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Visk

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[54] **DEMOLITION FIRING DEVICE**

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[52] U.S. Cl. .... **102/70.2 R**, 181/0.5, 340/16 C, 340/5, F 42 C 9/00

[51] Int. Cl. **F42c 11/02**, F42c 9/16

[58] Field of Search .... 102/70.2, 18; 340/16 C, 5; 181/0.5

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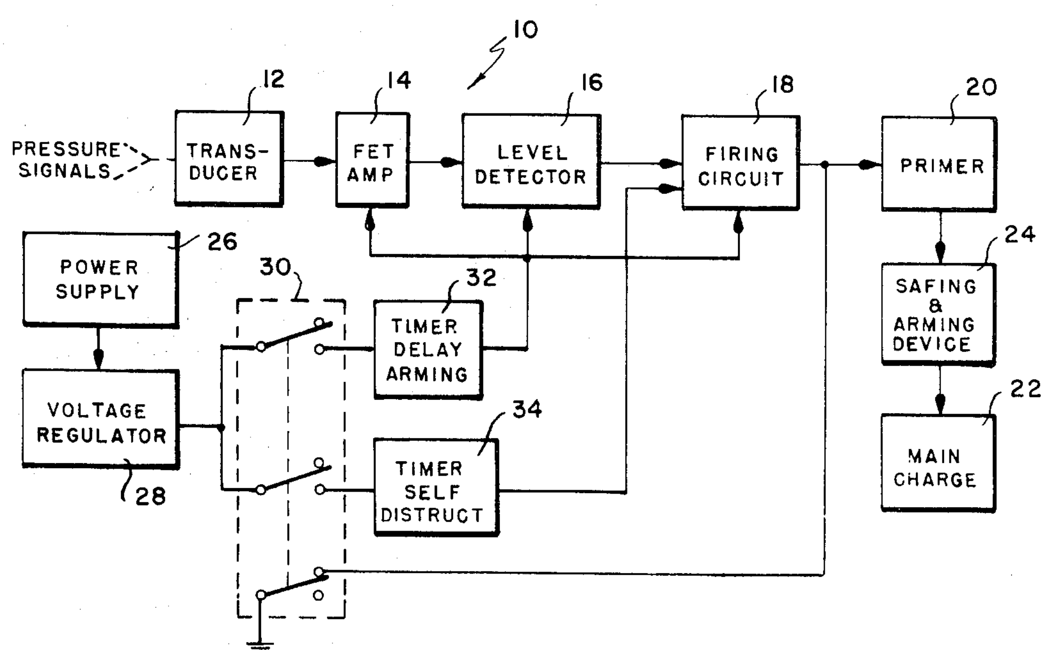
[57] **ABSTRACT**

A firing device is sympathetically activated by the pressure wave generated by a nearby air or underwater explosion. When activated, the firing device detonates a main charge to wich it is attached and the resultant sock wave initiates a similar firing device in chain reaction fashion. An incoming pressure wave is converted into an electrical signal by a hydrophone, amplified by an FET amplifier, and level detected by a programmable unijunction transistor. If the pressure wave is above a predetermined amplitude, the programmable unijunction transistor conducts, causing an SCR to become conductive. This allows a firing capacitor to discharge through an explosive primer, which in turn detonates a main charge. The firing device also includes delay arming circuitry and self-destruct circuitry.

8 Claims, 3 Drawing Figures



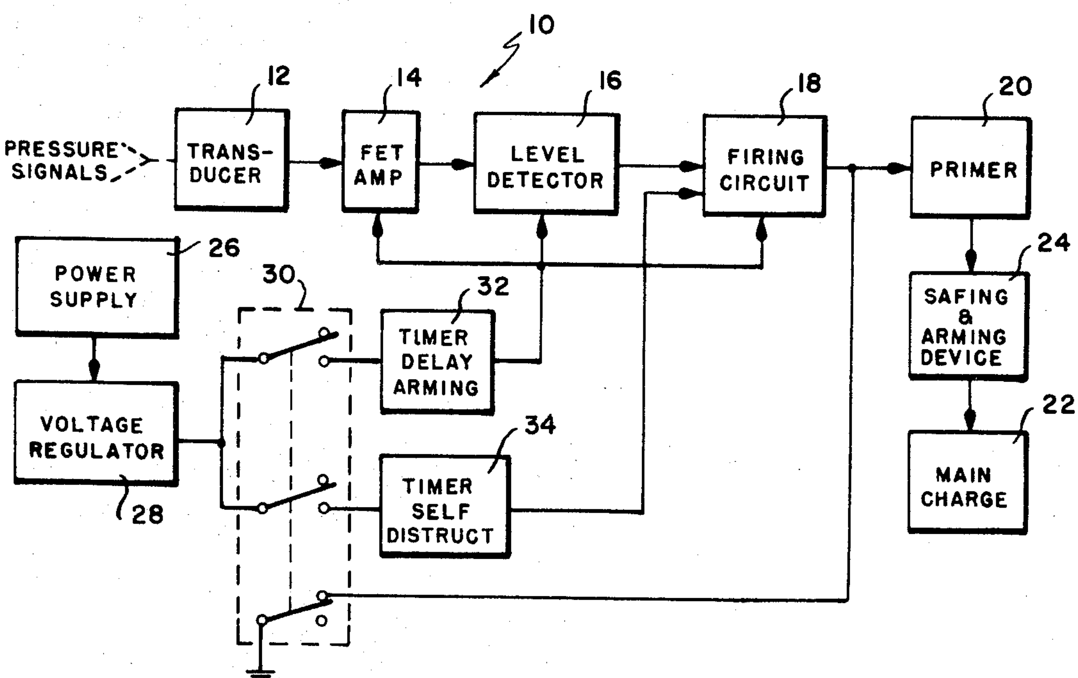


FIG. 1.

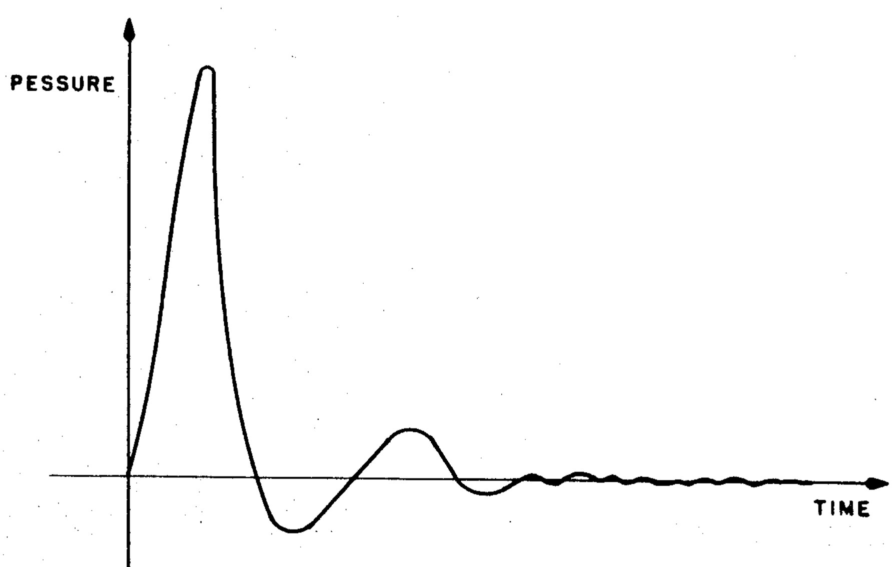


FIG. 2.

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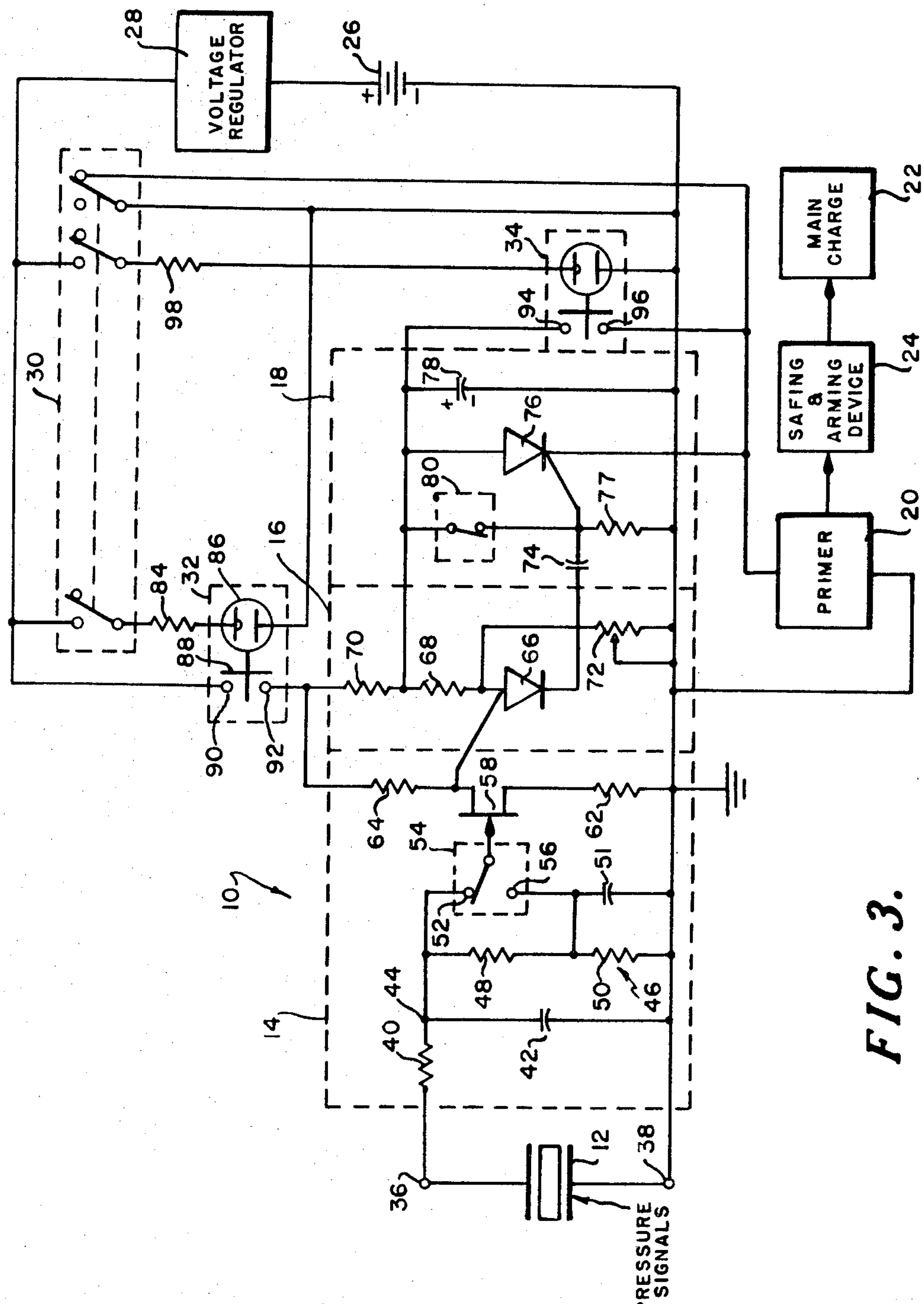

FIG. 3.

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DEMOLITION FIRING DEVICE

BACKGROUND OF THE INVENTION

This invention relates generally to firing devices for explosives, and more particularly to acoustically activated firing devices for explosives.

Previous methods of detonating a series of charges involved the stringing of electrical firing leads or detonating cords to each charge in a multi-charge detonating mission. As a result, prior art systems have several inherent disadvantages. First, these systems are unreliable, since it is not always possible to exercise great care in stringing the series of charges together. Any fault in the electrical cord or faulty connections at any given charge prevents detonation of all succeeding charges in the series array. Second, these prior art systems are relatively unsafe. Bearing the cumbersome cord to the objective and spending extended periods of time in wiring each individual charge unduly exposes the person performing the installation. The possibility of accidental detonation by careless handling or incorrect wiring is always present. Third, it is difficult to install the prior art systems, since usually each charge is first placed at the desired position, and then all of the charges are wired together in a series configuration. Finally, these systems are expensive, since the cost of the cord is a significant part of the overall cost of the system.

SUMMARY OF THE INVENTION

Accordingly, one object of the instant invention is to provide a new and improved firing device for detonating a series of explosives.

Another object of the instant invention is the provision of a firing device for a series of explosives that can be easily installed.

Still another object of the present invention is the provision of a safe firing device for a series of explosives.

A further object of the instant invention is to provide an inexpensive firing device for a series of explosives.

A still further object of the present invention is the provision of an acoustically activated firing device.

Briefly, in accordance with one embodiment of this invention, these and other objects are obtained by providing a demolition firing device that transduces acoustic pressure waves into electrical signals, amplifies and level detects the resultant electrical signals, and energizes an explosive primer if the detected electrical signal is above a predetermined amplitude. The explosive primer then detonates through a safing and arming device a main charge, and the resulting explosion creates an acoustic pressure wave that can be used to activate a similar nearby firing device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagrammatic view of the demolition firing device of the present invention;

FIG. 2 is a curve of the signature of a pressure wave produced by a high explosive; and

FIG. 3 is a schemetic diagram of the demolition firing device of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, a demolition firing device 10 is shown receiving pressure signals. As described

hereinafter, demolition firing device 10 is suitable for use in air or underwater. Thus, the pressure signals are transmitted either through an air medium or a water medium. These pressure signals strike a conventional pressure tranducer 12, such as a hydrophone, and are converted into electrical signals. When high explosives, such as TNT, are detonated, a shock wave is propagated through the medium. As shown in FIG. 2, the pressure signature of this wave is characterized by a steep leading edge of a considerable magnitude. Pressure transducer 12 generates electrical signals in response to this over pressure which are fed to a field effect transistor (FET) amplifier 14. As described hereinafter with reference to FIG. 3, FET amplifier 14 low pass filters these electrical signals to remove high frequency components, attenuates the low pass filtered signals if the pressure signals are received through a water medium, and amplifies the resulting signals. The output of FET amplifier 14 is supplied to a level detector 16, described hereinafter with reference to FIG. 3, that generates an output signal if the signal from FET amplifier 14 is above a predetermined level. This predetermined level is selected so that ambient pressure signals do not produce an output from level detector 16. Only relatively high pressure signals, such as produced by the aforementioned high explosives, will produce an output from level detector 16.

The output from level detector 16 is a pulse which is applied to a firing circuit 18, described hereinafter with reference to FIG. 3, which generates a firing pulse. This firing pulse detonates a conventional explosive primer 20 which is coupled to a conventional main explosive charge 22 through a conventional safing and arming device 24.

Operational power for demolition firing device 10 is supplied by a power supply 26, such as a battery, the output of power supply 26 is applied to a conventional voltage regulator 28 which insures a constant output voltage regardless of voltage fluctuations from power supply 26. A conventional triple pole, double throw mechanical switch 30 couples the output of voltage regulator 28 to a timer delay arming device 32, and simultaneously to a timer self-destruct device 34, both of which are described in greater detail hereinafter with reference to FIG. 3. The third section of switch 30 is connected between ground potential and primer 20. Prior to deployment of demolition firing device 10, switch 30 is in its disabled or safe position. Whereby an open circuit exists between voltage regulator 28 and timer delay arming device 32, an open circuit exists between voltage regulator 28 and timer self-destruct device 34, and the firing or "hot" lead of primer 20 is grounded. Thus, no power is supplied to the remaining circuit elements, and primer 20 is grounded to prevent spurious actuation, such as by a stray electromagnetic or electrostatic field.

With switch 30 in its other position, power is supplied to timer delay arming device 32 and timer self-destruct device 34 by voltage regulator 28, and the firing lead to 20 is disconnected from ground potential. The output of timer delay arming device 32 is coupled to FET amplifier 14, level detector 16, and firing circuit 18. Upon the closure of switch 30, operating power from voltage regulator 28 is prevented from reaching these circuits for a predetermined period of time by timer delay arming device 32. This time delay may be, for example, 30 minutes to allow deployment of demolition firing device **10** and evacuation from within its explosive range. After a longer predetermined period of time, such as **24** hours, timer self-destruct device **34** presents a closed circuit between voltage regulator **28** and the input to firing circuit **18**, thereby causing demolition firing device **10** to self-destruct.

Referring now to FIG. **3**, demolition firing device **10** is illustrated in greater detail. Incoming pressure signals strike pressure transducer **12** which is connected between a pair of input terminals **36** and **38**. Terminal **38** is connected to ground potential, and the resulting transduced electrical signals appear at terminal **36**. These signals are applied to FET amplifier **14**, as described hereinbefore. The input circuitry of FET amplifier **14** comprises a low pass filter consisting of a resistor **40** connected at one end to input terminal **36** and a capacitor **42** connected between the other end of resistor **40** and ground. The output of this low pass filter appears at a junction point **44** between resistor **40** and capacitor **42**. In the preferred embodiment of the instant invention, pressure transducer **12** is of relatively simple construction and inexpensive, and, consequently, has a relatively flat frequency response over a limited range of frequencies, for example 0 to 3,000 Hz. Above 3,000 Hz the frequency response may become extremely nonlinear, and it is the purpose of the low pass filter defined by resistor **40** and capacitor **42** to filter out all of the electrical signals above this critical frequency.

A resistor divider network **46** consisting of series connected resistors **48** and **50** is connected in parallel with capacitor **48** between junction point **44** and ground. A capacitor **51** connected in parallel with resistor **50** filters out any additional high frequency signals. Electrical signals appearing at junction point **44** are directly coupled to a first terminal **52** in a conventional single pole, double throw swtich **54**, and through resistor **48** to a second terminal **56** in switch **54**. Thus, the signal appearing at terminal **52** is unattenuated, equal to the signal appearing at junction point **44**, while the signal appearing at terminal **56** is attentuated by the action of resistor divider network **46**. In one position, the arm of switch **54** connects terminal **52** to the gate of a conventional P-channel field effect transistor FET **58**, while in its other position, the arm of switch **54** connects terminal **56** to the gate of FET **58**. These alternative inputs to FET **58** are provided because of the different environments in which demolition firing device **10** may be used. Under normal conditions, water is a superior medium to air for the transmission of pressure signals. Consequently, for a specified distance between a pressure wave source and a demolition firing device **10**, the pressure wave arriving at transducer **12** will have a higher amplitude when transmitted through water, than through air. This, in turn, will produce greater amplitude electrical signals at junction point **44** for water as opposed to air. To normalize the signal level for air and water operation, terminal **52** is connected to the gate of FET **58** when demolition device **10** is used in an air environment, and terminal **56** is connected to the gate of FET **58** when demolition firing device **10** is used underwater. Thus, the difference in transmissive characteristics between water and air is compensated by proper selection of the values of resistors **48** and **50**.

A field effect transistor is employed in amplifier **14** because of its extremely high input impedance which prevents loading on the aforedescribed circuitry. A resistor **62** is connected between the drain terminal of FET **58** and ground, and a resistor **64** is connected between the source terminal of FET **58** and timer delay arming device **32**, described hereinafter. The output of FET amplifier **14** is taken from the source terminal of FET **58** and applied to the gate of a programmable unijunction transistor (PUT) **66** in level detector **16**. A resistor **68** is connected to one end to the anode of PUT **66** and at the other end to one end of a resistor **70**. The other end of resistor **70** is connected to timer delay arming device **32**. Resistor **70** limits the current to firing circuit **18** to prevent primer detonation if one of the elements in firing circuit **18** is short circuited to primer **20**. A variable resistor **72** connected between the anode of PUT **66** and ground sets the potential at which PUT **66** fires by setting the anode potential of PUT **66**. If the voltage at the gate of PUT **66** drops more than approximately 0.7 volts below the anode potential of PUT **66**, PUT **66** produces an output pulse at its cathode which is applied to firing circuit **18**. By having a variable firing level for PUT **66**, the sensitivity of demolition firing device **10** to incoming pressure signals can be varied over a wide range.

The firing pulse from PUT **66** is coupled through a capacitor **74** to the gate of a silicon controlled rectifier (SCR) **76** in firing circuit **18**. The anode of SCR **76** is connected to the junction point between resistors **68** and **70**, and its cathode is connected to the firing or "hot" lead of primer **20**. A resistor **77** is connected between the gate of SCR **76** and ground, firing capacitor **78** is connected between the anode of SCR **76** and ground potential. With SCR **76** normally nonconducting, firing capacitor **78** charges to the potential between resistor **68** and **70**. When SCR **76** becomes conductive in response to a firing pulse from PUT **66**, capacitor **78** discharges through SCR **76** and primer **20** to ground, thereby causing primer **20** to detonate. If safing and arming device **24** is conditioned to allow detonation, main charge **22** detonates in response to the detonation of primer **20**.

To prevent tampering with demolition firing device **10**, a conventional trembler switch **80** is connected between the anode and gate of SCR **76**. If demolition firing device **10** is physically jostled or disturbed, trembler switch **80** momentarily closes, thereby applying the supply potential for firing circuit **18** obtained from the junction between resistors **68** and **70** to the gate of SCR **76**. This in turn causes SCR **76** to conduct and capacitor **78** to discharge through SCR **76** and detonate primer **20**, as described hereinbefore.

Timer delay arming device **32** and timer self-destruct device **34** are both conventional electrochemical delay arming switches which close contacts after a predetermined period of time. Referring to timer delay arming device **32**, for example, operation of switch **30** to its active position allows a current to flow from voltage regulator **28** through switch **30**, a resistor **84**, and an electrochemical section **86** of timer delay arming device **32**. Electrochemical section **86** is coupled to a spring loaded contact bar **88** in a well known manner. After a pre-determined amount of current has passed through the electrochemical section **86**, contact bar **88** is released, causing it to short together a pair of terminals **90** and **92**. Terminal **90** is connected to voltage regulator **28**, and terminal **92** is connected to the common junction between resistors **64** and **70**. Thus, by shorting together terminals **90** and **92,** power is supplied to FET amplifier **14,** level detector **16,** and firing circuit **18.** Resistor **84** and the voltage level of voltage regulator **28** control the amount of current flowing through electrochemical section **86.** Consequently, the value of resistor **84** and the regulated voltage level determine the time delay between the closure of switch **30** and the shorting together of terminals **90** and **92.** Timer self-destruct device **34** operates in the same manner as timer delay arming device **32** to short circuit a pair of terminals **94** and **96.** Terminal **94** is connected to the positively charged side of capacitor **78,** and terminal **96** is connected to the "hot" lead of primer **20.** Consequently, short circuiting of terminal **94** and **96** causes capacitor **78** to discharge through these terminals to primer **20,** thereby producing detonation as described hereinbefore. A timing resistor **98** coupled to the electrochemical section of timer self-destruct device **34** and the regulated voltage level determine the time delay between the closure of switch **30** and the shorting together of terminals **94** and **96.** Since timer delay arming device **32** operates to short circuit terminals **90** and **92** relatively soon after the deployment of demolition firing device **10,** and timer self-destruct device **34** operates to short circuit terminals **94** and **96** after demolition firing device **10** has been deployed for s substantial period of time, it should be apparent that resistor **98** is of substantially greater resistance than resistor **84.**

In operational use, it is envisioned that two or more demolition firing devices according to the present invention be deployed over an area such that each is within the detection range of an explosion produced by at least one other demolition firing device. After the delay arming interval determined by timer delay arming device **32,** a starter explosive is detonated within the detection range of at least one of the demolition firing devices. This explosion produces a pressure signal which causes that demolition firing device to detonate. Detonation of that firing device in turn produces a pressure wave that detonates nearby demolition firing devices. By chain reaction all of the demolition firing devices are detonated within a short period of time, determined by the spacing between the demolition firing devices and the speed of propagation of the pressure wave through the particular medium. If no starting charge is detonated, the first demolition firing device to self-destruct, as determined by timer self-destruct device **34,** will provide the initial explosion to trigger the remaining demolition firing devices. If, by mistake, one or more demolition firing devices have been placed at too great a distance from other demolition firing devices so that the pressure signals received by them are insufficient to produce detonation, these demolition firing devices will independently self-destruct after the period of time determined by timer self-destruct device **34.** Thus, by employing demolition firing devices of the presnt invention, it is possible to lay a land or water mine field or series of charges that are not connected physically, but which nevertheless detonate in chain reaction or series fashion.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. For example, other types of well known delay arming switches may be used. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A demolition firing device comprising:

transducer means for transducing pressure signals into electrical signals;

means coupled to said transducing means for filtering and amplifying said electrical signals;

level detecting means coupled to said filtering and amplifying means for generating an output pulse whenever the output of said filtering and amplifying means exceeds a predetermined variable voltage amplitude;

firing means connectable to an electrically activated explosive primer and coupled to said level detecting means for supplying a firing pulse to said explosive primer in response to said output pulse; and

electromechanical arming delay switch means connectable to a source of electrical potential connected for applying said electrical potential to said filtering and amplifying means, said level detecting means, and said firing means after a first predetermined period of time.

2. The demolition firing device of claim **1,** wherein said transducer means comprises a hydrophone.

3. The demolition firing device of claim **1,** wherein said filtering and amplifying means comprises;

a low pass filter coupled to said transducer means; and

means for amplifying the output of said low pass filter.

4. The demolition firing device of claim **3,** wherein said amplifying means comprises:

a resistor deivider network coupled across the output of said low pass filter and providing a plurality of output signals;

switching means for selecting any one of said plurality of output signals; and

a field effect transistor amplifier for amplifying said selected one of said plurality of output signals.

5. The firing device of claim **1,** wherein said level detecting means comprises:

a programmable unijunction transistor having its gate coupled to the output of said filtering and amplifying means and producing said output pulse at its cathode; and

means for biasing the anode of said programmable unijunction transistor to a selectable potential to establish said predetermined variable voltage amplitude.

6. The demolition firing device of claim **5,** wherein said biasing means includes a variable resistance connected to the anode of said programmable unijunction transistor and connectable to a source of reference potential.

7. The demolition firing device of claim **1,** wherein said firing means comprises:

a silicon controlled rectifier having its gate coupled to the output of said level detecting means, having its cathode connectable to said explosive primer, and having its anode connectable to said source of electrical potential;

a firing capacitor connected to the anode of said silicon controlled rectifier and connectable to a source of reference potential;

anti-tampering means for connecting the gate of said silicon controlled rectifier to said source of electrical potential in response to physical movement of said demolition firing device; and

self-destruct means for directly discharging said firing capacitor through said explosive primer after a second predetermined period of time.

8. The demolition firing device of claim **7,** wherein said antitampering means comprises a trembler switch connected between the anode and gate of said silicon controlled rectifier.

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