

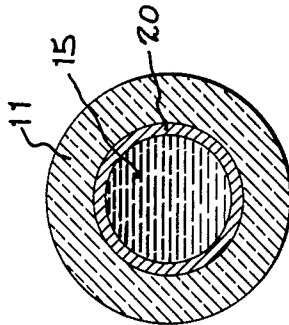
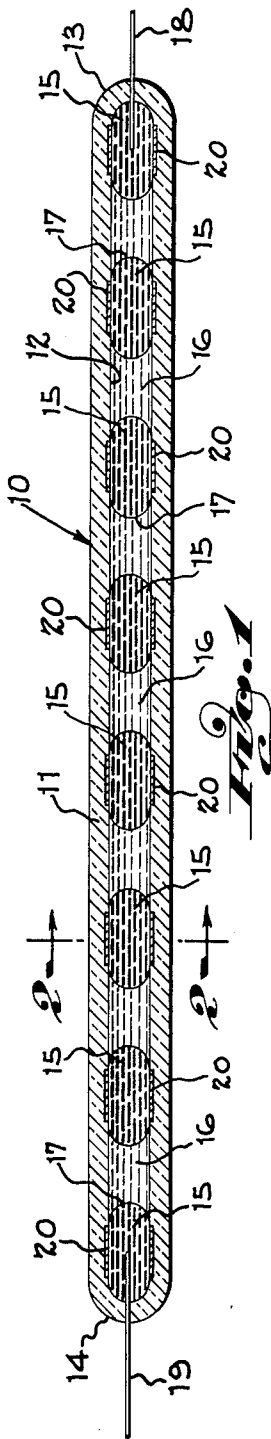
Feb. 21, 1956

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2,735,949

ELECTROLYTIC ACCELERATION SENSING DEVICE

Filed June 11, 1954



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2,735,949

ELECTROLYTIC ACCELERATION SENSING DEVICE

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Application June 11, 1954, Serial No. 435,977

11 Claims. (Cl. 310—2)

The present invention relates to accelerometers and is particularly directed to an electrolytic accelerometer embodying one or more liquid interfaces for producing an electric voltage, the magnitude of which is correlated with the acceleration of the device.

A conventional electrolytic accelerometer of this type comprises an elongated tube formed of an insulating material such as glass, plastic or the like and including a capillary bore or channel. A plurality of mercury globules are disposed within the bore, the globules being separated from one another by dilute sulphuric acid electrolyte. Such an accelerometer also includes two terminal, or lead-in wires, which are generally sealed at either end of the tube in contact with the mercury drops at the ends of the capillary channel.

While mercury and dilute sulphuric acid are the two most commonly employed liquids in electrolytic accelerometers, there are several other liquids which also may be employed. For example, gallium may be substituted for mercury in applications where the temperature remains above 30° C.; and any of a large number of organic or inorganic electrolytes such as an aqueous solution of an alkali halide can be used in place of sulphuric acid. As explained in greater detail below, the principles of the present invention can be utilized no matter what two liquids are employed in the accelerometer.

It has been experimentally determined that when a device of this type is accelerated in a direction parallel to the length of the capillary bore, a difference of potential is developed between the lead-in wires. Moreover, it has been observed that the magnitude of this potential varies directly with the rate of acceleration over a wide range of accelerations. While the exact nature of the phenomenon involved in the operation of such an accelerometer is still more or less obscure, it has been postulated that the interface between the two liquids behaves somewhat like a condenser. Since the shape of this interface is substantially changed when the device is accelerated, a charge unbalance is set up across the interface. It is believed that it is this charge unbalance which causes the externally observable potential.

Despite their simplicity and high sensitivity, electrolytic accelerometers have in the past been of little practical value and have been useful primarily as laboratory demonstration devices. The principal difficulty with previously proposed accelerometers is that they are not mechanically stable. That is, when the capillary bore is inclined the mercury globules gradually fall to the bottom of the bore where they ultimately coalesce, thereby rendering the device completely inoperative.

The principal object of the present invention is to provide an electrolytic accelerometer, embodying liquid interfaces, which is mechanically stable and may be used in any position for extended periods of time without any tendency of the mercury drops to become displaced and coalesce with one another.

The present invention is predicated upon the empirical discovery and determination that mechanical stability can

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be provided by mounting a plurality of retaining rings, or bands, formed of a material wettable by mercury or a corresponding heavy liquid, along the inner wall of the capillary bore. The bands are spaced from one another and the mercury is inserted in the tube so that each drop of mercury resides in contact with one band. The adhesion of the mercury to the surface of the band immobilizes the former but not to an extent that the mercury globules do not change shape appreciably upon acceleration of the device. Thus, although the mercury drops are restrained against translation, they are not prevented from changing shape so that the potential generative phenomenon upon which the device depends is not adversely affected.

I have determined that previously proposed electrolytic accelerometers are unstable because the mercury drops do not wet the glass or other material forming the capillary bore. Consequently, the electrolyte, which does wet the capillary tube, is free to pass between the tube and globules of mercury, allowing the mercury drops to displace the electrolyte and gradually fall to the bottom of the bore. By providing a plurality of retaining rings, wettable by mercury, and in engagement with the periphery of each drop any displacement of the electrolyte past the drops is prevented; and the mercury drops are immobilized in any position of the accelerometer.

More specifically, a preferred form of electrolytic accelerometer constructed in accordance with the present invention comprises an elongated tube formed of an insulating material and configured to form a capillary bore which is filled with alternate drops of suitable liquids such as mercury and dilute sulphuric acid. Each end of the tube is closed and a lead-in wire is sealed in place, the lead-in wires being in contact with the two endmost mercury drops. In addition, a plurality of spaced retaining bands are mounted in the wall of the capillary tube. In a preferred embodiment, these retaining bands are embedded in the wall of the tube flush with the bore and are formed of platinum which has been conditioned by the electro-deposition of mercury forming an amalgam with the platinum, so that the surface of the bands is wettable by the mercury drops. The mercury globules are placed within the bore so that the central portion of each drop engages a band while the ends of the drops forming interfaces with the electrolyte extend beyond the band. Each band is thus effective to hold a single drop of mercury in place, preventing seepage of the electrolyte between the tube wall and mercury drop; but does not affect the configuration of the mercury-electrolyte interface.

One of the principal advantages of the present accelerometer construction is that the accelerometer is completely stable from a mechanical point of view and can be stored or used in any position for indefinite periods. Furthermore, the retaining bands which immobilize the mercury drops do not impair the response of the device to varying accelerations.

A further advantage of the present accelerometer is that it is extremely simple and can readily be manufactured.

These and other advantages of the present invention will be more readily apparent from a further consideration of the following detailed description of the drawings illustrating a preferred embodiment of the invention.

In the drawings:

Figure 1 is a longitudinal cross sectional view of an electrolytic accelerometer constructed in accordance with the present invention.

Figure 2 is a transverse cross sectional view of the accelerometer taken along line 2—2 of Figure 1.

As shown in Figure 1, a preferred form of electrolytic accelerometer 10 embodying the principles of the present invention comprises an elongated tube 11 formed of electrically non-conductive material such as glass, Bakelite,

or a plastic. The tube is provided with a longitudinal capillary bore 12, the ends of which are sealed as at 13 and 14. While the exact size of the capillary bore is not critical, it has been determined that for optimum results the bore should be of the order of one-fourth to one-half of a millimeter in diameter. In general, if the capillary bore is made too small, undesirable secondary effects may be introduced, while if the bore is made too large the sensitivity of the accelerometer may be appreciably reduced.

Alternate drops of two immiscible liquids such as mercury and dilute sulphuric acid of a one to two normal concentration are disposed within the capillary channel. Each adjacent globule of mercury 15 and electrolyte 16 form an interface 17 across which the transducer phenomenon takes place. In addition to these specific materials there are many others which can be employed. For example, gallium can be used instead of mercury; and an aqueous solution of the hydroxides or sodium and potassium, or an aqueous solution of the alkali halides or some other inorganic or organic electrolytic material can be substituted for the sulphuric acid.

The mercury and electrolyte completely fill the capillary bore, a mercury globule preferably being formed at each end 13 and 14 of the bore. An electrical connection is made to each end globule of mercury as by means of wires 18 and 19. These wires are sealed in the ends of the tube 11 and are preferably formed from a conductive metal such as platinum which is inert to the mercury and sulphuric acid or other materials forming the transducer interface.

In addition to these elements, the electrolytic accelerometer is provided with a plurality of spaced stabilizing rings 20 which preferably are embedded in the walls of the tube flush with the surface of the capillary bore. Bands 20 are formed of a material which is wettable by the mercury or other heavy liquid employed. The stabilizing bands are preferably formed of a material which is relatively chemically inert and which has a minimum work function difference from the mercury, so that the conventional electrolytic cell formed by the band, mercury and sulphuric acid, develops no appreciable current and results in no appreciable evolution of hydrogen gas. In addition, the stabilizing bands are preferably formed of a material which does not dissolve appreciably in mercury.

I have found that a preferred form of acceleration sensing device is fabricated by embedding a plurality of platinum bands in tube 11 and then immersing the tube in a solution of mercurous nitrate floating above a quantity of liquid mercury. The negative terminal of a direct current source is connected to each of the platinum bands; and the positive terminal is connected to the mercury pool. The mercurous nitrate is electrolyzed and mercury is deposited on each of the platinum bands. Under these conditions the mercury so deposited forms a thin layer of amalgam with the platinum. This amalgam is wettable by the mercury and also is advantageous since it neither appreciably dissolves in the mercury nor results in the evolution of any appreciable quantity of hydrogen. It will, of course, be understood that other materials may be preferred for forming the stabilizing bands if a different heavy liquid, such as gallium, is used in place of mercury.

As shown in Figure 1, the relative size and position of the bands and mercury drops are such that the stabilizing bands contact the central portion of each drop of mercury, the ends of the drops extending beyond the bands so that the peripheries of the interfaces reside in engagement with the insulating tube 11 rather than the stabilizing bands. This construction minimizes the effect of the stabilizing bands upon the electrolytic transducer action at the interfaces. However, the contact of the stabilizing bands and mercury drops immobilizes the

latter by preventing any seepage of the electrolyte between the mercury drops and wall of the capillary tube.

In operation, tube 11 is disposed so that capillary channel 12 is aligned with the direction in which it is desired to measure acceleration. Since the mercury drops are effectively immobilized the accelerometer can be used indefinitely in any position. Terminal wires 18 and 19 are connected to a suitable high impedance potential measuring device such as a vacuum tube voltmeter. If desired, the dial of the voltmeter can be calibrated to read directly in units of acceleration such as feet per second rather than in volts.

When the tube is accelerated, the configuration of the interfaces 17 is substantially changed. That is, the leading interface of each drop tends to flatten out, while the trailing interface elongates. Each interface functions like a capacitor having an extremely high capacitance per unit area, so that the relative change in shape between the interface at opposite ends of each mercury drop results in a substantially different charge concentration at opposite ends of the drop. It is believed that this asymmetry causes a potential difference to appear across terminal leads 18 and 19. This potential, which is applied to the measuring device (not shown), indicates by its polarity the direction of acceleration or deceleration of the tube. Furthermore, the magnitude of the potential provides an accurate index of the rate of acceleration over wide ranges of acceleration values. It has been determined that this extremely close correlation of the magnitude of the potential developed and the magnitude of the tube's acceleration is not affected by the presence of the stabilizing bands.

From the foregoing discussion of the general principles of my invention and the disclosure of a preferred embodiment, those skilled in the art will readily comprehend the various modifications to which the invention is susceptible.

Having described my invention, I claim:

1. An acceleration sensing device comprising a housing formed of a non-conducting material and configured to form a capillary channel, a first and second immiscible liquid disposed within said channel said first liquid being one of the class comprising mercury and gallium, said second liquid constituting an electrolyte, said housing material not being wettable by the first liquid, said liquids forming at least one interface within said channel, and a stabilizing ring formed by a material wettable by the first liquid, said stabilizing ring being disposed in said capillary bore in contact with said first liquid and electrodes in contact with liquid on opposite sides of said interface.

2. An acceleration sensing device comprising a housing formed of a non-conducting material and configured to form a capillary channel, a first and second immiscible liquid disposed within said channel said first liquid being one of the class comprising mercury and gallium, said second liquid constituting an electrolyte, said housing material not being wettable by the first liquid, said liquids forming at least one interface within said channel, and a stabilizing ring formed by a material wettable by the first liquid, said stabilizing ring being disposed in said capillary bore in contact with said first liquid, said stabilizing ring being spaced from said interface, whereby the periphery of said interface contacts said housing material means providing electrical contact with liquid on opposite sides of said interface.

3. An accelerating sensing device comprising a housing formed of a non-conducting material and configured to form a capillary channel, mercury and an electrolytic liquid disposed within said channel, said housing material not being wettable by said mercury, said mercury and electrolytic liquid forming at least one interface within said channel, and a stabilizing ring formed by a platinum band coated with a mercury amalgam wettable by said mercury, said stabilizing ring being disposed in said capillary bore in contact with said mercury and means

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providing electrical connections to the interior of said capillary channel on opposite sides of said interface.

4. An acceleration sensing device comprising a housing formed of a non-conducting material and configured to form a capillary channel, a first and second immiscible liquid disposed within said channel said first liquid being one of the class comprising mercury and gallium, said second liquid constituting an electrolyte, said housing material not being wettable by the first of said liquids, said liquids forming at least one interface within said channel, and a circular stabilizing band having a surface wettable by the first of said liquids, said stabilizing band being embedded in said capillary bore flush with the wall thereof, and in contact with said first liquid in spaced relationship with said interface and means providing an electrical connection to liquid on opposite sides of said interface.

5. In a transducer including a housing formed of a non-conducting material and configured to form a capillary bore, and a first and second immiscible liquid disposed within said bore, said housing material not being wettable by the first liquid, said liquids forming at least one interface within said bore, means for preventing displacement of said liquids, said means comprising a stabilizing ring formed of a material wettable by the first liquid, said stabilizing ring being mounted in said capillary bore in contact with said first liquid and means providing electrical connection to liquid on opposite sides of said interface.

6. An acceleration sensing device comprising a housing formed of a non-conducting material and configured to form a capillary channel, alternate globules of two immiscible liquids disposed within said channel the first of said liquids being one of the class comprising mercury and gallium, the second of said liquids constituting an electrolyte, said globules forming a plurality of interfaces within said channel, said housing material not being wettable by the first of said liquids, a plurality of stabilizing rings formed by a material wettable by said first liquid, each of said stabilizing rings being mounted within said capillary bore in contact with a globule of said first liquid and means providing electrical connection to two globules of said first liquid.

7. An acceleration sensing device comprising a housing formed of a non-conducting material and configured to form a capillary channel, alternate globules of two immiscible liquids disposed within said channel the first of said liquids being one of the class comprising mercury and gallium, the second of said liquids constituting an electrolyte, said globules forming a plurality of interfaces within said channel, said housing material not being wettable by the first of said liquids, a plurality of stabilizing rings formed by a material wettable by said first liquid, each of said stabilizing rings being mounted within said capillary bore in contact with a globule of said first liquid, the globules of liquid in contact with said stabilizing rings extending beyond the stabilizing rings, whereby the peripheries of said interfaces are in engagement with the wall of said capillary tube, and means forming an electrical connection to two spaced globules.

8. An acceleration sensing device comprising a housing formed of a non-conducting material and configured

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to form a capillary channel, alternate globules of two immiscible liquids disposed within said channel the first of said liquids being one of the class comprising gallium and mercury, the second constituting an electrolyte, said globules forming a plurality of interfaces within said channel, said housing material not being wettable by the first of said liquids, a plurality of circular stabilizing rings having a surface wettable by said first liquid, each of said stabilizing rings being embedded within the wall of said capillary bore in contact with a globule of said first liquid, the globules of said first liquid extending beyond opposite ends of said stabilizing bands, whereby the peripheries of said interfaces are in engagement with the wall of said capillary tube, and means forming an electrical connection to two spaced globules.

9. An acceleration sensing device comprising a housing formed of a non-conducting material and configured to form a capillary channel, alternate globules of mercury and an electrolytic liquid disposed within said channel, said globules forming a plurality of interfaces within said channel, said housing not being wettable by said mercury, a plurality of stabilizing rings having a surface formed by a mercury amalgam, each of said stabilizing rings being embedded within said capillary bore in contact with a globule of said mercury, said globules of mercury extending beyond opposite sides of said stabilizing rings, whereby the peripheries of said interfaces are in engagement with the wall of said capillary tube, and means forming an electrical connection to two spaced globules of mercury.

10. A transducer comprising a housing formed of a non-conducting material and configured to form a capillary channel, alternate globules of two immiscible liquids disposed within said channel the first of said liquids being one of the class comprising mercury and gallium, the second liquid constituting an electrolyte, said globules forming a plurality of interfaces within said channel, said housing material not being wettable by the first of said liquids, a plurality of stabilizing rings formed by a material wettable by said first liquid, each of said stabilizing rings being mounted within said capillary bore in contact with a globule of said first liquid and means forming electrical connections to the interior of said capillary channel on opposite sides of said interface.

11. An acceleration sensing device comprising a housing formed of a non-conducting material and configured to form a capillary channel, alternate globules of a first liquid being one of the class comprising mercury and gallium, and a liquid electrolyte disposed within said channel, said globules forming a plurality of interfaces within said channel, said housing material not being wettable by said first liquid, and a plurality of elements disposed within said channel in contact with the globules of said first liquid, said elements being formed of a material wettable by said first liquid, and being effective to immobilize said globules, and means for providing electrical connections to two of the globules of said first liquid.

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