

March 17, 1970

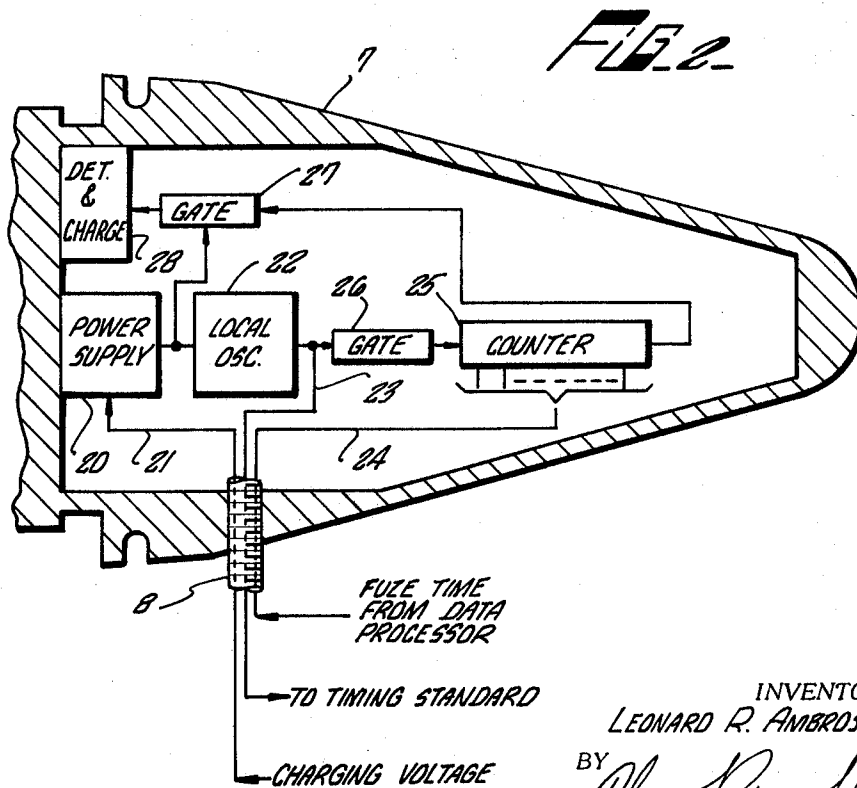
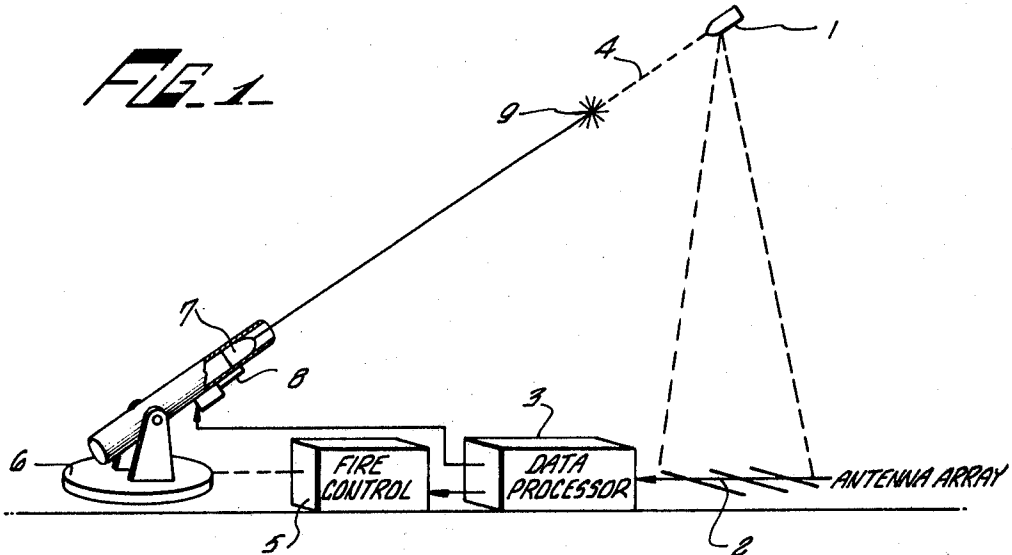
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3,500,746

WEAPON SYSTEM WITH AN ELECTRONIC TIME FUZE

Filed April 17, 1968

2 Sheets-Sheet 1



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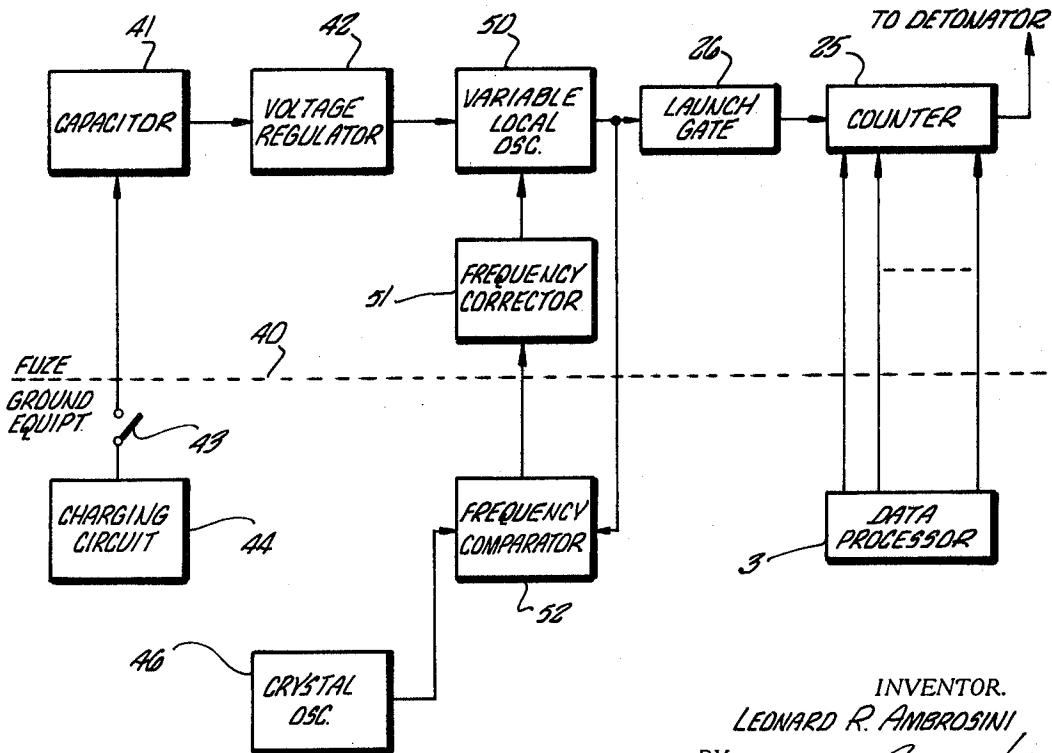
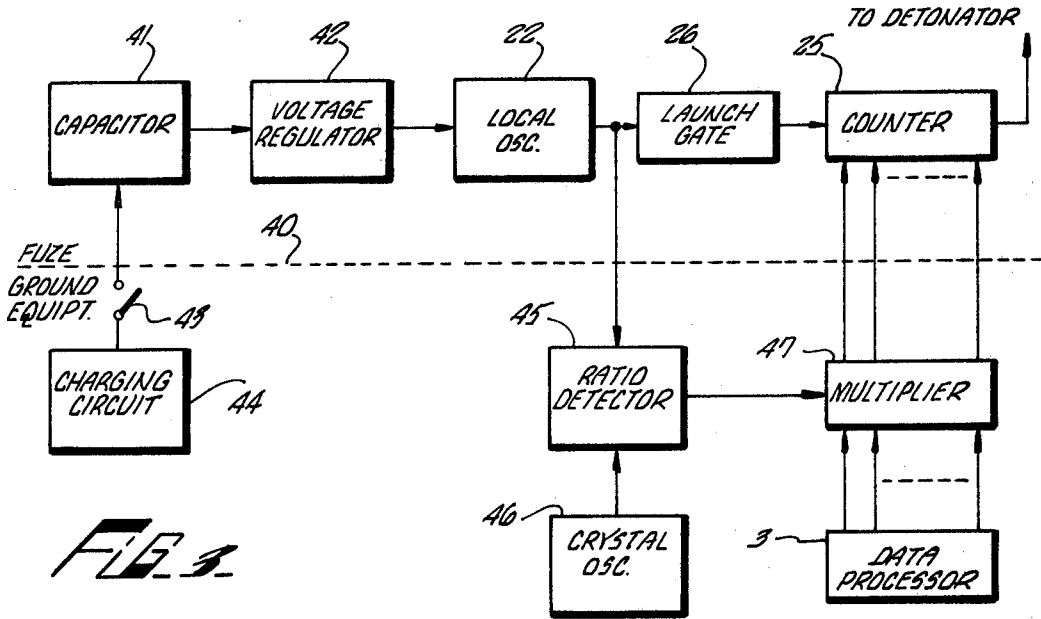
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WEAPON SYSTEM WITH AN ELECTRONIC TIME FUZE

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WEAPON SYSTEM WITH AN ELECTRONIC TIME FUZE

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Filed Apr. 17, 1968, Ser. No. 722,099

Int. Cl. F42c 11/06, 13/06, 15/40

U.S. Cl. 102—70.2

8 Claims

ABSTRACT OF THE DISCLOSURE

An electronic time fuze mounted in a projectile is connected to ground equipment through an umbilical cord until the projectile is launched. The umbilical cord exchanges information between the fuze and the ground equipment so the fuze can more accurately measure the time elapsed from projectile launch to detonation. The fuze includes a local oscillator that is energized by the power stored in the capacitor. Output pulses from the local oscillator are coupled through a launch gate to a counter which is set prior to launch. After the projectile is launched, the local oscillator pulses count down the setting of the counter until a zero state is reached, at which time the detonator is actuated. Prior to launch, the counter is set, errors in the frequency of the local oscillator are compensated for, and the power supply capacitor is charged through the umbilical cord. The errors in the local oscillator frequency are compensated for either by modifying the initial setting of the counter or correcting the frequency itself of the local oscillator.

BACKGROUND OF THE INVENTION

This invention relates to a time fuze mounted in a projectile and, more particularly, to a time fuze that actuates a detonator after the elapse of a predetermined time from launch of the projectile.

In the past, time fuzes have usually been mechanical devices involving a dial that is rotated to set a spring or other mechanical actuator. After the elapse of a certain fuze time determined by the amount of rotation of the dial, the fuze actuates a detonator to set off an explosive charge. Such mechanical devices are especially susceptible to vibration and temperature variations. In general, they do not possess sufficient accuracy or stability for use in projectiles that are intended to destroy offensive missiles or artillery shells, i.e., so-called antimissile or antishell weapons.

One prior art fuze has utilized electronic techniques in order to improve the accuracy of the measurement of the fuze time from launch to detonation. A magnetic core memory in the fuze stores a binary value, representative of a certain fuze time. After launch, a very stable local oscillator in the fuze supplies clock pulses to a binary counter. The binary value registered by the counter is continuously compared with the binary value stored in the core memory until identity occurs, at which time the fuze generates a detonation signal.

In this case, the stable local oscillator, which is expensive, cannot be reused because it is destroyed with the projectile. Another problem is that the electronic fuze is powered by a battery that is normally in an inactive state while the missile is being stored. It is this lack of a power source prior to launch that requires the addition of a magnetic memory required time data storage, which otherwise could be performed by the counter itself. Upon launch, the battery is activated responsive to a spin sensing mechanism. The time required to bring the battery terminal voltage up to its normal value is too long for many anti-

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shell applications. In addition, the long periods of nonuse that often precede launch give rise to unreliability. As a result, the nominal battery terminal voltage is sometimes never reached and the operating frequency of the local oscillator is adversely affected.

SUMMARY OF THE INVENTION

The invention is based on the use of an umbilical cord between the time fuze of a projectile to be launched and the accompanying ground equipment. Information is exchanged between the projectile and the ground equipment right up to the time of launch. In other applications, the invention allows some time to elapse from the separation of the umbilical cord or contacts to launch, depending from capacitor capability, which permits loading of shells in guns. Such an umbilical cord permits the fuze to store the required time from launch to detonation to a high degree of accuracy without precision components. The fuze includes a local oscillator that generates clock pulses and a binary counter whose initial setting at launch determines the fuze time. After launch, the clock pulses are applied to the counter to change its state. When the counter reaches a base state, a detonator is actuated and an explosive charge is set off.

A data processor that forms part of the ground equipment calculates the initial counter setting from data supplied by a radar unit that locates the approaching target shell. The data processor is connected through the umbilical cord to the counter in the fuze. Thus, the initial counter setting is provided by the data processor after the target is detected and its predicted trajectory is calculated. Thereafter, the initial counter setting is updated until launch to reflect any changes in the predicted trajectory of the target. In this way, an initial counter setting is insured at launch that accurately reflects the trajectory of the target. The counter is set while the projectile launcher is being trained on the target so no time is lost in setting the fuze.

The local oscillator is in communication through the umbilical cord with a very stable reference oscillator that forms part of the ground equipment. Thus, immediately prior to launch, any error in the local oscillator frequency is detected and compensated for. In one embodiment, the ground equipment generates a control voltage that is applied through the umbilical cord to a frequency correcting element associated with the local oscillator. In another embodiment, prior to transmission to the fuze, the initial setting of the counter is appropriately modified by the ground equipment to reflect the error of the local oscillator frequency.

The power supply for the fuze is a capacitor that is charged through the umbilical cord immediately prior to launch so that the initial terminal voltage can be accurately and reliably determined. After launch, the terminal voltage of the power supply is maintained by a voltage regulator.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of several specific embodiments of the invention are illustrated in the drawings, in which:

FIG. 1 is a diagram of an antimissile or antishell weapon system;

FIG. 2 is a diagram partially in block form of the head of a projectile in which an electronic fuze embodying the principles of the invention is housed;

FIG. 3 is a block diagram of one embodiment of an electronic fuze illustrating the connections to the ground equipment; and

FIG. 4 is a block diagram of another embodiment of an electronic fuze illustrating the connections to the ground equipment.

DESCRIPTION OF SPECIFIC EMBODIMENTS

In FIG. 1 a weapons system is shown for destroying a target shell or missile 1. An antenna array 2 forms part of a radar unit that detects shell 1 and provides data concerning the trajectory in which shell 1 travels. The trajectory data is supplied to a data processor 3 that computes a predicted trajectory designated 4 in FIG. 1 based on the past trajectory detected by the radar unit. From the predicted trajectory of shell 1, data processor 3 also generates signals to operate fire control apparatus 5, which directs a projectile launcher 6. Data processor 3 also derives a fuze time, that is the time after launch of a projectile that detonation of its explosive charge is to occur. This fuze time is coupled to the fuze of a projectile 7 by an umbilical cord 8. Responsive to the signals generated by data processor 3, fire control equipment 5 points launcher 6 in the correct direction and launches projectile 7 at a designated time to intercept shell 1 at a point 9 on its predicted trajectory. The fuze time is selected so detonation occurs when projectile 7 reaches point 9. The radar unit including antenna array 2, data processor 3, fire control equipment 5, and projectile launcher 6 are conventional pieces of equipment that are per se well known. The invention is concerned with a combination of these elements with an electronic fuze for projectile 7 that is maintained in communication with the ground equipment by umbilical cord 8.

In FIG. 2 the head portion of projectile 7 is depicted in which an electronic fuze is housed. The components of the electronic fuze are shown in FIG. 2 in block diagram. When a target is detected, a power supply 20 for the fuze is activated through umbilical cord 8 by a lead 21. Power supply 20 comprises a capacitor such as a tantalum capacitor and a voltage regulator. Quick charging batteries could also be considered as electrical energy capacitors. To activate power supply 20, a charging current is applied to the capacitor over lead 21. Then, a local oscillator 22 is energized and begins to operate. Local oscillator 22 generates clock pulses that are coupled by a lead 23 through umbilical cord 8 to the ground equipment. There, the frequency deviation of local oscillator 22 from a very stable reference oscillator is detected and the fuze time calculated by data processor 3 is modified to compensate for the error of local oscillator 22. The modified fuze time is coupled by a lead 24 through umbilical cord 8 to a binary counter 25 in the fuze. The initial setting of counter 25 at the time of launch determines the elapse of time until detonation. The fuze time is very accurately established because counter 25 remains in communication with data processor 3 right up to the time of launch so that the initial setting of counter 25 can be updated as the predicted trajectory of target shell 1 changes. The accuracy of the fuze time is further improved by taking into account the frequency error of local oscillator 22 immediately preceding launch in the initial counter setting coupled by lead 24 to counter 25.

After launch, umbilical cord 8 breaks away from projectile 7 and the electronic fuze becomes isolated from the ground equipment. Umbilical cord 8 has a conventional releasable connection to the body of projectile 7. As an alternative to an umbilical cord releasable at launch, the communication between the projectile and the ground equipment in some weapon systems could be made through a connector that is removed from the projectile when a ready condition is assumed. Thus, a delay would take place between interruption of communication and launch. A launch gate 26 couples local oscillator 22 to counter 25 after launch takes place. Launch gate 26 could be a normally open acceleration switch. The clock pulses generated by local oscillator 22 reduce the setting of counter 25 until it reaches a base state such as zero. When the base state is reached, counter 25 generates a detonating signal that enables a gate 27. The power stored in the capacitor of power supply 20 is then released through

gate 27 to actuate a detonator 28 and set off an explosive charge.

FIG. 3 is a block diagram that shows the components of the electronic fuze and the ground equipment as well as the connections therebetween through umbilical cord 8. The components of the fuze are located above an imaginary dashed line 40 and the components of the ground equipment in communication with the fuze are located below dashed line 40. A capacitor 41 and a voltage regulator 42 comprise power supply 20 (FIG. 2). Whenever a target shell is detected by the radar unit, a switch 43 is closed to connect a charging circuit 44 to capacitor 41. Thus, the voltage across capacitor 41 is brought up to a determined level immediately prior to launch. After launch occurs and charging circuit 44 is disconnected from capacitor 41, voltage regulator 42 maintains the terminal voltage of capacitor 41 at a substantially constant level. When capacitor 41 charges to its nominal terminal voltage, local oscillator 22 begins to generate clock pulses that are coupled to a ratio detector 45. The output of a very stable crystal oscillator, which serves as a reference, is also coupled to ratio detector 45. The output of ratio detector 45 is an analog voltage that represents the frequency ratio of the clock pulses generated by local oscillator 22 to the pulses generated by crystal oscillator 46. In other words, the output of ratio detector 45 is a signal that represents the error in the frequency of local oscillator 22. A binary value number representing the fuze time calculated by data processor 3 is coupled through a binary multiplier 47 to counter 25 of the fuze. Thus, the binary value representing the actual fuze time is multiplied by the ratio of the local oscillator frequency to the crystal oscillator frequency prior to transfer to counter 25. This compensates for any error in the frequency of local oscillator 22 so a more accurate measurement of the calculated fuze time takes place after launch.

FIG. 4 depicts an alternative to the arrangement of FIG. 3. In this case, the frequency error of the local oscillator is compensated for by actually correcting it to correspond to the frequency of crystal oscillator 46. A variable local oscillator 50 having a frequency corrector 51 replaces local oscillator 22 of FIG. 3. Frequency corrector 51 could be a motor and variable oscillator 50 could have a variable capacitor in its frequency determining tank circuit. Prior to launch, the output of variable local oscillator 50 is coupled to a frequency comparator 52, which is part of the ground equipment. The output of crystal oscillator 46 is also coupled to frequency comparator 52. An error signal is generated by frequency comparator 52 and coupled through umbilical cord 8 to frequency corrector 51 to establish for variable local oscillator 50 an operating frequency identical to that of crystal oscillator 46. In this embodiment, the binary value representing the actual fuze time calculated by data processor 3 is coupled through the umbilical cord 8 to counter 25 without modification. From the time of initial detection of a target shell until launch, variable local oscillator 50 is continually corrected to the frequency of crystal oscillator 46. After launch, the fuze time is so short variable oscillator 50 does not change sufficiently in frequency to introduce serious error in the measurement of the fuze time.

What is claimed is:

1. A weapon system comprising:

a projectile having a fuze and an explosive charge that is detonated by the fuze after the elapse of a predetermined time from launch of the projectile, the fuze including a local oscillator that generates clock pulses, means for counting the number of pulses generated by the local oscillator after launch of the projectile, and means for detonating the explosive charge responsive to the counting of a predetermined number of clock pulses by the counting means; means for launching the projectile;

means prior to launch for communicating between the fuze and ground equipment, the communicating means including a connection that couples the clock pulses from the local oscillator to the ground equipment;

the ground equipment including a very stable reference oscillator indicating the fuze time to be established for the projectile and means for determining the deviation of the clock pulse frequency from the frequency of the reference oscillator; and
means for compensating for the deviation of the clock pulse frequency from the reference oscillator frequency.

2. The system of claim 1, in which the local oscillator is a variable frequency oscillator, the frequency deviation determining means is a frequency comparator that produces an error voltage related to the difference in frequency between the clock pulses and the reference oscillator, and the compensating means is a frequency corrector that changes the variable frequency oscillator responsive to the error voltage.

3. The system of claim 1, in which the frequency compensating means modifies the number of clock pulses counted before the explosive charge is detonated.

4. The system of claim 1, in which the means for counting the clock pulses is a binary counter and the communicating means couple the source indicating the fuze time to the binary counter to set the counter initially.

5. The system of claim 1, in which the communicating means couples the source of signals indicating fuze time to the fuze.

6. In a weapon system an electronic fuze for detonating an explosive charge in a projectile comprising:

a local oscillator that generates clock pulses;
a binary counter, the initial setting of which determines the fuze time;

a gate operated in response to launch of the projectile for coupling the clock pulses from the local oscillator to the counter so as to change the counter state; means responsive to the arrival of the counter at a predetermined state for generating a detonating signal; and

a power supply for the oscillator comprising a capacitor and means for regulating the voltage across the capacitor after launch.

7. A weapon system for intercepting a moving target comprising:

a projectile having an explosive charge;

means for detecting and locating a moving target to be intercepted;

means responsive to the detecting and locating means for generating an indication of the time elapse after launch of the projectile that the charge is to be detonated in order to intercept the target;

means in the projectile for storing the time indication; means responsive to the detecting and locating means for launching the projectile toward the target;

means severable upon launch for coupling the indication from the generating means to the storing means in the projectile; and

means in the projectile for detonating the charge responsive to a time elapse after launch equal to the indication stored at launch.

8. A weapon system for intercepting a moving target comprising:

a projectile having an explosive charge;

means for detecting and locating a moving target to be intercepted;

means responsive to the detecting and locating means for launching the projectile toward the target;

means in the projectile for storing the time elapse from launch that the charge is to be detonated;

means on the projectile for generating clock pulses; means after launch for counting the generated clock pulses;

means in the projectile for detonating the charge after a number of clock pulses are counted corresponding to the time elapse;

means removed from the projectile for generating reference pulses; and

means for compensating for errors in the frequency of the clock pulses from the reference pulses before launch.

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