United States Patent [19]

Morrow

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[54] **PIEZOELECTRIC MULTI-PURPOSE DEVICE FOR PROJECTILES (U)**

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[21] Appl. No.: **12,519**

[52] **U.S. Cl.** ..... **102/70.2 GA**
[51] **Int. Cl.** **F42c 11/02**
[58] **Field of Search** 102/70.2, 81

[56] **References Cited**

UNITED STATES PATENTS

2,596,171	5/1952	Rabinow	102/81
3,359,904	12/1967	Nerheim	102/70.2 GA
3,417,699	12/1968	Piper et al	102/70.2 R

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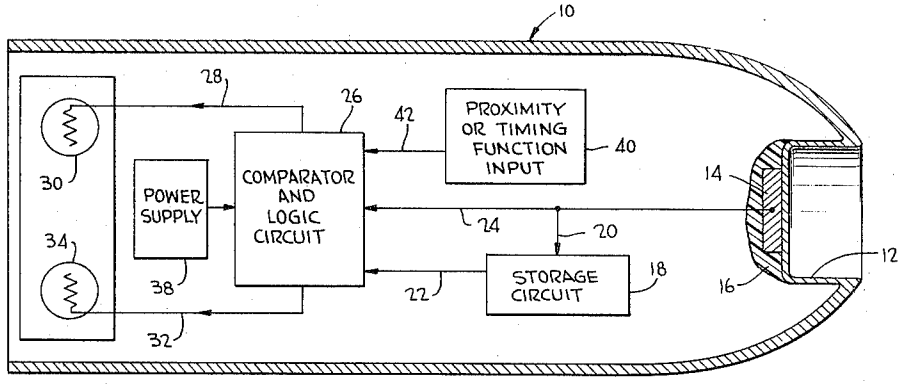
[57] **ABSTRACT**

A multi-purpose environmental sensing device for use in munition fuzing. A single piezoelectric crystal is adapted to perform three distinct functions: (1) sense launch; (2) sense velocity; and (3) sense impact. The crystal is compressed by the setback force to produce a first voltage signal. A second voltage signal is produced by air impinging upon a chamber in the nose of the fuze so as to vibrate the crystal attached to its reverse side. The fuze will arm only upon the plural validated receipt of both aforesaid signals. A third signal is created by the same crystal at impact, which is used as a point detonation trigger signal. The latter may be utilized in a main point detonation mode or as a backup to a proximity mode or preset time interval mode.

11 Claims, 2 Drawing Figures



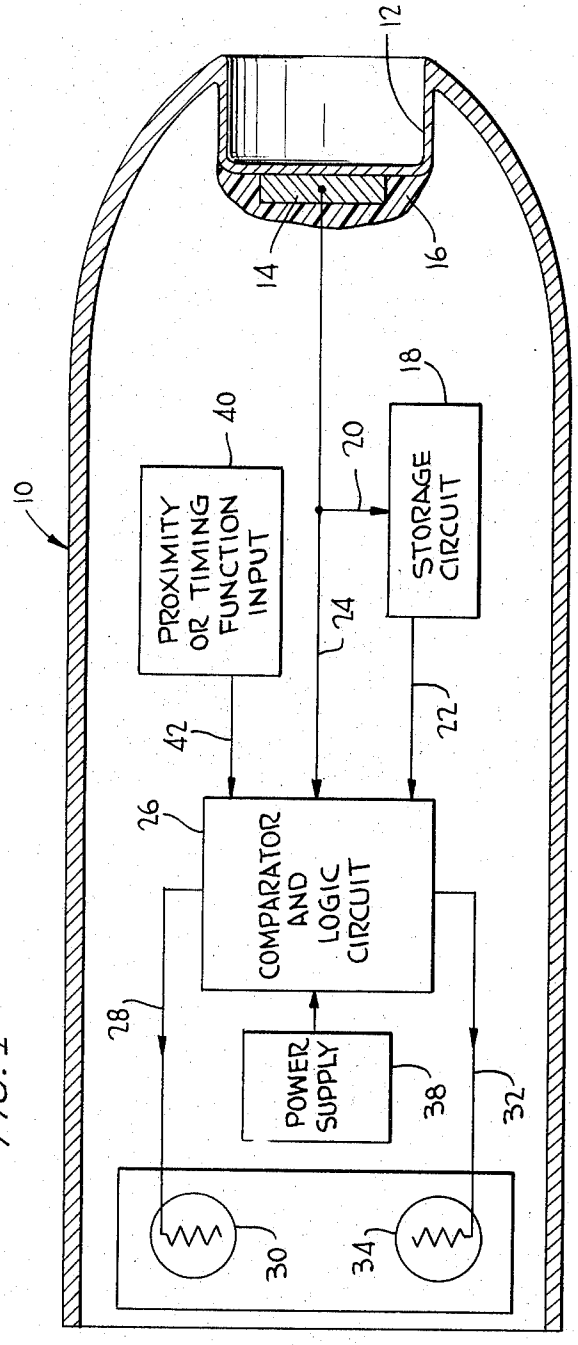


FIG. 1

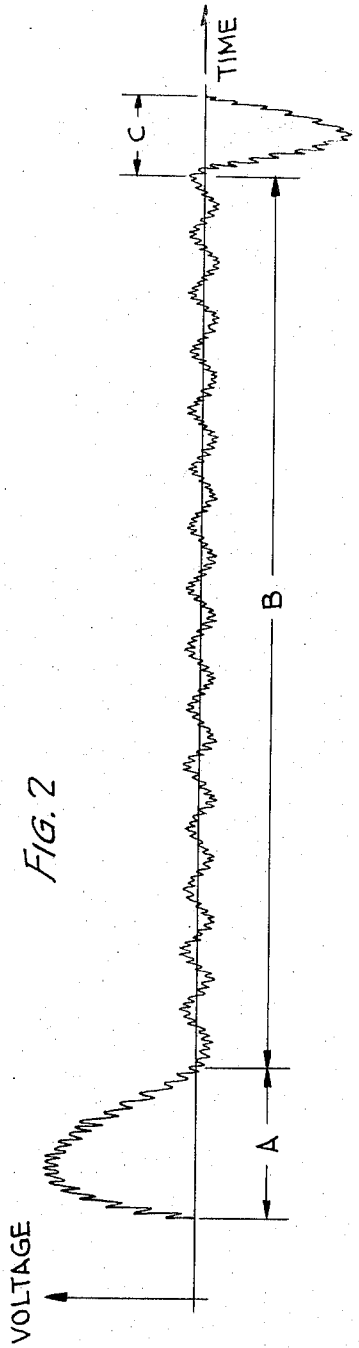


FIG. 2

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PIEZOELECTRIC MULTI-PURPOSE DEVICE FOR PROJECTILES (U)

RIGHTS OF GOVERNMENT

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

BACKGROUND OF INVENTION

This invention relates generally to munition fuzes and more specifically to munition fuzes utilizing piezoelectric crystals as environmental sensors. Much effort has been expended to develop reliable and economical sensors for use with munition fuzes to detect launch, inflight movement, and/or impact with the target and to transmit the associated information to the arming and detonating devices in the fuze for exploding the round at the optimum time. Generally, the type of devices developed for spin-operated projectiles have differed from those developed for non-spin projectiles arising from the inherent influences, associated with the spin type, such as centrifugal force. However, the parallel development of separate spin-type and nonspin-type devices to perform a particular function for different modes of operation is quite costly and involves considerable duplication of effort.

Additionally, many mechanical elements such as springs, rotors or sliding bars are commonly employed, for example, to detect the setback forces at launch which initiate various arming mechanisms. The problems associated with these types of devices have been primarily their inability to distinguish an actual launch from an accidental drop or shock that produces the same magnitude force and thus causes the fuze to arm prematurely. Such components are also subject to frictional deterioration and mechanical functioning.

Furthermore, each type of fuze requires vastly different circuitry depending on whether the fuze is intended for use as a point detonating type, i.e., a fuze that functions on impact with the target, or as a preset time fuze that is set to function after a preset time interval from launch has elapsed, or as a variable time radio fuze, commonly known as a proximity fuze. Attempts have been made to integrate two or more of the above functions into one versatile fuzing system. The results have been overly complicated, inefficient, unreliable, and costly beyond their benefit. Recognition has been made of the advantages of using piezoelectric crystals as setback or impact sensors, as evidenced by U.S. Pat. No. 3,359,904 to Nerheim, but broad application of such devices to fuzing in general has heretofore been unexplored.

A primary object of the present invention is therefore to provide a multipurpose fuzing device for use in both spin and non-spin type projectiles.

Another object of the invention is to provide a single device for use in munition fuzes that allows operation of the fuze in either a point detonation mode, a preset time mode, or a proximity mode.

An additional object of the invention is to provide a fuzing device in which a single piezoelectric crystal is utilized to perform three distinct functions.

A further object of the invention is to provide a dual influence safety and arming system for both spin-operated and non-spin projectiles.

A still further object of the invention is to provide a piezoelectric fuzing device that acts as a velocity sensor while the projectile is in flight. Another object of the invention is to provide a piezoelectric fuzing device that can be utilized as a power supply for the associated electronic components of the fuze.

SUMMARY OF THE INVENTION

Briefly, in accordance with the invention, an environmental sensing device is provided for multi-purpose use in both spin and non-spin projectiles. A piezoelectric crystal placed behind a chamber in the nose of the fuze senses the setback acceleration during launch and during the complete trajectory senses the velocity of the projectile. The velocity signal generated during flight is due to impact with air, increasing in amplitude with relative air velocity, and oscillating at the natural frequency of the crystal. If the setback signal and the velocity signal fall within predefined limits and time intervals, logic circuitry commands the fuze to arm. A signal similar but of opposite polarity to the setback signal is generated on impact for use either solely as a point-detonation function or as a backup mode in case of failure or either a proximity function or a preset time interval function. A battery may be required with low velocity projectiles to power the logic circuit; however, in some applications the velocity signal may be rectified and used as a power source.

BRIEF DESCRIPTION OF DRAWINGS

The specific nature of the invention as well as other objects, aspects, uses and advantages thereof will clearly appear from the following description and from the accompanying drawing, in which:

FIG. **1** is a block diagram of a preferred embodiment of the piezoelectric multi-purpose device of the present invention shown enclosed in a fuze body; and

FIG. **2** is a sample waveform illustrating the voltages generated by a piezoelectric crystal of the type embodied by the present invention during various points in flight.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** shows a sample fuze body **10** that encases the multi-purpose device of the present invention. At the nose of body **10** is a chamber **12** located to receive air while the projectile is in flight. Attached to the inner side of chamber **12** is a piezoelectric crystal **14**, which can be any one of a number of well-known types that generate an electric charge in response to mechanical vibration. Piezoelectric crystal **14** is held in place and protected from damage by a potting compound **16.** During in-bore acceleration occurring while the projectile is launched, crystal **14** is compressed and generates a voltage. Typically, this setback voltage is a half sine wave signal with a trailing end, as depicted by waveform segment A in the voltage versus time waveform of FIG. **2.** The magnitude and duration of waveform A can be predicted according to the charge and gun used in launch. This initial signal is fed by means of line **20** in FIG. **1** to a storage circuit **18.**

During flight, crystal **14** oscillates due to chamber **12** of fuze body **10** impacting with the air. The voltage signal generated by crystal **14** during flight has the general shape of a sine wave with superimposed noise as shown by waveform segment B of FIG. **2.** The frequency of

signal B is the natural frequency of the crystal, while the amplitude is proportional to the relative air velocity of the projectile, limited, of course, to the maximum output of the crystal in use. Thus the in-flight portion of the crystal signal output is an indication of the velocity of the projectile. The velocity signal is fed to the comparator and logic circuit **26** of FIG. **1** by means of line **24.** Meanwhile, circuit **26** has sampled the setback signal from circuit **18** by means of line **22** and has decided, as a first prerequisite to arming, whether the setback signal meets the preset amplitude requirements established for the particular projectile and gun under consideration. Shortly thereafter, circuit **26** examines both the amplitude and duration of the velocity signal to determine its validity. If both the setback signal and the velocity signal fall between predefined limits, logic circuit **26** commands the electric arming device **30** to arm by means of line **28.**

If the fuze is either of the proximity type or of the preset time interval type, the circuitry represented by block **40** will provide a detonating signal through line **42** to circuit **26,** which passes the signal out line **32** to detonator **34** is it is deemed valid.

If a point detonating function is desired, crystal **14** generates a third distinct voltage signal upon impact with the target. Comparator and logic circuit **26** triggers detonator **34** upon receipt of a proper impact voltage signal through line **24.** Circuit **26** can be keyed to trigger either upon the shock wave occuring just before impact or at impact itself. The impact voltage is represented by waveform segment C of FIG. **2.** The impact signal C is seen to be of a much higher amplitude than the velocity signal B and of opposite polarity to setback signal A, thus easily distinguishable by logic ciruitry **26.**

It is evident that the above-described invention provides a simple, lowcost, versatile safety, arming and detonating system, for use in both spin and non-spin rounds, in which a single piezoelectric crystal performs three distinct functions. In certain applications, such as in mortar fuzing, the system provides a new, additional environmental sensor (the velocity signal) that must be actuated before arming can take place, thus providing an additional safety margin in such rounds. It further provides, at no additional cost or weight, an impact signal which may be utilized as a primary detonating signal in a point detonation mode or as a fail-safe backup function if the proximity or time modes fail to operate properly.

Obvious modifications of the basic invention include keying logic circuit **26** to trigger detonator **34** upon the absence of the velocity signal, rather than upon the presence of the impact signal, thus providing a superquick point detonating capability. For certain applications, the voltage derived from the velocity signal may be rectified and used to power the fuze, eliminating the need for a separate power supply **38.** A conventionally shaped fuze ogive, as well as other designs, can be utilized if lower voltage levels are desired. Integrating the velocity signal would permit the arming of different speed projectiles at the same distance from the gun, corresponding to a variable-time arming mechanism.

I wish it to be understood that I do not desire to be limted to the exact details of construction shown and described, for obvious modifications will occur to a person skilled in the art.

I claim as my invention:

1. An environmental sensing device for use in both spin and non-spin projectile fuzes, comprising:

a. a chamber located in the nose section of the fuze body to receive air impinging thereon while said projectile is in flight;

b. a piezoelectric crystal affixed to the inner wall of said chamber;

c. storage means connected to said crystal to receive a first voltage signal generated in response to the setback forces produced as a result of the launching of the projectile;

d. means for receiving a second voltage signal generated by said crystal in response to its vibrations created by the air impinging upon said chamber while said projectile is in flight whereby the amplitude of said second voltage signal is proportional to the velocity of said projectile;

e. comparator circuitry for determining whether said first and second voltage signals fall with certain predefined voltage limits and time intervals established for the particular gun and projectile under consideration;

f. logic circuitry for producing an arming signal at a first output only upon the plural receipt of valid first and second voltage signals from said comparator means;

g. arming means for receiving said arming signal from said first output to arm said fuze; and

h. point detonating means for actuating the fuze detonator comprising receiving means for a third voltage signal generated by said crystal in response to the impact of said fuze with the target area and means within said logic circuitry for producing a detonation signal at a second output in response thereto.

2. The invention according to claim **1** further comprising preset detonating means for actuating the fuze detonator prior to said point detonating means comprising a proximity sensor circuit that delivers a signal to said detonator when a preset distance from the target is reached.

3. The invention according to claim **1** further comprising preset detonating prior to said point detonating means comprising a timing circuit that delivers a signal to said detonator when a preset time interval has elapsed from launch.

4. The invention according to claim **1** further comprising an integrator for integrating said second voltage signal for arming said fuze at preset distances from launch irrespective or projectile velocity.

5. The invention according to claim **1** further comprising means for rectifying said second voltage signal for use as a power source for said fuze.

6. The invention according to claim **2** wherein said signal to said detonator is first passed through said comparator circuitry to determine its validity.

7. The invention according to claim **3** wherein said signal to said detonator is first passed through said comparator circuitry to determine its validity.

8. An environmental sensing device for use in projectile fuzes, comprising:

a. a fuze body mounted on the forward end of a projectile;

b. a chamber formed in the nose section of said fuze body for receiving air impinging thereon while said projectile is in flight; and

c. means for generating a voltage signal in response to said impingement or air on said chamber, said means comprising a piezoelectric crystal affixed on an inner wall of said chamber within said fuze body, the amplitude of said voltage signal being proportional to the velocity of said projectile.

9. The device according to claim **8** further comprising means for determining whether the amplitude and duration of said voltage signal falls within predetermined limits.

10. The device according to claim **8** further comprising means for rectifying said voltage signal for use as a power source for said fuze.

11. The device according to claim **8** further comprising means for integrating said voltage signal to provide an output signal for use in variable-time arming means for said fuze.

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