

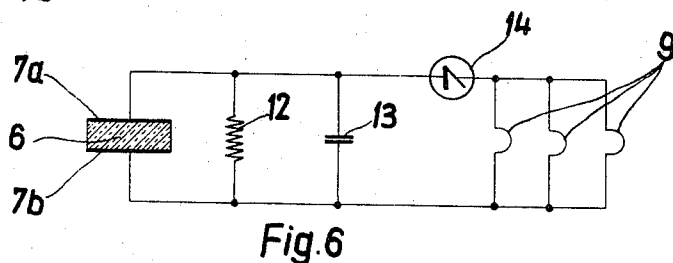
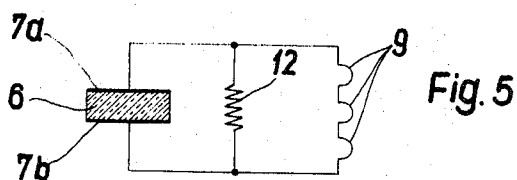
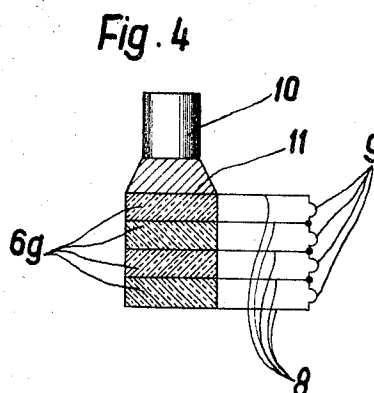
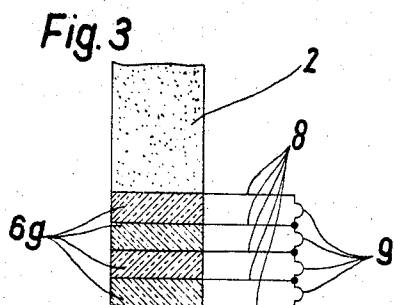
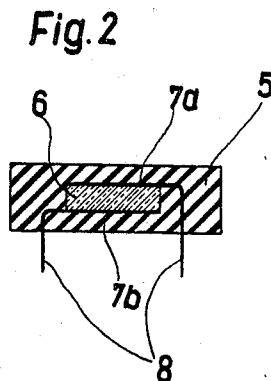
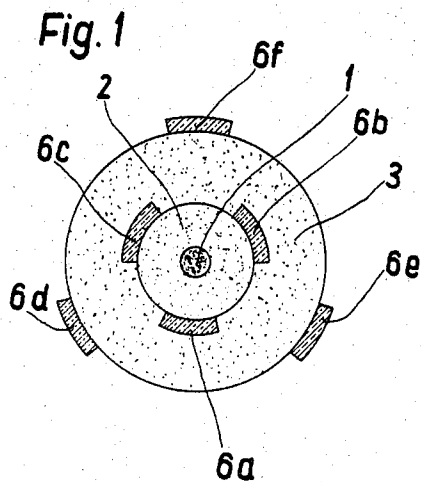
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FUSE ELECTRICALLY IGNITED BY PIEZOELECTRIC GENERATOR

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3,438,326

FUSE ELECTRICALLY IGNITED BY PIEZO-ELECTRIC GENERATOR

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15 Claims

ABSTRACT OF THE DISCLOSURE

The disclosure relates to a fuse electrically ignited by a piezoelectric generator which latter is activated by mechanical energy applied thereto. A relatively small auxiliary explosive charge is arranged in mechanical association with the piezoelectric generator electrically connected to the fuse. A mechanically activated fuse is operatively associated with the auxiliary explosive charge to detonate the latter to apply mechanical energy to the piezoelectric generator to ignite the electrically ignited fuse.

Various arrangements of piezoelectric generators and fuses, with various arrangements of the auxiliary explosive charge and the associated impact responsive fuse, are disclosed.

Background of the invention

The invention is directed to fuses, such as projectile fuses, which are electrically ignited by electrical currents supplied from a piezoelectric generator and, more particularly, to an improved fuse arrangement wherein a much generator mechanical force is applied to the piezoelectric generator to correspondingly generate a much higher electric current.

Piezoelectric generators providing an electric current at a certain voltage upon mechanical impact or shock, and for igniting fuses, are known. For example, such an arrangement is shown in German Auslegeschrift No. 1,001,160. The electrical energy output of the piezoelectric ignition generator is very small, due to the usually relatively low mechanical impact energy transferred to the piezoelectric ignition generator. For this reason, only extremely sensitive electrical fuses, having an energy requirement of only a few microjoules, can be ignited by such a piezoelectric generator.

For the purpose of reliably igniting relatively low ohmic fuses, which have a larger energy requirement and therefore are less sensitive to interference impulses, it has been proposed to interpose spark gaps for energy concentration and transformers for impedance matching, as disclosed, for example, in the above mentioned German Auslegeschrift. However, it has been found in practice that, even when such additional electrical components are used, the ignition of detonating charges by piezoelectric ignition generators can not be completely guaranteed. For example, when a projectile hits a target at an unfavorable angle, only a relatively small component of the mechanical impact force may act fully upon the piezoelectric ignition generator. In such case, the electrical energy output of the piezoelectric crystal is insufficient to ignite an insensitive electrical fuse, even when impedance matching and energy concentration are at an optimum.

In many war heads, such as, for example, hollow explosive charges, there is the additional problem of conducting a detonation initiated, for example, at the tip of a war head, as quickly as possible to a preselected detonation initiating point. The pyrotechnical means

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principally used for this purpose to date require high technical expenditures and involve undesirable time delays. Electrical propagation of ignition impulses to ignition initiation points more remote from the ignition generator is possible only in very limited measure due to the small amounts of electrical energy available, particularly when the projectile impact conditions are unfavorable.

Summary of the invention

The present invention is directed to an arrangement for igniting insensitive electrical fuses reliably by piezoelectric ignition generators, even when impact conditions are unfavorable. In addition, the present invention is directed to an arrangement providing a greater freedom of choice of the actual detonation initiation point, for example, in a war head.

In accordance with the invention, a relatively small auxiliary explosive charge, detonated by means of any known mechanically activated fuse, and preferably an impact responsive fuse, is provided to produce the mechanical impact energy effective on the piezoelectric crystal, thereby to increase the electrical output of the crystal.

The invention utilizes the extremely high pressure developed during the explosive reaction of an explosive material to provide a compressive stress concentration at a piezoelectric ignition generator. This makes it possible to generate a considerably greater amount of electrical energy or considerably higher output voltages. Thus, higher electrical energy is available to an extent sufficient for the ignition of insensitive, relatively low ohmic, electrical fuses without the necessity of additional means for energy concentration or impedance matching. Due to the fact that the piezoelectric ignition generator is activated by an auxiliary explosive charge, the energy output of the ignition generator is always the same and of an optimum magnitude irrespective of impact conditions, and is determined solely by a suitable choice of the auxiliary explosive charge.

By means of a traditional fuse, for example a percussion fuse with a breech cap, a small auxiliary explosive charge is detonated to provide a strong pressure wave acting upon the piezoelectric crystal causing the latter to develop an optimum amount of output electrical energy.

As a further development of the invention, several electrical fuses can be connected in the ignition circuit of a piezoelectric ignition generator, thus making it possible to transmit, through appropriate electrical connections, a detonation, initiated in a traditional manner at the tip of a war head, for example, to any detonation initiation points of the main explosive charge and virtually without delay. In this arrangement, only relatively small amounts of explosive material are detonated by a primary fuse of the traditional type, so that the pressure developed by such detonation acts upon a piezoelectric ignition generator which ignites, through electric conductors laid in any desired manner, electrical fuses disposed anywhere at or in the main body of explosive material and with substantially no time delay.

If several electrical fuses are connected to one piezoelectric ignition generator, as if they are in the same ignition circuit, the fuses can be selectively arranged either in parallel with each other or in series with each other. The series arrangement has the advantage that it effects simultaneously an impedance matching between the relatively low ohmic electrical fuses and the relatively high ohmic piezoelectric crystal. The electrical delay periods from fuse to fuse must, however, be negligibly small compared to the response periods of the various fuses, but this is a condition which is automatically present due to the dimensions of conventional war heads.

In another embodiment of the invention, several piezo-

electric ignition generators are so disposed at or in an explosive material that they are activated by a detonation wave originating at a primary ignition point, with a time delay as desired, and are caused to develop electrical energy outputs. Such an arrangement is advantageous, particularly in war heads in which a precisely predetermined ignition time difference between various initiation points in the main explosive charge is necessary.

The piezoelectric ignition generators can be imbedded in an insulating housing, such as a housing of ceramic or plastic material, so as to make it impossible for the electrically highly conductive ionized gas clouds, originating from a detonation, to short circuit the various ignition generators.

When very low ohmic, and therefor insensitive, fuses are connected in parallel to a piezoelectric ignition generator, the arrangement may include a capacitor discharging through the electric fuses through the medium of a four-layer diode acting as a spark gap upon attainment of a certain threshold voltage. Such an arrangement is advantageous when the required electrical excess energy of the piezoelectric ignition generator is insufficient to ignite, for example, several electrical fuses connected to the generator at the same time, as by being connected in parallel with each other to the generator.

Accordingly an object of the present invention is to provide an improved arrangement for igniting fuses connected in an ignition circuit supplied by a piezoelectric generator.

Another object of the invention is to provide such an arrangement capable of igniting insensitive electrical fuses reliably by piezoelectric ignition generators even when impact conditions are unfavorable.

A further object of the invention is to provide such an arrangement providing a greater freedom of choice of the actual detonation initiation point of the main explosive charge.

Still another object of the invention is to provide such an arrangement including an auxiliary explosive charge detonated by a conventional fuse and providing the mechanical impact energy for the piezoelectric ignition generator.

A further object of the invention is to provide such an arrangement in which the extremely high pressure developed during the explosive reaction of an explosive material provides a compressive stress concentrated at a piezoelectric ignition generator.

Yet another object of the invention is to provide such an arrangement in which the electrical energy output or voltage output of a piezoelectric ignition generator is very substantially increased.

A further object of the invention is to provide such an arrangement in which the auxiliary charge is detonated by a conventional fuse of the mechanically activated type.

Still another object of the invention is to provide such an arrangement in which several electrical fuses are connected in the ignition circuit of a single piezoelectric ignition generator means, and located at selected respective points in the main explosive charge.

A further object of the invention is to provide an arrangement as just described in which the fuses may be selectively connected to the piezoelectric generator means either in parallel with each other in or in series with each other.

Still another object of the invention is to provide such an arrangement in which several piezoelectric ignition generators are so arranged that a detonation wave originating at a primary detonation initiating point reaches the piezoelectric ignition generators with selected time delays.

A further object of the invention is to provide an arrangement of the type described in which the piezoelectric ignition generators are imbedded in a dielectric material for protection against short circuiting by the electrically highly conductive ionized gas clouds resulting from a detonation.

Still another object of the invention is to provide an arrangement of the type described involving low ohmic fuses connected in parallel to a piezoelectric ignition generator, and a capacitor supplying the electric energy to the fuses through a four-layer diode acting as a spark gap upon attainment of a certain threshold voltage.

Brief description of the drawings

For an understanding of the principles of the invention, reference is made to the following description of typical embodiments thereof as illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is a sectional view through an explosive charge illustrating the distribution of several piezoelectric ignition generators with respect to the explosive charge;

FIG. 2 is a sectional view illustrating a piezoelectric ignition generator imbedded in a dielectric material;

FIG. 3 is a view illustrating several piezoelectric ignition generators in series association with an auxiliary explosive charge;

FIG. 4 is a view illustrating several piezoelectric ignition generators in series relation with a conventional fuse and a pressure distributing plate;

FIG. 5 is a schematic wiring diagram illustrating an electric ignition circuit in accordance with the invention; and

FIG. 6 is a schematic wiring diagram illustrating an electric ignition circuit operable to ignite low ohmic fuses connected in parallel to a piezoelectric ignition generator.

Description of the preferred embodiments

Referring to FIG. 1, a conventional fuse 1, such as an impact or mechanically activated fuse, is disposed centrally of a substantially spherical explosive charge 2 having a certain diameter, and is effective to detonate charge 2. Piezoelectric ignition generators 6a, 6b and 6c are attached to the surface of the spherical explosive charge 2 and, in turn, are imbedded in a further spherical explosive charge 3 of substantially greater diameter. Additional piezoelectric ignition generators 6d, 6e and 6f are attached to the surface of explosive charge 3. The several piezoelectric ignition generators 6a-6f may be connected by electrical conductors, not illustrated in FIG. 1 and laid as desired, to electrical fuses which have not been shown in FIG. 1 and which may be disposed as desired.

A detonation of charge 2 effected by ignition of fuse 1 causes a detonation wave which propagates spherically and, in the sectional view as shown in FIG. 1, in a circular direction, thus reaching the piezoelectric ignition generators, 6a, 6b, and 6c at the same instant and causing these to develop an electrical energy output. Thereafter, the detonation wave expands further and uniformly in the spherical explosive charge 3 and, after an additional time delay, reaches the piezoelectric ignition generators 6d, 6e and 6f causing these to develop electrical energy outputs.

With the arrangement of FIG. 1, it is possible to transmit the detonation emanating from a certain point, such as the tip of a war head, with predetermined time delays to any desired number of individual ignition generators. These generators then deliver their ignition impulses to electrical fuses, which are also disposed as desired in the main explosive charge, such as a war head. Thus, a detonation initiated at the tip of a war head can be conducted at any desired instant to any selected detonation initiation point of the war head.

FIG. 2 illustrates a piezoelectric ignition generator 6 imbedded in an insulating material 5, such as a ceramic or plastic material. Conductors 8, connected to electrodes 7a and 7b of generator 6, are led out of the insulating material at the side thereof away from the direction of incidence of the detonation wave. Thereby, the ionized gas clouds, developed in the reaction of the explosive material upon detonation thereof, are prevented from reaching ignition generator 6 during the charge build-up time and electrically short circuiting electrodes 7a and 7b. The

desired blocking effect against the ionized gas clouds can also be provided by metallic absorbers disposed between the explosive and the piezoelectric ignition generators.

In the arrangement shown in FIG. 3, several piezoelectric ignition generators 6g are superposed on each other in the form of plates, and are connected to electrical fuses 9 by conductors 8. The ignition generators 6g, arranged as a column, are so activated by a detonation wave from an auxiliary explosive charge 2 that they generate ignition impulses directly and supply them to electrical fuses 9 each associated with a respective generator 6g.

FIG. 4 illustrates a similar arrangement in which stacked ignition generators 6g associated with electrical fuses 9 are activated by a conventional fuse 10 of relatively small dimensions through the medium of a pressure distributing plate 11. The generators 6g supply ignition impulses to electrical fuses 9 in the same manner as in the arrangement shown in FIG. 3.

In the electrical ignition circuit shown in FIG. 5, a piezoelectric ignition generator 6 is illustrated as having electrodes 7a and 7b. A resistor 12 is connected in parallel with generator 6 to suppress stray currents, and electrical fuses 9 are connected in series with generator 6. The electrical energy output of ignition generator 6 is sufficiently large to ignite fuses 9 reliably even without additional electrical components, such as energy concentration or impedance matching components.

Another form of ignition circuit is illustrated in FIG. 6 wherein, in addition to the circuit components shown in FIG. 5, a capacitor 13 is connected in parallel with ignition generator 6, and a four-layer diode 14 is connected in series with electrical fuses 9 connected in parallel with each other. In an arrangement where several electrical fuses are connected in parallel to a single piezoelectric ignition generator, if the electrical energy output of the generator is insufficient for positive ignition of all the connected electrical fuses, the energy output of ignition generator 6 is first stored in a capacitor 13. The voltage of capacitor 13 increases until it reaches the threshold voltage required to trigger four-layer diode 14 conductive. Capacitor 13 then suddenly discharges through the then conductive four-layer diode 14 and the electrical fuses 9.

Such four-layer diodes are particularly suited as spark gaps in ignition circuits, because their internal resistance is very small at the instant they become conductive, and thus the voltage drop across such a diode is less than one volt.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. In a fuse arrangement including at least one electrically ignited fuse constructed to detonate a main explosive charge and connected in an electric ignition circuit connected to the output of at least one piezoelectric generator activated by mechanical energy applied thereto, the improvement comprising, in combination, at least one relatively small auxiliary explosive charge in mechanical association with said piezoelectric generator; and at least one mechanically activated fuse operatively associated with said auxiliary explosive charge to detonate the latter to apply mechanical energy to said piezoelectric generator to ignite said electrically ignited fuse.

2. In a fuse arrangement, the improvement claimed in claim 1, including plural electrical fuses arranged at

predetermined locations within the main explosive charge and connected to the ignition circuit of said piezoelectric ignition generator.

3. In a fuse arrangement, the improvement claimed in claim 2, in which the electrical fuses connected in one common ignition circuit are connected in parallel with each other.

4. In a fuse arrangement, the improvement claimed in claim 2, in which the electrical fuses connected in one common ignition circuit are connected in series with each other; the mutual spacing of said fuses being so selected that the electrical delay periods of the respective ignition impulses are negligible.

5. In a fuse arrangement, the improvement claimed in claim 1, including plural piezoelectric ignition generators mechanically associated with a single auxiliary explosive charge; said generators being at different distances from a detonation initiation point.

6. In a fuse arrangement, the improvement claimed in claim 5, in which said distances are equal to each other.

7. In a fuse arrangement, the improvement claimed in claim 5, in which said distances are unequal.

8. In a fuse arrangement, the improvement claimed in claim 1, in which said piezoelectric generator has output electrodes connected to said ignition circuit; and means insulating said electrodes relative to the ionized gas clouds developed by detonation of said auxiliary explosive charge.

9. In a fuse arrangement, the improvement claimed in claim 8, in which said means comprises metallic means.

10. In a fuse arrangement, the improvement claimed in claim 8, in which said means comprises ceramic material.

11. In a fuse arrangement, the improvement claimed in claim 8, in which said means comprises cast resin material.

12. In a fuse arrangement, the improvement claimed in claim 1, including a plurality of piezoelectric ignition generators superposed to form a column.

13. In a fuse arrangement, the improvement claimed in claim 12, in which said auxiliary explosive charge is in the form of a column engaged with one entire surface of one piezoelectric ignition generator.

14. In a fuse arrangement, the improvement claimed in claim 12, including a pressure distributing plate in engagement with one entire surface of one piezoelectric ignition generator, and operable to distribute the mechanical impact energy of said auxiliary explosive charge over said one entire surface.

15. In a fuse arrangement, the improvement claimed in claim 1, including a capacitor connected across said ignition circuit in parallel with said piezoelectric ignition generator; and a four-layer diode connected across said capacitor in series with at least one electrical fuse.

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U.S. Cl. X.R.

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