FIRING DEVICE FOR AN INITIATOR

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Appl. No.: 13/102,329

Filed: May 6, 2011

ABSTRACT

An initiator firing device has a firing member adapted to generate heat for allowing the initiation of an energetic material arranged in the initiator. The device also has an electrical switch mounted in series with the firing member, the switch changing from an open condition to a closed condition by application at its terminals of a voltage higher than a predetermined cut-in voltage.
FIRING DEVICE FOR AN INITIATOR

FIELD OF THE INVENTION

[0001] The present invention relates to a firing device for firing an initiator. Advantageously, the initiator, which is electrical, will be a pyrotechnic initiator, a priori a controllable pyrotechnic initiator. Typically, it can be an igniter or a detonator. More particularly, the firing device will be of the type allowing the ignition of the initiator by heat production, mainly by Joule effect or by radiation.

BACKGROUND OF THE INVENTION

[0002] Is already known a projected-layer detonator that allows the initiation of a secondary safety explosive induced by a primary impact or initiation. In such a detonator, an electric conductor produces plasma used for propelling at high velocity a small projectile delivering the shock wave required for the initiation of the secondary explosive. Such a detonator requires a voltage equal to or higher than 2000 V and a voltage rise time lower than 1 µs, which leads to the use of a complex power supply and a very demanding low inductance connector technology.

[0003] This particularly high voltage allows the projected-layer type to meet the STANAG 4560 safety standards, notably preventing the initiator from reacting when an alternating current of 500 V (with peaks of 710 V) is directly connected on its terminals, otherwise the initiator shall mechanically interrupt the pyrotechnic chain located downstream of the energetic material.

[0004] However, this particularly high voltage exhibits the drawback of having a rather cumbersome firing device, therefore limiting the use of the projected-layer detonators.

[0005] Furthermore, is also known an optical detonator wherein a laser emitted by a laser source (preferably, a laser diode) ignites a secondary explosive arranged in a first level that propels a small projectile delivering the shock wave required for the initiation of the secondary explosive of the second level.

[0006] Such a detonator has several advantages, particularly, that of requiring very little energy (a laser diode requires less than 2 W and less than 1 A to emit light), of being compact (the laser diode is less cumbersome than a low voltage converter/high voltage converter), and of not being very sensitive to static electricity (the optical fiber may be up to hundreds of meters long, the laser diode may be integrated in the protected enclosure of the computer).

[0007] Nevertheless, the "laser diode-fiber-opto-pyrotechnic initiator" set is equipped with an electrical initiator, for the first time, in the third edition of the STANAG 4368 standard from the fact that the laser diode is an electrical component. Consequently, as 2 V are enough for initiating the laser diode, such a detonator cannot remain insensitive to an alternating voltage of 500 V and, so as to respect the aforementioned 4560 STANAG safety standard, it should exhibit an interruption of optical line, upstream of the energetic material initiated by the laser light.

[0008] Yet, an optical switch arranged on the optical fiber is cumbersome, has additional cost and is unable to stand up to harsh environments (mechanical and thermal) that some initiators endure.

[0009] US 2008/0112235 discloses the fact of protecting the heating component of an initiator by an electrical component, swapping by itself from an insulating state to a conducting state, and that is only from a certain voltage at its terminals. Yet, this electrical component does not act as a switch: the switch is added in series to the protection component. FR 2408114 and FR 2866703 also refer to the same type of protection as the one described above. In FR 2408114, various electronic components are concerned and wherein the thyristor is used as a switch guided by its trigger. In FR 2866703, the component is called micro switch and acts as a breakable insulator or a spark-gap.

[0010] Thus, an initiator firing device is already known, said device comprising a firing member adapted to generate heat for initiating an energetic material arranged in the initiator, an electrical switch arranged in series with the firing member and switchable between an open position to a closed position via application, on its terminals, of a voltage higher than the predetermined cut-in voltage.

[0011] However, this does not address the above mentioned problem.

[0012] It should also be noted that in WO2008/112235, repeated mention is made to TVS and not to thyristor. And yet, the TVS are different components (made of avalanche diodes). Their breakover voltages are very low in this case.

[0013] In addition, in the prior art documents, the thyristor was only mentioned in its normal function of a switch controlled by its trigger. It was not used outside its normal function and limits, in contrast to the requirement of the invention.

SUMMARY OF THE INVENTION

[0014] The invention is intended to produce a firing device that allows the initiator with which it is associated be insensitive to the alternating voltages of 500 V (and thus not requiring a line interruption), while being compact.

[0015] A proposed solution provides in this respect that the electrical switch comprises at least one thyristor having a non-used trigger and a breakover voltage corresponding (i.e. equal) to the predetermined cut-in voltage.

[0016] Thus, the switch itself will be the protection component.

[0017] In the present solution, it is further recommended that the firing member is a resistive element (for an electrical initiator) or a laser diode (for an optical initiator).

[0018] In order to meet the STANAG 4560 safety standard, the electrical switch is selected so as its predetermined cut-in voltage is higher than 500 V (alternating voltage), which corresponds to peaks of 710 V. Moreover, to guarantee compactness and simple setting, the electrical switch is selected so as its predetermined cut-in voltage is lower than 1000 V.

DESCRIPTION OF THE FIGURES

[0019] Other features and advantages will appear more fully in the following embodiments given only by way of non-limitative examples and illustrated in the accompanying drawings, wherein:

[0020] FIG. 1 illustrates a diagram of a firing device of a first embodiment, the device comprising, in series, a thyristor and a diode, FIG. 1 showing also a diagram illustrating the voltage U and the light output I, according to the intensity I.

[0021] FIG. 2 illustrates a firing device of a second embodiment, said device comprising, in series, a thyristor and a resistive component, FIG. 2 showing also a diagram illustrating the voltage according to the intensity I.
FIG. 3 illustrates the intensity crossing the firing device of the first embodiment for an alternating current with 660 V spikes.

FIG. 4 illustrates the intensity crossing the firing device of the first embodiment following application of a voltage of 800 V.

FIG. 5 illustrates the intensity crossing the firing device of the first embodiment following application of a voltage of 1000 V, and

FIGS. 6 and 7 represent each a diagram of a firing device of another embodiment, said device comprising, in series, FIG. 6, a triac and a diode and, FIG. 7, a triac and a resistive component.

**DETAILED DESCRIPTION OF THE INVENTION**

The invention relates to a firing device 1 allowing the ignition of an electrical initiator. Such an initiator may be used for firing actuators or propellants.

Powder or explosive firing devices are involved.

The firing device 1 comprises a firing member 2, 3 adapted to generate heat allowing the initiation of an energetic material arranged in the initiator.

In the first embodiment, the firing member is a laser diode 2 that allows the generation of a laser light which, after focalizing, allows igniting the energetic material enclosed in the initiator.

As illustrated in FIG. 1, the laser diode 2 starts conducting the electrical current from a voltage threshold (Ud1 curve) and, from a minimal intensity crossing through, emitting a light the power of which is proportional to this intensity (curve I).

In the second embodiment, the firing member is a resistive element 3 (here, an electrical resistance 3) that generates, by Joule effect, heat allowing igniting the energetic material enclosed in the initiator.

As shown in FIG. 2, the intensity crossing the resistance 3 is proportional to the voltage at its terminals (curve Ur), and the delivered power is proportional to the square of this intensity.

The firing device 1 also comprises an electrical switch 4 mounted in series with the firing member 2, 3 and which switches between an open state and a closed state by application of a voltage higher than the predetermined cut-in voltage. More particularly, the electrical switch 4 comprises (at least) a thyristor 4 the trigger of which is not used, with a breakover voltage equal to the predetermined cut-in voltage. In the embodiments of FIGS. 1 and 2, the electrical switch 4 is a single thyristor.

Typically, such a thyristor is intended for being used with a voltage inferior to its breakover voltage and switching from its open position to its closed position by application of an electrical pulse on its trigger. In the present invention, the trigger is not used, the characteristic of the thyristor utilized is its switching from its open state to its closing state, following application, between its cathode and its anode, of a voltage higher than its breakover voltage (cf. Ut curve of FIGS. 1 and 2).

Thus, the firing device 1 of the present invention does not conduct current when the predetermined cut-in voltage of the electrical switch 4 is not reached (cf. FIGS. 3 and 4 wherein the intensity crossing through remains zero). When this predetermined cut-in voltage is reached, the firing device 1 acts as the firing member 2, 3 by itself with a voltage a bit higher (cf. curves U of FIGS. 1 and 2).

FIG. 5 illustrates the behavior of a firing device 1 following the application of a voltage of 1000 V at its terminals: once the voltage reaches the breakover voltage of the electrical switch function thyristor 4 (here, 900 V), an electrical current crosses the device, which allows the ignition of the associated initiator.

The electrical initiator 4 and the initiation member 2, 3 can be placed in the same casing so that they come together as one component (with only two connections at the output of the casing—the trigger being not used). The electrical switch 4 and the heating component 2, 3 may be arranged side by side or fused onto the same substrate.

The use of an electrical switch 4 the predetermined cut-in voltage of which (the breakover voltage in the case of a thyristor) is higher than the peaks of 710 V of an alternating voltage with 500 V allows to meet the STANAG 4560 safety standard, without interruption of the line. Accordingly, such a firing device 1 allows having a highly reliable and a highly safe initiator, at the level of functioning, handling and implementation. In addition, the costs of electrical switches such as the thyristors or the triacs are low, allowing for the production of very highly safe initiators at a very low price compared to those that are currently on the market.

Furthermore, the use of an electrical switch 4 the predetermined cut-in voltage of which (the breakover voltage in the case of a thyristor) is lower than 1000 V allows to have a simple implementation and therefore to miniaturize the firing device 1. For example, it is possible to use such a device for the firing of four impulsors onboard a 30 mm diameter projectile.

In addition, to have the smallest circuit possible, it is favorable to select an electrical switch 4 the breakover voltage of which is scarcely over that allowed under the regulations (typically, starting from 800 V).

These initiators’ firing devices are therefore of the utmost safety while not being of high energy.

They enable the firing of detonators meeting the 4187 STANAG standards and comprising only the secondary explosives which are conform to the STANAG 4170 standards, as well as the firing of igniters in line with the 4368 STANAG standards and charged with safety pyrotechnic compositions. As a reminder, an igniter is a trigger device that produces a deflagration (rapid combustion).

In the case of an optical initiator (igniter or detonator), said initiator can be conform to one of the applications EP 1 067 356, EP 1 067 357, EP 1 306 643 and EP 1 742 009.

In the case of an electrical initiator, and more particularly, in the case of a detonator, the resistive element 3 can also be any passive electrical component (resistor or capacitor) or active (diode or transistor) enabling to transmit its heat to the energetic material with a high efficiency. Joule effect does not allow to make a secondary explosive to detonate, it is therefore required to use a two-stage detonator with a deflagration detonation transition or a shock-detonation transition. For reliability reasons, the shock-detonation functioning is favored.

Thus, the resistive element can be a tantalum capacitor having the advantages of being small, of being easy to operate, and of having two impedance curves differing according to their direction of use: this capacitor can be taken as a diac when it is stressed directly as it has a negative resistance curve above a certain limit, or to a direct diode when it is reverse stressed as it has a positive resistance curve beyond a certain limit.
Consequently, in this invention, the initiator to which is associated the firing device has the three following advantages: a reliable functioning with less than 1 000 V (and hence a simple implementation), a successful and unaltered resistance to alternating current 500 V tests, and a use of insensitive active materials.

Other embodiments are possible. Therefore, the electrical switch can be a triac.

FIGS. 6, 7 incidentally illustrate such a triac (Triode for Alternating Current)

FIGS. 6, 7 correspond to the mountings in FIGS. 1, 2, respectively, except that the thyristor has been replaced by the triac.

The triac is an electronic component equivalent to two thyristors or Semiconductor Controlled Rectifier (SCR) mounted anti-parallel to each other. A triac is sometimes referred to as a bidirectional thyristor. It has the same characteristics as those of the thyristor, and can be used here in the same way as the thyristor, instead of said thyristor, provided that it has the same breakover voltage value. It can even be considered more practical in the case of a resistive element initiator, since it can be used interchangeably in the two current flow directions and does not require tracking.

What was afore presented in relation with the thyristor operating method applies to the triac.

Thus, in FIGS. 6, 7, it can be found the firing device 1 comprising the firing member, respectively 2 and 3, adapted to generate heat allowing the energetic material disposed within the electrical initiator to be initiated. FIG. 6, the firing member is the laser diode 2. FIG. 7, the firing member is the resistive element 3. In both cases, the firing device 1 further comprises the electrical switch 4 which presently comprises a Triac, and which is disposed in series with the firing member 2, 3. This Triac switches from an open state to a closed state by application at its terminals of a voltage larger than a predetermined cut-in voltage.

1. An initiator firing device comprising a firing member adapted to generate heat to initiate an energetic material arranged in the initiator, an electrical switch arranged in series with the firing member and having states changing from an open state to a closed state by application at terminals of a voltage larger than a predetermined cut-in voltage, wherein the electrical switch comprises at least one thyristor having a non-used trigger and a breakover voltage corresponding to the predetermined cut-in voltage.
2. The firing device according to claim 1, wherein the electrical switch comprises a single thyristor.
3. The firing device according to claim 1, wherein the electrical switch comprises a Triac.
4. The firing device according to claim 1, wherein the predetermined cut-in voltage is higher than an alternating voltage of 500 V.
5. The firing device according to claim 1, wherein the predetermined cut-in voltage is lower than 1 000 V.
6. The firing device according to claim 1, wherein the firing member comprises a laser diode.
7. The firing device according to claim 1, wherein the firing member comprises a resistive element.
8. The firing device according to claim 1, wherein the resistive element comprises a resistance.
9. The initiation device according to claim 1, wherein the resistive element comprises a tantalum capacitor.
10. An initiation system of a pyrotechnic chain comprising: a firing device which comprises a firing member adapted to generate heat to initiate an energetic material arranged in the initiator, an electrical switch arranged in series with the firing member and switching from an open state to a closed state by application at terminals of a voltage higher than a predetermined cut-in voltage, wherein the electrical switch comprises a thyristor having a non-used trigger and a breakover voltage corresponding to the predetermined cut-in voltage, and an initiator to which the firing device is connected.
11. The initiation system according to claim 10, wherein the initiator is a detonator.
12. The initiation system according to claim 10, wherein the initiator is a detonator.
13. The initiation system according to claim 10, wherein the electrical switch comprises a single thyristor.
14. The initiation system according to claim 10, wherein the electrical switch comprises a Triac.