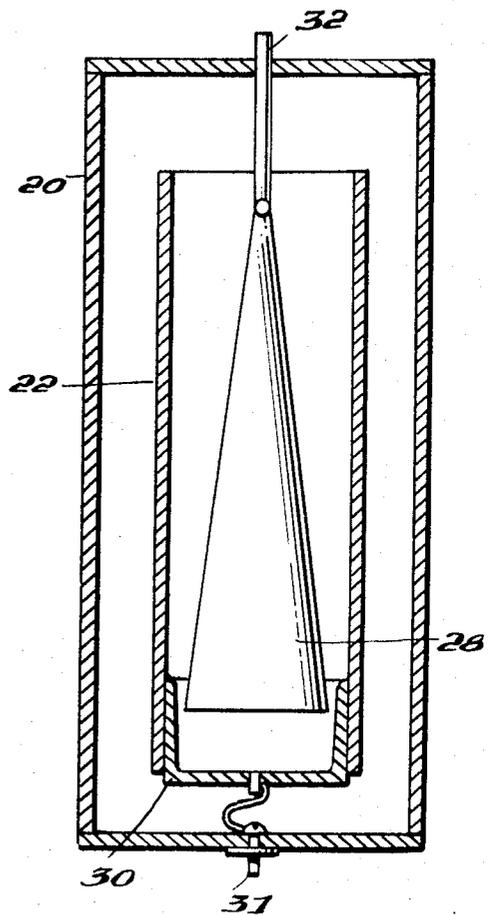
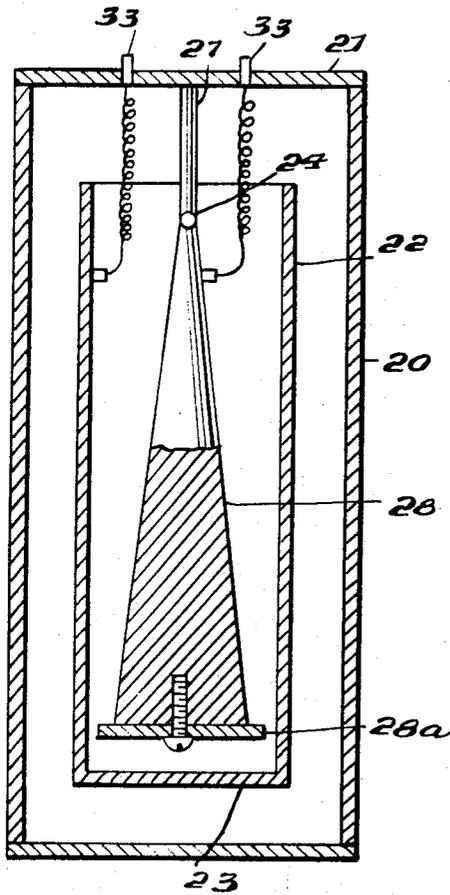
Fig. 3.

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Fig. 4.

Fig. 5.



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Fig. 8.

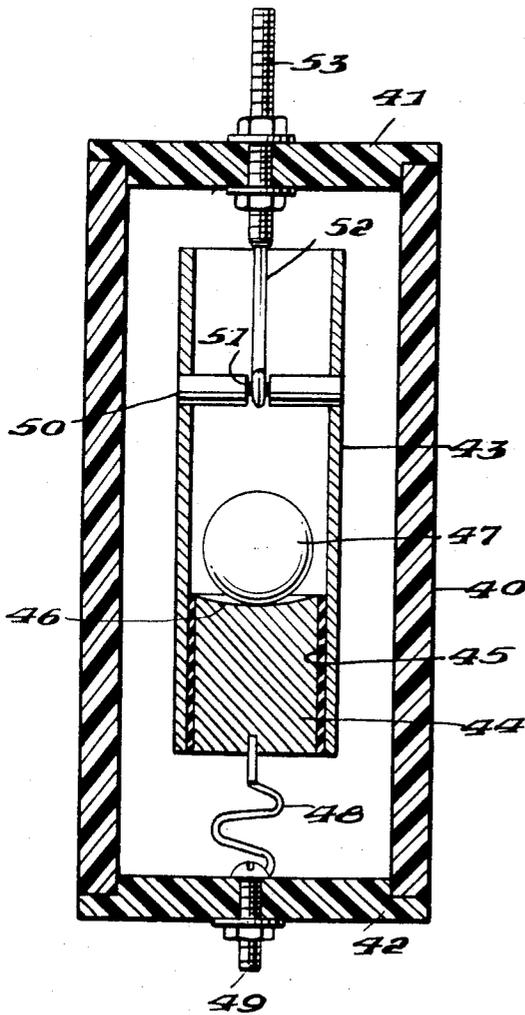


Fig. 6.

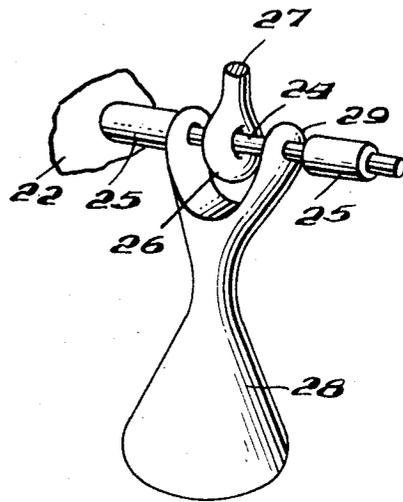
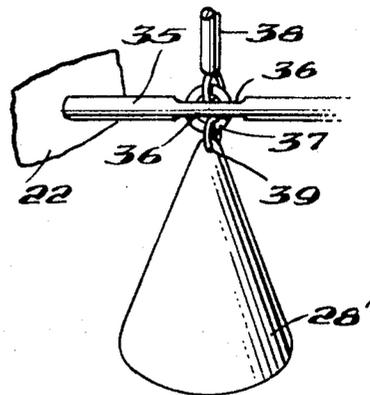


Fig. 7.



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SELF-ALIGNING MOTION DETECTORS

SUMMARY OF THE INVENTION

This invention relates to improvements in motion detectors for energizing or controlling a suitable sensor, alarm or monitor system when the device or object on which the detector is mounted is subjected to linear motion in any direction.

A motion detector for this purpose must have sensitivity of a very high order to be effective for signalling motion of the device. While pendulum switches have been suggested heretofore for controlling various electric circuits, either they do not have sufficient sensitivity for the effective performance of the function required in this environment or, if they do have sufficient sensitivity, then they require extremely careful initial alignment to the object on which they are mounted.

One object of this invention is to simplify and improve devices for controlling electric circuits which will respond effectively to small but finite motion and indicate by control of an electric signal to a suitable sensor, alarm or monitor system.

Another object of the invention is to provide an assembly which, when subjected to initial misalignment, will be self-adjusted to allow a more sensitive detection of the motion than would be practical otherwise.

Another object of this invention is to provide means to have different sensitivity to motion along one axis than along a cross axis.

Still another object of the invention is to provide in a motion detector both outer and inner pendulums or bodies, one within the other, and which respond to motion imparted to their pivot point so as to maintain their original positions. This causes a forcing function or drive to initiate swinging of the pendulums. Having different natural frequencies or periods they will move into contact with each other closing an electric circuit depending on the extent of such movement. The inner pendulum or body is designed for as free motion as possible whereas the outer pendulum is designed for slower response.

These objects may be accomplished, according to one embodiment of the invention, by providing an outer case for enclosing a pair of pendulums, one within the other and both mounted for universal movement in all directions with respect to each other and relative to the case. The inner pendulum is disposed so as to make contact with the outer pendulum or with contact means thereon, thereby to close an electric circuit to a suitable sensor, alarm or monitor system for indicating the movement of the device on which the case is mounted.

These objects may also be accomplished by an alternate embodiment wherein the inner pendulum becomes a spherical ball rolling on a concave curved surface. This curved surface is located near the bottom of an outer pendulum. The radius of curvature of this surface determines the effective (or equivalent) length of the inner pendulum or body so mechanized. The ball seat is electrically connected to one output terminal and the outer pendulum contact surface (or ring) is electrically connected to the other terminal and they are electrically insulated from each other. The ball makes contact, as before, in response to motion imparted to the outer pendulum.

The motion constraint of the outer pendulum may be accomplished by immersing the same in a suitable damping fluid contained within the case to vary the response time of the outer pendulum. The dynamics of the pendulums may also be varied by relative adjustment of the effective length thereof or by compound characteristics of the outer pendulum.

Sensitivity can also be adjusted by means of a contact ring mounted within the outer pendulum, the inner diameter of which is then elliptical so as to vary the sensitivity of the detector along the two respective axes of the inner surface of the ring. The inner surface is subject to contact by the inner pendulum or pendulous body upon relative swinging motion, and the degree of swinging for contact will be varied according to whether the inner pendulum or pendulous body strikes along the long or short axes of the elliptical inner surface.

BRIEF DESCRIPTION OF THE DRAWINGS

This embodiment of the invention is illustrated in the accompanying drawings, in which:

5 FIG. 1 is a vertical section through the motion detector; FIG. 2 is a horizontal section therethrough on the line 2—2 in FIG. 1;

FIG. 3 is a horizontal section through the pendulums on the line 3—3 in FIG. 1;

10 FIG. 4 is a vertical section through a circuit closer, showing a modification;

FIG. 5 is a similar view, showing a further modification;

FIG. 6 is a detailed perspective view, showing a support for the inner pendulous body;

15 FIG. 7 is a similar view, showing a modification of the support; and

FIG. 8 is a vertical section of a further modification.

DETAILED DESCRIPTION OF THE DRAWINGS

20 The motion detector is capable of being used on any object, the motion of which it is desired to be indicated or recorded. For example, it may be used on a suitable transport vehicle, truck or other conveyance to detect the unauthorized use and movement thereof. It should be connected with a suitable sensor, alarm or monitor system which will respond to the action of the detector in closing an electric circuit. The responsive means is not indicated in detail, but any suitable form thereof may be used for the purpose.

25 The detector comprises a case, generally indicated by the numeral 1, which is adapted to be mounted in a suitable position fixed upon the device whose motion is to be detected. The case 1 is in the form of a closed receptacle having a cover 2 thereon for purpose of access to the case.

30 Mounted within the case 1 is an upright tubular outer pendulum, generally indicated at 3. The pendulum 3 is suspended in the case for freedom of universal movement relative thereto. A suitable universal joint is shown at 4 illustrative of an appropriate mounting for the pendulum.

35 Located within the upright tubular pendulum 3 is an inner pendulum 5 which extends throughout a substantial portion of the length of the outer pendulum 3, although the relative dimensions may be varied as found desirable. The inner pendulum 5 is supported on a universal mounting 6 within the outer pendulum 3 as, for example, on a support wire 7 extending diametrically across the outer pendulum 3.

40 The connection between the inner pendulum 5 and the wire 7 will be such as to permit of this freedom of motion. If the wire has sufficient yieldability for freedom of swinging movement of the inner pendulum 5 relative to the outer pendulum 3, this may be a fixed connection, but if the support be substantial, it may be in the form of a universal joint of conventional form.

45 The lower end of the inner pendulum 5 has a weight 8 or ball mounted thereon for electrical contact either within the inner face of the pendulum 3 or with a contact ring 9 mounted therein. The contact ring 9 is supported by suitable fastenings 10 on the inner wall of the outer pendulum 3 fitting the surface thereof. For varying the sensitivity of the device, the inner surface of the ring 9 may be in the form of an ellipse, as illustrated in FIGS. 2 and 3, so as to register variations according to the direction in which the inner pendulum swings relative to the outer pendulum along the short or long axis of the elliptical surface 11.

50 The control circuit may be connected with the detector through suitable electrical connections, such as wires 12 and 13 shown as connected respectively to the ring 9 and the inner pendulum 5. These wires should be led out through the case 1 in any suitable manner as, for example, through the universal joint 4.

55 The motion of the outer pendulum 3 may be suitably damped by immersing this pendulum in a body of liquid 14 contained in the bottom of the case 1. The viscosity of the liquid and the height thereof in the case may be varied as found desirable for variations in sensitivity and reaction time.

It is desired that the liquid should not extend into the tubular outer pendulum 3 so as to leave the latter and the pendulum 5 free for relative motion. Accordingly, the bottom end of the tubular outer pendulum 3 is shown as being drawn closed and sealed, as indicated generally at 15 in FIG. 1.

It will be apparent that any motion of the supporting device on which the detector is mounted will result in relative motion between the outer and inner pendulums and if substantial motion is involved, will cause a closing of the circuit between the wires 12 and 13 by engagement of the contact member 8 on the pendulum 5 with the inner surface of the contact ring 9, thereby controlling the electric circuit to indicate the motion.

The contact ring 9 should be suitably insulated. The outer pendulum 3 may be made of a suitable insulating material such as plastic, with the conductor contact ring 9 supported on the inner surface thereof. However, if the outer pendulum 3 is of metal, a suitable insulating material may be interposed between the surfaces of this outer pendulum and the contact ring 9.

The inner pendulum 5 will make contact with the outer pendulum or the contact ring thereon when the device is subjected to linear motion along any horizontal axis.

The detector uniformly affords self-adjustment to initial set-up misalignment and provides a more sensitive detector than would be practical otherwise.

The outer pendulum is constrained to move in a more sluggish manner than the inner pendulum as by reason of the damping fluid 14 between the outer pendulum and the case or by the compound pendulum aspects of the dynamics associated with a compound outer pendulum or variations in relative length between the pendulums, or a combination of these factors, depending upon the gross sensitivity and/or the response time to motion at or over the sensitivity threshold level.

This invention allows adjustable sensitivity. The sensitivity can be controlled by setting the gap between the inner pendulum and the outer pendulum. Also the gap and thus the sensitivity for two orthogonal, horizontal axes can be set independently. For example, the user may wish to have great sensitivity along one axis; whereas normal expected motion along a perpendicular to this axis would cause false firing and thus reduced sensitivity is required.

Sensitivity is also adjusted independently along any two orthogonal axes, such as the adjustment that will result from the use of a ring inside the outer pendulum and having an elliptical opening in position for electrical contact therewith of the inner pendulum upon relative motion therebetween. By varying the elliptical configuration, the sensitivity of the detector can be varied along the two axes independently and along all axes relative to the two pendulums.

Differential sensitivity may be obtained for this embodiment by blocking off sections of the contact ring 9 so that the ball has to behave vigorously and thereby crosscouple some motion to the sensitive axis before contact will be made in response to motion along the de-sensitized axis.

Depending upon application, the motion detector may use means to constrain the movement of the outer pendulum such, for example, as the damping fluid enclosed in the case and in which the pendulum is immersed. The device is self-adjusting, especially for misalignment in mounting.

The outer pendulum corrects any misalignment of the case and always has its operating center in a vertical direction. Both of the pendulums respond to gravity, with suitable damping or other constraint of the outer pendulum as by varying the quantity of liquid damping fluid or by adding effective length thereof so as to change the dynamics of motion.

Another form of motion detector that will be self-aligning is illustrated in FIG. 4. Here the upright case is illustrated at 20 having a top cover 21 and is preferably closed at the bottom for receiving a body of liquid therein, as described above. This case may be mounted in any suitable manner upon an object, as also described above.

Within the case 20 is a cylindrical outer pendulum or pendulous body 22 having an end cap 23 closing the lower end thereof. This body forms the outer pendulum and extends upright in the case, being in the form of a tube closed at the lower end. This outer pendulum may be mounted in the case 20 for universal movement with respect thereto as, for example, by the mounting illustrated in FIG. 6.

Thus, the tubular outer pendulum, which is preferably of electrically conductive material, has opposite sides of the tube connected together through a cross shaft 24 with spacers 25 sleeved thereover inwardly of the opposite walls of the outer pendulum. The shaft 24 is mounted within an eye 26 loosely thereon capable of universal movement and which eye 26 is suspended by a bracket member 27 extending upwardly to and supported by the cap 21 of the case. This will allow freedom of swinging movement of the outer pendulum in any direction with respect to the case.

Also suspended from the shaft 24 is an inner pendulum, illustrated generally at 28. The mounting of the pendulum 28 by a yoke 29 on the shaft 24 allows freedom of universal movement of the inner pendulum with respect to the shaft, the holes being sufficiently enlarged so as to permit of freedom of movement in any direction.

The outer and inner pendulums 22 and 28 are electrically connected with terminals 33 on the cover 21 of the case.

The lower end of the inner pendulum may be in position to swing into electrical conducting relation with the inner surface of the outer pendulum 22, or a contact plate 28a may be detachably connected with the lower end of the pendulum 28 for making contact with the inner surface of the outer pendulum 22. This contact plate would have a larger outside diameter than the lower end of the inner pendulum, but may be varied in size or characteristics for adjustment of the cap and for varying the sensitivity of the device. The outer and inner pendulums would both be of electrically conductive material in this illustration.

This form would function substantially as described above with respect to the form of the invention illustrated in FIGS. 1 to 3.

FIG. 5 shows a further modification in the form of circuit closer illustrated in FIG. 4 in that the outer pendulum 22 is in the form of a tube with an end cap 30 that is sleeved into the lower end of the tube and detachable and removable therefrom so that it may be replaced with another end cap when it is desired to vary the gap and the sensitivity of the device.

It will be noted that the lower end of the inner pendulum 28 makes electrical contact with the inner surface of the cup-shaped end cap 30 that is sleeved into the tubular outer pendulum 22. This cup-shaped end cap 30 is electrically connected with a terminal 31, shown in this instance as attached to the bottom of the case 20. A single terminal 32 is provided on top of the case, electrically connected with the inner pendulum.

Another form of support for the inner pendulum is illustrated in FIG. 7 as a modification of the structure shown in FIG. 6. Here the shaft 35 extends transversely between opposite sides of the outer pendulum 22 and has a slot therethrough, as indicated at 36. Mounted in the slot 36 is a ring 37 which may be retained in the slot, if needed, by a cross pin therein. This ring 37 is interconnected with an eye of a suspending bracket 38 similar in character to the bracket 27, described above. Connected with the opposite side of the ring 37 is a ring 39 fixed to the upper end of the pendulum 28'. The interconnection provided by the rings 37 and 39 with the bracket 38 and shaft 35 mount both pendulums for universal movement with respect to the case or support for the bracket 38. In other respects, the structure operates in the manner described above.

Another form of motion controller is illustrated in FIG. 8. Here the case is formed by a surrounding wall 40 having top and bottom end caps 41 and 42. These parts preferably are formed of a suitable plastic material and are secured and

sealed together in conventional manner. They may contain a body of liquid if desired.

Located within the wall 40 of the case is an outer pendulum, generally illustrated at 43, preferably tubular in form and made of a suitable electrically conductive material. The tubular outer pendulum 43 is closed at the bottom by an end cap 44 which may be in the form of a rod of electrically conductive material and insulated from the outer pendulum 43 by a suitable insulating material 45.

The upper end of the end cap 44 has a spherical surface 46 upon which is seated a ball 47 of electrically conductive material. The lower end of the end cap 44 is electrically connected through a wire 48, with a terminal 49 mounted in the end plate 42 of the case.

The outer pendulum is suspended by a rod 50 which extends diametrically across opposite sides of the tubular outer pendulum 43 with a reduced intermediate portion 51 in the rod. This reduced portion 51 extends through an eye in a suspending bracket or hook 52 loosely with respect thereto, which bracket or hook 52 extends up to a terminal 53 mounted in the end plate 41 of the case.

It will be apparent that the outer pendulum 43 is suspended for universal movement with respect to the case about a center within the parts 51 and 52 and responds to variations in motion imparted to the case. The outer pendulum 43 is of electrically conductive material and thus will be connected electrically to the terminal 53. The ball 47 forms a pendulous body freely and loosely suspended upon the spherical surface 46 so as to respond in movement to vibrations or motion imparted to the case and to the pendulum 43 so as to make contact with the inner surface of the latter upon such relative motion. This ball 47 is electrically connected to the terminal 49 through the end cap 44, and these parts therefore form a circuit closer for a circuit connected with the terminals 49 and 53.

In other respects this form of the invention operates in the manner described above and for the purposes herein set forth.

Some applications of this invention are to mobile objects to detect motion over a predetermined threshold of trucks, trailers, railroad cars, airplanes, boxes, equipment; also to stationary structures to detect motion over a predetermined threshold, as fences, walls, doors, bridges, buildings. These are given as examples, and the invention may be applied in many other ways.

While the invention has been illustrated and described in certain embodiments, it is recognized that other variations and changes may be made therein without departing from the invention set forth in the claims.

I claim:

1. A self-aligning circuit closer comprising a support, an elongated tubular pendulous contact member extending upright relative to the support, a horizontal axial support connected to said tubular member, means for suspending said contact member on an upright axis for universal movement relative to the first mentioned support about a center located on said axis, a second contact member supported on the pendulous contact member by said horizontal axial support for universal movement relative thereto with a center of suspension located on said upright axis, said contact members having different dynamics of motion about the respective centers of suspension on said axis, and means on the tubular contact member in position for contact engagement by the second contact member upon relative swinging movement for closing a circuit therebetween.

2. A circuit closer according to claim 1, wherein the tubular contact member has a cross member extending transversely between opposite sides thereof, and means having a supporting connection with the cross member and forming a universal support for the respective contact members on a common horizontal axis for freedom of movement of the contact members relative to each other.

3. A circuit closer according to claim 1, including means for damping the motion of the tubular contact member.

4. A circuit closer according to claim 1, including a damping fluid housed in the casing, with the lower end portion of the tubular contact member extending into the fluid.

5. A circuit closer according to claim 1, including a contact ring secured to the inner face of the tubular contact member around the lower end portion of the second contact member and has an irregular contact face.

6. A circuit closer according to claim 5, wherein the inner face of the contact ring is elliptical about the second contact member.

7. A self-aligning motion detector comprising an outer tubular pendulum contact member, a pendulum contact member extending lengthwise in said tubular member, horizontal axial support connected to said tubular member, means supporting the respective pendulum contact members at one end thereof about a said horizontal axial support for universal movement relative to each other, said pendulum members having different dynamics of motion about the centers of suspension thereof for relative motion upon the application of force thereto, and means forming contact portions between the members upon relative motion therebetween.

8. A motion detector according to claim 7, including means for damping the motion of the outer pendulum member.

9. A circuit closer comprising an upright casing, an upright tubular contact member in the casing, means connected with the upper end of the tubular contact member mounting said member in the casing for universal movement relative thereto, a pendulum contact member extending downwardly in the tubular contact member and having a contact portion on the lower end thereof, a contact ring mounted on the inner wall of the tubular contact member surrounding the contact portion for contact engagement therebetween, and a wire member extending in bridging relation across the tubular contact member and having the upper end portion of the pendulum contact member mounted thereon for universal movement relative to the tubular contact member.

10. A circuit closer according to claim 9, wherein the contact ring has the inner face thereof extending elliptically about the contact portion of the pendulum contact member.

11. A circuit closer comprising an upright tubular contact member, means connected with the upper end portion of the tubular contact member mounting said member for universal movement, means forming a spherical surface in the lower portion of said tubular contact member, a ball seated on the spherical surface in position for freedom of rolling contact with an inner contact surface in the tubular contact member, and means for electrical connection with the ball and with the inner contact surface and for closing a circuit therebetween upon rolling motion of the ball into contact with the inner contact surface.

12. A circuit closer according to claim 11, wherein the tubular contact member has a conductor rod secured in the lower end portion thereof and electrically insulated from the tubular contact member, said conductor rod having the spherical surface on the upper end thereof.

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