

SENSOR FOR EARLY WARNING OF SEISMIC ACTIVITIES

Field of the Invention

[0001] The present invention relates to a detector. In particular, the invention relates to a method and system, detecting and early warning of seismic activities.

Background

[0002] Earthquakes can cause large-scale destruction over a wide area. Without any early warning and sufficient time for evacuation, valuable lives can be lost. For those who survive in a destructive earthquake, the physical trauma and mental agony of the loss may be tremendous.

[0003] The occurrence of an earthquake in a specific magnitude range will occur in a specific region and time window. Seismologists are unable to predict earthquakes accurately. The unpredictability of earthquake surprises those affected and present victims with little or no time to respond especially at peak traffic hours or when victims are asleep.

[0004] Common seismic alarm system involves complicated setup and is generally costly. Parts of South-East Asia were recently crippled by jolts of earthquakes and tsunamis and most of the brunt was borne by the poor and the needy. More are predicted. There was definitely a need to develop a simple engineering solution to save them.

[0005] Most earthquake detectors use a heavy weight attached to a coil moving inside a magnetic field. Seismic activity causes the ground and attached magnet to move. Elaborate electronic filters and damping needs to be employed before a meaningful signal is obtained. Such a system is not suitable for home use.

[0006] Home quake detectors employ a small pendulum suspended within a metallic electrically connected cone. As the tremors are felt, the pendulum hits against the cone wall and a signal is generated. However, these detectors are prone to a large number of false alarms due to nature of motion detection. These detectors also employ signal detection using a combination mechanical means and digital signal processing techniques which add to the cost of the manufacturing of the device and are hence expensive to own and use in rural areas.

[0007] US5,001,466 issued on 19 March 1991 to David E. Orlinsky et. al. discloses an earthquake detector. The detector requires two mercury-type switches as tilt sensor for the detector. The detector can be adjusted to tune its sensitivity to a particular application. It is however understood that when the sensitivity is too high, the sensors pick up all extraneous events, such as door slamming, and trigger false alarm. On the other hand, when the sensitivity is too low, it may not sense pre-earthquake vibrations to trigger early warning to the user. Furthermore, mercury is toxic and has relatively high viscosity to react instantaneously.

Summary

[0008] In accordance with one aspect, the present invention provides a sensor for sensing vibration comprises a container for containing conductive fluid; a ground electrode provided within the container, wherein the ground electrode is in contact with the conductive fluid when the sensor is operational; and a sensing electrode adjacent to the ground electrode in space, the sensing electrode is configured to be in a close proximity to the conductive fluid; wherein, in operation, the conductive fluid causes electrical conduction between the ground electrode and the sensing electrode when fluid ripples occur and the sensing electrode touches the conductive fluid.

[0009] In accordance with one embodiment, the sensing electrode may define a capillary groove. In accordance with another embodiment, the sensing electrode may be positioned closing to the ground electrode to provide capillary effect.

[0010] In accordance with another embodiment, the sensor further comprises a fluid level sensor for detecting the fluid level.

[0011] In the above aspect, it is possible that the conductive fluid has a low viscosity. Further, the conductive fluid may be water.

[0012] In accordance with yet another embodiment, the sensor may further comprise a plurality of sensing electrodes adjacent to the ground electrode. The plurality of sensing electrodes may have a same proximity from the fluid surface. It is also possible that the plurality of sensing electrodes has a different proximity from the fluid surface from each other.

[0013] In accordance with yet another embodiment, the fluid level sensor comprises a sharp tip electrode.

[0014] In yet another embodiment, the sensor further comprises an automatic fluid re-filler triggered by the fluid level sensor. It is possible that the automatic fluid re-filler is a mini syringe or a diffuser pump.

Brief Description of the Drawings

[0015] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0016] FIG. 1A illustrates a schematic diagram of a seismic sensing system in accordance with one embodiment of the present invention;

[0017] FIG. 1B illustrates a schematic diagram of the sensing system of FIG. 1A when the sensing system is triggered on;

[0018] FIG. 2 illustrates electrodes layout of a sensor in accordance with one embodiment of the present invention;

[0019] FIG. 3 illustrates a configuration of electrodes of the sensor in accordance with another embodiment of the present invention;

[0020] FIG. 4 illustrates a sensor in accordance with yet another embodiment of the present invention;

[0021] FIG. 5A illustrates an exploded view of a sensor in accordance with yet another embodiment of the present invention; and

[0022] FIG. 5B shows a perspective view of a bottom surface of a sensing plate of the sensor of FIG. 5A in accordance with one embodiment of the present invention;

[0023] FIG. 6 illustrates a circuit of a seismic sensing system in accordance with one embodiment of the present invention; and

[0024] FIG. 7 illustrates a circuit of a seismic sensing system in accordance with an alternative embodiment of the present invention.

Detailed Description

[0025] In line with the above summary, the following description of a number of specific and alternative embodiments are provided to understand the inventive features of the present invention. It shall be apparent to one skilled in the art, however that this invention may be practised without such specific details. Some of the details may not be described at length so as not to obscure the invention. For ease of reference, common reference numerals will be used throughout the figures when referring to the same or similar features common to the figures.

[0026] **FIG. 1A** illustrates a schematic diagram of a seismic sensing system **100** in accordance with one embodiment of the present invention. The sensing system comprises an alarm **102**, a power source **104**, a main switch **106**, and a sensor **110** connecting to each other in serial connection. Briefly, the alarm **120** provides audio and visual warning when the sensing system **100** is triggered. Audio warning can be generated by any loudspeaker or siren or the like depending on the level and the type of audio that is to be sounded. Visual warning can be generated by any warning light, such as beacons, strobe lights. The power source **104** provides power to energize the sensing system **100**. The main switch **106** is a main power on and off switch. The sensor **110** serves as a sensing switch that is configured to be normally opened. When the sensor **110** senses any vibration, it will be triggered close for activating the alarm **102** to provide warning signals.

[0027] Still referring to **FIG. 1A**, the sensor **110** comprises a fluid column **112**, fluid **114**, a ground electrode **116** and a sensing electrode **118**. The fluid column **112** is

a sealed container having two terminals (not shown) expose on the top exterior surface of the fluid column **112** for electrical connection. The fluid column **112** has a hollow space for containing the fluid **114**. The fluid **114** only fills up the hollow space partially. The ground electrode **116** and the sensing electrode **118** are two elongated conducting metals that extended into the hollow space of the fluid column **112**. Each of the electrodes **116**, **118** is connected to one of the two terminals. The two electrodes **116**, **118** are located adjacent to each other in space to avoid direct electrical contact with each other. The ground electrode **116** has a longer length than the sensing electrode **118** whereby when the sensor **110** is oriented upright and still, the ground electrode **116** has one end dips into or touches the fluid **114** where the sensing electrode **118** is just slightly short of it, i.e. having a close proximity to the surface of the fluid **114**. That makes the sensor **110** a normally opened switch when it is in an operating orientation. The sensing electrode **118** has a capillary groove **119** defined at the end of the sensing electrode **118**.

[0028] **FIG. 1B** illustrates a schematic diagram of the sensing system **100** of **FIG. 1A** when the sensor **110** is triggered on, i.e. the sensor **110** is closed. The sensor **110** is triggered on when it senses vibrations. When the sensor **110** senses vibrations, the fluid **114** there within produces ripples, i.e. waves interference between longitudinal and transverse waves upon physical vibration. The surface of fluid **114** in the fluid column **112** produces up-down (Z-Axis) movements when the container shakes in a lateral or sideways (X-Y Axis) mode. Due to the ripples, the fluid **114** touches the sensing electrode **118** and causes electrical conduction between the ground electrode **116** and the sensing electrode **118** thereby triggering the sensor **110**.

[0029] In the above embodiment, the sensitivity of the sensor **100** depends on the distance between the sensing electrode **116** and the fluid level. This can be customized according to the geographical area in which this sensing system **100** would be used. It is possible that the sensor **110** may provide more than one sensing electrode **116** in accordance with an alternative embodiment of the present invention. Each of the sensing electrodes is provided in a different length for sensing different level of vibrations.

[0030] The capillary groove **119** provides capillary effect to hold fluid onto the sensing electrode even after the fore-shocks/vibrations have subsided to allow the alarm to sound continuously thereby enhancing effectiveness and detect short impulsive fore-shocks of an impending strong earthquake.

[0031] In the above embodiment, it is provided that the ground electrode **116** has a length that providing contact with the fluid when the sensor **110** is oriented upright and still, i.e. in the operating orientation. In accordance with an alternative embodiment, the internal surface of the fluid column **112** can be made as the ground electrode to the sensor **110**.

[0032] FIG. 2 illustrates electrodes layout of a sensor **200** in accordance with another embodiment of the present invention. The sensor **200** has a ground electrode **202** and a plurality of sensing electrode **204**. The ground electrode **202** is located substantially at the center of the sensor **200**. Surrounding which, the plurality of sensing electrodes **204** are spaced apart in a plurality of locations. The ground electrode **202** is connected to a terminal (not shown) for the sensor **200**. The plurality

of sensing electrodes **204** are connected to a common terminal (not shown) for the sensor **200**. All the sensing electrodes **204** have a same length within the sensor **200**. The ground electrode **202** is longer than the sensing electrode **204** and aligned with the sensing electrode **204** within the sensor **200** in a manner similar to the sensor **110** of FIG. 1A.

[0033] Referring back to FIG. 1A, the sensing electrode **118** provides the capillary groove for trapping fluid therein when fluid ripples occurred. FIG. 3 illustrates a configuration of electrodes of the sensor **300** in accordance with yet another embodiment of the present invention. The sensor **300** has similar feature as the sensor **110** of FIG. 1A. The sensor **300** has two electrodes **302**, **304** placing side by side closely but not in electrical contact with each other. The distance between the electrodes is configured to be closed enough for providing capillary effect to trap fluid between the gap of the two electrodes. Specifically, when the fluid ripples occurs causing the sensing electrode **304** touches the fluid, some fluid **310** traps between the two electrodes **302**, **304**.

[0034] FIG. 4 illustrates a sensor **400** in accordance with yet another embodiment of the present invention. The sensor **400** has similar features and configuration of the sensor **110** of FIG. 1A. The sensor **400** further comprises a fluid level sensor **410**. The fluid level sensor **410** is provided for sensing if the fluid inside the fluid column is in a desired level **420**. When the fluid level sensor **410** detects that the fluid level is below a desired level, the fluid level sensor **410** sends out a signal to the circuit connected there to. The signal can be used in various ways, for example, the signal can be used to trigger a warning sign or the like to indicate that the fluid level is

below the desired level and require refilling. The signal can also be used to trigger an automatic refiller to refill the fluid when the fluid is low.

[0035] Still referring to **FIG. 4**, the fluid level sensor **410** has a sharp tip for sensing the fluid level to avoid fluid adhesion. If a broad surface detector tip is use, as the fluid level is dropping gradually below a desired level, to a certain extend, the fluid may still cling onto the broad surface detector tip. Under the circumstance, the fluid level sensor **410** will not trigger any warning signal or the automatic refiller to top up fluid when the fluid drop below the desired level. The sharp tip, on the other hand, provides a clean break with the fluid surface as soon as the fluid level falls below the desired level and triggers the warning signal or automatic refiller to top up fluid.

[0036] **FIG. 5A** illustrates an exploded perspective view of a sensor **500** in accordance with one embodiment of the present invention. The sensor **500** comprises an automatic refiller **510**, a sensing plate **520**, a container **530** and an electronic sub-system plate **540**. The automatic refiller **510** is a fluid refiller for supplying fluid when required. The automatic refiller **510** is mounted on a top surface of the sensing plate **520**. The automatic refiller **510** can be a mini syringe or a diffuser pump or the like trigger by a fluid sensor for refilling fluid when necessary. The sensing plate **520** is adapted to cover the container **530**. The electronic sub-system plate **540** is adapted for housing printed circuit board therein for the necessary operation of the sensor **500**. **FIG. 5B** shows a perspective view of a bottom surface **522** of the sensing plate **520** in accordance with one embodiment of the present invention. Various components can be shown on the bottom surface **522**. The components include a shock sensing electrode **525**, a fluid level sensor **527** and a ground electrode **529**. The shock sensing electrode

525 is in a form of three quarter round plate having a plurality of capillary grooves 526 defined thereon. The ground electrode 529 is in a form of a substantially quarter round plate locating beside the shock sensing electrode 525 in space. The fluid level sensor 527 is a L-shaped bar attached on the sensing plate 520 between the shock sensing electrode 525 and the ground electrode 529. The ground electrode 529 has a greater thickness than the shock sensing electrode 525. Similarly, when the sensor 500 is assembled, the ground electrode 529 will dip into the fluid while the sensing electrode is slight short of it. The fluid level sensor 527 senses the fluid level within the container 530. When there is not enough fluid within the container 530, the fluid level sensor 527 triggers the automatic refiller 510 to refill fluid to a desired level.

[0037] FIG. 6 illustrates a circuit 600 of a seismic sensing system in accordance with one embodiment of the present invention. The circuit 600 comprising a battery 610, a main switch 620, an alarm 640, a sensor 630 and a battery indicator 615. The battery 610 is the power source for the circuit 600. Beyond which, a main switch 620 is connected in series for controlling the circuit 600 on and off. The alarm 640 that includes a loud speaker 642 and a beacons 644, connecting in parallel, for providing audio and visual alarm indication in the case of emergency. The alarm 640 is connected in series with the battery 610. A switching transistor 645 is connected between the alarm 640 and the negative terminal of the battery 610 as an electronic switch. Suitably, a bipolar junction NPN transistor can be used for the circuit 600. The sensor 630 is connected between the switch 620 and the alarm 640 to trigger the alarm 640. The sensor 630 has a ground electrode 632 and a sensing electrode 634 with a similar configuration as the sensor 110 of FIG. 1A. The sensing electrode 634 is connected to a base of the switching transistor 645. When fluid ripples occurs due to

physical vibrations, the two electrodes 632 and 634 are shorted and a small current is sent to trigger the switching transistor 645 to activate the alarm 640. The circuit 600 also includes a power status indicator 615 for indicating the battery 610 status.

[0038] FIG. 7 illustrates a circuit 700 of a seismic sensing system in accordance with an alternative embodiment of the present invention. The circuit 700 is substantially the same as the circuit 600 of FIG. 6 except that the circuit 700 provides a fluid level sensing circuit. The circuit 700 comprising a battery 710, a main switch 720, an alarm 740, a sensor 730 and a battery indicator 715. The battery 710 is the power source for the circuit 700. Beyond which, a main switch 720 is connected in series for controlling the circuit 700 on and off. The alarm 740 that includes a loud speaker 742 and a beacons 744, connecting in parallel, for providing audio and visual alarm indication in the case of emergency. The alarm 740 is connected in series with the battery 710. A switching transistor 745 is connected between the alarm 740 and the negative terminal of the battery 710 as an electronic switch. Suitably, a bipolar junction NPN transistor can be used for the circuit 700. The sensor 730 is connected between the switch 720 and the alarm 740 to trigger the alarm 740. The sensor 730 has a ground electrode 732 and a sensing electrode 734 with a similar configuration as the sensor 110 of FIG. 1A. The sensing electrode 734 is connected to a base of the switching transistor 745. When fluid ripples occurs due physical vibrations, the two electrodes 732 and 734 are shorted and a small current is sent to trigger the switching transistor 745 to activate the alarm 740. The circuit 700 also includes a power status indicator 715 for indicating the battery 710 status.

[0039] Still referring to **FIG. 7**, the sensor **730** further comprises a fluid level detector **736** for detecting the fluid level within the sensor **730**. The fluid level detector **736** is connected to a fluid level indicator **750** that is connected parallelly to the alarm **740**. The fluid level indicator **750** comprises speaker **754** and a LED light **752** to alert user to top-up fluid when the fluid in the sensor **730** falls below a desired level. The fluid level detector **736** triggers the fluid level indicator **750** via two switching transistors **755**.

[0040] In the above embodiments, fluid is used as a detection medium for detecting vibration. One of most common fluid found in house hold is water. The water can be purified water added with electrolyte, or the like as long as it conducts electricity. Further, it is understood that other fluid may also be desired for the present invention. Generally, fluid with low viscosity may provide higher sensitivity to the vibrations.

[0041] The sensitivity of the sensors in accordance with the above embodiments can be varied by the water level, the length of the sensing electrode, the number of sensing electrodes and the distances between the sensing electrodes and the ground electrode. It provides a relatively low cost, simple and robust early warning apparatus for earthquake sensing which is affordable by the public. It can be used to sense the initial pre-quake tremors and gives out an audio-visual alarm for people to take evasive action. It is designed to cater to the rural population staying in earthquake-prone areas and is equally applicable to the urban areas.

[0042] In accordance with yet another embodiment, the apparatus can be rigidly mounted at the intersection of two walls of a house at a high position, as such, minor vibrations caused by the earthquake in its initial stage will cause the fluid inside the container to ripple.

[0043] The sensor in the above embodiment is suitable for detecting low frequency earthquake-like physical vibrations caused to the sensor. Hence, high frequency sound, vibrations caused by the vehicles and machinery will not trigger the sensor to cause "false-alarm".

[0044] While specific embodiments have been described and illustrated, it is understood that many changes, modifications, variations and combinations thereof could be made to the present invention without departing from the scope of the invention.

Claims

1. A sensor for sensing vibration comprising:
 - a container for containing conductive fluid;
 - a ground electrode provided within the container, wherein the ground electrode is in contact with the conductive fluid when the sensor is operational; and
 - a sensing electrode adjacent to the ground electrode in space, the sensing electrode is configured to be in a close proximity to the conductive fluid;wherein, in operation, the conductive fluid causes electrical conduction between the ground electrode and the sensing electrode when fluid ripples occur and the sensing electrode touches the conductive fluid.
2. The sensor according to claim 1, wherein the sensing electrode defines a capillary groove that provides capillary effect.
3. The sensor according to claim 1 or 2, wherein the sensing electrode is positioned closing to the ground electrode to provide capillary effect.
4. The sensor according to any one of the preceding claims, further comprising a fluid level sensor for detecting the fluid level.
5. The sensor according to any one of the preceding claims, wherein the conductive fluid has a low viscosity.

6. The sensor according to any one of the preceding claims, wherein the conductive fluid is water.
7. The sensor according to any one of the preceding claims, further comprising a plurality of sensing electrodes adjacent to the ground electrode.
8. The sensor according to claim 7, wherein the plurality of sensing electrodes has a same proximity from the fluid surface.
9. The sensor according to claim 7, wherein each of the plurality of sensing electrodes has a different proximity from the fluid surface from each other.
10. The sensor according to claim 4, wherein the fluid level sensor comprises a sharp tip electrode.
11. The sensor according to claim 4, wherein the sensor further comprises an automatic fluid re-filler triggered by the fluid level sensor.
12. The sensor according to claim 11, wherein the automatic fluid re-filler is a mini syringe.
13. The sensor according to claim 11, wherein the automatic fluid re-filler is a diffuser pump.