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Schuster et al.

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[54] **WEAPON SYSTEM FOR A SET IN-FLIGHT DIGITAL TIME FUZE WITH MUZZLE ACTION**

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[51] **Int. Cl.** **F42c 11/06,** F42c 11/00, F42c 9/00

[58] **Field of Search** ..... 102/70.2 R; 244/3.19

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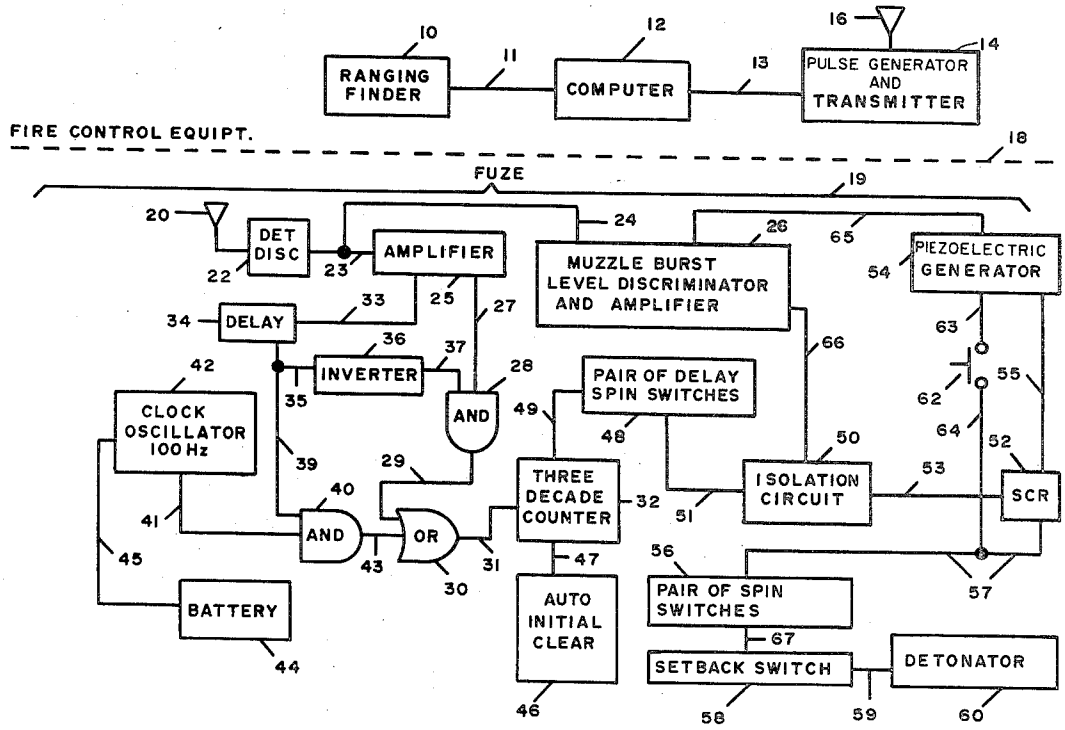
[57] **ABSTRACT**

An improved rapid fire weapons system that permits a projectile while in flight to be safely and accurately set and armed for either muzzle action or long distance detonation of the projectile against either moving or stationary targets by a coded high frequency transmitted pulse or in the event of an electrical failure by a hand settable switch to muzzle action.

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

9 Claims, 2 Drawing Figures



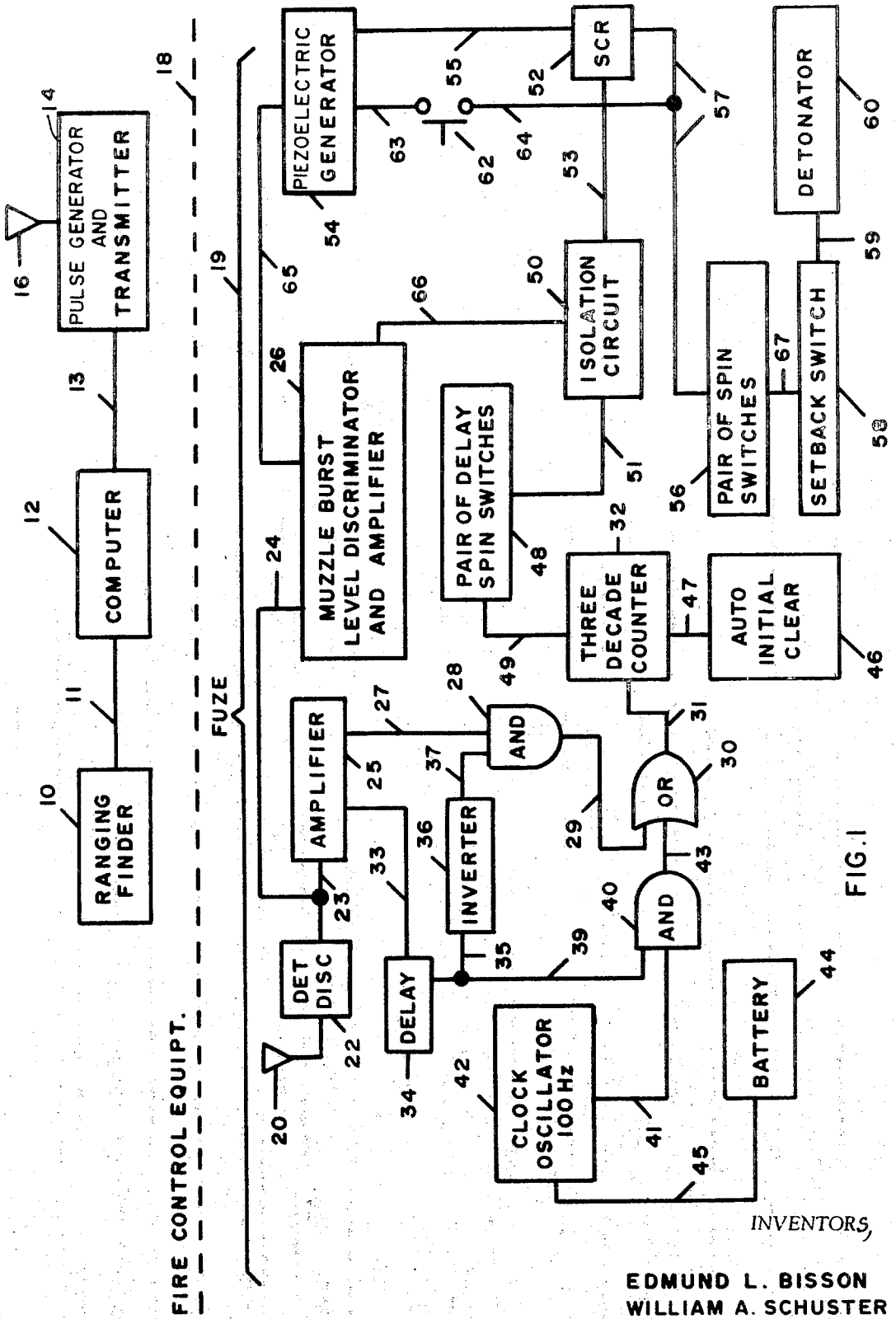


FIG. 1

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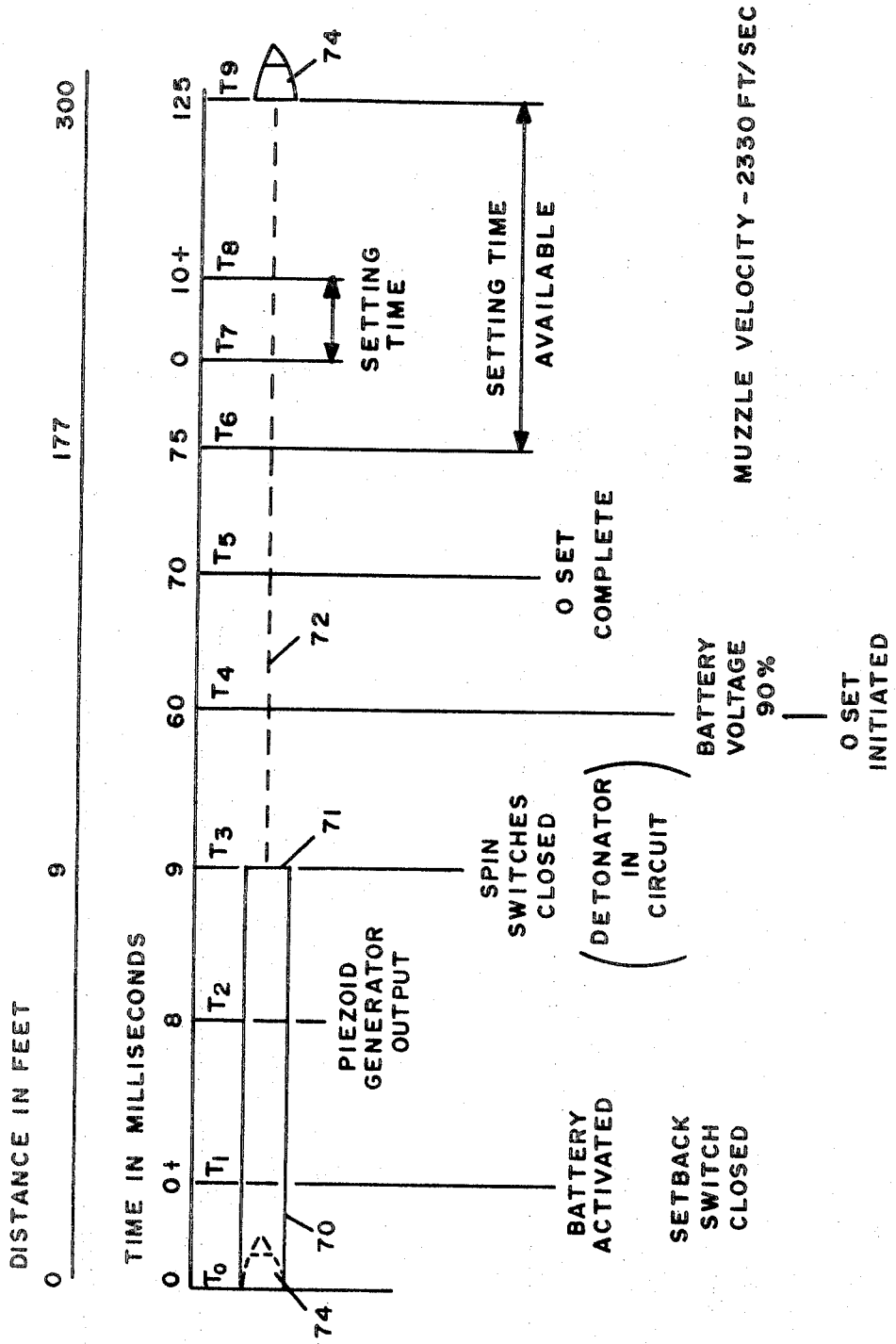

FIG. 2

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WEAPON SYSTEM FOR A SET IN-FLIGHT DIGITAL TIME FUZE WITH MUZZLE ACTION

BACKGROUND OF THE INVENTION

This invention relates to a weapons system for setting a fuze and has particular reference where the projectile is alternatively either set-in flight by a transmitted coded high frequency electromagnetic signal or by manually setting the fuze in emergency situations such as where the transmitting equipment becomes inoperative.

Prior art fuzes have had the capability of being set mechanically by hand, electrically, chemically, and/or combinations of these methods. In all of these instances the fuze was set prior to the firing of the projectile from the launching weapon. The development of automatic loaders and rammers for rapid fire weapons has made access to the fuze which requires mechanical manual setting by hand impractical. A mechanical fuze setter for available mechanical time fuzes is too large and heavy to be adaptable for mobile automatic high rate of fire equipment.

For fuzes which are set before they are loaded into the gun an error is introduced, in the fuze setting, by the varying time parameters required to load and fire the gun, thus making it very difficult, if not impossible to hit fast moving targets. Using our set in-flight digital time fuze invention minimizes these timing errors and makes it feasible to shoot at fast moving targets with a rapid fire rate with greater accuracy.

Those fuzes which are electronically set prior to firing of the projectile, while still in the launching weapon, are encumbered with electrical connections which must make contact with an electrical umbilical cable which is usually connected to the fire control equipment. In our invention there is no necessity for an umbilical connection between the fuze and the ground equipment because the fuze is set while in flight. In prior art fuze systems described aforesaid malfunctions can occur because of faulty contact between the connectors from the projectile and the umbilical cord which transmits the electrical signals for setting the fuze.

Another problem with prior art fuze systems, which are set prior to launch, is the danger that a malfunction which occurs in the time fuze, while the projectile is in the weapon, will endanger the launch crew. For systems which use an actuated in-flight counter concept, the system has been found unsatisfactory to meet the need for rapid rate of fire since the tracking radar must illuminate the projectile in-flight until functioning occurs at the desired range. Where the range is approximately **5000** meters the flight time is generally 10 to 15 second, thus the tracking time required has a limiting effect on the resultant rate of fire. In the present invention the digital time fuze is set subsequent to weapon firing and very shortly after the projectile leaves the muzzle of the gun by means of "high frequency" pulses sent from a pulse transmitter at the weapon site to a receiver in the fuze. These high frequency pulses contain coded information received from collaterally coupled ranging and computing equipment which arm and detonate the projectile a given distance from the oncoming target. As used throughout the specification and claims, the term "high frequency" refers to a range of frequencies between 20 megaherz and 10 gigaherz.

SUMMARY OF THE INVENTION

The present invention relates to a set in-flight digital time fuze which can be armed and detonated by either coded high frequency pulses received from a pulse transmitter activated by collaterally coupled ranging and computing equipment, or manually set by hand.

The projectile after exiting from the gun, and having traveled a predetermined distance generally ranging from 175 feet to 300 feet, receives a series of high frequency pulses of approximately 0.5 microseconds duration. These pulses are propagated from a transmitter in the fire control equipment and received by the receiving antenna in the fuze. The number of pulses transmitted being a function of time to be set in the fuze. These pulses after being received by the receiving antenna are detected by a detector/discriminator circuit which will only favorably receive signals from the fire control pulse transmitter. The output of the detector/discriminator is coupled to an amplifier where the signal is amplified and fed to a three decade counter through an intermediate first "And" and an "Or" gate, and to a delay circuit which inhibits a second "And" gate which prevents a clock oscillator output signal from reaching the three decade counter, until the amplified pulse settings from the fire control signal are entered into the counter. After a delay of approximately 0.015 seconds the output of the delay circuit not only initiates the internal fuze counting, but is also used to inhibit the first "And" gate so that no additional pulses from the amplifier can reach the three decade counter. At this point the fuze oscillator continues to fill the counter until the maximum count is reached which switches a silicon controlled rectifier, or other suitable electronic gate causing the detonator to function.

Electrical energy is provided for the aforementioned circuitry by a suitable reserve battery which is activated on setback. Electrical energy for initiation of the detonator is provided by a piezoelectric generator whose energy is also derived from the setback force.

In order to insure that the counting circuits are in the "O" set state, at the time that the high frequency pulses are inserted into the three decade counter, an automatic initial clear circuit operates as soon as the battery voltage achieves approximately 90 percent of its full output voltage.

Where activation of the projectile is desired at or near the muzzle a high amplitude long duration pulse is sent to the fuze as soon as the projectile emerges from the weapon. This special high amplitude long duration signal by-passes the amplifier and is coupled directly into the muzzle burst level discriminator and amplifier circuit. The muzzle burst level discriminator-amplifier circuitry is powered by the piezoelectric generator. The output of the muzzle burst level discriminator-amplifier is coupled to the silicon controlled rectifier whose activation causes the initiation of the detonator. During the muzzle burst operation the fuze oscillator, three decade counter, delay, and gating circuits, amplifier, and detector/discriminator circuitry are not operative since the battery voltage is relatively low. Safety due to electrical malfunction, in the fuze during muzzle burst operation, is provided by a pair of normally open spin switches and setback switch which isolate the electrical circuits between the detonator and the piezoelectric generator.

In case of power failure or damage to the range finding, computing and transmitting equipment, which is usually located in or on the launch vehicle or weapon carrier, muzzle action can be obtained by manually setting the fuze by a hand settable switch to a muzzle action mode.

One of the objects of this invention is to provide a set in-flight digital time fuze which can arm and detonate a projectile fired by a rapid fire weapon.

Another object of this invention is to improve the setting of fuzes in rapid fire weapons without any loss of accuracy.

Another object of this invention is to insure that a set in-flight fuze will not endanger the launch crew because of malfunction.

A further object of this invention is to enable a projectile fuze to be electronically set for rapid fire weapons or, in case of an emergency, to be manually set.

Another object of this invention is to provide an improved set-in flight fuze which can set the time for arming and detonating a projectile after launch without the disadvantage and limitation of prior art arrangements which utilize umbilical electrical connections to the fuze from a fire control system.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram of a set-in flight time fuze and fire control equipment for a weapon system.

FIG. 2 is a chart showing the time sequence for the fuze components as a function of the distance of travel of a projectile having a muzzle velocity of 2,330 ft/sec.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a block diagram of a set in-flight digital time fuze with muzzle action. The components of the fuze **19** located in the projectile are shown below the dashed line **18**, the components above the dashed line are those used in the weapon for electronic fire control. Ranging equipment **10** is coupled to a computer **12** through conductor **11**; computer **12** evaluates the distance between the projectile launch vehicle (not shown) and the target (not shown) and feeds an output through conductor **13** to pulse generator and transmitter **14**; pulse generator and transmitter **14** generates coded pulses of high frequency energy which is transmitted by a transmitting antenna **16**. The coded high frequency burst of pulses is received by the fuze receiving antenna **20**; these pulses are of a specific pulse duration, amplitude, and frequency. The number of pulses transmitted are a function of the time it takes for the projectile to reach the target area. The further the target, the smaller the number of pulses transmitted.

The coded pulse signal is received by the fuze antenna **20** and detected by the detector/discriminator **22** which selectively discriminates between these coded pulses and spurious signals and favorably receives the transmitted coded pulse signals. The detector/discriminator **22** is similar to diode detectors described in "Electronic Designers Handbook," Pages 703–707, McGraw Hill by R. W. Landee, D. C. Davis, A. P. Albrecht. The output of the detector/descriminator **22** is coupled to an amplifier **25** by a conductor **23**, and to a muzzle burst level discriminator and amplifier circuit **26** by conductor **24**. The amplifier **25** is similar to, and may be obtained, from Motorola Semi-conductor Prod. Inc., 5005 E. McDowell Rd., Phoenix, Ariz. 85008, Model MC 1510 Wideband Integrated Circuit Amplifier. The muzzle burst level discriminator and amplifier **26** consists of a Schmitt Trigger and Wideband Amplifier. The Schmitt Trigger is similar to Schmitt Triggers described in "Transistor Circuits and Applications" pp 136–137, Prentice-Hall Inc., Englewood Cliffs, N. J. (1968) by Laurence G. Cowles. The widebank amplifier is available from the Motorola Semiconductor Products Inc., 5005 E. McDowell Rd., Phoenix, Ariz. 85008, Model MC 1510.

The amplifier output is coupled by conductor **27** to a first "And" gate **28** which permits the coded signal to pass thru. The first "And" gate **28** is coupled to an "Or" gate **30** by conductor **29**. The output of "Or" gate **30** actuates the three decade counter **32**, by conductor **31**, for the specific number of pulses transmitted. The decade counter **32** is available from Fairchild Semiconductors, 313 Fairchild Dr., Mt. View, Calif. 94040, Model DTUL 945 Flip-Flop. At the same time that the amplifier **25** sends a signal to the first "And" gate **28**, a pulse is fed to delay **34** through conductor **33**. The output from delay **34** actuates the inverter **36** by conductor **35**. The delay **34** is similar to a delay which may be obtained from Fairchild Semiconductor Model DTL 951. The output of inverter **36** is coupled to the first "And" gate **28** by conductor **37** and inhibits the further transmission of pulses through the first "And" gate **28**. The purpose of the circuit consisting of delay **34**, inverter **36**, and first "And" gate **28** is to inhibit spurious transmitted pulses from entering the three decade counter **32** after the required information is received. This circuit insures that the first fuze time set by the initially received pulses from the fire control transmitter is not disturbed by subsequent pulse trains. This is advantageous because it prevents the fuze that is once set from being accidentally or purposely disturbed.

After a fixed period of time, predetermined by the characteristics of delay circuit **34**, a signal is transmitted from delay **34** by conductor **39** to a second "And" gate **40** making it receptive to pass pulses received from clock oscillator **42** by means of conductor **41**. The clock oscillator **42** is similar to the clock oscillator described in "Transistor Circuits and Applications," pp 191–192, Prentice-Hall, Inc., Englewood Cliffs, N. J. (1968) by Laurence G. Cowles. "And" gate **40** output is coupled by conductor **43** to "Or" gate **30** which transmits the clock oscillator **42** pulses which supply to the three decade counter **32** the remaining additional pulses necessary to fill the counter and cause an activation signal. The "Or" gate **30**, "And" gates **28** and **40**, and inverter **36** are available from Fairchild Semiconductors, **313** Fairchild Dr., Mountain View, Calif. 94040, Model DTL **946** Quad Two-Input Gate Element, Fairchild Diode-Transistor Micrologic.

The clock oscillator **42**, detector/discriminator **22**, amplifier **25**, delay **34**, inverter **36**, gates **28**, **30**, and **40**, and an auto initial clear circuit receive their energy from a battery **44** which is activated by setback forces upon launch of the projectile through conductor **45**.

In order to insure that the three decade counter **32** is in the "zero" count position before it receives any initial signal detected from the pulse transmitter **14**, an auto initial clear circuit **46** transmits by conductor **47**

a signal to the three decade counter 32 when approximately 90 percent of the battery 44 maximum output voltage is reached. The auto initial clear circuit 46 is similar to the circuit described in "Electronic Digital Techniques," pp 150–151, McGraw Hill (1960) by Paul M. Kintner. The signal generated by the auto initial clear circuit 46 will initiate a pulse establishing a "zero" setting for each decade of the three decade counter 32. At least one pulse is necessary to be received by the fuze receiving antenna 20 and passed through to "And" gate 40 before the clock oscillator 42 pulses will pass "And" gate 40 and be counted by the three decade counter 32. The three decade counter 32 will deliver an actuation signal after it has received a predetermined number of counts; this actuation signal is electrically connected by conductor 49 to a first pair of delay spin switches 48. The first pair of delay spin switches 48 are normally open mechanical switches whose function is to protect against a premature firing signal from the decade counter 32. After the projectile has reached a given angular velocity the delay spin switches 48 will permit the decade counter 32 actuation signal to be electrically coupled by conductor 51 to a matching isolation circuit 50 and to the trigger terminal of a silicon controlled rectifier 52, or any other equivalent electronic gate, by conductor 53. The isolation circuit 50 is similar to the isolation circuit described in "Transistor Circuits and Applications," pp 29–31 Prentice-Hall Inc., Englewood Cliffs, N. J. (1968) by Laurence G. Cowles. Silicon controlled rectifiers similar to silicon controlled rectifier 52 are available from the Semiconductor Products Department, General Electric Co., Syracuse, N. Y. 13201; Model Number: C 20B. The output of a piezoelectric generator 54 which is activated by the pressure forces of setback provides the energy necessary to initiate a detonator 60. The output of the piezoelectric generator 54 is coupled to the silicon rectifier 52 by a conductor 55. When the silicon controlled rectifier 52 receives an actuation signal generated by the three decade counter 32, the energy of piezoelectric generator 54 will be conducted through the SCR 52 by conductor 57 through a second pair of spin switches 56 and through conductor 67 to a series coupled setback switch 58 through a conductor 59 to said detonator 60. The piezoelectric generator rectifier 54 is similar to rectifiers described in "Electronic Designers Handbook", pp 15–2 to 15–17, McGraw Hill, by Landee, Davis and Albrecht.

The energy from the piezoelectric generator 54 can be supplied either through the SCR 52, or where mechanical hand setting is desirable, by a normally open hand settable switch 62 via conductors 63 and 64, through spin switches 56 and setback switch 58 to the detonator 60. This alternate path of conduction permits the projectile to be safely armed and detonated even though there is a failure in the fire control circuitry or pulse generating circuitry.

The additional pair of spin switches 56 and a setback switch 58 are located intermediate to SCR 52 and the detonator 60 by conductor 57, and intermediate to the normally open hand settable switch 62, in order to prevent the projectile from firing in the barrel of the gun in the event that there is premature discharge of SCR 52, or a spurious output from the piezoid generator 54.

The energy from the piezoid generator 54 also supplies energy to operate the muzzle burst level discriminator and amplifier circuit 26 by a conductor 65. The muzzle burst level discriminator and amplifier 26 is activated when the ranging equipment 10 determines that a target is very close to the launching weapon, and transmits a special high voltage long duration signal to which the muzzle burst level discriminator and amplifier 26 is receptive. The muzzle burst level discriminator 26 is insensitive to the normal range setting pulses. Upon receiving the special muzzle action signal the muzzle burst level discriminator 26 transmits a pulse to the silicon rectifier 52 through conductor 66, isolation circuit 50 and conductor 53, enabling the energy from the piezoid generator 54 to initiate the detonator a short distance from the muzzle of the gun. Thus, muzzle action can be accomplished either by mechanically operating the hand settable switch 62, or electronically by having the muzzle burst level discriminator and amplifier 26 be responsive to a special signal generated by the fire control circuitry as shown above the dashed line 18.

FIG. 2 is a chart which shows a plot of the time sequence for setting an in-flight digital time fuze as a function of the distance from the breach of the gun or launch vehicle whose projectile muzzle velocity is approximately 2,330 feet per second. At time t_o the projectile 74 is shown in the breach end of the gun 70. At time t_1 the projectile 74 has just received its initial propelling thrust which causes a sufficient acceleration to activate battery 44 and close setback switch 58. After approximately 8 milliseconds, at time t_2, while the projectile 74 is still in the weapon, the accelerating forces within the projectile 74 generate sufficient pressure for the piezoid generator 54 to develop an output voltage. When the projectile approaches the muzzle end 71 of the gun 70, after 9 milliseconds, as shown at t_3. the normally open spin switches 48 and 56 close, electrically connecting the detonator 60 in the circuit. At t_4 the projectile 74 has, after 60 milliseconds, reached a point in time where the battery 44 has developed approximately 90 percent of its maximum output voltage which is sufficient to initiate the auto initial clear circuit 46 to deliver a pulse to the three decade counter 32 so that each of its decades are "0" set. At time t_5, 70 milliseconds after firing of the projectile propellant, the auto initial clear circuitry 46 completes its function. After the projectile travels between 75–125 milliseconds as shown by time t_6 and t_9 a distance of 177 feet and 300 feet respectively, the projectile 74 is ready to receive a coded pulse which sets detonation time of the projectile in response to the pulse transmitted from the fire control circuitry as shown above dashed line 18 in FIG. 1. The increment of time between t_7 and t_8 represents the duration of time required for setting the fuze electronically for the maximum time setting and using the parameters of the system described.

From the above description it will be evident that the invention provides a means for accurately setting a time fuze in a projectile while it is in flight. The in-flight setting is accomplished without the use of encumbering electrical cables. The fuze can, in the event of electrical failure, remain operative by being mechanically hand set. In addition the invention has electrical circuitry and mechanical components which protect the launch crew in the event of a malfunction in the circuitry or the receipt of unwanted spurious signals.

We wish it to be understood that we do not desire to be limited to the exact detail of construction shown and

described for obvious modification will occur to a person skilled in the art.

What is claimed is:

1. An improved rapid fire weapon system of the type wherein a moving target is tracked by a range finder having an output electrically connected to a computer that assimilates the range finder output producing a computer output which relates the distance from a fired projectile, as it exits from a muzzle of a gun to the target, said computer output being electrically connected to a pulse transmitter to cause said pulse transmitter to radiate a coded high frequency electromagnetic pulse as a function of the range finder sensed distance between said projectile while in flight and the target, wherein the improvement comprises:

a receiving antenna located in said projectile for picking up said transmitted signal;

a detector/discriminator, electrically connected to said antenna, detects said coded pulses transmitted and delivers at least one or more output pulses to an electrically connected amplifier and to an electrically connected muzzle burst level discriminator and amplifier when the detector/discriminator detects a high voltage long duration signal from the pulse transmitter calling for muzzle burst action, said muzzle burst level discriminator and amplifier being nonresponsive to the normal range setting pulses generating a first activation signal which can initiate a detonator;

means for counting, electrically connected to said amplifier and responsive to said range setting pulses, generates a second activation signal after a predetermined maximum number of counts;

means for gating the input to said means for counting responsive to said range setting pulses to prevent said counting means from receiving additional pulses from spurious signals which may be received by said antenna after the range setting pulses have been detected and amplified;

means for generating additional pulses within said projectile are electrically coupled to said gating means, filling said means for counting with the additional pulses necessary to reach the predetermined maximum number of counts, said additional pulses being a function of the distance from the projectile as it leaves the muzzle of the gun and the target;

a first means for supplying energy to operate circuitry of said detector/discriminator, amplifier, means for gating, and means for generating additional pulses after the projectile is launched;

a second means for supplying energy to initiate said detonator upon receipt of an activation signal from either the means for counting and the muzzle burst level discriminator and amplifier;

a hand settable switch is electrically connected intermediate to said second energy source and said detonator providing for initiating said detonator in the event of electrical circuits failure in the pulse transmitter;

means for safely arming said projectile is electrically connected intermediate to said counting means and said detonator, between said muzzle burst level discriminator and amplifier and said detonator, and between said hand settable switch and said detonator; and

an electronic gate responsive to either said first or second activation signal and electrically coupled intermediate to said second energy source and said detonator, discharges energy from said second energy source into said detonator through said arming means.

2. An improved rapid fire weapon system as recited in claim 1 wherein the means for counting comprises:

a three decade counter coupled to said means for gating, first sequentially counts the number of coded pulses generated by said pulse transmitter and passed by said detector/discriminator and amplifier circuits, secondly, said counter is responsive to the output of the means for generating additional pulse, said means for generating additional pulses supplies the additional counts necessary to fill the counter to the predetermined maximum number and is directly related to the distance from the projectile to the target, the further the distance the greater number of additional counts necessary to fill the three decade counter; and

an automatic initial clear circuit, electrically coupled to said three decade counter, generates a signal, after the projectile has left the muzzle of the gun, which sets the decades of said three decade counter to zero thus assuring a setting responsive only to the pulse transmitter.

3. An improved rapid fire system as recited in claim 1, wherein the means for gating comprises:

a first "And" gate, having a first input electrically coupled to the output of said amplifier, allows pulses generated by the pulse transmitter to pass, having a second input;

an "Or" gate, electrically coupled intermediate to said first "And" gate and said three decade counter permits the pulses generated by said amplifier to pass to said three decade counter;

means for delaying said first "And" gate electrically connected intermediate to said amplifier and said second input of said first "And" gate inhibiting said first "And" gate from passing any subsequent spurious signals; and

a second "And" gate having first input and a second input electrically connected to said means for generating additional pulses coupled to said delaying means and intermediate to said "Or" gate prevents passage of pulses generated by said means for generating additional pulses from reaching the three decade counter until a signal is received from said delay means making said second "And" gate responsive.

4. An improved rapid fire system as recited in claim 3 wherein the delaying means comprises:

a delay circuit having its input electrically coupled to the output of said amplifier for generating after a fixed predetermined period of time a signal;

an inverter having its input electrically connected intermediate the output of said delay and said second "And" gate second input and its output electrically coupled to said first "And" gate second input for inhibiting said first "And" gate from passing subsequent signals received from said amplifier, when said delay delivers said signal simultaneously to said electrically coupled second "And" gate making it responsive to pass additional pulses from said means for generating additional pulses.

5. An improved rapid fire system as recited in claim 4 wherein the means for generating additional pulses is a clock oscillator having an output pulse frequency of 100 herz.

6. An improved weapon system as recited in claim 1 wherein the first means for supplying energy is a reserve battery activated by the set back forces created when projectile is launched, said battery activates said automatic initial clear circuit when 90 percent of the battery output voltage has been reached, and supplies energy to operate said clock oscillator, detector/discriminator, means for gating, means for delay, amplifier and three decade counter.

7. An improved weapon system as recited in claim 1 wherein the second means for supplying energy is a piezoid generator, said piezoid generator supplies energy to operate electrically coupled said muzzle burst level discriminator and amplifier and initiates said coupled detonator when said electronic gate is triggered either by said muzzle burst level discriminator and amplifier or said activation signal of said three decade counter, said piezoid generator provides the energy to fire said detonator by the intermediate electrically connected said hand settable switch.

8. An improved weapon system as recited in claim 1 wherein the means for safely arming said projectile comprises:

a first pair of delay spin switches intermediate to said electrically coupled three decade counter and a coupled isolation circuit, said isolation circuit matches the impedance of said three decade counter to the impedance of said coupled electronic gate; and

a second pair of spin switches electrically connect both the hand settable switch and the output of said electronic gate through an in series setback switch to said detonator preventing said detonator from receiving a malfunctioning timing signal from said muzzle burst level discriminator and amplifier, said three decade counter or said electronic gate prior to the projectile being launched from said gun.

9. An improved weapons system as recited in claim 1 wherein said electronic gate is a silicon controlled rectifier.

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