# United States Patent [19]

**Johnson**

[11] **3,742,478**

[45] **June 26, 1973**


[54] **CIRCUIT BOARD MOTION SENSITIVE SWITCH**


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[73] Assignee: **Transport Security Corporation,** Minneapolis, Minn.



[22] Filed: **Nov. 3, 1971**

[21] Appl. No.: **195,437**

[52] **U.S. Cl.** ..... **340/262 R,** 340/224 R

[51] **Int. Cl.** ..... **G08b 21/00**

[58] **Field of Search** ..... 340/262 R



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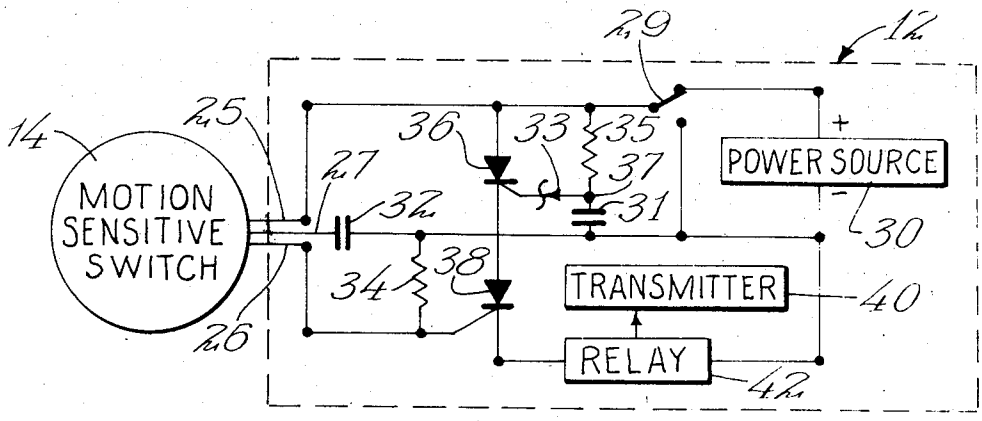
[57] **ABSTRACT**

A motion sensitive switch in which a steel ball is positioned to roll freely across the surface of a printed circuit board having three separate circuits positioned thereon in a spaced relationship. If the switch is moved even slightly the steel ball rolls from circuit to circuit making and breaking connections so as to sound an alarm. In addition, a circuit is shown whereby an alarm is sounded only upon the steel ball contacting two of the circuits so as to charge a capacitor and then rolling into contact with a different pair of circuits so as to discharge the capacitor into an alarm relay. The motion sensitive switch is also shown in conjunction with a covering or tarpaulin designed to be draped over goods to be protected.


**13 Claims, 6 Drawing Figures**



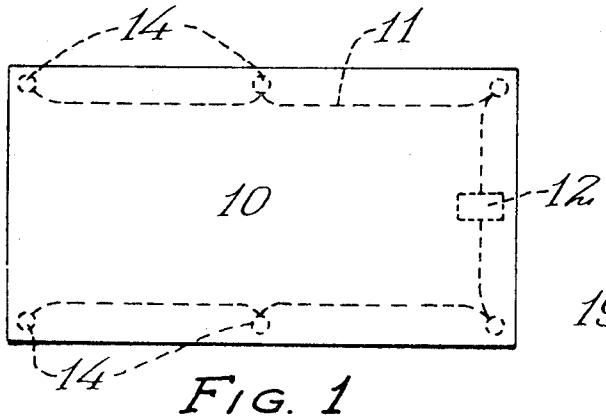



FIG. 1

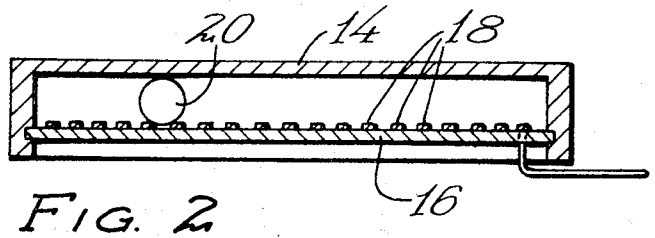



FIG. 2

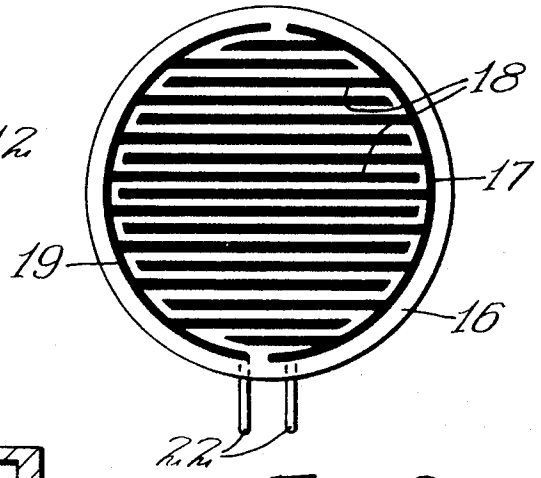



FIG. 3

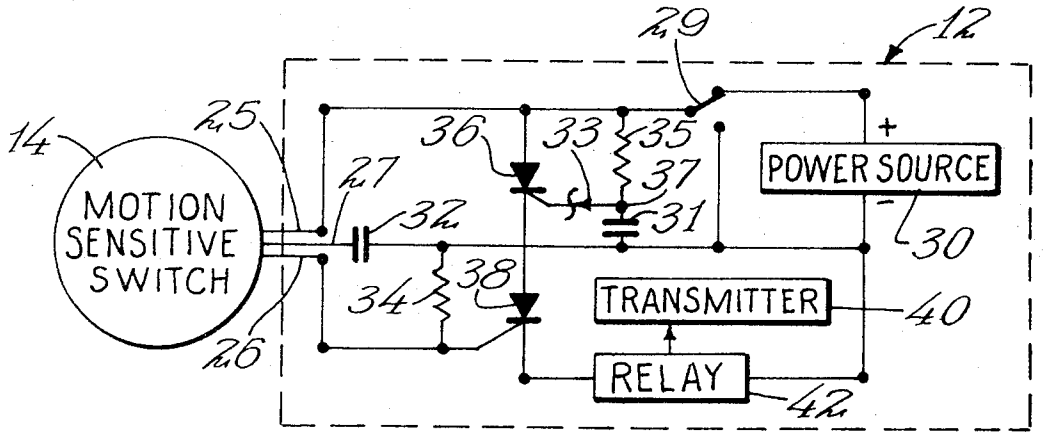



FIG. 5

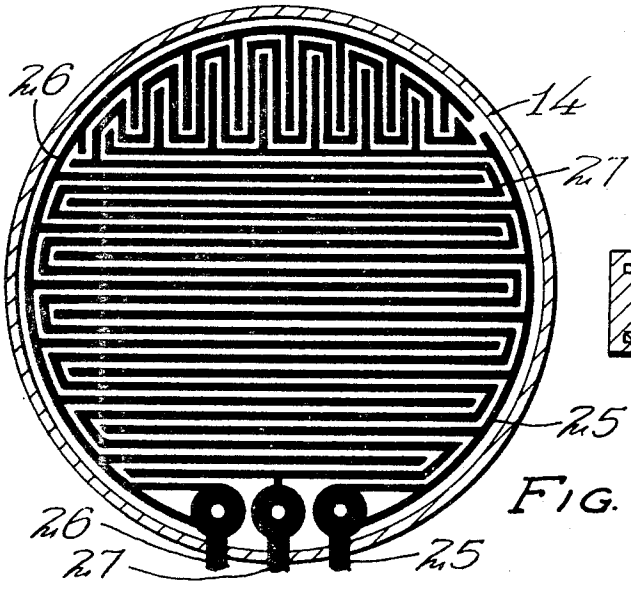



FIG. 4

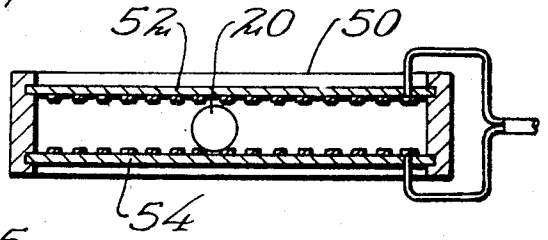



FIG. 6

# CIRCUIT BOARD MOTION SENSITIVE SWITCH

## BACKGROUND OF THE INVENTION

Prior art motion sensitive alarm switches generally comprise pendulous apparatus which has suffered from many disadvantages. First the device must always be leveled carefully in order to be operative. This prevents the alarm switch from being used in a casual manner as, for example, concealed in a tarpaulin designed to cover goods. Secondly, the complicated mechanical apparatus must be gently handled and positioned to avoid damaging the delicate apparatus. Another disadvantage in the prior art is that devices including pendulums, mercury switches, or the like can only be utilized in one position namely level and thus their utility is greatly reduced. These prior art devices are also overly sensitive to momentary vibrations caused by passing vehicles or other natural occurrances and therefore give many false alarms causing a great expense and waste of time. My invention avoids all of the above disadvantages and provides an extremely simple switch which is very rugged, can be used in virtually any position, is insensitive to transitory vibrations, and need not be level for its operation.

## SUMMARY OF THE INVENTION

Briefly, my invention contemplates providing a generally circular housing to enclose a printed circuit board upon which two or more separate circuits are laid out in a spaced relationship in a repetitive pattern. A steel ball is then disposed within the housing so as to roll across the surface of the circuit board. The printed circuit patterns are intertwined with each other in a complex pattern so that any movement of the housing causes the ball to roll across at least a small portion of the circuit board making and breaking contacts between the various circuits. In the case of a circuit board having two separate circuits this making and breaking of contacts can be utilized simply to trigger an electronic circuit sounding an alarm. However, in the preferred embodiment a more sophisticated approach is contemplated. Three separate circuits are printed onto the board one of which comprises an input lead, the second of which comprises a capacitive circuit, and the third comprising an output or alarm lead. As the steel ball rests across the capacitor and input lead the capacitor is charged. Upon the movement of the housing the ball is caused to roll a significant distance so that it bridges the gap between the capacitive circuit and the alarm circuit thus sounding an alarm. This preferred embodiment avoids a vibration problem commonly encountered in the prior art. Transitory natural vibrations could cause the steel ball to make and break contact between the two circuits upon which it was resting even though it did not move a significant distance. This could cause false alarms. However, in the preferred embodiment utilizing three circuits the ball must actually roll from a position in contact with two of the circuits to a position in contact with a third circuit. It has been found by experimentation that the switch of my invention is nearly vibration proof and immune to false alarms without sacrificing any of the delicate sensitivity inherent in the design. Furthermore, my invention can operate in any position without the need of leveling since any displacement of the housing will always cause the ball to roll a sufficient distance to change the circuits upon which it is resting. In fact, in one embodiment it is contemplated that two circuit boards could be provided in the housing positioned on both sides of the steel ball so that absolutely no position of the housing could trap the steel balls in a single locked position. Thus it may be seen that it is an object of my invention to provide an improved motion sensitive alarm and circuit therefore. Further objects and advantages will become apparent upon consideration of the following description and drawings.



## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a tarpaulin with my invention incorporated therein.

FIG. **2** is a cross sectional side view of one embodiment of the present invention.

FIG. **3** shows a circuit pattern for the printed circuit board of the present invention in which two separate circuits are employed.

FIG. **4** shows a sectional top view of my invention with a circuit board therein having three separate circuits printed thereon.

FIG. **5** shows an electronic alarm circuit suitable to be used with the circuit board of FIG. **4.**

FIG. **6** shows an embodiment of the invention wherein circuit boards could be positioned both above and below the ball.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1** one application of the present invention is shown. A tarpaulin **10** of the type typically used to cover goods for weather protection has a number of small circular disc shaped alarms **14** constructed according to the principles of the present invention sewed therein. Alarms **14** are all connected by suitable electrical connections shown as dashed lines **11** to a logic circuit **12.** Circuit **12** includes a radio transmitter and a switch and as will be described later operates in conjunction with motion sensitive switches **14** to give an alarm at a remote location in response to any disturbance of the tarpaulin. To utilize the tarpaulin of FIG. **1** it is only necessary to activate the circuitry **12** by throwing a switch. A time delay circuit allows the tarpaulin to be placed over the goods without triggering the alarm. After a chosen interval, which may, for example, be one to five minutes, circuit **12** automatically activates itself. If anyone attempts to disturb the tarpaulin at least one of the motion sensitive switches **14** is disturbed. This activates circuitry **12** so as to send a radio signal out to a remote location where a plurality of these tarpaulins can be monitored.

In FIG. **2** motion sensitive switch **14** is shown in section as viewed from the side to better understand its principles of operation. Switch **14** comprises a generally cylindrical disc shaped housing within which is placed a circuit board **16** having numerous electrical circuit elements **18** printed thereon. A ball **20** which may comprise any electrically conductive material is positioned within switch **14** and disposed to roll across the surface of circuit board **16.** In the preferred embodiment a steel ball is utilized which has a shape and size chosen to rest in contact with two adjacent elements **18.** For an understanding of how circuit elements **18** are positioned reference should be had briefly to FIG. **3** which shows an embodiment having two separate circuit **17** and **19.** A pair of lead-in wires **22** are brought from the bottom of circuit board **16** through

two small holes and soldered to the two separate circuits 17 and 19. These two separate circuits 17 and 19 have numerous extensions on them which comprise elements 18 and which alternate with each other in spaced relationship. Referring again to FIG. 2 it may be seen that any slight disturbance of switch housing 14 will cause ball 20 to roll thus momentarily breaking contact between the two circuits upon which it is resting and then reestablishing contact once it has travelled across one of the elements 18 to rest in the next groove between two elements. Any of a number of alarm triggering electronic circuits may be connected to the circuit board of FIG. 3 since this making and breaking of electrical contacts are well known to those skilled in the art. In a switch built according to the principles of FIG. 3 it has been found that vibrations from spurious sources can cause the ball to bounce or move thus breaking a connection momentarily even through no one is disturbing the tarpaulin or other apparatus within which the switch is mounted. To avoid such problems a more sophisticated embodiment is proposed for the preferred embodiment and is shown in FIGS. 4 and 5.

In FIG. 4 a circuit board is shown which has three separate circuits in a spaced alternating relationship. In FIG. 4 it may be seen that the input and output circuits are numbered 25 and 26 and alternate with each other in a fashion similar to that shown in FIG. 3. However, a third circuit 27 is provided between circuits 25 and 26. The electronic circuit shown in FIG. 5 is connected to the three circuits so that the steel ball must roll from a position in contact with circuit 25 and 27 into a position in contact with circuit 27 and 26. The circuitry is designed to be immune to transistory vibrations which might cause the steel ball to momentarily break connection between two of the circuits. The alarm is sounded only if the steel ball moves a small distance setting up a new combination of connections. Before describing the circuitry in detail it should be noticed in FIG. 4 that the pattern of the circuit is caused to run in a perpendicular direction at one end of the switch. This is done because it has been found that in the preferred embodiment if the pattern is allowed to run all in one direction it is possible for the switch to lie in a position with the ball at one end where, due to the circuit shape of the switch, a large movement of the ball is possible without triggering the alarm. This is because the movement of the ball is along the length of two of the circuit elements so that it is not caused to cross from one circuit pair to another circuit pair. To aleviate this problem the direction of the circuit elements may be changed as shown. It is possible, of course, to produce making an even more complicated pattern on the circuit board. However, the arrangement shown in FIG. 4 has been found to be very effective in the preferred embodiment. It should be understood that the preferred embodiment would actually comprise a greater number of elements than that shown in FIG. 4. FIG. 4 has been altered for maximum clarity and is not intended to limit the various patterns that could be used in the present invention.

In FIG. 5 an electronic circuit 12 is shown which is adapted to be connected to the motion sensitive switch 14 as shown in FIG. 4. A power source 30 which may comprise a small battery or other similar source is connected through a switch 29 to provide power to motion sensitive switch through circuit 25. When switch 29 is positioned as shown power from power source 30 also flows through a resistor 35 so as to charge a capacitor 31. When the voltage at point 37 rises to a predetermined level a Zener diode 33 is caused to fire thus triggering the gate of a silicon controlled rectifier 36 so that silicon controlled rectifier 36 becomes conducting. This operation provides some delay between the time at which the switch is thrown and the circuit is activated so that whatever device the motion sensitive switch is attached to may be placed in position without triggering the alarm. By adjusting the sizes of capacitor 31 and resistor 35 the time constant can be chosen to be any convenient value as was mentioned with respect to FIG. 1. Once silicon controlled rectifier 36 becomes conducting the circuit is activated and any additional disturbance of motion sensitive switch triggers the alarm. Switch 14 rests in one of two possible modes. Ball 20 either is resting in contact with two elements so as to make an electrical connection between circuits 25 and 27 or between circuits 27 and 26. In the former case power from power source 30 is conducted by the ball into circuit 27 and causes a capacitor 32 to be charged. Any disturbance of switch board 14 which then causes the ball to roll to a new position in which it establishes contact between circuits 27 and 26 allows capacitor 32 to discharge into circuit 26. Current in circuit 26 is presented to the gate of silicon controlled rectifier 38 so as to make silicon controlled rectifier 38 conducting. Current is passed through silicon controlled rectifiers 36 and 38 to a relay 42 which in turn activates a radio transmitter 40. Transmitter 40 sends a signal to a remote alarm station having a suitable radio receiver. Of course, other types of alarm systems could be used also. Relay 42 and radio transmitter 40 are exemplary only. A resistor 34 is used between the center ground circuit and circuit 26 for trimming purposes. It should be noticed that switch 29 in the off position is connected to short circuit capacitor 31 so as to drain capacitor 31 to zero so that the next time the circuit 12 is activated it will take a similar period of time for silicon controlled rectifier 36 tor turn on again.

If motion sensitive switch 14 comes to rest in a position with steel ball 20 resting against circuits 26 and 27 then the alarm is sounded only when the steel ball has rolled two positions, first into contact with circuit 25 and circuit 27 so as to charge capacitor 32, and then into contact with circuit 26 and 27 so as to discharge capacitor 32 as described earlier. The size of capacitor 32 is chosen to be relatively small so that even though the ball moves very quickly gate 38 is activated.

It should be noted that switch 14 as shown in FIG. 4 can operate in virtually any position and need not be level. Even if the switch is standing nearly on its side when deployed slight movements cause the ball to rock back and forth along the side walls making contact with the various elements on the circuit board. In FIG. 6 an embodiment is shown in which the switch can even work in an inverted position. In FIG. 6 an embodiment is shown in which the housing comprises a circular member 50 having two circuit boards 52 and 54 therein positioned above and below the electrically conducting ball 20. The circuits from the boards are connected together in parallel so that the ball performs as described with respect to FIGS. 4 and 5 regardless of the switch attitude. Of course, many variations can be made to the design of the circuit pattern on the circuit board and to the housing shape so as to insure that the steel ball will

always be in contact with one or more circuit boards. Furthermore, the alarm is suitable for use on any device whose movement is to be detected. Thus, the following claims are presented to cover the novel new motion sensitive switch in the fair spirit and scope of the invention without being limited to the particular arrangement or embodiments shown in the drawings.

I claim:

**1.** A motion sensitive switch comprising a housing adapted to contain a generally planar member which planar member comprises a circuit board with a plurality of electrical conductors formed in a spaced relationship thereon, said housing containing an electrically conductive rolling member adapted in size and shape to roll on said planar member in response to movement of said housing so as to intermittently electrically connect pairs of said plurality of electrical conductors together, said housing shaped to have a minimum of indentations which might trap said rolling member in a stationary position.

**2.** The switch of claim **1** in which said planar member comprises a printed circuit board and said rolling member comprises a ball adapted to roll on the circuit side of said board.

**3.** The switch of claim **2** in which said plurality of conductors comprise two circuits on said board positioned alternate to each other in a repetitive pattern.

**4.** The switch of claim **2** in which at least a portion of said plurality of conductors comprise first, second, and third circuits on said board positioned alternate to each other in a repetitive pattern.

**5.** The motion sensitive switch of claim **1** in combination with a radio transmitter, said combination being concealed in a protective covering for goods so that movement of said covering moves said switch and activates said transmitter to sound an alarm at a remote location.

**6.** The motion sensitive switch of claim **3** in combination with a radio transmitter, said combination being concealed in a protective covering for goods so that movement of said covering moves said switch and activates said transmitter to sound an alarm at a remote location.

**7.** The switch of claim **4** in which said first circuit is positioned between the other two circuits so that said ball can not electrically connect the other two circuits together at any position within said housing.

**8.** The switch of claim **7** including capacitive means connected to said first circuit and in which said second circuit is connected to a source of electrical current and said third circuit is connected to activate an alarm circuit so that the capacitive means may be charged when said ball connects said first and second circuits together and said alarm circuit may be triggered when said ball later connects the charged first circuit and the third circuit together.

**9.** The apparatus of claim **8** in which said alarm circuit comprises electronic gate means operable to open and pass electrical current to a suitable alarm device upon receiving electrical current from said first circuit through said third circuit.

**10.** The motion sensitive switch of claim **9** in combination with a radio transmitter, said combination being concealed in a protective covering for goods so that movement of said covering moves said switch and activates said transmitter to sound an alarm at a remote location.

**11.** The apparatus of claim **10** including timed electronic delay means connected between said second circuit and said source of current so that the power may be turned on and the protective covering positioned before the alarm is activated.

**12.** The apparatus of claim **11** in which said delay means comprises a capacitor charging circuit connected to the gate of a first silicon controlled rectifier.

**13.** The apparatus of claim **12** in which said electronic gate means comprises a second silicon controlled rectifier which is driven from said first silicon controlled rectifier in response to current from said third circuit.

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