

EARTHQUAKE DETECTION AND EARLY WARNING SYSTEM

Field of the Invention

5 This invention relates to a device for detecting vibration. More particularly, this invention relates a device for detecting seismic waves and providing early warning. Still more particularly, this invention relates to a system comprising a plurality of devices located at different locations for detecting seismic waves and providing early warning.

Background of the Invention

Earthquakes frequently happen in the world and bring a great deal of destructive disasters. Since earthquakes cannot be avoided, people are trying to find ways to detect and predict earthquakes in order to reduce losses. When an earthquake occurs, energy
15 travels through the earth as three types of waves, namely primary waves, secondary waves and surface waves. Primary waves are the fastest seismic waves (at relatively low frequencies of approximately 5-20 Hz) and always arrive first at our houses. These waves generally move twice as fast as the secondary waves and can travel through any type of materials. Hence, various instruments have been invented to detects primary waves and
20 provide early warning to the public before arrival of the stronger and destructive secondary waves.

Damages and injuries caused by earthquakes may be reduced if early warning of an earthquake is available. Although the warning time between signal arrival and that of
25 ground motion may be relatively short (typically less than 1 minute), it does provide useful warning to certain important public establishments, such as train stations or airports, so that some operations can be shut down immediately. An earthquake warning instrument is typically comprised of arrays of seismic motion sensors installed at different locations for detecting seismic waves. Computers and communication systems
30 are employed to collect and analyse the sensors' readings so that emergency procedures can be initiated and early warning signals can be transmitted to the areas likely to be

affected. These early warning instruments and systems usually tend to be bulky, costly, complicated and not user-friendly.

Further, most of the earthquake detectors in the market use electronic means of detecting seismic waves. They use accelerometers to detect seismic waves and use digital signal processing to filter and identify the seismic waves. This method is less reliable as it is prone to failure and false detection due to its electronic means.

In another approach, a sensor having multiple electrodes is used to detect seismic waves. This approach is described in PCT Patent Application No. PCT/SG2007/000144 entitled "Sensor for Early Warning of Seismic Activities". However, this approach is less efficient, less reliable and less user-friendly, and the fluid adjustment of the sensor is performed manually.

Therefore, those skilled in art are constantly striving to provide a sensing device that is reliable, accurate, less expensive, portable, easy to implement and use.

Summary of the Invention

The above and other problems are solved and an advancement in the art is made by an earthquake detection device in accordance with this invention.

In accordance with a first aspect of this invention, there is provided a device for detecting vibration due to seismic waves. The device comprises a container for holding a conductive fluid; a fluid adjuster for supplying and discharging of the conductive fluid through an opening in the container; a ground conductor in contact with the conductive fluid in the container; and a plurality of electrodes within the container. The plurality of electrodes comprise a sensing electrode having a first end in close proximity to the conductive fluid in the container to cause contact with the conductive fluid by ripples in the conductive fluid caused by a vibration that establishes an electrical connection with the ground conductor to detect the vibration; and a level electrode having a first end

proximate the conductive fluid in the container such that contact between the conductive fluid and the first end of the level electrode establishes an electrical connection with the ground conductor wherein the level electrode is in electrical communication with the fluid adjuster to indicate to the fluid adjuster to supply the conductive fluid to the container when no electrical signal is received in order to maintain the conductive fluid at a desired level to control sensitivity of the sensing electrode and wherein the position of the first end of the level electrode with respect to fluid level is adjustable relative to the sensing electrode to define a minimum amplitude level of ripples in the conductive fluid that is detectable by the sensing electrode. The device provides an efficient, controlled and reliable manner to detect seismic waves. Unwanted fluctuations of the fluid level in the container will automatically be rectified by the fluid adjuster and thus the conductive fluid is always maintained at the desired level. Therefore, false alarm due to fluctuations of the fluid level is minimised and sensitivity of the sensing electrode is consistent at all times. The position of the level electrode is adjustable to control the sensitivity of the sensing electrode. The device is portable and easy to implement and use.

In accordance with embodiments of this invention, the fluid adjuster is configured to supply the conductive fluid to the container in response to the conductive fluid dropping below the desired level. The fluid adjuster is configured to stop supplying the conductive fluid to the container in response to the conductive fluid being in contact with the first end of the level electrode establishing an electrical connection with the ground conductor. The device provides an efficient way to maintain the fluid level in the container as the fluid adjustment is performed automatically.

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In accordance with embodiments of this invention, the fluid adjuster is operable in a reset operation to discharge the conductive fluid from the container and then to supply the conductive fluid to the container until the conductive fluid is in contact with the first end of the level electrode establishing an electrical connection with the ground conductor. In accordance with embodiments of this invention, the reset operation is triggered by a change in ambient conditions or triggered manually. The device provides

an efficient way to reset the conductive fluid to the desired level when there is a significant change in ambient conditions.

5 In accordance with embodiments of this invention, the fluid adjuster comprises a pump for self-driving the conductive fluid into and out of the container.

10 In accordance with embodiments of this invention, the plurality of electrodes further comprises a control electrode in contact with the conductive fluid in the container to establish an electrical connection with the ground conductor that indicates the level of the conductive fluid in the container wherein the control electrode is in communication with the fluid adjuster to allow the fluid adjuster to control flow rate of the conductive fluid into the container such that the flow rate of conductive fluid into the container is reduced in response to the conductive fluid being in contact with the control electrode. This feature prevents the conductive fluid from exceeding the desired level.

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In accordance with embodiments of this invention, the device further comprises a warning system in connection to the sensing electrode wherein the warning system is triggered in response to an electrical connection between the sensing electrode and the ground conductor being established.

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In accordance with embodiments of this invention, the sensing electrode is coated with a primer with a hydrophobic compound to prevent the conductive fluid from clinging onto the sensing electrode. Similarly, the level electrode is coated with a primer with a hydrophobic compound to prevent the conductive fluid from clinging onto the level electrode.

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In accordance with embodiments of this invention, the first end of the sensing electrode is tapered. Similarly, the first end of the level electrode is tapered. The tapered end provides a clean break between the conductive fluid and the electrode when a separation is expected.

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In accordance with embodiments of this invention, the minimum amplitude level of ripples in the conductive fluid that is detectable by the sensing electrode is 0.1 mm. This allows the device to detect primary seismic waves at relatively low amplitudes.

5 In accordance with embodiments of this invention, there is provided a method for detecting vibration due to seismic waves using a sensing device as described above. The method comprises maintaining the conductive fluid at the desired level by detecting a lack of electrical signal from the level electrode in the fluid adjuster indicating that conductive fluid is to be added to the container by the fluid adjuster; and establishing an
10 electrical connection between the sensing electrode and the ground conductor in response to ripples in the conductive fluid causing the conductive fluid to contact the first end of the sensing electrode.

In accordance with embodiments of this invention, the step of maintaining of the
15 conductive fluid at the desired level comprises stop supplying the conductive fluid to the container by the fluid adjuster in response to the conductive fluid being in contact with the first end of the level electrode.

In accordance with embodiments of this invention, the step of maintaining of the
20 conductive fluid at the desired level comprises discharging the conductive fluid from the container by the fluid adjuster followed by supplying the conductive fluid to the container by the fluid adjuster until the conductive fluid is in contact with the first end of the level electrode.

25 In accordance with embodiments of this invention, the method further comprises triggering a warning system in response to an electrical connection between the sensing electrode and the ground conductor being established.

In accordance to a second aspect of this invention, there is provided a system for
30 detecting vibration due to seismic waves. The system comprises a central processing unit; a memory readable by the central processing unit; and a plurality of sensing devices

located at different locations and in communication with the central processing unit. Each sensing device comprises a container for holding conductive fluid; a fluid adjuster for supplying and discharging of the conductive fluid through an opening in the container; a ground conductor in contact with the conductive fluid in the container; and a plurality
5 of electrodes within the container. The plurality of electrodes comprises a sensing electrode having a first end in close proximity to the conductive fluid in the container to cause contact with the conductive fluid by ripples in the conductive fluid caused by a vibration that establishes an electrical connection with the ground conductor to detect the vibration wherein a vibration signal is generated and transmitted to the central
10 processing unit in response to an electrical connection between the sensing electrode and the ground conductor being established; and a level electrode having a first end proximate the conductive fluid in the container such that contact between the conductive fluid and the first end of the level electrode establishes an electrical connection with the ground conductor wherein the level electrode is in electrical
15 communication with the fluid adjuster to indicate to the fluid adjuster to supply the conductive fluid to the container when no electrical signal is received in order to maintain the conductive fluid at a desired level to control sensitivity of the sensing electrode and wherein the position of the first end of the level electrode with respect to fluid level is adjustable relative to the sensing electrode to define a minimum amplitude
20 level of ripples in the conductive fluid that is detectable by the sensing electrode. The central processing unit is configured by instructions in the memory to determine whether an earthquake will occur based on the received vibration signals from the plurality of sensing devices. The system provides an efficient, controlled and reliable manner to detect seismic waves in a large area, e.g. a city.

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In accordance with embodiments of this invention, the plurality of electrodes of each sensing device further comprises a control electrode in contact with the conductive fluid in the container to establish an electrical connection with the ground conductor that indicates the level of the conductive fluid in the container wherein the control electrode
30 is in communication with the fluid adjuster to allow the fluid adjuster to control flow rate of the conductive fluid into the container such that the flow rate of conductive fluid into

the container is reduced in response to the conductive fluid being in contact with the control electrode.

5 In accordance with embodiments of this invention, the system further comprises a warning system in connection to the central processing unit to trigger emergency procedures in response to an earthquake is confirmed by the central processing unit. This enables the system to provide early warning to the affected area or potentially affected area.

10 In accordance with embodiments of this invention, the central processing unit is configured by the instructions in the memory to determine whether an earthquake will occur based on number of the sensing devices affected by a vibration wherein an earthquake is confirmed if sum of the sensing devices affected by the vibration over a period is greater than a predetermined threshold value.

15 In accordance with embodiments of this invention, the central processing unit is configured by the instructions in the memory to determine whether an earthquake occurs based on locations of the sensing devices affected by a vibration wherein an earthquake is confirmed if the sensing devices affected by the vibration are located adjacent to each other.

20 In accordance with embodiments of this invention, the central processing unit is configured by the instructions in the memory to determine whether an earthquake will occur based on locations of the sensing devices affected by a vibration wherein an earthquake is confirmed if the sensing devices are triggered by the vibration propagating in a particular direction.

25 In accordance with embodiments of this invention, each vibration signal received by the central processing unit comprises the date and/or time of vibration, and the strength of vibration. This information is useful for identifying seismic waves.

Brief Description of the Drawings

The above and other aspects of this invention will now be described, by way of example only, with reference to the accompany drawings, in which:

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Fig. 1 illustrates a schematic diagram of a sensing device in accordance with an embodiment of this invention;

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Fig. 2 illustrates a block diagram of a system having a plurality of sensing devices in accordance with an embodiment of this invention; and

Fig. 3 illustrates a block diagram of a system of Fig. 2 with each sensing device is associated with a fixed area (cell) in accordance with an embodiment of this invention.

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Detailed Description of the Invention

This invention relates a sensing device for detecting seismic waves and providing early warning signals. More particularly, the sensing device is capable of detecting seismic waves in an efficient, controlled and reliable manner. Still more particularly, this invention relates to a system comprises a plurality of sensing devices for detecting seismic waves at different locations and identifying an earthquake based on several seismic detection algorithms.

Fig. 1 shows a schematic diagram of a seismic sensing device in accordance with an embodiment of the present invention. Sensing device 100 comprises container 101 for holding conductive fluid 103; fluid adjuster 105; ground conductor 107; a plurality of electrodes including sensing electrode 108, level electrode 109 and control electrode 110; alarm system 111; and power source 113. Alarm system 111 provides audio and/or visual warnings to alert people when sensing device 100 is triggered by a vibration. Examples of alarm system 111 include loudspeakers and LED displays. Power source 113 provides operating power for the entire sensing device 100. Power source 113 can be

standard batteries, AC power supply, or solar energy (if sensing device 100 is installed at outdoor).

Container 101 is a sealed hollow structure that is capable of holding fluid and is used to house components of sensing device 100. Container 101 is portable and can be in any shapes, such as rectangular or cylindrical. The portability of container 101 allows it to be carried by a person to different places easily. Container 101 can be mounted on a floor or a surface of a structure by a locking mechanism so that conductive fluid 103 in container 101 is kept stable during operation. An opening can be formed in container 101 and is sealable by a removable cover. The opening should be large enough to allow access to the interior of container 101. At standby mode, part of container 101 is filled with conductive fluid 103. Conductive fluid 103 can be any medium that is suitable for conducting electricity, for example water for normal environment and an anti-freeze solution for harsh temperature environment.

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Fluid adjuster 105 is mounted to container 101. Fluid adjuster 105 is capable of supplying and discharging conductive fluid 103 into and out of container 101 through an opening 115 in the container. Preferably, an elongated hollow tube 117 is provided with one end connected to opening 115 and the other end extending to bottom side of container 101. This configuration allows conductive fluid to be added into container 101 without disturbing the surface level of conductive fluid 103 in container 101. Fluid adjuster 105 is connected to reservoir 119 that provides storage for conductive fluid. The fluid communication between reservoir 119 and container 101 through fluid adjuster 105 is performed automatically without user's intervention. Preferably, fluid adjuster 105 is an electronic pump that is capable of self-driving conductive fluid into and out of container 101 when an electrical signal is received by fluid adjuster 105.

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Ground conductor 107 is an elongated conductor disposed within container 101 and at least a portion of the conductor is in contact with conductive fluid 103. Ground conductor 107 is served as a common return path for electric current. Ground conductor

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107 can be in any forms and sizes so long as it can act as grounding for electrical conduction.

A plurality of electrodes for facilitating vibration detection are disposed within container 101 and in connection to ground conductor 107. These electrodes include sensing electrode 108 for detecting vibration in conductive fluid 103, level electrode 109 for determining fluid level in container 101 to control sensitivity of sensing electrode 108, and control electrode 110 for controlling flow rate of conductive fluid 103 into container 101. Preferably, electrodes 108-110 are in elongated shape and vertically disposed within container 101 as shown in Fig. 1. Sensing electrode 108 has a first end in close proximity to conductive fluid 103 leaving a small gap 120 between the first end of sensing electrode 108 and the surface level of conductive fluid 103. The small gap 120 can be as low as 0.1 mm so that primary waves at relatively low frequencies of approximately 5-20 Hz can be detected by sensing electrode 108. At standby mode, sensing electrode 108 is separated from conductive fluid 103 (i.e. normally open) and a closed loop is formed with ground conductor 107 when conductive fluid 103 is in contact with sensing electrode 108. When a vibration occurs, ripples are formed in conductive fluid 103 and propagate across the fluid surface. If the amplitude of the fluid ripples is higher than the small gap 120, fluid ripples will be in contact with the first end of sensing electrode 108 to establish an electrical connection with ground conductor 107 and hence detects the vibration. When a vibration is detected, alarm system 111 that is connected in series with sensing electrode 108 and ground conductor 107 will be triggered to alert public. Preferably, sensing electrode 108 is disposed about center region of container 101 surrounded by other electrodes so that ground movements like vehicular movements or construction activities or other than the ones caused by seismic activities are not detected by sensing electrode 108 and hence false detections can be minimised.

The sensitivity of sensing electrode 108 is determined by the small gap 120. If gap 120 becomes larger, sensing electrode 108 becomes less sensitive to vibration, i.e. only strong fluid ripples are detectable. If gap 120 becomes smaller, sensing electrode 108 becomes more sensitive to vibration, i.e. small fluid ripples are detectable. Therefore, in

order to obtain accurate detection results and to minimise false alarms, fluid level in container 101 has to be maintained at the desired level at all time. Further, in order to increase the detection efficiency, the process of keeping conductive fluid 103 at the desired level is performed automatically. The above can be achieved through level electrode 109 and fluid adjuster 105. Level electrode 109 has a first end proximate conductive fluid 103 such that contact between conductive fluid 103 and the first end of level electrode 109 establishes an electrical connection with ground conductor 107 and thus indicates the desired level of conductive fluid 103 in container 101. At standby mode, level electrode 109 is in contact with conductive fluid 103 to define the minimum fluid level in container 101. Level electrode 109 is in electrical communication with fluid adjuster 105 to allow fluid adjuster 105 to supply conductive fluid to container 101 when no electrical signal is received from level electrode 109. This allows to keep conductive fluid 103 at the desired level and to control the sensitivity of sensing electrode 108. The position of the first end of level electrode 109 with respect to the fluid level is adjustable relative to sensing electrode 108 to define a minimum amplitude level of the fluid ripples that is detectable by sensing electrode 108.

In some embodiments, sensing electrode 108 and level electrode 109 are coated by a primer with a hydrophobic compound to prevent conductive fluid 103 from clinging onto the electrodes. The first ends of both electrodes 108 and 109 are tapered to reduce the contact area with conductive fluid 103. This prevents conductive fluid 103 from clinging onto the first ends of the electrodes when a clean separation is expected. These features improve the reliability of sensing device 100.

The auto top-up operation of conductive fluid to container 101 is performed in the following manner. When conductive fluid 103 in container 101 dropping below the desired level (i.e. conductive fluid 103 is not in contact with level electrode 109 and hence no electrical signal in fluid adjuster 105 from level electrode 109), fluid adjuster 105 will be triggered to supply conductive fluid into container 101 automatically from reservoir 119. Conductive fluid is stopped from adding into container 101 once conductive fluid 103 touches the first end of level electrode 109. The auto reset

operation of conductive fluid in container 101 is performed in the following manner. Firstly, fluid adjuster 105 is triggered to discharge conductive fluid 103 from container 101 and hence the fluid level will be slowly dropping below the desired level. After a short interval, conductive fluid will be added into container 101 by fluid adjuster 105 until conductive fluid 103 is in contact with the first end of level electrode 109. The reset operation can be triggered automatically due to a change in ambient conditions which causes the fluid level in container 101 to be increased or decreased. The ambient conditions include, but not limited to, temperature, pressure, and humidity. For example, the ambient temperature is measured at every preset time interval and if the difference between the current temperature and the last recorded temperature is more than a predefined value, the reset operation will be triggered. A user, for example by pressing a reset button, may also trigger the reset operation manually.

Control electrode 110 is capable of controlling the flow rate of conductive fluid 103 into container 101. This feature is useful to prevent conductive fluid 103 from exceeding the desired level. Control electrode 110 is in electrical communication with fluid adjuster 105 to allow fluid adjuster 105 to change the flow rate of conductive fluid into container 101 such that the flow rate is reduced when conductive fluid 103 is in contact with control electrode 110, i.e. an electrical connection with ground conductor 107 is established. The contact of conductive fluid 103 with control electrode 110 indicates that the fluid is approaching the first end of level electrode 109.

Sensing device 100 has an event logging system that records all events executed by the device. A log file can be downloaded from the device for analysis.

Fig. 2 shows a block diagram of a system for detecting vibration due to seismic waves in accordance with an embodiment of this invention. System 200 comprises central processing unit 201, memory 203 readable by central processing unit 201, central warning system 205 and a plurality of sensing devices 206-210 in communication with central processing unit 201. Each sensing device 206-210 is same as sensing device 100 as described above and shown in Fig. 1. Sensing devices 206-210 are installed at

different locations in an area (e.g. within a city) so that vibration in a particular region due to seismic waves can be detected by sensing devices 206-210 installed at locations within that particular region. Upon detection of a vibration by a particular sensing device 206-210, a vibration signal will be generated and transmitted to central processing unit 201 by that particular sensing device 206-210. The information carried by the transmitted signal includes, but not limited to, the date and time of the vibration and the strength of the vibration.

Central processing unit 201 is configured to perform analysis on the received vibration signals and determine whether a real earthquake will occur based on the seismic detection algorithms installed in memory 203. If an earthquake is confirmed by central processing unit 201, central warning system 205 will be activated to trigger a series of emergency procedures, such as sending warning signals to the affected locations or locations likely to be affected. However, if a false detection is confirmed, the sensing devices 206-210 being triggered will be reset and resumed in standby mode.

In the present invention, several types of seismic detection algorithms are used. A first type of algorithm is called simple threshold value detection which is based on the number of sensing devices 206-210 being triggered over a time interval. An earthquake is confirmed if the total number of sensing devices 206-210 being triggered is greater than a predefined threshold value. For example, consider a system of fifty sensing devices 206-210 and an earthquake is confirmed if the total number of sensing devices 206-210 being triggered is more than twenty. The threshold value is a random number that may be refined based on the results of field trials and analysis data. A variant of the above described simple threshold value detection method is to assign a weight (between 0 and 1) to each sensing device 206-210.

A second type of algorithm is called linear motion detection algorithm which is based on velocity of seismic waves. This method is suitable for heavy moving objects such as trains and trucks. Consider two sensing devices D1 and D2 installed at locations S1 and S2 are triggered at times T1 and T2. The velocity of propagation of the trigger

event (v) is determined using the equation, $v = (S2 - S1)/(T2 - T1)$. The measured velocity (v) is compared with the primary wave velocity which is the speed of sound and the secondary wave velocity which is about 60% of the speed of sound. If $v > f_p$, an earthquake is confirmed wherein f_p is a function of primary wave velocity (e.g. $f_p = 0.9 \times c$ wherein c is the velocity of sound). If $v > f_s$, an earthquake is confirmed wherein f_s is a function of secondary wave velocity (e.g. $f_s = 0.55 \times c$ wherein c is the velocity of sound).

A third type of algorithm is called areal detection algorithm which is based on locations (i.e. topography) of sensing devices 206-210 being triggered over a time interval. In this method, each sensing device 206-210 is associated with a fixed area (cell) that is monitored for seismic activity. An unstructured grid of cells could be formed as shown in Fig. 3. An earthquake is confirmed if sensing devices 206-210 being triggered are located adjacent to each other, i.e. they are immediate neighbours with one or more borders being shared. For an example with reference to Fig. 3, any group of four neighbouring cells (e.g. cells 4, 5, 6 and 7) being triggered will constitute an earthquake confirmation. If a few random cells are being triggered and they do not form a group of neighbouring cells (e.g. cells 1, 5, 14 and 15) over a time interval, the alarm will be shut off and the system resets and resumes its operation in standby mode.

A variant of the third type of algorithm as described above is based on the direction of the cells being triggered. An earthquake is confirmed if the cells are being triggered in a particular direction. For an example with reference to Fig. 3, an earthquake is confirmed if any group of four cells being triggered are located in a relative linear direction (e.g. 11, 12, 13 and 14).

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While preferred embodiments of the present invention have been described and illustrated above, it is to be understood that they are exemplary of the invention and are not to be considered to be limiting. It is expected that those skilled in the art can and will design alternative embodiments that infringe this invention as set forth in the following claims.

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What is claimed is:

1. A device for detecting vibration due to seismic waves, the device comprising:

a container for holding conductive fluid;

5 a fluid adjuster for supplying and discharging of the conductive fluid through an opening in the container;

a ground conductor in contact with the conductive fluid in the container; and

a plurality of electrodes within the container comprising:

10 a sensing electrode having a first end in close proximity to the conductive fluid in the container to cause contact with the conductive fluid by ripples in the conductive fluid caused by a vibration that establishes an electrical connection with the ground conductor to detect the vibration;

15 a level electrode having a first end proximate the conductive fluid in the container such that contact between the conductive fluid and the first end of the level electrode establishes an electrical connection with the ground conductor wherein the level electrode is in electrical communication with the fluid adjuster to indicate to the fluid adjuster to supply the conductive fluid to the container when no electrical signal is received in order to maintain the conductive fluid at a desired level to control sensitivity of the sensing electrode and wherein the
20 position of the first end of the level electrode with respect to fluid level is adjustable relative to the sensing electrode to define a minimum amplitude level of ripples in the conductive fluid that is detectable by the sensing electrode.

25 2. The device of claim 1 wherein the fluid adjuster is configured to supply the conductive fluid to the container in response to the conductive fluid dropping below the desired level.

30 3. The device of claim 1 wherein the fluid adjuster is configured to stop supplying the conductive fluid to the container in response to the conductive fluid being in contact with the first end of the level electrode establishing an electrical connection with the ground conductor.

4. The device of claim 1 wherein the fluid adjuster is operable in a reset operation to discharge the conductive fluid from the container and then to supply the conductive fluid to the container until the conductive fluid is in contact with the first end of the level
5 electrode establishing an electrical connection with the ground conductor.

5. The device of claim 4 wherein the reset operation is triggered by a change in ambient conditions or triggered manually.

10 6. The device of claim 1 wherein the fluid adjuster comprises a pump for self-driving the conductive fluid into and out of the container.

7. The device of claim 1 wherein the plurality of electrodes further comprises:
a control electrode in contact with the conductive fluid in the container to
15 establish an electrical connection with the ground conductor that indicates the level of the conductive fluid in the container wherein the control electrode is in communication with the fluid adjuster to allow the fluid adjuster to control flow rate of the conductive fluid into the container such that the flow rate of conductive fluid into the container is reduced in response to the conductive fluid being in contact with the control electrode.

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8. The device of claim 1 further comprising:
a warning system in connection to the sensing electrode wherein the warning system is triggered in response to an electrical connection between the sensing electrode and the ground conductor being established.

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9. The device of claim 1 wherein the sensing electrode is coated with a primer with a hydrophobic compound to prevent the conductive fluid from clinging onto the sensing electrode.

10. The device of claim 1 wherein the level electrode is coated with a primer with a hydrophobic compound to prevent the conductive fluid from clinging onto the level electrode.

5 11. The device of claim 1 wherein the first end of the sensing electrode is tapered.

12. The device of claim 1 wherein the first end of the level electrode is tapered.

13. The device of claim 1 wherein the minimum amplitude level of ripples in the
10 conductive fluid that is detectable by the sensing electrode is 0.1 mm.

14 A method for detecting vibration due to seismic waves using a device comprising:
a container for holding conductive fluid;
a fluid adjuster for supplying and discharging of the conductive fluid through an
15 opening in the container;
a ground conductor in contact with the conductive fluid in the container; and
a plurality of electrodes within the container comprising:

a sensing electrode having a first end in close proximity to the conductive
fluid in the container to cause contact with the conductive fluid by ripples in the
20 conductive fluid caused by a vibration that establishes an electrical connection
with the ground conductor to detect the vibration;

a level electrode having a first end proximate the conductive fluid in the
container such that contact between the conductive fluid and the first end of the
level electrode establishes an electrical connection with the ground conductor
25 wherein the level electrode is in electrical communication with the fluid adjuster
to indicate to the fluid adjuster to supply the conductive fluid to the container
when no electrical signal is received in order to maintain the conductive fluid at a
desired level to control sensitivity of the sensing electrode and wherein the
position of the first end of the level electrode with respect to fluid level is
30 adjustable relative to the sensing electrode to define a minimum amplitude level

of ripples in the conductive fluid that is detectable by the sensing electrode, the method comprising:

maintaining the conductive fluid at the desired level by detecting a lack of electrical signal from the level electrode in the fluid adjuster indicating that conductive fluid is to be added to the container by the fluid adjuster; and

establishing an electrical connection between the sensing electrode and the ground conductor in response to ripples in the conductive fluid causing the conductive fluid to contact the first end of the sensing electrode.

15. The method of claim 14 wherein the maintaining of the conductive fluid at the desired level comprising:

stop supplying the conductive fluid to the container by the fluid adjuster in response to the conductive fluid being in contact with the first end of the level electrode.

16. The method of claim 14 wherein the maintaining of the conductive fluid at the desired level comprising:

discharging the conductive fluid from the container by the fluid adjuster followed by supplying the conductive fluid to the container by the fluid adjuster until the conductive fluid is in contact with the first end of the level electrode.

17. The method of claim 14 further comprising:

triggering a warning system in response to an electrical connection between the sensing electrode and the ground conductor being established.

18. A system for detecting vibration due to seismic waves comprising:

a central processing unit;

a memory readable by the central processing unit; and

a plurality of sensing devices located at different locations and in communication with the central processing unit wherein each sensing device comprising:

a container for holding conductive fluid;

a fluid adjuster for supplying and discharging of the conductive fluid through an opening in the container;

a ground conductor in contact with the conductive fluid in the container; and

5 a plurality of electrodes within the container comprising:

a sensing electrode having a first end in close proximity to the conductive fluid in the container to cause contact with the conductive fluid by ripples in the conductive fluid caused by a vibration that establishes an electrical connection with the ground conductor to detect the vibration wherein a vibration signal is generated and transmitted to the central processing unit in response to an electrical connection between the sensing electrode and the ground conductor being established;

15 a level electrode having a first end proximate the conductive fluid in the container such that contact between the conductive fluid and the first end of the level electrode establishes an electrical connection with the ground conductor wherein the level electrode is in electrical communication with the fluid adjuster to indicate to the fluid adjuster to supply the conductive fluid to the container when no electrical signal is received in order to maintain the conductive fluid at a desired level to control sensitivity of the sensing electrode and wherein the position of the first end of the level electrode with respect to fluid level is adjustable relative to the sensing electrode to define a minimum amplitude level of ripples in the conductive fluid that is detectable by the sensing electrode;

25 the central processing unit is configured by instructions in the memory to determine whether an earthquake occurs based on the received vibration signals from the plurality of sensing devices.

19. The system of claim 18 wherein the plurality of electrodes of each sensing device further comprises:

a control electrode in contact with the conductive fluid in the container to establish an electrical connection with the ground conductor that indicates the level of the conductive fluid in the container wherein the control electrode is in communication with the fluid adjuster to allow the fluid adjuster to control flow rate of the conductive fluid into the container such that the flow rate of conductive fluid into the container is reduced in response to the conductive fluid being in contact with the control electrode.

20. The system of claim 18 further comprising:
a warning system in connection to the central processing unit to trigger emergency procedures in response to an earthquake is confirmed by the central processing unit.

21. The system of claims 18 wherein the central processing unit is configured by the instructions in the memory to determine whether an earthquake occurs based on number of the sensing devices affected by a vibration wherein an earthquake is confirmed if sum of the sensing devices affected by the vibration over a period is greater than a predetermined threshold value.

22. The system of claim 18 wherein the central processing unit is configured by the instructions in the memory to determine whether an earthquake occurs based on locations of the sensing devices affected by a vibration wherein an earthquake is confirmed if the sensing devices affected by the vibration are located adjacent to each other.

23. The system of claim 18 wherein the central processing unit is configured by the instructions in the memory to determine whether an earthquake occurs based on locations of the sensing devices affected by a vibration wherein an earthquake is confirmed if the sensing devices are triggered by the vibration propagating in a particular direction.

24. The system of claim 18 wherein each vibration signal received by the central processing unit comprises the date and/or time of vibration.

25. The system of claim 18 wherein each vibration signal received by the central
5 processing unit comprises the strength of vibration.

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