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PIEZO-ELECTRIC ENERGY SOURCE FOR SPACE VEHICLES

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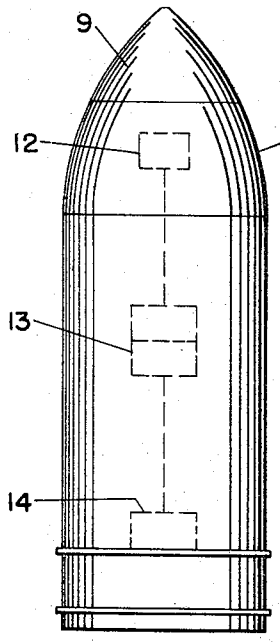


FIG. 1.

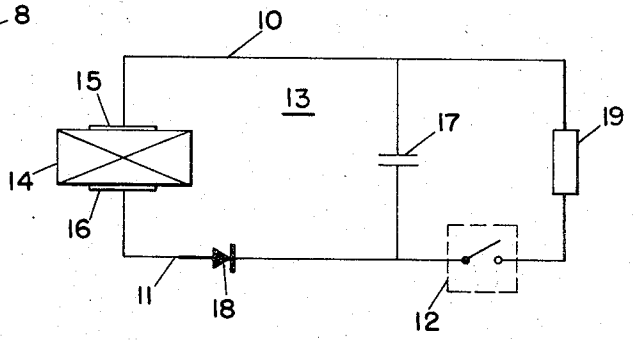


FIG. 2.

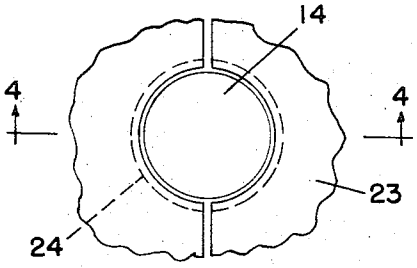


FIG. 3.

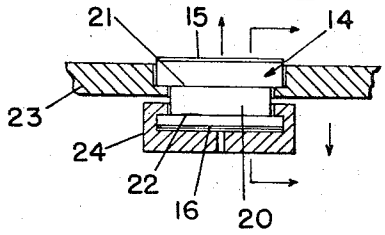


FIG. 4.

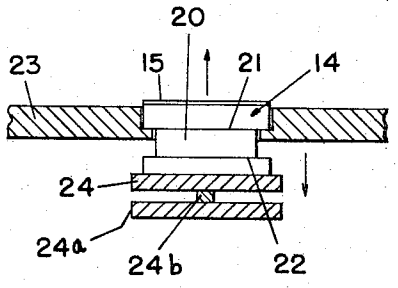


FIG. 5.

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PIEZO-ELECTRIC ENERGY SOURCE FOR SPACE VEHICLES

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2 Claims. (Cl. 310—8.4)

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 piezo-electric energy voltage sources for projectiles and like space vehicles. Upon take-off, launching or firing, projectiles, rockets, missiles, and the like space vehicles are often subject to high inertial or setback forces acting along the longitudinal or flight axes thereof due to the high degree or rate of acceleration. The setback causes a potential or voltage to be developed across the poles of a piezo-electric element by compressing it and the potential increases as setback compression increases. The setback force may increase beyond a safe limit and cause excessive potential or voltage increase. In some cases it may go as far as from double the work force to a thousand times that force for example. Thus, the piezo-electric element may be destroyed by over-voltage or burn out unless some form of protective device is provided.

In present known apparatus such a device may be in the form of a shorting bar that is acted upon by the inertial forces to move and short circuit the piezo-electric element and reduce the potential thereof to zero during a period of expected over-compression and resultant over-voltage output. When the setback forces begin to decrease and are reduced to a safe value with the projectile in flight, the shorting bar opens and a potential or voltage is once again generated across the poles of the piezo-electric element. Thus, it is left free to perform its function as a voltage for pulse source in the missile or projectile when the setback forces are reduced to substantially zero. In general, the stored charge is used in projectiles of this type to ignite or fire an electric detonator at an appointed or selectable time during flight.

As compared with other energy sources in use in military projectiles and the like, such as batteries, generators and other forms of transducers, the compressible piezo-electric generator is desirable because of its light-weight, low cost and compact structure. It provides a simplified energy source or generator for producing electric pulses or voltages at takeoff, launch or firing of the projectile, and it serves to store the pulse or voltage from that time on during the flight, whereby it may be used after launch, during flight and even during and after impact. Because of the great compressional forces to which it may be subject and which would cause over-voltage or burnout, shorting bar or like inertially-operated switch means must be added to a piezo-electric element or generator to protect it. However, it has been that the shorting bar is a troublesome mechanism in practice, that it is relatively costly to produce, and provides a wide dispersion in operating results or characteristics between individual shorting bar mechanisms. A shorting bar or like switch means also requires additional space, which may be at a premium in small space vehicles of the projectile and rocket type.

It is therefore an object of the present invention to provide an improved piezo-electric energy source for military projectiles and the like which is of simplified, low cost construction and more dependable and accurate in its operation especially for short periods of time such as

is required to ignite an electric detonator, for example.

It is a still further object of this invention to provide an improved piezo-electric pulse or voltage generator for military projectiles and the like, wherein a maximum voltage or potential is generated by setback due to the acceleration of firing, launching or takeoff, and that potential or voltage is not exceeded, and wherein no shorting bar or other switch means is required.

In accordance with one form of the invention, a piezo-electric element is subject to inertial or setback forces in tension rather than compression through a destructible coupling which connects the element with an inertial mass acting through the axis of the element to provide a tension force sufficient to generate the full voltage output before the coupling ruptures. The piezo-electric element is connected to charge a capacitor to this voltage and then the piezo-electric element itself as part of the link, or the connecting link as a separate element, is destroyed when the tension force increases and the output voltage tends to exceed the predetermined maximum safe limit without discharging the capacitor. The capacitor can hold a charge for a much longer period of time than the piezo-electric element and provides a reliable and ready voltage source for use in the projectile following takeoff or firing.

Thus, in the improved voltage or pulse generator of the present invention, a potential or voltage is generated by tension force acting on a piezo-electric element and this voltage is transferred to a capacitor, generally through a rectifier, which is poled to hold the charge after the tension force is removed from piezo-electric element. This tension force is removed by the destruction of the link coupling it with the inertial mass element by which it is placed under tension. The voltage or pulse generator of the present invention finds use in military applications and the like, where accurate (fixed voltage levels) and dependable sources of energy are required for short periods of time, such as firing electric detonators and the like.

The invention will further be understood from the following description of certain embodiments thereof when considered with reference to the accompanying drawings, and its scope is pointed out in the appended claims.

In the drawings:

FIG. 1 is a view in elevation of a military projectile embodying the piezo-electric energy source of the present invention,

FIG. 2 is a schematic circuit diagram of the interior apparatus of the projectile of FIG. 1 showing the various elements of the piezo-electric generator and the use thereof for firing a detonator,

FIG. 3 is a fragmentary plan view of a portion of the projectile of FIG. 1 showing a piezo-electric device in place therein for operation in accordance with the invention,

FIG. 4 is a cross-sectional view of the structure of FIG. 3, taken on the sectional lines 4—4 thereof, and showing further details of construction in accordance with the invention, and

FIG. 5 is a similar cross-sectional view of the device of FIG. 4 showing a modification thereof, also in accordance with the invention.

Referring to the drawing, wherein like parts throughout the various figures are designated by like reference numerals, and referring particularly to FIG. 1, a projectile casing **8** is provided with an adjustable head **9** which is connected internally with a timing switch **12** for adjusting the firing point thereof. The switch **12** controls the flow of detonating current or voltage from a piezo-electric generator or energy source **13** to the detonator **19**.

Referring to FIG. 2 along with FIG. 1, it will be seen that the piezo-electric energy source **13** comprises a piezo-electric element **14** having output electrodes **15** and **16**

on opposite faces thereof and connected in parallel relation with a storage capacitor **17** through a rectifier **18**. The timing switch **12** is connected in series with the detonator **19** to apply a firing current or voltage thereto at the appointed or selectable time determined by the adjustment of the switch **12**. The rectifier **18** is poled to pass a charge from the source **13** to the capacitor **17**, and to prevent discharge of the capacitor back through the piezo-electric device.

Referring now to FIGS. 3 and 4, the piezo-electric element **14** is provided with an intermediate section **20** of reduced size and tensile strength between its two end faces and electrodes **15** and **16**.

In the present example, the piezo-electric element is round so that the section **20**, which is the mid-section, is effectively of reduced diameter with respect to the ends and is thus provided with two shoulders, an upper shoulder **21** and a lower shoulder **22** as viewed in FIG. 4. A suitable holder or mounting plate **23** engages and holds the upper section of the piezo-electric device while the lower section below the section of reduced diameter **20** carries a tension mass or body **24** which locks onto the shoulder **22** as indicated in FIG. 4. Setback causes the tension mass **24** to exert a stretch or tension on the neck or reduced section **20** and applies sheer stress on the lower section of the piezo-electric element. The tension force on the piezo-electric element generates a potential or voltage across the poles or electrodes **15** and **16**.

The potential or voltage output is used to charge the capacitor **17** through the rectifier **18**. At a predetermined value of the applied tension force which would tend to cause an excessive voltage to be generated, the construction is such that either the neck or section of reduced size **20** fails from tension or the lower section of the piezo-electric element shears at the shoulder **22** as the tension force is increased. Thus, the maximum potential or voltage which existed at the moment of break is the potential or voltage which is stored in the capacitor. The rectifier prevents the discharge of the capacitor until it is desired, that is, as when the timing switch **12** closes to apply the output to the detonator **19**, for example. Thus in the present example the final result effectively is that the capacitor is charged by inertial or setback forces. As indicated in FIGS. 3 and 4 the holder or plate **23** and the tension mass **24** may be split or divided to seat onto the piezo-electric element in connection with the shoulders **21** and **22** to hold it securely and preserve the proper tension as the acceleration increases.

Thus the piezo-electric pulse or voltage generator in accordance with the invention, generates a potential or voltage by tension force on a piezo-electric element, which voltage is transferred to a capacitor through a rectifier, and the capacitor remains charged after the tension force is removed from the piezo-electric element and at the maximum permissible voltage. In the present example, as shown in FIG. 4, the lower element of the piezo-electric device is caused to rupture and thus cut off the output voltage.

As stated hereinbefore the maximum potential or voltage which exists at the moment of break in the connection between the piezo-electric device and the inertial mass connected therewith, is the potential which is stored in the capacitor. In this system, the components are well-known, simple devices, with no shorting bar or complicated switching required. The capacitor can hold a potential or voltage for a much longer time than the piezo-electric element, and due to the fact that the rupture point of the connection with the inertial mass can be predetermined accurately, the desired maximum potential can be much more accurately set than with corresponding devices of the prior art.

Instead of breaking or destroying the piezo-electric element, substantially the same results may be obtained by having a portion of the tension mass disrupt or break off at the predetermined point having a value at which it is desired to charge the capacitor. By this means, the inertial force acting upon the piezo-electric device is maintained below a danger point in the output voltage by reason of the increased velocity or acceleration forces. This also permits the charge to be retained on the piezo-electric element as well as on the capacitor.

Referring to FIG. 5 along with the preceding figures, a modification in the construction in accordance with the above concept is shown. Instead of attaching the tension mass to the bottom of the piezo-electric element by means of a contact with the flange or edge **22**, the tension mass **24** is cemented to the bottom of the piezo-electric element as shown, thus eliminating the need for the flange on the bottom in some cases. In this construction is will be noted that the mass **24** is divided by a narrow neck **24*b*** attaching it to the remainder of the mass **24*a***. Upon increased acceleration and inertial forces causing an over-voltage from the piezo-electric element **14**, the narrow neck portion **24*b*** ruptures and removes the additional weight from the mass thereby reducing the inertial force to safe limits regardless of the amount of acceleration to which it is subjected. In some cases this may mean the entire removal of the mass except for a thin film by which it is cemented to the bottom of the piezo-electric element.

In any case, the piezo-electric element is connected with a mass which acts in a direction to apply tension to the piezo-electric element by the setback force and the connection between the piezo-electric element and the mass is ruptured at some point to remove the mass from acting thereon to a point where an over voltage would be produced. In the example of FIG. 4 the crystal or piezo-electric element itself is destroyed by the disruption of the connection between the lower element and the mass **24**, whereas in the construction of FIG. 5 the mass itself is ruptured or disconnected from the piezo-electric element which remains intact. In either case the over voltage is prevented without the use of a short-circuiting bar and its complicated and often times undependable operation.

Since this charging operation takes place at takeoff, launching or firing, the electric pulse or voltage can be stored from that time on and can be used after launch, during flight and during and after impact as desired.

In actual construction, the piezo-electric element **14** is substantially less than ½ inch in diameter although piezo-electric elements of greater or lesser diameter can be used. The maximum applied voltage between the electrodes **15** and **16** as applied to the capacitor **17** before rupture of the transistor or its connection with the tension mass can be as high as 1,000 volts D.C. as it is presently constructed. Thus a relatively high and effective pulse voltage is made available and ready for any purpose.

I claim:

1. A piezo-electric pulse generator comprising in combination:

a piezo-electric element of a round configuration having output electrodes at opposite ends thereof,

means for holding said piezo-electric element at one electrodal end thereof and applying a tension force to the other electrodal end thereof to generate an output voltage between said electrodes,

a capacitor connected with said output electrodes to receive a charge therefrom at said output voltage,

said first named means including an inertial mass coupled to said other electrodal end of said piezo-electric element for applying said tension force thereto by inertia or setback in response to accelerated movement of said piezo-electric element,

means providing a rupturable coupling between said piezo-electric element and said mass for limiting said tension force in response to an inertial or setback force which tends to cause a full output voltage output to be reached, thereby to place a full voltage charge on said capacitor,

said last-named means including a neck portion of re-

duced diameter between the electrodal ends of said element providing a flanged shoulder to which said mass is attached to effect disruption thereof and separation therefrom at the point of full voltage output, and utilization means connected with said capacitor for selectively deriving the pulse voltage output therefrom.

2. A piezo-electric voltage generator comprising in combination:

a piezo-electric element having two electrodal ends and an integral intermediate section of reduced cross-section providing a coupling link between said ends which ruptures in response to tension force of predetermined magnitude,

means for holding one electrodal end of said element fixed,

means including an inertial mass coupled to the other electrodal end for applying increasing tension force thereto in response to accelerated movement along the axis of said element to provide an increasing output voltage at said electrodal ends, said piezo-electric element having a predetermined full-voltage output in response to a tension force of said predetermined magnitude at which said coupling link ruptures thereby to cut off further tension force and voltage increase,

a capacitor connected with said electrodal ends to receive a full-voltage charge therefrom at cut-off, and

rectifier means connected serially in circuit between the piezo-electric element and said capacitor and poled for cutting off current flow from the capacitor to the said piezo-electric element.

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