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[54] **BI-INPUT SAFE DETONATOR**

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[51] **Int. Cl.**[4] **F42C 11/02**

[52] **U.S. Cl.** **102/210**

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[57] **ABSTRACT**

A detonator comprises a housing which contains a weak explosive charge ignitable by a bridge wire and a piezoelectric semiconductor buffer positioned in the housing for receiving a shockwave from the weak explosive charge when it is ignited. A high voltage lead is connected to the buffer for applying a high voltage signal to the buffer. If the high voltage signal is applied to the buffer at the same time that the weak explosive charge is ignited, the piezoelectric buffer will amplify a shockwave from the ignited charge to produce a detonation charge of sufficient amplitude to ignite a secondary or main charge which can form part of the detonator or be positioned against a surface of the detonator. In this way only the simultaneous ignition of the weak explosive charge and the activation of the piezoelectric buffer will cause ignition of the secondary or main charge. The weak charge itself is insufficient to ignite the secondary or main charge and application of a high voltage signal to the buffer alone produces an insufficiently high impulse for this purpose.

9 Claims, 2 Drawing Figures

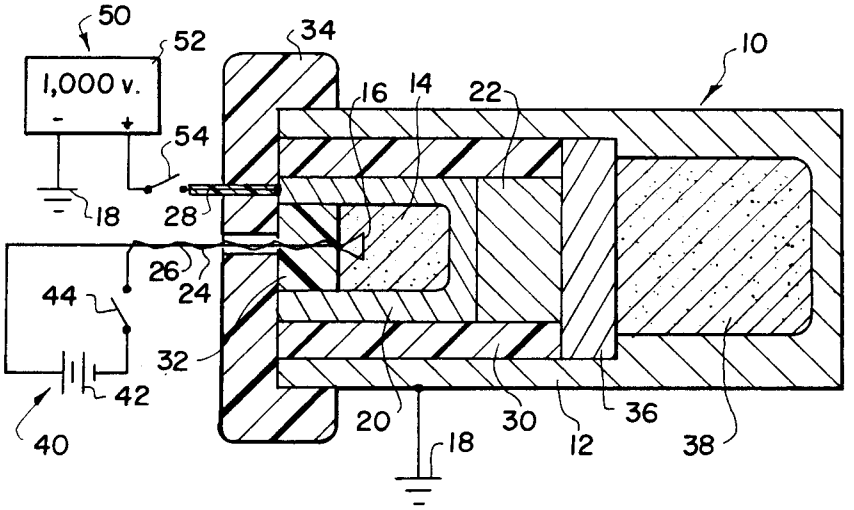

FIG. 1

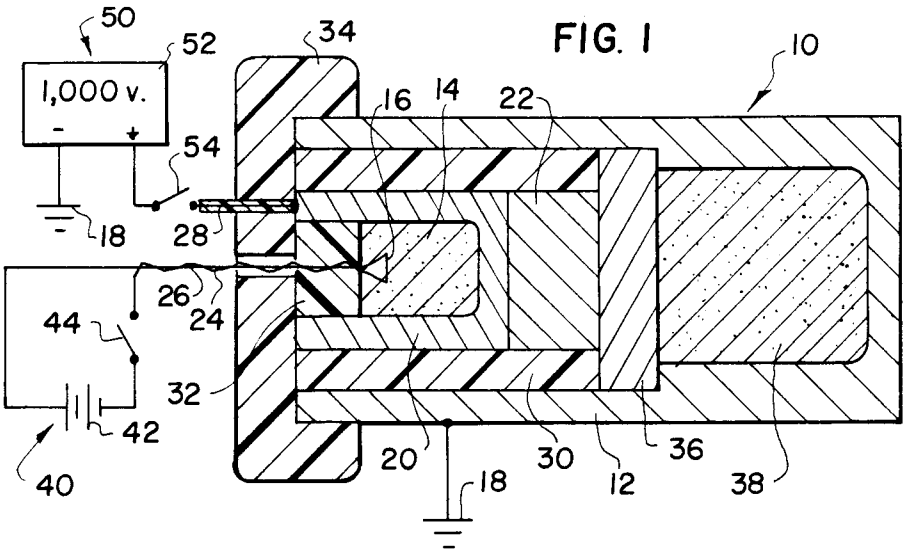
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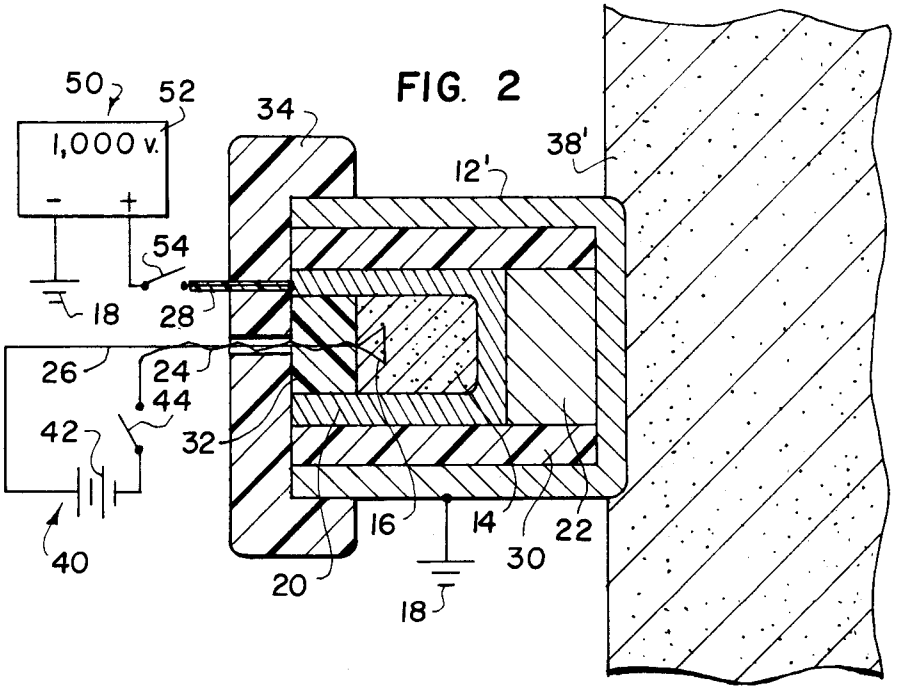
FIG. 2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BI-INPUT SAFE DETONATOR

STATEMENT OF GOVERNMENT INTEREST

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

This application is a continuation, of application Ser. No. 713,132, filed Mar. 18, 1985.

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates in general to explosive devices and in particular to a new and useful detonator which requires the simultaneous application of two voltage signals to detonate. One voltage signal is applied to a detonator bridge wire for igniting a weak explosive charge while the other voltage signal, in the form of a high voltage DC pulse, is applied to a piezoelectric semiconductor buffer in the detonator. The detonator is designed to provide an impulse of sufficient amplitude only if the weak explosive and buffer are activated simultaneously. An impulse from either the weak explosive or the buffer alone is insufficient to ignite a secondary of main explosive charge associated with the detonator. The buffer acts to amplify a shockwave from the weak explosive to produce an amplified shockwave of sufficient strength to ignite the secondary of main explosive charge.

Detonators which can be ignited by applying a voltage to a bridge wire alone can be unsafe because of the simplicity of igniting such detonators. Known detonators include a primary explosive main charge which is used for example to ignite a secondary explosive charge, or for other purposes.

Piezoelectric semiconductor devices are also known which, when receiving an electric impulse, produce a mechanical response. Conversely a mechanical impulse on such devices produces an electrical response. Experiments dealing with infinitesimal amplitude (ultrasonic) effect physics of piezoelectric devices can be found in an article by A. R. Hudson, J. H. McFee, and D. L. White, in *Physical Review Letters*, 7, page 237 (1961). Theory concerning these effects is discussed in an article by D. L. White in *J. Appl. Phys.*, 33, page 2547 (1962).

SUMMARY OF THE INVENTION

The present invention is drawn to a detonator which requires two simultaneous inputs before the detonator produces a sufficient shockwave to ignite a secondary explosive forming part of the detonator, or a main explosive charge which is external of the detonator.

According to the invention the detonator includes a weak explosive which can be ignited by a bridge wire to produce a shockwave. The detonator includes a piezoelectric semiconductor buffer which receives the shockwave and which, when activated by a suitably high voltage impulse, amplifies the shockwave to produce an amplified shockwave of sufficient amplitude to ignite the secondary or main explosive charge.

If voltage signals to the bridge wire and buffer are not simultaneous, the amplitude of a shockwave from the detonator will be insufficiently high to detonate the secondary or main explosive charge. The inventive detonator is thus safer to operate than detonators which only require a signal on a bridge wire since two simultaneous signals must be applied or else a sufficiently effective detonation will not occur.

Accordingly an object of the present invention is to provide a detonator comprising, a housing, a weak explosive charge in the housing, a bridge wire associated with the weak explosive charge which is activatable to ignite the weak explosive charge, first power supply means connected to the wire for activating the wire to ignite the weak charge and produce a shockwave, a piezoelectric semiconductor buffer in the housing positioned to receive the shockwave and second power supply means connected to the buffer for activating the buffer to amplify the shockwave from the weak charge to produce a detonation wave sufficient to ignite a secondary or main explosive charge. The first and second power supply means must activate the wire and buffer substantially at the same time for the amplification effect to take place. Otherwise the shockwave alone or an impulse from the piezoelectric buffer alone are insufficient to ignite the secondary or main charge.

A further object of the invention is to incorporate a secondary charge in the housing which can be ignited by the detonation wave but which cannot be ignited by the shockwave alone or by an impulse of the piezoelectric semiconductor buffer alone.

A still further object of the invention is to provide a detonator which is safer to operate than prior art detonators in that two simultaneous inputs must be established before the detonator will detonate.

Another object of the invention is to provide a bi-input safe detonator which is simple in design rugged in construction and economical to manufacture.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its uses, references is made to the accompanying drawings and descriptive matter in which preferred embodiments of the invention are illustrated.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a side sectional view showing one embodiment of the inventive detonator; and

FIG. **2** is view similar to FIG. **1** showing another embodiment of the inventive detonator.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, the invention embodied therein comprises a bi-input detonator generally designated **10** which has a housing **12** that is preferably metallic and electrically grounded at **18**. Housing **12** defines a space which contains a weak explosive charge **14**. Charge **14** is surrounded by a metallic casing **20** which acts as an electrode for an n-type piezoelectric semiconductor buffer **22**.

A bridge wire **16** extends in weak charge **14** and is connected to bridge wire leads **24** and **26**.

An insulated high voltage lead **28** is connected to the electrode **20**.

The buffer **22** has a length along the central axis of detonator **10** which is about one centimeter. The buffer **22** as well as the electrode or casing **20** is surrounded by an electric insulator layer **30** made for example of plastic or ceramic. An insert filler **32** made of inert material

plugs the opening of casing **20** and retains the charge **14** therein. Leads **24,26** extend through this filler.

Casing **12** is closed by an insulating end cap **34**. Leads **24,26** as well as insulated high voltage lead **28** extend through this end cap.

On a side of buffer **22** opposite from the charge **14** is a second metal electrode **36**. Since metal electrode **36** is in contact with buffer **22** as well as metal housing **12**, the piezoelectric buffer **22** can be electrically activated over insulated lead **28** and ground **18**.

In the embodiment of FIG. **1**, housing **12** also defines a space which contains a secondary explosive **38** adjacent the second electrode **36**.

Leads **24** and **26** for bridge wire **16** form part of first power supply means generally designated **40**. These means are shown schematically to include a battery **42** and a switch **44** which can be closed to apply a voltage to wire **16** for the purpose of igniting weak explosive charge **14**.

Insulated high voltage lead **28** forms part of a second power supply means **50** which includes a switch schematically shown at **54** and a high voltage source **52** connected between switch **52** and a ground which as with the ground connected to housing **12**, is numbered **18**.

Means **40** and **50** are shown only schematically. Any known mechanism for applying signals to wire **16** and buffer **22** can replace these means. The switches **44** and **54** are also shown schematically.

In operation, a signal is applied to wire **16** to ignite weak explosive charge **14**. Simultaneously a sufficiently high voltage is applied to the insulated high voltage lead **28**. The effect of this is to amplify a shockwave from the ignited charge **14** to the buffer **22**. The shockwave is only amplified when both the buffer and the charge are activated substantially at the same time.

The amplified shockwave, termed a detonation wave, is only then sufficiently high to detonate the secondary explosive charge **38**. The amplified shockwave is transmitted through electrode **36** which has a thickness selected for this purpose.

With an n-type piezoelectric semiconductor buffer **22** of one centimeter in thickness, approximately one thousand volts must be applied to insulated high voltage lead **28**. The n-type piezoelectric material for example may be cadmium sulfide with an electron mobility of about 10^{-2} Mks units.

For a p-type buffer **22**, the insulated high voltage lead **28** is provided with a negative voltage in order to produce the shockwave amplification effect.

The shockwave amplification occurs by virtue of accelerated electrons transferring energy and momemtum to the mass density shockwave which was applied by the igniting charge **14** on the buffer **22**. In order to transfer momemtum and energy to the shockwave the electron drift velocity must be formed with an electric field of approximately one thousand volts per centimeter. This accounts for the required one thousand volts applied to the one centimeter thick buffer **22**.

If the charge **14** is ignited without applying a voltage to buffer **22**, or if the buffer **22** receives the high voltage signal but charge **14** is not ignited, a resulting shockwave is insufficient to ignite the secondary charge **38**. In this way a safety feature is realized in that both buffer **22** and charge **14** must be activated at substantially the same time or else the detonator will not operate.

FIG. **2** shows an alternate embodiment of the invention wherein the same reference numerals are utilized to designate the same parts. As with the embodiment of FIG. **1**, bridge wire **16** can be activated by its lead wires **24** and **26** by a first power supply means (not shown in FIG. **2**).

Insulated lead wire **28** in FIG. **2** is connected over a first electrode **30** to the buffer **22**. Weak charge **14** is disposed in a space defined by electrode **30** and is held in that space by a plug **32** through which wires **24,26** extend.

The end of a housing **12'** is closed by an insulated end cap **34** which, as in FIG. **1**, is glued in place.

Unlike the embodiment of FIG. **1**, housing **12'** is shortened and does not include a space for a secondary explosive charge. The housing **12'** is grounded at **18** and forms a second electrode for buffer **22**. The end of housing **12** opposite end cap **34** is engaged against a main secondary charge **38'** which can only be ignited with the simultaneous activation of weak charge **14** and buffer **22**. Only when this happens will a detonation wave from the end of housing **12'** be sufficiently high in amplitude to ignite main charge **38'**.

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. A detonator comprising:

a housing;

a weak explosive charge in said housing;

a wire associated with said weak explosive charge which is activatable to ignite said weak explosive charge;

first power supply means connected to said wire for activating said wire to ignite said weak explosive charge and produce a shockwave;

a piezoelectric semiconductor buffer in said casing positioned to receive the shockwave; and

second power supply means connected to said buffer for activating said buffer to amplify the shockwave when said first power supply means activates said wire at substantially the same time that said second power supply means activates said buffer, to produce an amplified detonation wave.

2. A detonator according to claim **1**, wherein said second power supply means comprises a first electrode engaged against one side of said buffer and defining a space, said weak explosive charge disposed in said space, said second power supply means including a second electrode engaged with an opposite side of said buffer which is disposed away from said weak explosive charge.

3. A detonator according to claim **2**, wherein said first power supply means includes a pair of leads connected to said wire for applying voltage to said wire to ignite said weak explosive charge.

4. A detonator according to claim **3**, wherein said housing includes an open end, an insulating end cap engaged over and closing said open end, said leads for said wire extending through said end cap, said second power supply means including an insulated high voltage lead connected to said first electrode and extending through said end cap.

5. A detonator according to claim **4**, wherein said housing is metallic and is connected to said second electrode, said housing defining a space on a side of said second electrode opposite said buffer, and a secondary

explosive in said space of said housing for detonation upon receiving the amplified detonation wave.

6. A detonator according to claim 4, wherein said housing is metallic and forms said second electrode by engaging a side of said buffer opposite from said first electrode.

7. A detonator according to claim 4, wherein said piezoelectric semiconductor buffer is made of n-type material, said second power supply means comprising a source of positive voltage for application to said first electrode.

8. A detonator according to claim 4, wherein said piezoelectric semiconductor buffer is made of p-type material, said second power supply means provided for applying a negative voltage to said first electrode.

9. A method of detonating a secondary explosive charge comprising igniting a weak explosive charge at a selected time to produce a shockwave which by itself is insufficient to ignite the secondary charge, providing a piezoelectric semiconductor buffer between the weak explosive charge and the secondary charge, and applying voltage to the buffer at the selected time for amplifying a shockwave to produce a detonation wave for the secondary explosive of sufficient high amplitude to ignite the secondary explosive.

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