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2,644,049

PRESSURE ACTUATED SWITCH

Filed July 18, 1951

2 Sheets-Sheet 1

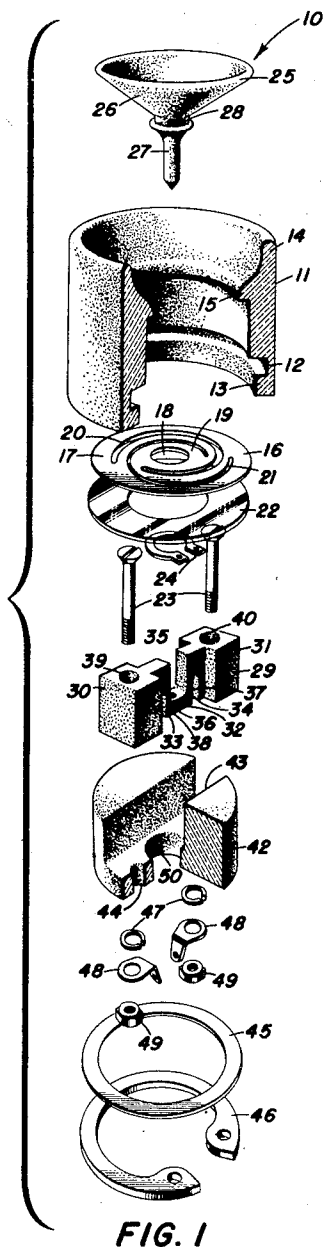


FIG. 1

FIG. 2

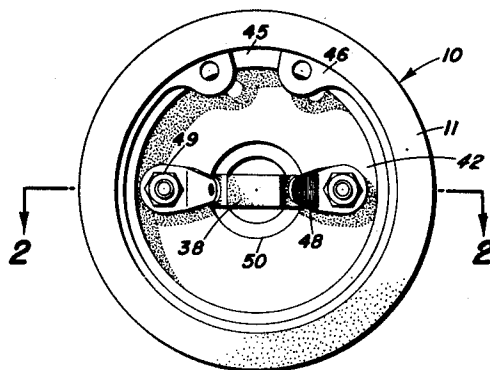
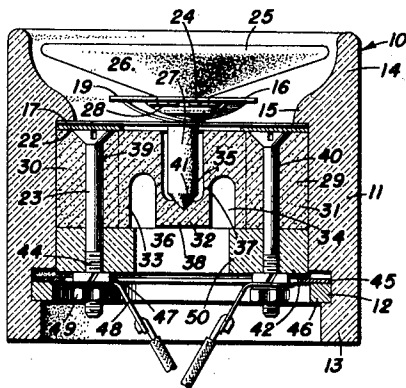


FIG. 3

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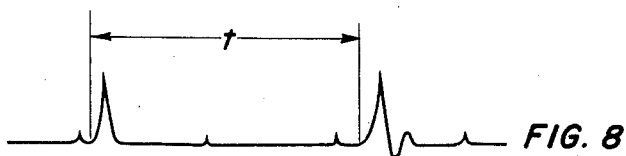
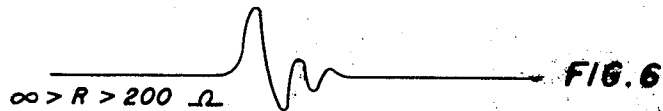
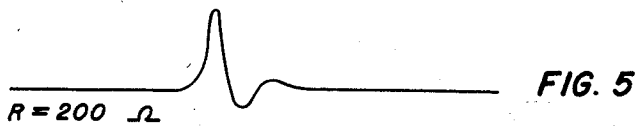
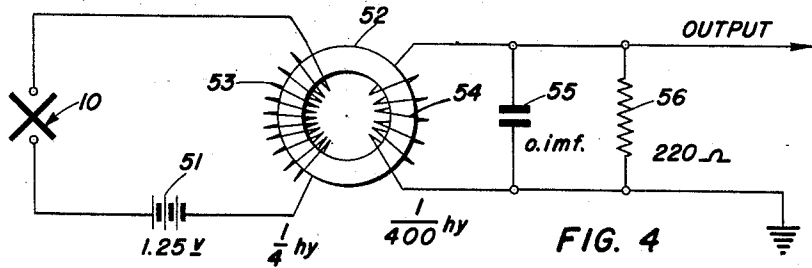
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2 Sheets-Sheet 2



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PRESSURE ACTUATED SWITCH

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8 Claims. (Cl. 200—52)

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This invention relates generally to pressure-actuated switches and more particularly to a switch for use in measuring the transit time of pressure or shock waves.

In studying the behavior of pressure or shock waves, it is important to be able to ascertain the time it takes for a wave to travel from its source to a fixed point at some predetermined distance. In order to accomplish this purpose, a time recording device at the point to be observed is connected in an electrical circuit which includes a pressure-operated switch placed on or near the axis of the wave. When the wave strikes the switch it operates thereon to break the switch contacts and open the electrical circuit, thus giving a measurement of the time of arrival of the wave. Previously-known switches of this type were unsatisfactory due to their inherent long time lag and their inability to withstand high temperature conditions.

It is therefore an outstanding object of this invention to provide a light-weight pressure-actuated switch that will interrupt an electrical current and which will do so with an extremely short time lag.

It is a further object of this invention to provide a switch of the type described having a low resistance previous to the time it is actuated and a high resistance after actuation.

It is still another object of this invention to provide a switch whose internal resistance will not increase with a high temperature gradient.

It is a further object of the invention to provide a switch than can withstand high thermal shock and which will operate satisfactorily after such shock.

Still another object of the instant invention is to provide a switch, the axis of which can be misaligned appreciably from the line of pressure propagation without appreciably affecting its operation.

A further object of this invention is to provide a switch which will not be affected in its operation by conditions of high humidity and the like.

With these and other objects in view, as will be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto.

The character of the invention, however, may be best understood by reference to certain of its structural forms, as illustrated by the accompanying drawings in which:

Fig. 1 is an exploded view of the switch of the invention with the elements thereof arranged in their proper relative positions;

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Fig. 2 is a sectional view of the assembled switch, on the line 2—2 of Fig. 3;

Fig. 3 is a bottom view of the switch as shown in Fig. 2;

Fig. 4 is a schematic showing of a circuit in which the switch of the invention may be used; and

Figs. 5, 6, 7, and 8 are graphic showings of signals obtainable from the circuit of Fig. 4, used in conjunction with the switch of the invention.

Like reference characters denote similar parts in the several figures of the drawings.

Referring first to Fig. 1, which best shows the general shape, size, and arrangement of the parts, it can be seen that the switch, generally designated 10, comprises a housing 11 in which all the elements can be contained. The housing 11 is formed of a vitrified ceramic material preferably containing aluminum, silicon, and magnesium; this particular combination of material has been selected for its excellent heat resisting properties. The housing 11 is of short tubular shape and has a relatively thick wall having an annular groove 12 formed internally near one end. The purpose of this groove is to accommodate a washer and locking ring which will be described more fully hereinafter. The thickness of the portion 13 of the wall immediately below the groove 12 is somewhat less than the thickness of the wall above it, in order to facilitate positioning of this washer and locking ring. The opposite end of the housing has a cup portion 14, the thickness of which increases along an ogee curve inwardly of the end and which flares out to form a shoulder 15.

A metallic spring 16 is provided, said spring being of circular shape and of such diameter that it may fit within the housing under the shoulder 15. The spring has an unbroken peripheral margin 17, an aperture 18, and an unbroken central margin 19 surrounding the aperture. Two spaced spiral slots 20 and 21 are formed in the spring symmetrically of the center thereof, providing for characteristics which are very useful in the present device, as will be better understood from the following description.

A thin mica washer 22 is provided, having an outer diameter equal to that of the spring 16 and having a large central aperture.

Bolts 23 are of standard form. A locking collar 24 is of a generally U-shaped form. A pressure pad 25 is composed of a conically shaped head 26 and an axial pin 27 having a conically-pointed free end and an annular groove 28 therein. The

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pad is made of the same ceramic material as the housing 11.

A resistance element 29 is formed of brittle carbon material whose electrical resistance does not change under conditions of high temperature. As can be seen from the drawing, vertical slots have been cut into the opposite faces of this element, thus defining end blocks 30 and 31 joined by a relatively thin center section 32. Slots 33, 34 and 35 have been cut into the center section, thus defining frangible thin-walled sections 36 and 37 by which means a pressure block 38 is suspended from the remainder of the element 29. The blocks 30 and 31 are provided with bolt holes 39 and 40, respectively, and the pressure block 38 is provided with a conical depression 41, the purpose of which will be explained hereinafter.

A supporting block 42 is formed of the same ceramic material used in the housing 11, is of a generally cylindrical shape, and is of such a size as to fit snugly into the housing 11. The block 42 has a generally diametric slot 43 of such a width as to receive the element 29 and the bottom wall of the slot is provided with bolt holes 44 arranged to align with those of the element 29 and is also provided with an axial aperture 50. A washer 45 and a locking ring 46 are of the proper diameter to fit snugly into the groove 12 in the housing 11. Various other hardware, such as the washers 47, terminal members 48, and nuts 49, are provided for purposes to be described hereinafter.

Referring next to Fig. 2, which best shows the switch in assembled condition, the pressure pad 25 is shown with its head 26 resting in the cup portion 14 of the housing 11 with its pin 27 extending axially therewithin. The spring 16 resides within the housing with its periphery 17 situated behind the lip 15. The central margin 19 surrounding the aperture 18 is drawn substantially out of the plane of the periphery 17, with the stem 27 of the pressure pad 25 extending through the aperture 18 of the spring. The central margin 19 is maintained adjacent the head 26 of the pressure pad by means of the locking collar 24 which resides in the groove 28 of the pin 27. It can be seen, then, that the pressure pad 25 is resiliently biased downwardly into the housing 11. The resistance element 29 is positioned in the groove 43 of the supporting block 42 which, in turn, lies snugly within the housing immediately beneath the washer 22. The resistance element 29 and the block 42 are held firmly together by the bolts 23 which pass through the bolt holes 39 and 40 and bolt holes 44 of the element and block, respectively, and fixed therein by means of the washers 47 and the nuts 49, which also hold the terminal members 48 in place on the bolts. The resistance element, block, bolts, etc., thus form a sub-assembly which rests within the housing and is held therein by means of the washer 45 and the locking ring 46 which are snapped into the groove 12 in the housing 11. The elements making up this sub-assembly are such that the snapping of the lock ring 46 into place in the groove causes the sub-assembly to be pressed tightly into place against the shoulder 15. Furthermore, in assembled condition, the conical end of the pin 27 of the pressure pad is passed firmly into the depression 41 of the resistance unit. The spring tension is chosen such that in the normal condition of the switch, the pressure of the pad against the resistance unit is such as to stress the thin-walled sections 36 and 37 thereof almost to failure. It can be seen, also, that a very small pressure on the

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head of the pressure pad results in a relative large pressure of the pin against the pressure block 38 of the resistance unit because of the relative areas involved. Furthermore, very little pressure in addition to the normal amount between the pin and the pressure block causes fracture of the thin-walled sections. When leads are attached to the terminal members 48, current from an external circuit may be passed through the switch. In the normal condition of the switch, a complete conductive circuit exists through one terminal member, into one bolt, through a block of the resistance element, down one thin-walled section into the pressure block 38 and out through the other thin-walled section, the other block, the other bolt, and the other terminal member. A shock wave striking the pressure pad stresses the thin-walled sections beyond the breaking point; the pressure block is then free to be propelled through the aperture 50 of the supporting block, thus opening the circuit. The opening of the circuit occurs, therefore, in sensitive response to a shock wave front, and the switch can therefore be connected in circuit with an indicating means of any desirable type. A specific circuit that can be used to give such an indication will be shown and described hereinafter. The unusual qualities of the switch of the invention which result from the structure described above should now be apparent. For instance, the novel arrangement between the pressure pad and the spring allow for the same delicate response of the spring even when the axis of the switch is out of alignment with the line of propagation of the shock wave. By use of the switch of the present invention it has been possible to provide for opening the indicator circuit within 10 microseconds of the time at which the shock wave reaches the pressure pad.

In Fig. 4 is shown an electrical apparatus which may be used in conjunction with the pressure-actuated switch of the invention to measure the time of arrival of shock waves and the like from their source. In ascertaining the time consumed by a pressure wave in traveling from its source to a point located a known distance away, a pressure-actuated switch is placed at said point and is connected in an electrical circuit which in turn feeds a recording instrument. A wave striking the switch operates thereon to open the electrical circuit, whereupon an instantaneous timing pulse is formed which is then applied to the recording instrument. Referring to Fig. 4, the pressure-actuated switch 10 of the invention is connected in series with a source of D. C. voltage 51 and the primary of a transformer to be described hereinafter. A transformer 52 is used to generate the required audio frequency pulses and is wound on a powdered iron core which is in the form of a toroid. The winding is of insulated copper wire and, in order to match a low impedance load on the secondary, is wound with a turn ratio of 9:1 in the preferred embodiment. It is to be understood that, by making a suitable adjustment in the secondary winding, a satisfactory match can be obtained with whatever type of load is presented. The toroidal construction shown is advantageous in that a primary winding 53 will provide maximum inductance consistent with the D. C. resistance limits and will also minimize both flux leakage and iron losses.

A secondary winding 54 is shunted by a capacitor 55, thus forming a tuned circuit the tuning frequency of which is determined by the parameters of these two components. A resistor 56 is

connected across the above circuit and serves to dampen the oscillations as further described hereinafter.

While the circuit constants shown in Fig. 4 are capable of a wide degree of variation, the particular values indicated in the drawings are illustrative of one set that has been found acceptable in order to obtain the desired results.

When the pressure-actuated switch 10 is in its normal, or closed, condition, a small current flows in the primary circuit. When the switch is actuated by a shock wave, the primary circuit of the transformer 52 is opened instantaneously resulting in a rapid collapse of the magnetic field in the primary winding 53. Referring to Fig. 5, this rapidly-changing magnetic field induces a sharp voltage rise in the secondary winding, the signal obtained with an optimum value of the resistance 56 being shown in this figure. Due to the tuned circuit characteristics of the secondary winding 54 and the capacitor 55, the induced voltage will oscillate at the particular frequency to which the circuit is tuned and, with the presence of the resistor 56, these oscillations will decay rapidly. With a higher value of resistance, the damping will take longer, as shown in Fig. 6, while Fig. 7 shows the result obtained when there is no resistor at 56 (infinite resistance).

An understanding of the use of this circuit in pressure waves can best be seen by reference to Fig. 8. A cathode ray oscillograph is used as a measuring device and is supplied with a main trace having a number of small "pips" said "pips" being evenly spaced at some known time interval. At the time the pressure wave is originated, an impulse is fed to the vertical plates of the oscillograph. A pulse, representing the output of the presently-described circuit, is subsequently fed to the oscillograph upon the opening of the primary circuit. Therefore, by ascertaining the point at which the secondary voltage starts its initial rise, the transit time of the shock wave can be found, since this point occurs at the same time as the opening of the switch 10.

It is obvious that minor changes may be made in the form and construction of the invention without departing from the material spirit thereof. It is not, however, desired to confine the invention to the exact form herein shown and described, but it is desired to include all such forms as properly come within the scope claimed.

What is claimed is:

1. A pressure-actuated switch comprising a frangible element, and a pressure pad held adjacent to said element to break the element and open the switch in response to pressure upon the pad, said pressure pad having a broad head and a relatively reduced pin extending therefrom.

2. A pressure-actuated switch comprising a frangible element and a pressure pad, said pressure pad being resiliently biased into contact with said frangible element and serving to break the element and open the switch in response to pressure on the pad.

3. A pressure-actuated switch comprising a frangible resistance element and a pressure pad, said pressure pad having a broad head and a relatively reduced pin extending therefrom, said pressure pad being resiliently biased so that the pin contacts the frangible element and serves to break the element and open the switch in response to pressure on the head of the pad.

4. A pressure-actuated switch comprising a frangible resistance element, a spring, and a pressure pad, one portion of said spring being fixed

relative to said element and another portion of said spring being attached to said pad, whereupon said pressure pad is resiliently biased into contact with said frangible element and serving to break the element and open the switch in response to pressure on the pad.

5. A pressure-actuated switch comprising a frangible resistance element, a spring, and a pressure pad, said pressure pad having a broad head and a relatively reduced pin extending therefrom, one portion of said spring being fixed relative to said element and another portion of said spring being attached to said pad whereupon said pressure pad is resiliently biased so that the pin contacts the frangible element and serves to break the element and open the switch in response to pressure on the head of the pad.

6. A pressure-actuated switch comprising a frangible resistance element having two spaced end blocks and a pressure block suspended therebetween by integral thin-walled sections, a spring, and a pressure pad having a broad head and a relatively reduced pin extending therefrom, one portion of said spring being fixed relative to the end blocks of said element and another portion of said spring being attached to said pad, whereupon said pressure pad is resiliently biased so that the pin contacts the pressure block of the frangible element and serves to break the element and open the switch in response to pressure on the head of the pad.

7. A pressure-actuated switch comprising a frangible resistance element having two spaced end blocks and a pressure block suspended therebetween by integral thin-walled sections, a spring comprising a centrally-apertured disk having slots which enable the area surrounding the aperture to be pressed out of the plane of the area at the periphery thereof, and a pressure pad having a broad head and a relatively reduced pin extending therefrom, the periphery of said spring being fixed relative to the end blocks of said element and the area surrounding the aperture of said spring being attached to said pad with the pin thereof extending through said aperture, the area around the aperture of said spring being held out of the plane of the periphery, whereupon the pin is resiliently biased against the pressure pad and serves to break the thin-walled sections and open the switch in response to pressure on the head of the pad.

8. A pressure-actuated switch comprising a tubular housing having an annular shoulder extending around the medial portion of the inner surface, a pressure pad having a conical head, the apex of which extends inwardly of the housing from one end thereof, and having a pin extending from said apex, a frangible element extending diametrically across the housing and held against the shoulder on the side thereof away from the head of the pressure pad, and terminal members connected to the frangible element to permit said element to be connected to an electrical indicating circuit, said pin serving to break the frangible element and open the switch in response to pressure on said pad.

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