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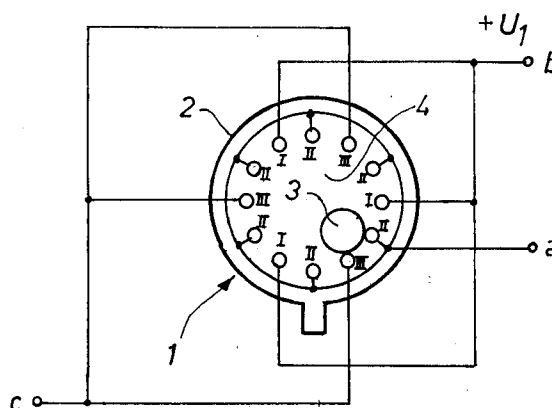
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EUROPEAN PATENT APPLICATION(21) Application number: **92202699.2**(51) Int. Cl.⁵: **F42C 13/00**(22) Date of filing: **07.09.92**(30) Priority: **16.09.91 SE 9102662**(43) Date of publication of application:
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DE GB NL(71) Applicant: **Bofors Aktiebolag****S-691 80 Karlskoga(SE)**(72) Inventor: **Bjelvert, Sven****Anells väg 6****S-633 69 Eskilstuna(SE)**Inventor: **Sahlin, Göran****Klarbärsvägen 2****S-633 53 Eskilstuna(SE)**(74) Representative: **Nydell, Peder****Nydells Patentbyrå Hägnen 2573****S-380 30 Rockneby (SE)**(54) **A position-disturbance sensor.**

(57) A position-disturbance sensor for sensing any position-disturbance or "upset" of the sensor from a predetermined rest position. The sensor (1) includes a housing (2) with an easily movable metal ball (3) or the like, which, upon any upset of the sensor, makes contact with two of a plurality of contact pins (I-III) fixedly placed in the housing for connecting or disconnecting a supply voltage (U_1) to an electronic circuit (5). The circuit has a first capacitor (C2) capable of, at each connection of the supply voltage, receive a charge addition, the voltage across the capacitor (C2) reaching a predetermined level only upon a certain number of connections of the supply voltage, in order to indicate an upset of the sensor. The circuit has also a second capacitor (C1) being incorporated in a RC-circuit (R1, C1) which is so dimensioned that the second capacitor (C1) will not substantially be discharged during rapid contact changes of the ball (3), e.g. when the sensor is upset as a result of an explosion at the vicinity of the sensor.

**FIG. 1****EP 0 537 812 A2**

TECHNICAL FIELD

The present invention relates to a position-disturbance sensor for sensing any position-disturbance or "upset" of the sensor from a predetermined rest position, including a housing and an easily movable contact means therein capable of moving randomly within the housing, even as a result of the slightest upset of the sensor housing from its rest position, to simultaneous contact with two electrical contact points of a plurality of electrical contact points being fixedly placed in the housing, and thereby, like a switch, close an electric contact between the two contact points, said contact closure being an indication of said position-disturbance or "upset" of the sensor.

The sensor may for instance be placed on an object where one wishes to obtain an indication of any unauthorized displacement from a predetermined storage. Alternatively, the sensor may be placed on an explosive mine being buried in the ground, where any indication of an upset of the mine is arranged to initiate the detonation of the explosive charge of the mine.

BACKGROUND PRIOR ART

Sensors of the aforementioned kind are known in the market as so called tilt sensors. The known sensors are, however, not designed to distinguish between different types of upsets of the actual object, but they will indicate an upset of a buried object also at the slightest natural change of the inclination of the object, such that they for instance respond to natural ground sinks due to depressions in the land surface.

DE-B1-2.709.397 discloses a sensor capable of distinguishing between different types of upsets. However, this known sensor is not designed to avoid any indication of such upsets of the actual object that are caused by very rapid contact changes of the movable contact means, for instance if the upsets originate from an explosion at the vicinity of the object.

DISCLOSURE OF THE INVENTION

The object of the present invention is, therefore, to provide an upset sensor of the kind mentioned by way of introduction, which gives indication of upset only upon sensing of a plurality of contact closures, such that natural tilts, for instance caused by ground sinks, will not give any upset indication.

Another object of the invention is to provide an upset sensor of the kind mentioned by way of introduction, which is able to distinguish between contact changes of different rapidities, and which

prevents indication of upset, if the upset originates from rapid contact changes caused by an explosion at the vicinity of the sensor.

These two objects are achieved by a sensor according to the invention having the characterizing features set forth in Claim 1. Further developments of the invention are set forth in the depending Claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described in more detail by reference to the accompanying drawings which illustrate a preferred embodiment of the invention.

Fig. 1 is a schematical top view of a sensor head of an upset sensor according to the invention.

Fig. 2 is an electric circuit diagram of an electronic circuit incorporated in the upset sensor of the invention.

PREFERRED EMBODIMENT

Fig. 1 shows an upset sensor 1 for sensing any upset of a buried, explosive land mine (not shown). The sensor 1 consists of a cylindrical housing (or cup) 2 having an easily movable contact means in the form of a metallic ball 3. The ball 3 rests on a surface 4 in the housing 2, and is surrounded by a ring of equally spaced, fixed contact points in the form of contact pins (twelve pins in the embodiment shown) denoted I (three pins), II (six pins) and III (three pins), respectively, every pin being insulated from the surface 4 in the housing 2.

The ball 3 can move very rapidly along the surface 3, if the mine (and thus the housing 2) is subjected to a push or an upset. The ball 3 may alternatively consist of a drop of mercury.

The twelve contact pins I-III are, according to a predetermined pattern, connected to a respective one of contact terminals a, b and c, respectively. Contact terminal a, to which the pins II are connected, serves as an input terminal of an electronic circuit 5 of the sensor 2, shown in Fig. 2. Contact terminal b, to which the pins I are connected, is connected to a supply voltage +U1 volts. Contact pin c, to which the pins II are connected, is connected to ground, but may, alternatively, have another voltage.

The ball 3 of Fig. 1 can, as a response to any upset of the sensor housing 2, randomly move along the surface 4 in the housing 2 into simultaneous contact with two of the contact pins, i.e. with a pin I and a pin II, or alternatively with a pin II and a pin III. The contact pins are so arranged that the ball 3 cannot contact a pin I and a pin III simultaneously, since this would otherwise have resulted in a short-circuit via ground of the supply voltage.

Therefore, the ball 3 will obtain the same function as a switch, and is, therefore, shown as a switch contact 3' in Fig. 2. Contact 3' can have anyone of two different positions, i.e. a position where it contacts terminal b, i.e. where it connects the supply voltage U1 to input terminal a of circuit 5, and another position, where it contacts terminal c, i.e. where it connects input terminal a of the circuit to ground. These two positions correspond to the cases where the ball 3 contacts pin I and II, or pin II and III, respectively.

Electronic circuit 5 contains, between terminals a and c, a series arrangement of a capacitor C1, a diode D1 which is coupled in its reverse direction (in relation to supply voltage U1) and a resistor R1, the electronic circuit also containing a parallel arrangement of a capacitor C2 and a resistor R2. These two arrangements are separated from each other by a diode D2 which is coupled in its conducting direction (in relation to the supply voltage).

The voltage Ud across resistor R2, i.e. at terminal d in Fig. 2, is fed to a comparator 6, where the voltage Ud is compared with a preselected reference voltage Uref. If the voltage Ud is greater than or equal to the voltage Uref, an output signal will appear at output terminal e of the comparator, indicating an upset of the mine.

The function of electronic circuit 5 will now be described more detail. In order to better understand the function of the circuit, the following exemplary values are assumed: U1 = 10 volts, C1 = 10 nF, C2 = 90 nF and R2 = 1 Mohm.

If C1 is initially discharged, a voltage peak appears at point C1/D1/D2 when contact 3' is closed to U1. Since the capacitance of C1 is 9 times greater than the capacitance of C2, U1 will be distributed by 9.0 volts across C1 and 1.0 volt across C2, provided that the voltage drop across diode 2 can be neglected. In order to again produce a charging current through C1 upon repeated closure to U1, it is required that C1 must be discharged, which is done by closure to ground, i.e. via terminal c. If such discharge of C1 has been effected, while C2 has substantially maintained its charge due to its high time constant R2C2, a subsequent closure to U1 will distribute a voltage of 9.0 volts between C1 and C2, meaning that the voltage across C2 will rise from 1.0 to 1.9 volts. A further discharge of C1 followed by a closure to U1, will give a further charge amount to C2 of 0.81 volts, and so on. The voltage Ud across C2 will thus increase gradually to a level which equals or is greater than reference voltage Uref, such that comparator 6 emits the above-mentioned output signal at terminal e.

If C1 is not completely discharged, the voltage peak at point C1/D1/D2 will be low. The discharge velocity of C1 upon closure of contact 3' to ground

depends on the resistance of resistor R1.

When rapid contact changes of the ball 3 occur (e.g. thrusts originating from an explosion at the vicinity of the mine), the amplitude of the voltage peak will be low and the charge addition in C2 will be low. When slow contact changes (tilting and removal of the mine), the voltage peak will go high, and the charge addition to C2 will be greater.

It will be apparent that the time constant R2C2 must be so great that the discharge that occurs between the voltage peaks, is not greater than the respective charge addition.

By suitable dimensioning of the various circuit components the sensitivity of the sensor may be varied as desired.

Claims

1. A position-disturbance sensor for sensing any position-disturbance or "upset" of the sensor from a predetermined rest position, including a housing (2) and an easily movable metallic contact means (3) therein capable of moving randomly within the housing, even as a result of the slightest upset of the sensor housing from its rest position, to simultaneous contact with two electrical contact points of a plurality of electrical contact points (I-III) being fixedly placed in the housing, and thereby, like a switch (3'), close an electric contact between the two contact points, said contact closure being an indication of said position-disturbance or upset of the sensor, **characterized** in that, in order to provide the upset indication only as a result of a plurality of such contact closures, the contact points (I-III) are so connected to an electronic circuit (5) of the sensor that each one of said contact closures randomly either connects a supply voltage (U1) to the circuit or disconnects the supply voltage from the circuit, the circuit including a capacitor (C2) being dimensioned to, at each said connection of the supply voltage, receive a charge addition, but at each said disconnection of the supply voltage substantially not be discharged, such that the voltage (Ud) across the capacitor (C2) upon a certain number of connections of the supply voltage, has gradually reached a predetermined level (Uref) corresponding to said plurality of contact closures, the capacitor (C2) being connected in series with a second capacitor (C1) which is incorporated in a RC-circuit (R1, C1) which is so dimensioned that the second capacitor (C1) will not be substantially discharged during such rapid contact closures of the movable means that occur upon an upset of the sensor as a result of an explosion at the vicinity of the sensor, which non-

appearing discharge of the second capacitor (C1) causes that a subsequent connection of the supply voltage (U1) across the circuit prevents any charging current from flowing in any appreciable degree through the two capacitors, and thus substantially prevents any charge addition to the first capacitor (C2). 5

2. A sensor according to Claim 1, **characterized** in that the sensor housing (2) is rigidly connected to an explosive mine being buried in the ground. 10

3. A sensor according to any preceding Claim, **characterized** by a voltage comparator (6) for detecting the voltage (Ud) across the first capacitor (C1) and comparing it with a reference voltage (Uref) corresponding to said predetermined level. 15

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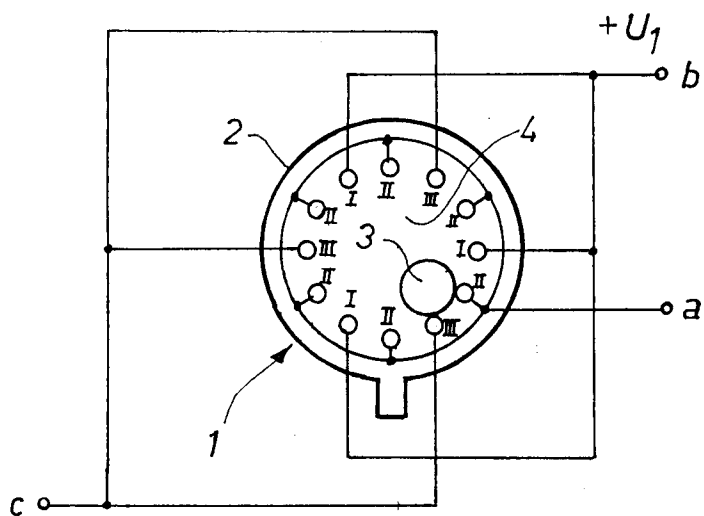


FIG. 1

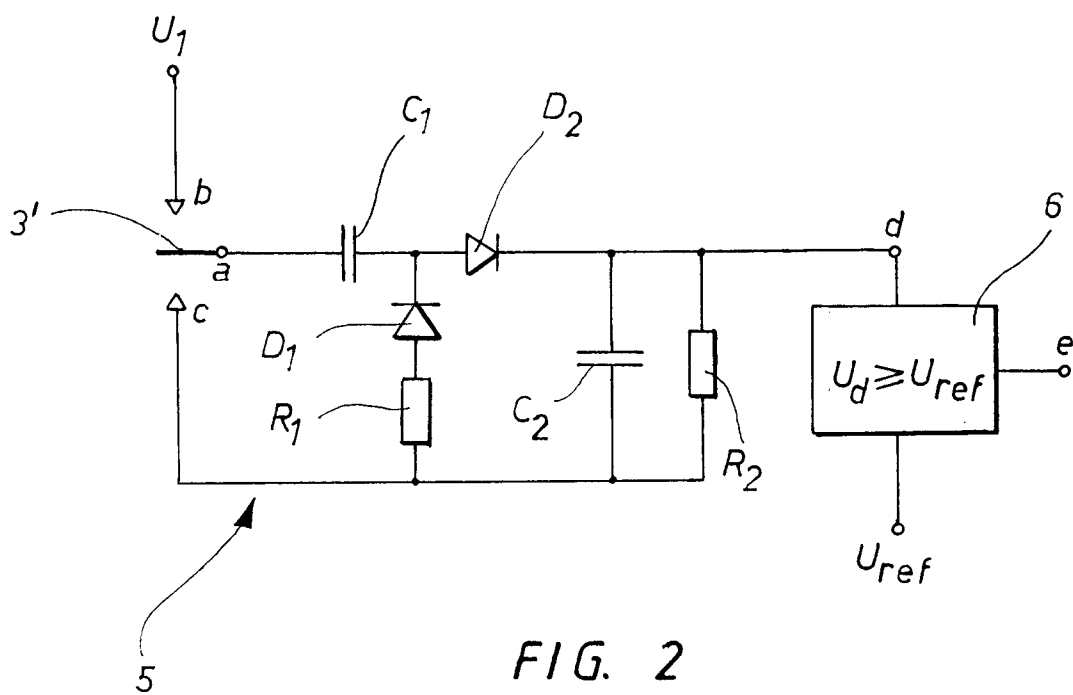


FIG. 2