

[54] FUZE ACTUATING SYSTEM

[75] Inventor: Richard T. Ziemba, Burlington, Vt.

[73] Assignee: General Electric Company,
Burlington, Vt.

[22] Filed: Aug. 3, 1972

[21] Appl. No.: 277,562

Related U.S. Application Data

[62] Division of Ser. No. 843,478, July 22, 1969, Pat. No. 3,714,898.

[52] U.S. Cl. 102/70.2 P, 102/80

[51] Int. Cl. ... F42c 13/04, F42c 15/04, F42c 11/00

[58] Field of Search 102/70.2

[56] References Cited

UNITED STATES PATENTS

3,688,701 9/1972 Kern 102/70.2 P

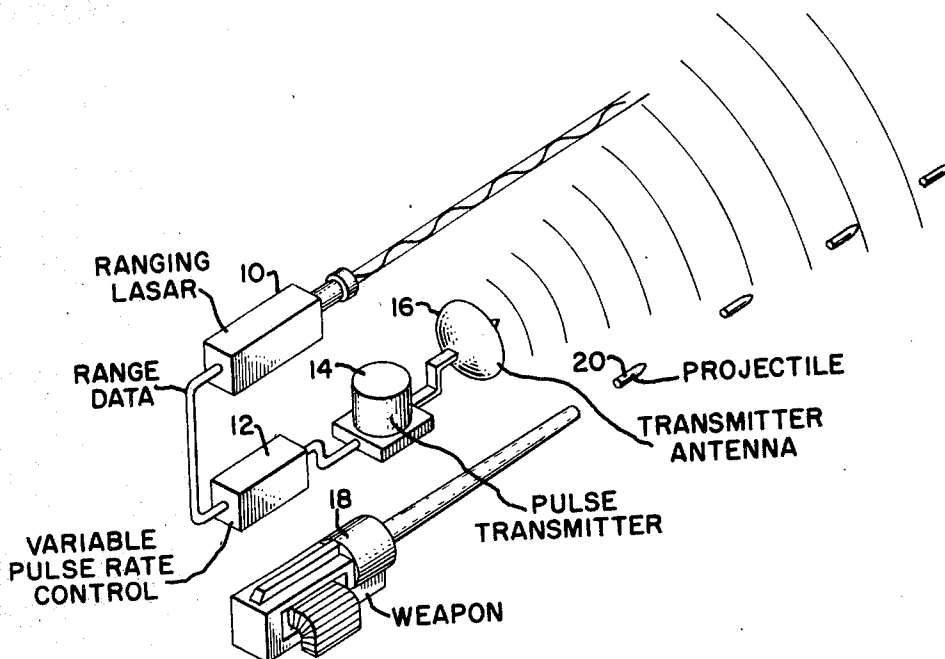
Primary Examiner—Benjamin A. Borchelt
Assistant Examiner—Thomas H. Webb
Attorney—Bailin L. Kuch et al.

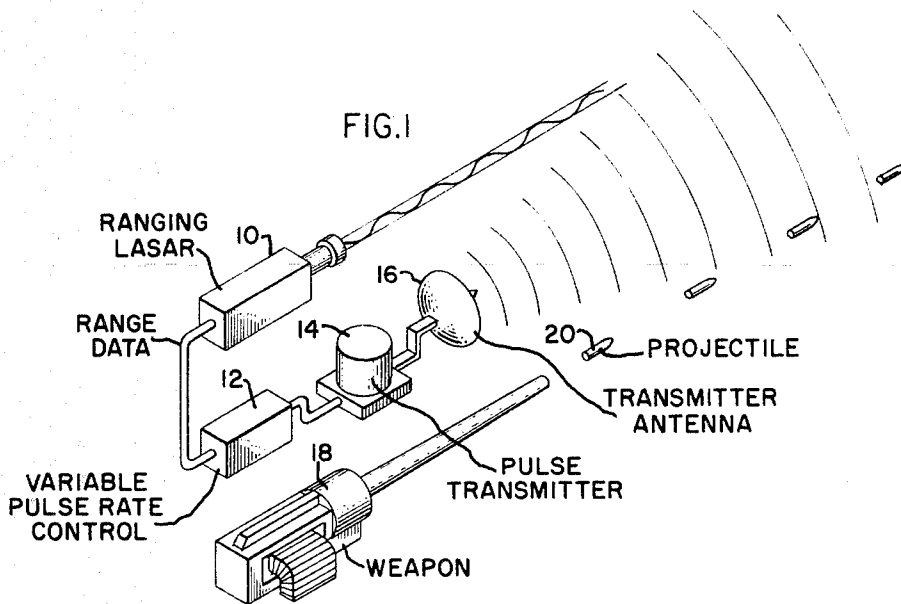
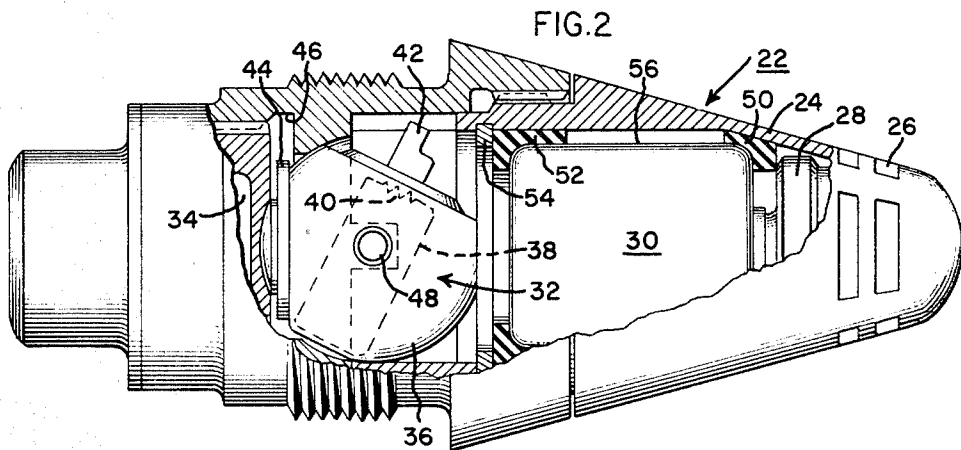
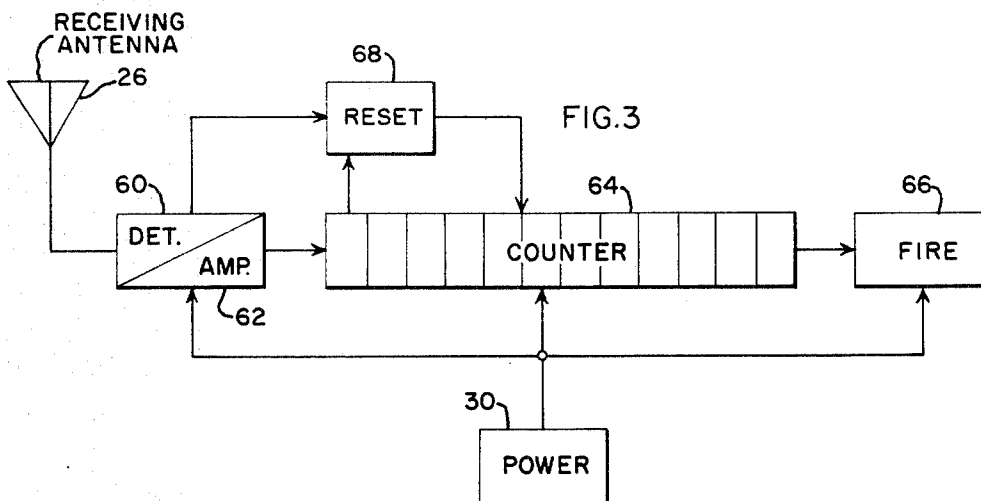
[57]

ABSTRACT

An electronic, digital, time fuze, has a time base which is introduced over a radar command link at a rate which is inversely proportional to the desired projectile flight time. A target following ranging device, such as a ranging laser, provides target range information to a pulsed radar transmitter. The range signal from the ranging device controls a variable pulse rate control unit which in turn adjusts the transmitter pulse rate to a value inversely proportional to the target range. The transmitter is fixed to the weapon system and radiates in the direction of the projectile flight path. Each projectile includes a fuze actuating circuit consisting of an antenna, an r.f. detector, a fixed-set counter and a firing circuit. At launch, the fuze actuating circuit within each projectile becomes actuated a short distance after departure from the gun muzzle. As the projectile travels towards its target it receives a series of r.f. pulses at a rate which will just fill the counter when the projectile is at the proper range. The counter within the fuze counts the pulses received during its flight to target. When the fixed-set number has been accumulated, the firing circuit detonates the payload.

1 Claim, 7 Drawing Figures





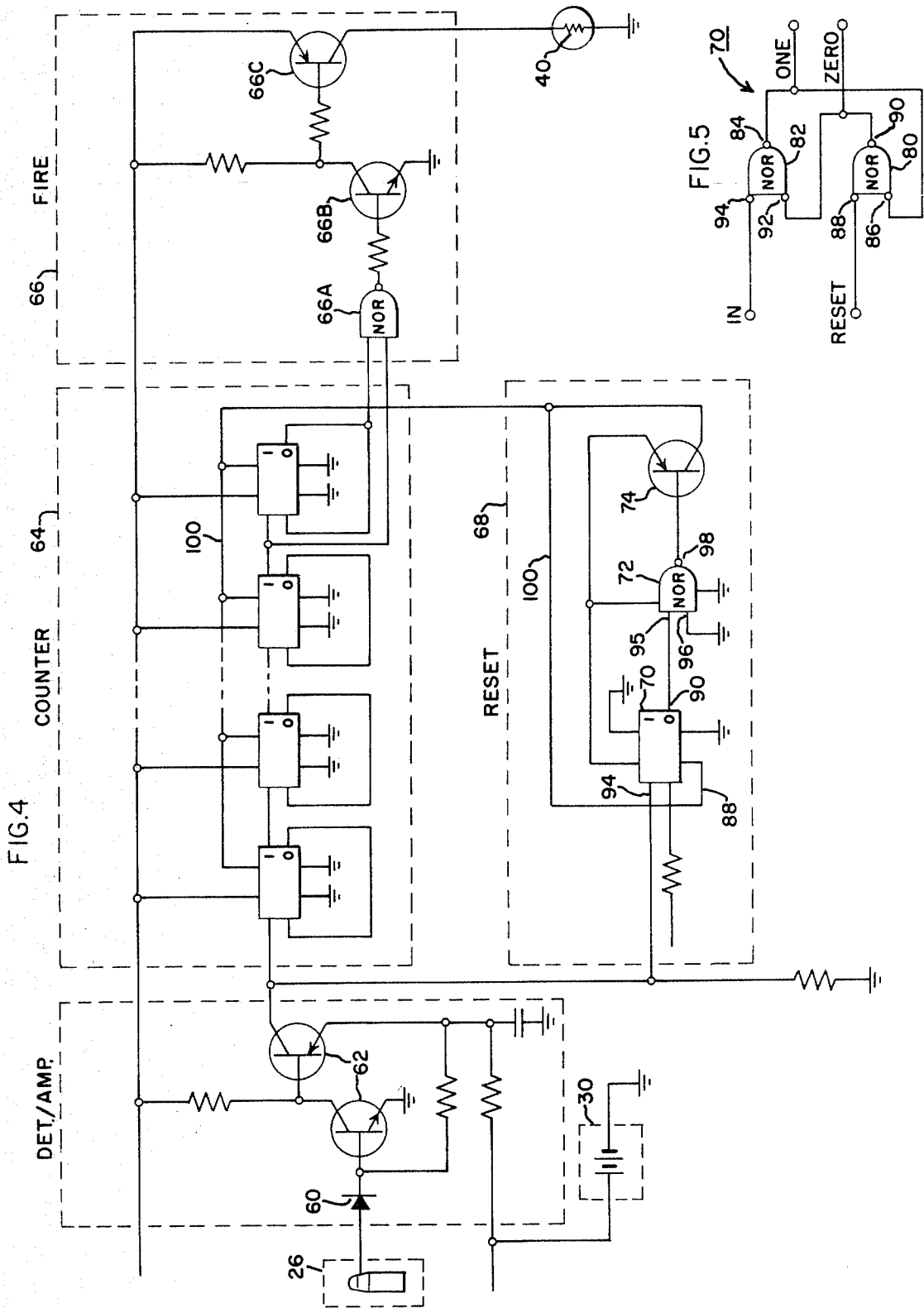


FIG. 6

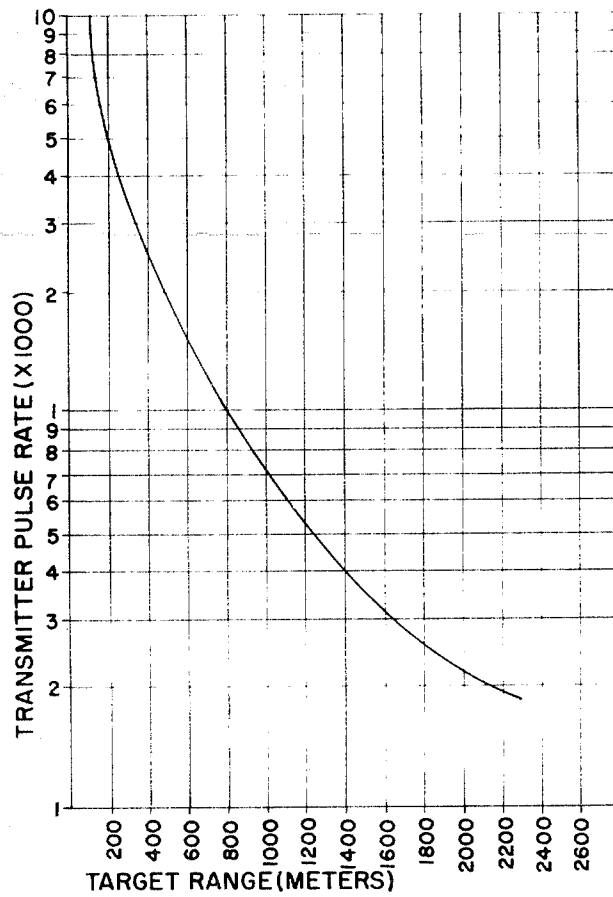
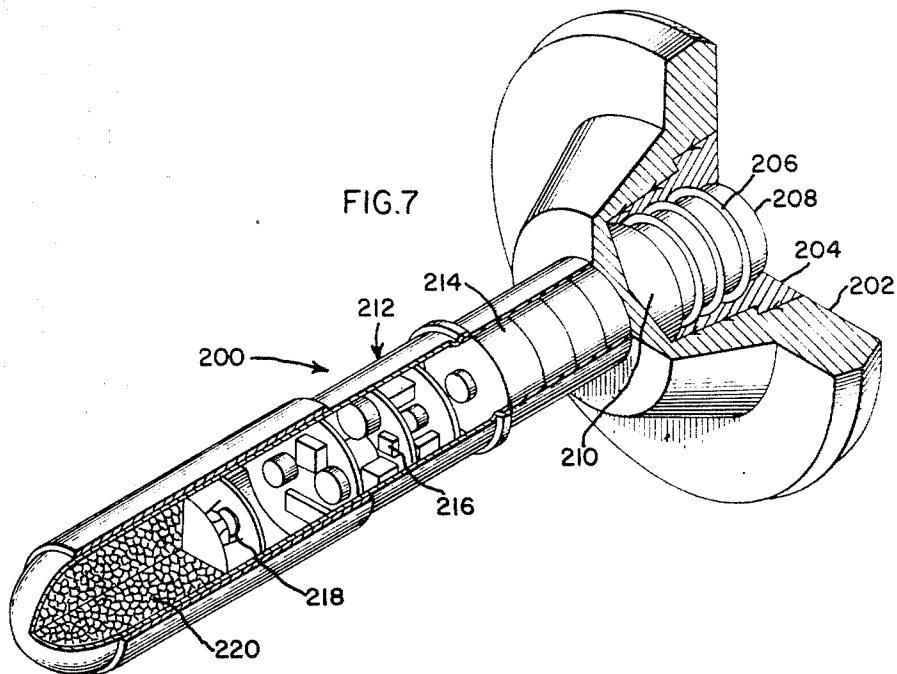


FIG. 7



FUZE ACTUATING SYSTEM

This application is a division of copending U.S. Pat. 3,714,898, filed July 22, 1969 and issued Feb. 6, 1973.

BACKGROUND OF THE INVENTION

1. Field of Art

This invention relates generally to fuze actuating systems, and especially to systems wherein the range adjustment may be varied in flight.

2. Prior Art

Conventional fuzes may be grouped according to different actuating characteristics: Briefly,

1. Timing out preset interval required to travel to target,

a. Mechanical timing,

b. Chemical timing,

c. Electronic timing,

i. Analogue timing,

ii. Digital timing;

2. Detecting proximity of target; and

3. Impacting on target.

Once a conventional timing fuze has been preset and sent into flight, control by the gunner is lost, and accuracy is subject to unaccounted-for movement of the target and the accuracy of the timing system. Once a conventional proximity detecting fuze has been sent into flight, control by the gunner is lost, and the fuze may be subject to premature detonation by other proximate objects. Once a conventional target impacting fuze is sent into flight, control by the gunner is lost.

BRIEF SUMMARY OF THE INVENTION

It is an object of this invention to provide a system having the inherent accuracy of an electronic, digital timing actuator plus the ability of the gunner to adjust the interval in flight to actuation, thereby attaining the best characteristics of a digital timer and a proximity fuze.

A feature of this invention, (as shown in FIG. 1) is an electronic, digital, time fuze, whose time base is introduced over a radar command link at a rate which is inversely proportional to the desired projectile flight time. A target following ranging device, such as a ranging laser, provides target range information to a pulsed radar transmitter. The range signal from the ranging device controls a variable pulse rate control unit which in turn adjusts the transmitter pulse rate to a value inversely proportional to the target range. The transmitter is fixed to the weapon system and radiates in the direction of the projectile flight path. Each projectile includes a fuze actuating circuit consisting of an antenna, an r.f. detector, a fixed-set counter and a firing circuit.

At launch, the fuze actuating circuit within each projectile becomes activated a short distance after departure from the gun muzzle. As the projectile travels towards its target it receives a series of r.f. pulses at a rate which will just fill the counter when the projectile is at the proper range. The counter within the fuze counts the pulses received during its flight to target. When the fixed-set number has been accumulated, the firing circuit detonates the payload. Once the rate at which pulses are to be generated is set, as a function of target range, each projectile must travel the same time, and the same range, before it accumulates the same full count. Thus, by adjusting the pulse rate frequency

(PRF) of the transmitter, the gunner adjusts the range at which the payload is detonated.

Some unique advantages of this system are:

1. The system is insensitive to the rate at which projectiles are fired. That is, with either single-shot or burst fire, payload detonation will occur at the same range.

2. The desired resolution of the detonation range is limited only by the capacity of the counter within the fuze and the pulse rate of the transmitter.

3. The detonation range can be automatically adjusted if automatic range information is available.

4. The detonation range can be intentionally varied while the projectile is in flight to the target.

5. Jamming is difficult since a special transmitter is required to communicate with the projectile and the projectile receiving antenna is directional aft wards.

A similar system (as shown in FIG. 7) may be utilized to initiate a rocket motor in a boosted projectile at a range most appropriate for its programmed trajectory. Projectile muzzle velocity, weapon elevation and target range information are processed to provide time-to-ignition-point data which is subsequently translated into a transmitter pulse repetition frequency.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects, features and advantages of the invention will be apparent from the following specification thereof taken in conjunction with the accompanying drawing in which:

FIG. 1 is a diagram of a controlled range air burst fuze system for a shell incorporating this invention;

FIG. 2 is a side view, partially in cross-section, of a fuze package according to this invention particularly adapted for insertion in the forward end of a small caliber projectile;

FIG. 3 is a block diagram of the electronic circuitry of the fuze of FIG. 2;

FIG. 4 is an electronic circuit diagram of the fuze of FIG. 2;

FIG. 5 is a block diagram of the electronic circuitry of the reset flip-flop;

FIG. 6 is a plot of projectile range vs. radar pulse repetition frequency; and

FIG. 7 is a perspective view, partially in cross-section, of a fuze package according to this invention, particularly adapted for insertion in the aft end of a rocket boosted projectile.

THE PREFERRED EMBODIMENT

As discussed above with respect to FIG. 1, the preferred embodiment of the system includes a source of range data, such as a ranging laser 10, a variable pulse rate control 12, a pulse transmitter such as an X-band radar 14, a transmitter antenna 16, a weapon 18, and one or more projectiles 20. Each projectile 20 has a fuze 22 which, as seen in FIG. 2, includes a housing 24 containing an antenna such as a slot antenna 26, electronic circuitry 28, a battery 30, which may be a thermal battery, a rotor-detonator assembly 32 and a booster charge 34.

The rotor-detonator assembly 32 may be of the type shown in U.S. Pat. Application Ser. No. 804,443 filed Mar. 5, 1969 by R. T. Ziemba. Briefly, the assembly 32 comprises an out of line ball rotor 36 having a detonator charge 38 with a filament 40 and a contact brush 42, and a C-shape spring retainer 44. The rotor is held

in the out of line, safe disposition until the projectile, in flight, has developed adequate spin to centrifugally enlarge and enable the spring retainer 44 to pass into an annular recess 46 in the housing to release the rotor. The rotor then rotates to axially align its center of gravity and the detonator charge with the longitudinal axis of the projectile. The rotor is journaled on a transverse axis at 48 to constrain the rotor to rotation within a predetermined longitudinal plane so that the contact 42 wipes through this plane.

The thermal battery 30 may be of the type shown in U.S. Pat. Application Ser. No. 695,144 filed Jan. 2, 1968 by R.T. Ziemba. Briefly, the battery includes two electrodes spaced apart by a normally solid and non-conductive thermally fusible electrolyte. Thermitic material is mounted in thermally conductive relation with the electrolyte and is ignitable by a percussion cap which is disposed between two rigid surfaces, one of which is a relatively displaceable striker element. The battery is normally inactive, until the projectile is subjected to a set-back force on firing, which causes the striker element to percuss the cap, which explodes and actuates the thermitic material, which melts the electrolyte to activate the battery. The battery 30 is supported in a cavity in the housing by a forward dielectric ring 50 and an aft dielectric ring 52 and is retained forward by a spring clip 54. The outer case 56 of the battery serves as the negative contact, and is adapted to be wiped by the detonator contact 42.

The electronic circuitry 28 includes the antenna 26, and a diode detector 60, a two stage video amplifier 62, a counter 64, a firing circuit 66, and a reset circuit 68. The antenna consists of a double four-port slot antenna, whose dimensions and probe phasing are designed to increase antenna gain to the rear of the projectile. The slot configuration, using two diametrically opposed double pairs of adjacent slots, quarter-wave spaced, gives an antenna gain in the aft direction of +5 decibels over a standard dipole. Antenna power is peak-detected with the hot carrier diode 60, whose output signal is the transmitted PRF envelope. The signal voltage level at this point is approximately 0.05 volt, from a 40 kilowatt (peak) transmitter at a 3,000-meter range. The detected pulses are amplified by the two-stage amplifier 62 to a level adequate to drive the counter 64. The counter consists of twelve flip-flop stages in a cascade configuration which provide an input to output count ratio of 2^{12} or 2048. Switchover of the last stage is detected to actuate the output circuit, so only a count of 1,024 is realized from the counter. When the one-output terminal of the eleventh flip-flop is low, and the zero-output terminal of the twelfth flip-flop is low, the output terminal of the gate 66A will be high, drawing current via the output amplifiers 66B and 66C through the filament 40 of detonator charge 38 to actuate the detonator after a finite interval which is a function of time and current.

After the projectile is accelerated out of the weapon and the battery is actuated, the battery requires a finite period of time to reach full output voltage. When a voltage adequate for operating the flip-flops is reached, each of these flip-flops may assume either of its one terminal high and zero terminal low, or one terminal low zero terminal high states. Absent the automatic reset circuit, should the eleventh flip-flop one output terminal be low and the twelfth flip-flop zero terminal be low the detonator filament 40 will start drawing current.

Detonation would otherwise occur after a period of time. Less catastrophic, but not desirable, should any of the flip-flop assume its one-output high state, the counter will give a short count.

The automatic reset circuit 68 forces each of the counter flip-flop one output terminals to its low state upon the initial provision of power to the fuze from the battery 30. This reset occurs in less than one microsecond, which precludes premature actuation of the detonator. The reset flip-flop 70, the reset NOR gate 72 and the reset pnp common emitter driver 74 are used to implement the reset circuit as a race loop. The reset flip-flop 70, as seen in FIG. 5 may be structured as two NOR gates 80 and 82. The one output terminal 84 of the gate 82 is coupled to one of the input terminals 86 of the gate 80, whose other input terminal 88 serves as the pulse input-terminal. The zero output terminal 90 of the gate 80 is coupled to one of the input terminals 92 of the gate 82, whose other input terminal 94 serves as the reset input terminal. The zero-output terminal 90 of the flip-flop 70 is coupled to one input terminal 95 of the NOR gate 72, whose other input terminal 96 is coupled to ground. The output terminal 98 of the gate is coupled to the base of the driver 74. The emitter of the driver is coupled to the supply voltage and the collector is coupled to the reset bus 100. The NOR gate 72 provides the longest delay in the loop, i.e., the slowest input to output transfer; and the driver provides the least delay.

The operation of the reset circuit may be broken into three phases, viz: Phase I, the interval during power coming up; Phase II, the interval after reset and before receipt of the first transmitter pulse; and Phase III, the action on receipt of the first transmitter pulse.

Consider Phase I. The reset flip-flop zero output terminal 90 may initially assume either a high or low state. Assume the zero output terminal 90 is high, then the NOR gate output terminal 98 is initially and steady state low, the base electrode is initially and steady state low, and the driver initially and steady state conducts so that the reset bus 100 is initially and steady state high. The high signal on the reset bus resets all of the counter flip-flops. The high reset signal at input terminal 94 also provides a low signal at output terminal 84 and thence a low signal at input terminal 86 and thus maintains output terminal 90 high. Assume the zero output terminal is low, then the NOR gate output terminal 98 is initially low, and, because of the long transfer delay, the base electrode is initially low and the driver initially conducts so that the reset bus 100 is initially high. The initial high signal on the reset bus 100 resets all of the counter flip-flops, and also resets the reset flip. After the long transfer delay the NOR gate output terminal 98 becomes high, making the base electrode high and turning off the driver so that the reset bus becomes low. However, the reset flip-flop has already been reset, so that its zero output terminal is now high, and as described previously the driver conducts and the reset bus again becomes high.

Thus, in Phase II, the reset flip-flop zero output terminal is high, the NOR gate output terminal 98 is low, the driver conducts, and the reset bus 100 is high. Also, the reset flip flop one output terminal 84 is low.

When, in Phase III, the first transmitter pulse is received, it is coupled to the input terminal 94 so that the zero output terminal 90 goes low. However, the transmitter pulse is shaped to have a width greater than the

NOR gate 72 transfer delay, so that when the NOR gate output terminal 98 goes high the driver stops conducting, making the reset bus 100 low, while the zero output terminal remains low. The reset bus remains low, and the counter is free to count subsequent transmitter pulses without reset.

The advantages of the reset circuit include:

1. Priority and speed of operation sufficient to preclude accidental detonation.

2. Independence of the rise characteristics of the power supply.

3. Ease of testing the configuration before assembly to the war head since operation is dependent only on the presence of a voltage which might cause an accidental detonation.

The variable pulse rate features of the transmitting radar is illustrated in FIG. 6 which shows the variation in pulse rate required to detonate a fuze payload as a function of target range with a counter capacity of 1,024, i.e., 2^{10} , counts. The pulse rate varies from about 10,000 pps at 100 meters to 200 pps at 2,000 meters. At 2,000 meters, fuze detonation resolution is ± 0.01 meter. This assumes a constant rate PRF which is the manner in which the radar would normally be operated in a burst fire mode. For single-shot firings the PRF may be programmed to increase in rate as the projectile travels down range, thereby providing higher resolution at maximum projectile range.

A SECOND EMBODIMENT

As shown in FIG. 7, a fuze embodying this invention may be incorporated in a rocket-boosted projectile as an in-flight igniter assembly. The assembly 200 includes a nozzle plug 202, an inner plug 204 supporting a three-turn helical antenna 206 wound on a dielectric

core 208, a detector assembly 210, and a cannister 212. The cannister includes a thermal battery 214, the counter and reset circuitry 216, the detonation initiator 218, and the rocket igniter 220. The circuitry is substantially identical to that shown in FIG. 4, with the substitution of the helical antenna for the slotted antenna.

The counter and reset flip-flops may be 913 elements and the NOR gates may be 910 elements as shown in the May 1964 catalogue of Fairchild Semiconductor Division of Fairchild Camera and Instrument Corporation.

What is claimed is:

1. A weapon system comprising:

a projectile having a fuze;

said fuze including

a receiving antenna for receiving pulses,

an r.f. detector having an input terminal coupled to said receiving antenna and an output terminal,

a fixed-set counter having a plurality of multi-state stages, an input terminal coupled to said detector output terminal for accumulating pulses therefrom and an output terminal for presenting a full-count signal when a preset count of pulses has been accumulated;

a firing circuit having an input terminal coupled to said counter output terminal for detonating said fuze when said full-count signal is presented by said counter; and

reset means for automatically forcing each of said stages of said counter to a predetermined one of said states.

* * * * *

40

45

50

55

60

65