April 6, 1965 D. N. SHAW 3,177,322

INSTANTANEOUS ELECTRO-CHEMICAL SWITCH

Filed Sept. 18, 1962

Fig. 1.

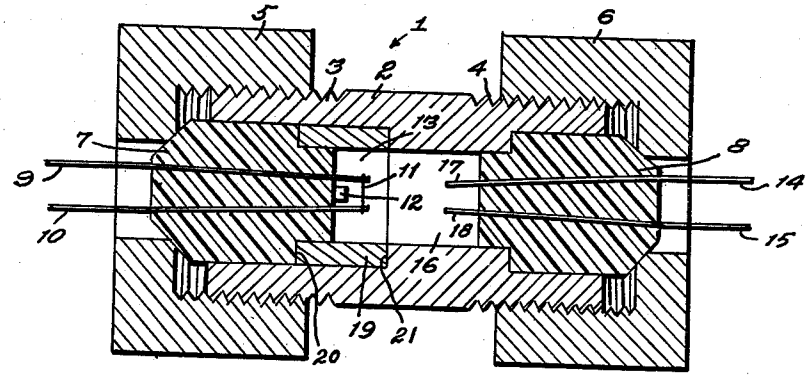


Fig. 2.

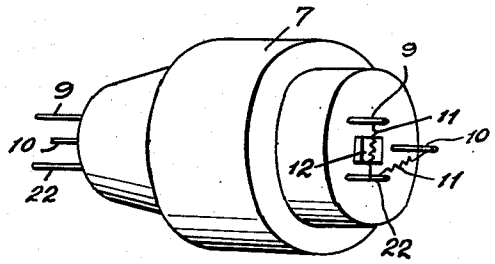
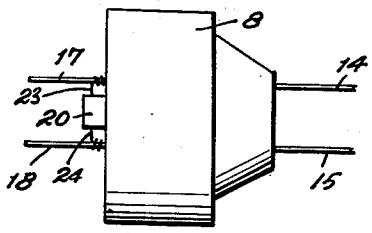


Fig. 3.



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INSTANTANEOUS ELECTRO-CHEMICAL SWITCH

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(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

The present invention relates to an improvement in the art of switching and more particularly to a switch of the electro-chemical type.

Electrical switches having a very short time delay between the application of an activating signal and the start of conduction have found various uses in modern circuits. One of the uses for such a switch is in the performance of certain initiating circuits of rockets where near instant response is required for proper operation. Heretofore it has been extremely hard to obtain the desired operating speed or reliability with the well known relay, gas tube or semi-conductor switching circuit.

The various prior art devices used to accomplish electrical switching involved either mechanical make and break switches, such as electro-mechanical relays, solenoids, mechanical switches and explosively actuated switches, or such devices as high vacuum and gaseous electron tubes, transistors, and diodes, in which switching is accomplished through utilization of the properties of either thermionic emission or the conductivity of semiconductor materials. Both of these types have proven undesirable in circuits where speed of operation, low power consumption, low current flow resistance, vibration-free operation and low cost, are necessary. The make and break type devices are relatively slow in operation because of the moving parts involved thus giving rise to a considerable delay time between the application of the switching stimuli and actual completion of the switching operation. Further, these devices are subject to a phenomenon called "chatter" which is the "bouncing" of the contacts on closure. This chatter causes one or more temporary interruptions in the current flow within the circuit. Arcing also frequently occurs during the initial closure and subsequent chatter intervals causing a loss of energy in the circuit and the generation of undesirable radio frequencies. Tubes, transistors and diodes used as switches generally possess a much faster operating time than the make and break switches but suffer from other undesirable traits. Among these are the use of heater power required in certain tubes and the high internal resistance of these devices as compared with the make and break type switch. Furthermore, the construction of both types is relatively complicated and costly. Both types are also relatively fragile and may be rendered inoperable by shock, vibration, or acceleration forces unless intensive protective precautions are taken in design and construction of the switch circuit. These switching circuits are especially vulnerable to shock, vibration, and acceleration forces of the magnitudes encountered in missiles and rockets.

A third group or type of electrical switch has recently been developed. These switches utilize a gasless powder located between the switching terminals which, upon burning, becomes conductive thereby permitting the passage of an electrical current. Conduction between the terminals of the switch by use of these gasless powders is accomplished either by fusing of the powder material into a solid conductive path or from ionization of the air

surrounding and external to the gasless powder. These switches, while free from moving parts and fragile construction, possess an inherently long functioning time, usually in the order of 25 milliseconds, when compared with switches constructed in accordance with this invention wherein the material itself changes into a conductive gaseous state. The electrical resistance of the ionized air type of switch is also relatively high since the conduction of the switch is dependent upon the resistivity of a path through ionized air.

Accordingly, it is an object of this invention to provide an electrical switch which possesses a fast functioning time while exhibiting low internal resistance.

Another object of this invention is to provide a switch which is not vulnerable to shock, vibration or acceleration forces.

Yet another object of the invention is to provide an electro-chemical switch which does not require the presence of air for proper operation.

Still another object of this invention is to provide a switch which has no moving parts and is relatively simple, easily and cheaply constructed.

A further object is to provide a switch which may be actuated by any one of a plurality of circuits and which, when operated, will assure that the switch will remain conductive.

Generally described, this invention comprises a closed container with four or more electrical contacts extending through the container walls. At least two contacts, hereinafter called triggering contacts, are permanently connected to one or more electric ignition circuits consisting of an explosive material which produces an electrical conductive gas upon burning. This explosive material may be ignited by any proper electrical stimulus applied to the triggering contacts. Two or more additional electrical contacts, hereinafter called the switch contacts, are electrically insulated from each other and are not connected to the explosive material nor to one another. When an electrical potential is externally applied across the switch contacts prior to ignition, no current flows except leakage current across the insulating material. Upon ignition of the explosive material through the triggering contacts, the material produces conductive gaseous vapor which is transmissible and highly conductive to an electrical current. The gaseous vapor is propagated by the explosion to the space between the insulated switch contacts. Since this gas is highly conductive, the gas introduces a low resistance path between the switch contacts thereby allowing current to flow through the switch.

The novel features that are considered characteristic of this invention will be better understood from the following description taken in connection with the accompanying drawings in which:

FIGURE 1 is a cross-sectional view of a practical device embodying the invention, while

FIGURES 2 and 3 show modifications of certain elements of FIGURE 1.

Referring now specifically to the drawing, FIGURE 1 illustrates an instantaneous electro-chemical switch **1** constructed in accordance with this invention. The switch **1** consists of a tubular container **2** having threaded ends **3** and **4**. Caps **5** and **6** are shown threaded onto the container **2** so as to retain the end plugs **7** and **8**, which are constructed of electrical insulated material, within the ends of the container. Since no air is required for operation of the switch, the container may be constructed so as to be air tight with any air present within the container being exhausted thus forming a vacuum. Extending through the plug **7** are two electrical conductors **9** and **10**, hereinafter called triggering contacts,

which are connected to an igniting element 11 such as, for example, an electrical resistance wire. Placed immediately adjacent to the element 11 is an explosive material 12 capable of being ignited when the element 11 has an electrical potential applied to it through the triggering contacts 9 and 10. The explosive material 12 is of the type that, upon burning or detonation, produces a gaseous vapor that is electrically transmissible and conductive. The balance of the region 13 may also be filled with the same or different explosive material if such is found desirable. If additional material is placed within the region 13, this material may be confined to region 13 by using any suitable cap or diaphragm placed across the tube 2.

The electrical insulated end plug 8 has two electrical conductors 14 and 15, hereinafter called switch contacts, extending through the plug into the region 16 defined by the end plugs 7, 8 and the tubular casing 2. Region 16 may be under vacuum if such is desirable. The ends 17 and 18 of the switch contacts are spaced from one another by a suitable distance and from the explosive material 12 by a distance that can be controlled by proper selection of the ferrule 19. The ferrule 19, shown in FIGURE 1, is an annular sleeve like member adapted to be inserted into the tube 2. This ferrule serves as a spacer between the end plugs 7 and 8 by preventing the portion 20 of plug 7 from being seated directly against the recessed portion 21 of the tube 2. It can readily be seen that by using a ferrule having different lengths, the distance between the switch contacts and material 12 may be increased or decreased. Assuming a shorter ferrule 19 is used, this would allow the cap 5 to be threaded further down the tubular container 2 thereby moving the end plug 7 inwardly and closer to the end plug 8. This of course will shorten the distance by which the material 12 and the switch contacts are separated. By thus adjusting the spacing of these elements, the time that is required for the exploding conductive gas to move from where the material 12 is located to the switching contacts, thereby causing the switch to close, may be varied. The length of time required for conduction to occur is, therefore, determined by the length of time required to ignite the explosive material 12, and to transmit the conductive gaseous vapor produced to the space between the switching contacts 17 and 18. The length of time required to operate an electro-chemical switch constructed in accordance with this invention has been found to be well under five microseconds.

As can readily be seen by proper selection of the ferrule used, the switching time may be varied. This adjustment in switching time allows direct substitution of a switch of the present invention in circuits requiring longer switching time than five microseconds such as, for example, delayed electrical fuses that heretofore have used conventional switches. By using switches of the present type in such circuits, additional reliability at a reduction in cost and weight is readily achieved.

FIGURE 2 shows a modification of the end plug 7 in which numerals refer to like parts as described in reference to FIGURE 1. End plug 7 is shown with an additional electrical connector 22 which is electrically connected to the center of the igniting wire 11. This arrangement of connectors and igniting wires allows two external firing circuits to be connected to the switch with either circuit being able to close the switch by applying an appropriate potential between connector 9 or 10 and the common connector 22. As can readily be seen, this arrangement may be expanded so that any desired number of external firing circuits may be connected to the switch and yet the circuits will not be unduly influenced by one another since they are effectively isolated from each other by the resistance of the igniting wire 11 which may be selected to be high if desired.

The amount of explosive or combustible material 12 and the strength of the tubular container 2, shown in FIGURE 1, may be balanced to permit the switching assembly to remain intact for a finite length of time thereby assuring that conduction has taken place and that the circuit to be controlled has received a proper operating signal through the switch.

However, if it is desirable that permanent conduction take place through the switch even though the container is ruptured upon firing of the explosive material, an end plug as shown in FIGURE 3 may be used. In FIGURE 3, like reference numerals refer to like parts as defined in reference to FIGURE 1. Between the ends 17 and 18 of the conductors 14 and 15 is an explosively operated mechanical switch, represented by box 20, of any type such as is well known in this art. The only requirement placed upon the type switch used is that it must fit within the space available and that it will close upon igniting of the explosive material 12. The leads 23 and 24 from the mechanical switch 20 are secured to the ends 17 and 18 respectively of the conductors 14 and 15. The switch 20 is normally open thereby passing no current between the ends of the conductors; however when the explosive material 12 is ignited the switch 20 will be closed in a manner well known in the art. The closing of the switch 20 will assure that an electrical conductive path between the ends 17 and 18 will be maintained even should the container 2 rupture and allow the conductive gas created by the explosion to escape. It should be noted that the instantaneous speed of the electro-chemical switch is not affected by the addition of the mechanical switch 20 since conduction between the ends 17 and 18 through the gas will still occur in a manner described in reference to FIGURE 1. The addition of switch 20 only insures that continued conduction will occur if the container is ruptured by the explosive material.

From the above description it will be apparent to those skilled in the art that the invention can be constructed from a number of components and materials, and in a number of embodiments, without departing from the scope and spirit of the invention. For example, the electro-chemical switch could be constructed of one piece tube and plug assembly made of glass or plastic, or a plurality of pairs of switch contacts could be provided if a greater number of output circuits were to be controlled. Since variations of the switch are possible, it is intended that the invention be limited only by the scope of the appended claims.

What I claim and desire to protect by Letters Patent is:

1. An electrical switch comprising a tubular means, a first end plug inserted into one end of the tubular means, sleeve means inserted in the tubular means against which the first end plug rests, the sleeve means being replaceable by shorter or longer sleeve means to thereby vary the distance that the first plug may be inserted into the tubular means, a second end plug inserted into the other end of the tubular means, means securing the first and second end plugs into the respective ends of the tubular means thereby forming an enclosed chamber, a first set of conductor means electrically separated from one another and extending through the first plug into the chamber, a conductive gaseous producing explosive material located within the chamber to be ignited by the first set of conductors, a second set of conductor means extending through the second plug into the chamber, the ends of the second conductors extending into the chamber being spaced and insulated from one another, a first circuit means connected to the first set of conductor means and adapted to produce a potential for igniting the explosive material so that a gaseous electrical conductive material is produced, a second circuit means connected to the second set of conductor means whereby an electrical circuit is established through the gaseous electrical conductive material, second conductor means and the second circuit means.

2. An electrical switch in accordance with claim 1 in which the first set of conductor means consists of at least

three conductors, the conductors being paired and having interconnections for igniting the explosive material in response to flow of current in any pair of conductors.

3. An electrical switch in accordance with claim 1 in which a mechanical switch is electrically connected between the ends of the second conductor means, the said mechanical switch being adapted to establish an electrical circuit between the conductors when the explosive material is ignited.

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