United States Patent

Furlani et al.

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[54] ELECTRONIC DEVICE APPLICABLE TO ORDNANCE SAFETY AND ARMING SYSTEMS

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[52] **U.S. Cl.** ..... **102/70.2 R**

[51] **Int. Cl.** **F42c 11/02,** F42c 11/06, F42c 15/40

[58] **Field of Search** ..... 102/70.2 G

[56] **References Cited**

UNITED STATES PATENTS

3,353,486	11/1967	Haiken	102/70.2 GA
3,359,904	12/1967	Nerheim	102/70.2 GA
2,555,384	6/1951	Watt	102/70.2 GA
2,640,417	6/1953	Bjork et al	102/70.2 GA

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[57] **ABSTRACT**

An all-electronic device for the detection and processing of those environmental signatures associated with the launching of a munitions round. The non-mechanical device imposes stringent requirements that the environmental signatures must meet before the device will issue a command signal to arm the round. Two transducers are utilized to sense two distinct conditions that are peculiar to the round's launching. In a particular embodiment, the two transducers used are a piezoelectric crystal that senses acceleration setback and a magnet and coil arrangement that is triggered when the round leaves the gun barrel. Furthermore, the environmental signatures that are sensed must fall within certain voltage ranges and time intervals that have been preselected according to the particular weapon and round combination under consideration. When the various signals meet all requirements, the device will provide a useable signal for any subsequent delay and arming function of the round.

7 Claims, 3 Drawing Figures

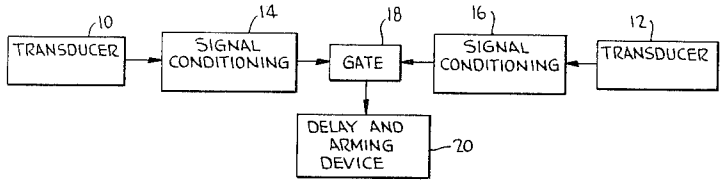


FIG. 1

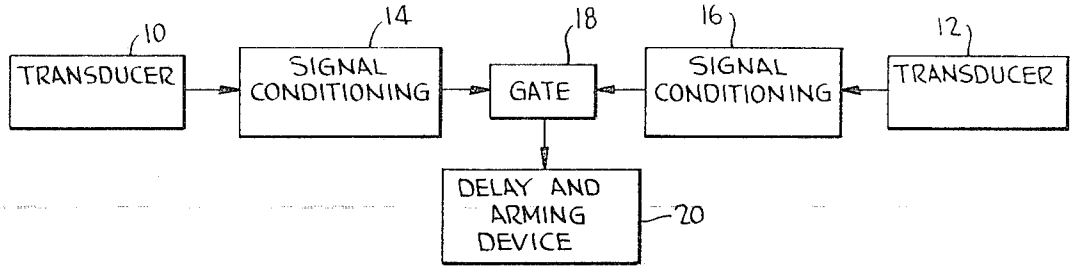


FIG. 2

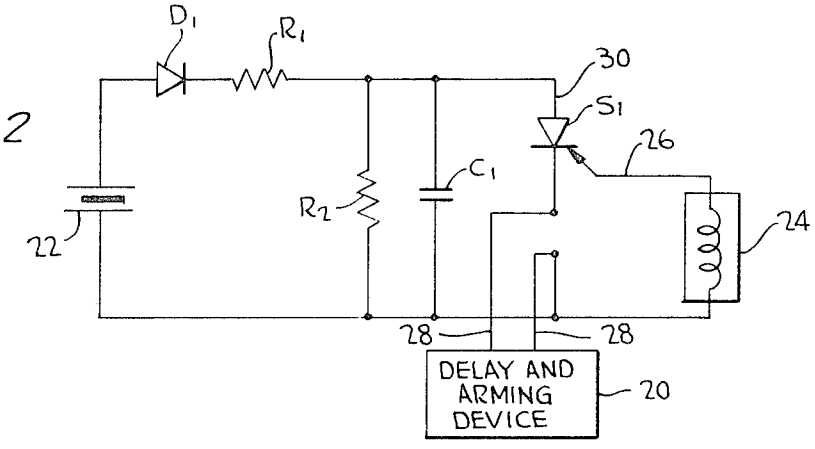
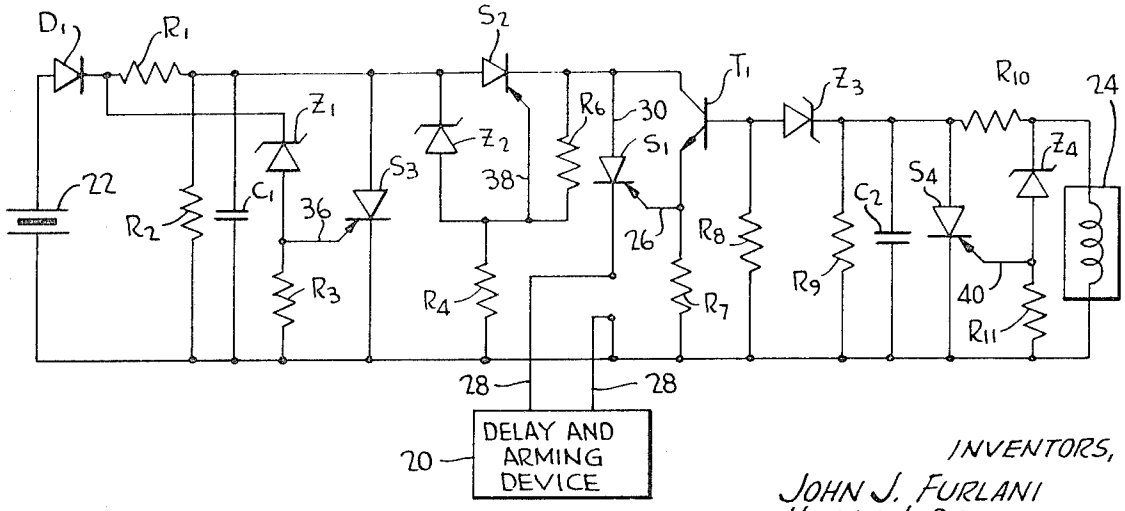


FIG. 3



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ELECTRONIC DEVICE APPLICABLE TO ORDNANCE SAFETY AND ARMING SYSTEMS

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 us of any royalty thereon.

BACKGROUND OF THE INVENTION

This invention relates generally to safety and arming devices for use in ordnance fuzing and, more particularly, to an all-electronic device that senses signatures peculiar to a projectile's launching which can be used to arm that projectile.

Safety and arming devices in general are responsible for four basic functions: discriminating, delaying, switching, and arming. The device of the present invention is primarily concerned with the first of these functions: discriminating between environmental signatures peculiar to launch and accidental spurious signals that closely approximate the desired signatures. The safety of a munitions round rests, in a large part, on the ability of the associated discriminating system to positively determine when launching has occurred. Once the signals associated with launching are sensed, a safety and arming device will process the signals by a time delay and switching scheme in order to arm the projectile in manners well known in the art.

Most discriminatory devices currently in use are mechanical in nature, employing such schemes as a mass suspended in a viscous fluid to sense a predetermined acceleration level of the projectile, or a spring or magnetically held mass that is responsive to the setback force at launch or the centrifugal forces encountered by a spin-operated projectile. Due to mechanical complexity and to the fact that appreciable movement is involved, these devices tend to lack ruggedness. Additionally, accidental dropping or the like may be sufficient to cause such a device to arm. These problems have led to the use of supplementary mechanical means that must, for example, be manually operated before the projectile is placed in the launcher for firing. Such auxiliary means often merely add to the complexity of the device while offering little additional protection against severe vibrations or shocks that the projectile may be subjected to prior to firing. Additionally, such mechanical devices are apt to lose efficiency and reliability upon exposure to environmental temperature and pressure extremes.

Accordingly, it is a primary object of this invention to provide a nonmechanical device for use in a safety and arming system that is insensitive to spurious shock and vibration prior to launching.

It is another object of this invention to provide a nonmechanical device for use in safety and arming systems that electronically senses and discriminates in favor of conditions peculiar to a projectile's launching as prerequisites to the arming of the projectile.

A further object of the present invention is to provide a nonmechanical device for use in safety and arming systems that has no moving parts therein and is thus subject to a minimum of deterioration and wear.

SUMMARY OF THE INVENTION

Briefly, in accordance with the invention, an electronic device is provided for use in a munition fuze safety and arming system. The device senses and processess electronic signatures derived from and peculiar to the projectile's launching conditions. These signatures are sensed and recognized by the device in an electronic discriminatory manner heretofore unobtained. The device in a preferred embodiment form uses two transducers that must sense two distinct signatures associated with launching and that occur in a particular time sequence in order for the device to generate an arming signal. Signal conditioning means that only pass signatures of certain preselected time or voltage levels act on the basic transducer-generated signals to discriminate against unwanted spurious signals and thus enhance the safety of the unit. The discriminatory scheme of the invention is readily integrated with other electronic fuze safety elements. Fuzes incorporating the invention are sensitive, effective, and economical to manufacture.

BRIEF DESCRIPTION OF THE 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 discriminatory scheme in accordance with the invention;

FIG. **2** is a schematic diagram of a preferred embodiment of the device of FIG. **1**; and

FIG. **3** is a schematic diagram of the device of FIG. **2** further incorporating additional discriminatory circuitry to enhance the safety of the device.

DESCRIPTION OF PREFERRED EMBODIMENT

FIG. **1** illustrates in a block diagram form the basic principle behind the electronic sensing and decision-making device suitable for ammunition use. At **10** and **12** are shown two transducers, each of which is used to detect a distinct launching condition which is transformed into a useable signal by signal processing or conditioning means **14** and **16**, respectively. The detectable launching conditions could be, for example, setback acceleration, shell vibrations, muzzle flash or an environmental change due to the shell leaving the gun's barrel. A gate **18** is responsive to the outputs of transducers **10** and **12** such that it provides a signal to the delay and arming device **20** only when the signal conditioning circuits **14** and **16** deem the detected signatures valid. Gate **18** can be made responsive only to a certain time sequence of the signatures generated by transducers **10** and **12** which would provide additional discrimination against unwanted or spurious signatures. Thus, in order for the delay and arming device **20** to receive any signal whatsoever, the signatures corresponding to the certain events during launch must occur in a certain order and within certain time intervals.

FIG. **2** shows a basic electronic schematic incorporating the features of FIG. **1**, in which transducer **10** of FIG. **1** is a piezoelectric crystal **22** and transducer **12** of FIG. **1** is a coil and magnet **24**. While experiencing setback generated by launching, crystal **22** generates a charge which energizes a firing capacitor C_1. The signal generated by crystal **22** is rectified by a diode D_1 and the time required to charge capacitor C_1 is controlled by the time constant R_1C_1.

Coil and magnet **24** is arranged in the projectile so as to experience a change in its electrical reluctance when leaving the weapon's barrel. An example of such a sensing device can be found in U.S. Pat. No. 3,417,700 by J. J. Furlani entitled "-Fuze Arming System." The change in reluctance of coil **24** generates a voltage which turns ON the silicon controlled rectifier S_1, thus delivering the energy stored in the capacitor C_1 to the output terminals **28**. The silicon controlled rectifier S_1 operates in the manner of a switch in that a signal appearing at the anode **30** of S_1 will not travel through the device until a control signal is received on the gate **26**. Upon receipt of such a control signal, the device S_1 will conduct current, switching from an OFF condition to an ON condition. Hereinafter, we shall refer to the silicon controlled rectifiers as simply switches.

A resistor R_2 will dissipate any charge stored by capacitor C_1 in the event switch S_1 does not receive a signal on its gate **26** within the time interval given by time constant R_2C_1. If a signal is received by gate **26**, the resultant electrical energy appearing at output terminals **28** is used to initiate the operation of delay and arming device **20**. This energy may for example initiate a chemical or explosive transducer, or provide a starting pulse for a timer, or be used for any number of well-

established arming schemes known in the art. It is seen in the embodiment of FIG. 2 that setback must first occur and then the projectile must leave the weapon's barrel in order for an arming signal to be generated and released. The charge-discharge time constants, controlled by the values of the resistive and capacitive components R_1, R_2 and C_1, provide simple signal conditioning means corresponding to block 14 of FIG. 1 whereby bore and storage safety can be assured.

In FIG. 3 can be found a more sophisticated embodiment which illustrates an electronic circuit that imposes more stringent requirements that a signal sensed by either transducer must meet prior to its being detectable as a valid command signal. It is assumed that the various parameters involved with the particular weapon, barrel and shell have already been carefully taken into consideration in that the detectable voltage limits of acceleration setback and barrel exit velocity have been established for a particular combination of the above parameters and have been used judiciously in the selection of component values for a particular circuit of the type as presented in FIG. 3.

In operation, the output of the setback sensing crystal 22 is rectified by a diode D_1 and time integrated by a resistor R_1 and a capacitor C_1. If the acceleration sensed by crystal 22 is greater than the specified upper limit, the amplitude of the resultant signal will cause a Zener diode Z_1 to conduct which will turn ON switch S_3 by means of gate 36 just long enough to dump the charge stored on capacitor C_1 as a result of the false signal. On the other hand, if the signal developed by crystal 22 falls below the upper limit and above the lower limit, i.e. if the acceleration meets the minimum specification, the resultant signal will cause Zener diode Z_2 to conduct which closes switch S_2 by means of gate 38, thus providing a signal at the anode 30 of switch S_1. As previously pointed out, switch S_1 remains OFF until such time as a signal is received by gate 26. As long as S_1 is OFF, capacitor C_1 will gradually discharge through resistor R_2, and also through Zener diode Z_2 and resistor R_4. Thus the gate 26 must be triggered before capacitor C_1 discharges and while Zener diode Z_2 is conducting in order for the delay and arming device 20 to receive a command signal by way of lines 28.

The magnet and coil arrangement at 24 is responsible for generating the voltage necessary to close switch S_1 by way of gate 26. Capacitor C_2 will be charged up by the voltage generated when the round leaves the end of the gun barrel. If a voltage is generated by coil 24 that is greater than that specified for the specific gun-barrel arrangement, i.e. if a high voltage spurious signal is detected, Zener diode Z_4 will conduct current through gate 40 and thus turn ON switch S_4 which acts to short circuit coil 24 and thus discharge capacitor C_2. However, if the generated voltage falls below the upper limit and above the lower limit. i.e. if the round's exit velocity is satisfactory, a Zener diode Z_3 will swing into conduction and turn ON transistor T_1 which provides current amplification for the signal and turns ON switch S_1 by way of gate 26. If gate 26 has received a signal, i.e. if the round has left the gun barrel, before the charge on capacitor C_1 drops below the threshold of Zener diode Z_2, current will flow through switch S_1 to actuate the delay and arming device 20 by way of wires 28.

Accidentally generated signals that might occur during the normal course of handling of a particular round would result in the charging of capacitors C_1 and C_2. However, such a series of below threshold signals cannot gradually accumulate on these capacitors to a dangerous level due to the presence of resistors R_2 and R_9, which will dissipate any such low level signals, thus providing additional pre-launch safety.

It should be noted that the circuit of FIG. 3 is only typical of an entire family of circuits that may be built to perform the functions according to FIG. 1. For example, if the circuit of FIG. 3 were to be built into an integrated circuit the threshold devices would probably be biased amplifiers rather than Zener diodes. Also, switch S_1 of FIG. 3 could be connected so as to enable another transducer such as a fluidic power supply. Additionally, other transducers could be substituted or added to the present scheme in order to increase the safety of the system. For example, a strain gauge could be added that would sense shell vibrations, or an optical sensor which would see muzzle flash could be substituted for either transducer. Or, a single multipurpose transducer could be utilized in a series configuration as a discriminatory device to activate the logic circuitry. Another basic modification would be to utilize external power supplies to power the system rather than the self-generating transducers 10 and 12 of FIG. 1. In this case, passive transducers could be substituted for either transducer shown. Alternatively, certain power requirements would permit the use of the output of the self-generating transducers as the power supply for the system. Additionally, the signal conditioning means could be extended to include, for example, doubly-integrating a signal received from acceleration sensitive transducers. The integrated signal would be an indication of the distance the shell has traveled from the weapon and would provide a delay function for the safety and arming device.

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

We claim as our invention:

1. An electronic device for use in an ordnance fuze safety and arming system comprising:
   a. first and second transducers responsive to launching conditions of said ordnance fuze for generating signals providing first and second environmental signatures;
   b. first and second signal processing means adapted to act on said first and second environmental signature signals, respectively, in order to electronically discriminate against and prohibit passage of signals indicative of non-launch signatures; and
   c. an electronic gate adapted to receive said first and second environmental signature signals from said first and second signal processing means, respectively, and to provide an output signal for arming means only upon plural receipt of said signatures.

2. The device according to claim 1 wherein said first transducer comprises a piezoelectric crystal adapted to sense the acceleration setback of said ordnance fuze and to generate said signals of the first environmental signature in proportion thereto.

3. The device according to claim 2 wherein said second transducer comprises a magnet and coil adapted to sense when said ordnance fuze exits from the gun barrel from which it is launched and to generate said signals of the second environmental signature in proportion thereto.

4. The device according to claim 1 wherein said electronic gate comprises a silicon controlled rectifier adapted to receive said signals of the first environmental signature on its anode and said signals of the second environmental signature on its gate whereby said output signal issues from its cathode only upon plural receipt of said signals of the first and second environmental signatures.

5. The device according to claim 4 wherein said first signal processing means comprises a storage capacitor to store a charge generated by said first transducer, a plurality of electronic switches and threshold devices to prohibit passage of any electronic signal that does not fall within prespecified voltage levels and time intervals, and which delivers passable signals to said anode of said silicon controlled rectifier.

6. The device according to claim 5 wherein said second signal processing means comprises a storage capacitor to store a charge generated by said second transducer, a plurality of electronic switches and threshold devices to prohibit passage of any electronic signal that does not fall within prespecified voltage levels and time intervals, and which delivers passable signals to said gate of said silicon controlled rectifier, whereby the receipt of said signal on said gate will release said signal on said cathode and deliver said output signal for the arming means.

7. An electronic device for use in an ordnance fuze safety and arming system, comprising:

a. means for generating a plurality of electronic signals when said ordnance fuze is launched;

b. means for inhibiting those of said plurality of electronic signals that fall beyond prespecified limits;

c. gating means for receiving those signals not inhibited by said inhibiting means; and

d. arming means for receiving a signal from said gating means only upon the plural receipt by said gating means of all of said plurality of electronic signals.

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