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Rudman

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[54] **ELECTRONIC FIRING DEVICE FOR SOFT RECOIL WEAPONS**

[75] Inventor: **Ronald H. Rudman,** Chatsworth, Calif.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

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[52] **U.S. Cl.** ..... **89/42 B;** 89/134

[51] **Int. Cl.**[2] **F41F 19/10**

[58] **Field of Search** ..... 89/41 ME, 42 B, 135

[56] **References Cited**

UNITED STATES PATENTS

3,677,135 7/1972 Haug ..... 89/42 B

Primary Examiner—Stephen C. Bentley

Attorney, Agent, or Firm—Samuel Kane; Nathan Edelberg; Robert P. Gibson

[57] **ABSTRACT**

An electronic device which senses the velocity of the forwardly accelerating recoilable parts of a soft recoil weapon system and converts it into signals for initiating firing of the weapon and termination of the forward acceleration of the recoilable parts. The device includes circuitry which compensates for ignition delay and for variations in ignition delay caused by changes in temperature, and which is settable for use with a variety of rounds of ammunition, each round containing a different quantity of propellant than the other rounds.

11 Claims, 3 Drawing Figures

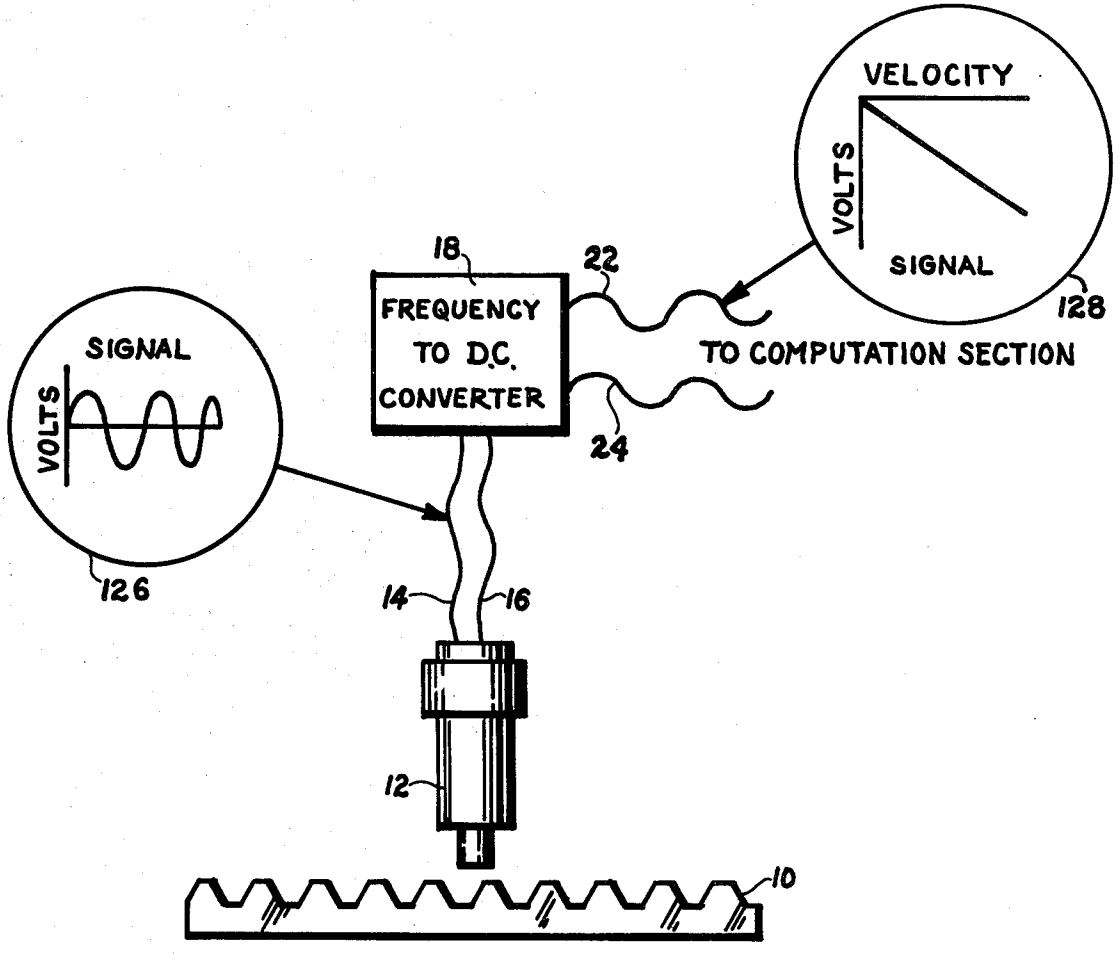


Fig.1

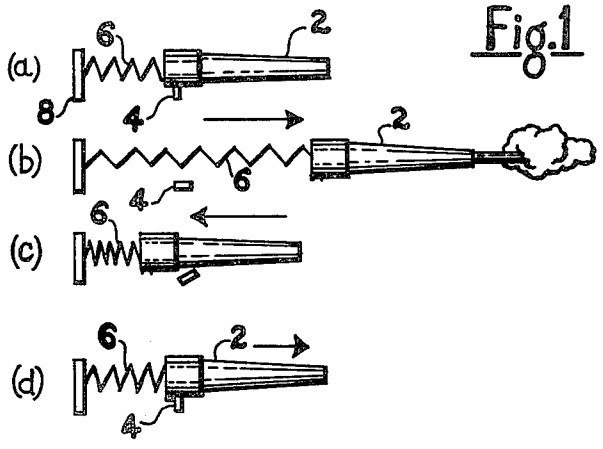
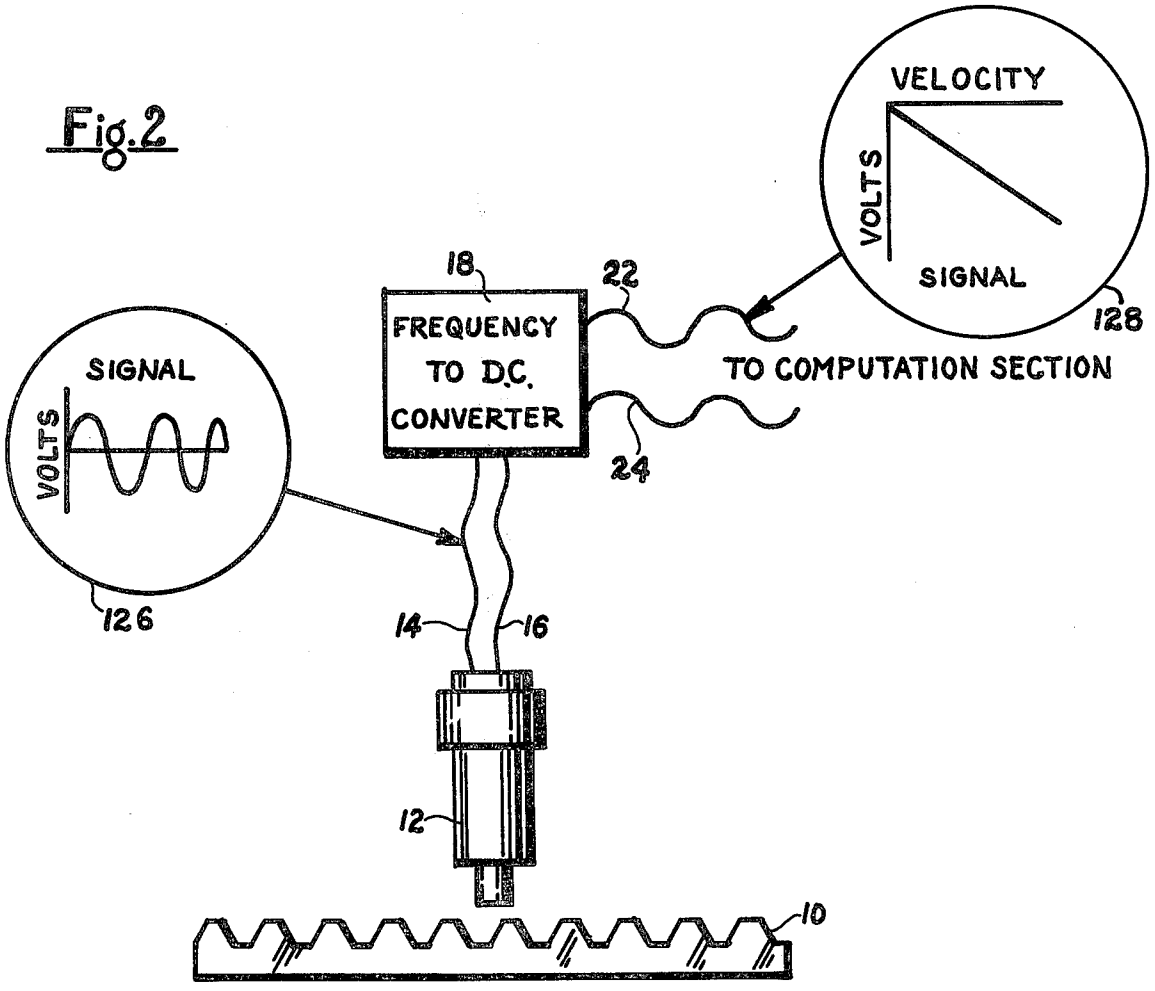

(a)
(b)
(c)
(d)
2
4
6
8

Fig.2


VELOCITY
VOLTS
SIGNAL
128
18
FREQUENCY TO D.C. CONVERTER
22
TO COMPUTATION SECTION
24
SIGNAL
VOLTS
126
14
16
12
10

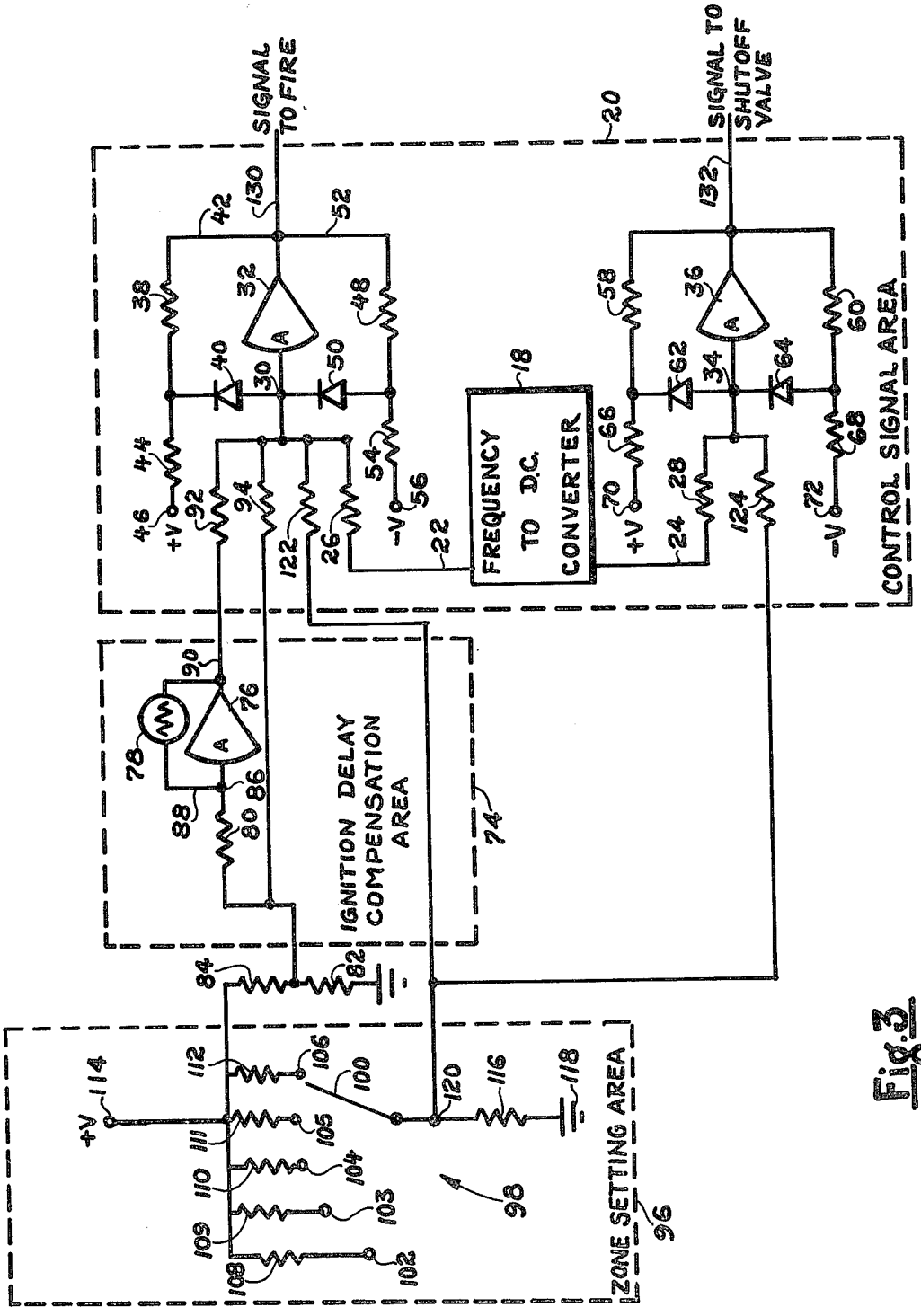

SIGNAL TO FIRE
SIGNAL TO SHUTOFF VALVE
20
CONTROL SIGNAL AREA
FREQUENCY TO D.C. CONVERTER
18
IGNITION DELAY COMPENSATION AREA
24
ZONE SETTING AREA
96
+V
-V
A

Fig. 3

ELECTRONIC FIRING DEVICE FOR SOFT RECOIL WEAPONS

STATEMENT OF GOVERNMENT INTEREST

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

BACKGROUND OF THE INVENTION

This invention relates generally to fire control apparatus for a weapon system and particularly to such apparatus for obtaining precise timing of fire control signals in a weapon system which uses a variety of rounds of ammunition under different temperature conditions, While not limited thereto, the invention finds special application for controlling the signal to fire and the signal to terminate forward acceleration of the recoilable parts in a soft recoil weapon system, and therefore the invention will be described hereinafter in connection with such use.

In the operation of a soft recoil weapon system such as artillery, for example, the recoilable parts are accelerated forwardly in the direction of the target until they reach the firing velocity at which time a signal to fire the weapon is generated. The resulting combustion of the projectile propellant produces a gas pressure which propels the projectile down the gun tube and exerts a force on the gun breech tending to move the weapon in a direction opposite to projectile motion. The time lapse between initiation of propellant ignition and the application of the forece on the gun breech constitutes a delay in ignition which must be compensated for in the design of a firing device for soft recoil weapon system.

SUMMARY OF THE INVENTION

A principle object of the invention, therefore, is to provide a firing device which compensates for ignition delay in a weapon system.

Another object of the invention is to provide a firing device which compensates for variations in ignition delay in such a system due to variations in propellant temperature.

A further object of the invention is to provide a firing device which is sensitive to the forward velocity of the recoilable parts of a soft recoil weapon system for generating fire control signals.

Still a futher object of the invention is to provide a firing device which compensates for ignition delay in a soft recoilable weapon system and is settable for use with different rounds of ammunition, and wherein each round has a different quantity of propellant than the other rounds.

In accordance with the above objects and considered first in one with the invention for a soft recoil weapon system having recoilable parts adapted for mounting a round of ammunition, nonrecoilable parts supporting the recoilable parts, and means for accelerating the recoilable parts relative to the nonrecoilable parts during a portion of a firing cycle may comprise a toothed member mounted on one of the recoilable and nonrecoilable parts and a sensing means mounted on the other of said parts and sensitive to the toothed surface of the toothed member during acceleration of the recoilable parts for generating a first electrical signal. There is also provided a delay circuit connected to a source of input voltage for generating a second electrical signal which is a function of temperature. The device also includes a plurality of networks each connectible for forming a voltage divider and each voltage divider having a terminal whose voltage constitutes a third signal representative of an individual round of ammunition. Also included are first and second control means, the first control means being responsive to the input voltage and the first, second, and third electrical signals for generating a signal to fire the weapon, and the second control means being responsive to the first and third electrical signals for generating a signal to terminate acceleration of the recoilable parts.

The invention will be more clearly understood when the following detailed description of the preferred embodiment thereof is read in conjunction with the accompanying drawing which is described below.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a diagrammatic illustration of a firing cycle of a soft recoil weapon system in which firing is controlled by means of the present invention.

FIG. **2** is a diagrammatic view of the velocity pickup section of the invention.

FIG. **3** is a schematic circuit diagram of the computation section of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In a soft recoil weapon system of a kind whose firing cycle is illustrated in FIG. **1**, such as a field Howitzer, for example, the recoil mechanism may, for example, be of the hydro-pneumatic, fire-out-of-battery type. In a mechanism of that type the recoilable parts are held mechanically by a latching mechanism, with a driving mechanism including a gas spring acting in the direction of firing. In FIG. **1**(*a*) the recoilable parts are represented by a cannon **2**, the latching mechanism by a latch **4**, and the driving mechanism including the gas spring by a compression spring **6**. A vertical bar **8** represents the nonrecoilable parts of the weapon system.

When the gunner pulls the lanyard or otherwise initiates firing of the weapon, the latching mechanism **4** will be released and forward acceleration of the recoilable parts **2** in the direction of the target by the driving mechanism and gas spring **6** will occur. When the recoilable parts **2** reach the required firing velocity the accelerating force will automatically be terminated to allow the recoilable parts to coast prior to the firing impulse. Signals to terminate the forward acceleration of the recoilable parts **2** and to fire the weapon are generated by the present invention, as will appear more clearly hereinafter.

When the weapon fires, as depicted in the forward or rightward position of the recoilable parts **2** in FIG. **1**(*b*), the firing impulse will overcome the forward momentum of the recoilable parts **2** and force these parts to the rear, or leftwardly as shown in FIG. **1**(*c*), against the gas spring **6** and past the latching position. The gas spring **6** will then return the recoilable parts **2** forwardly, or to the right as depicted in FIG. **1**(*d*), to the latching position where they will again be locked by the latch **4**, thereby completing the firing cycle.

Turning now to the details of the invention, the velocity pickup section (FIG. **2**) comprises a rack **10** constructed of a ferrous metal and secured to the nonrecoilable parts of the associated weapon system, not shown. A sensing element **12** is secured to the recoila-

ble parts of the weapon system closely adjacent to the toothed surface of the rack **10** and connected by output leads **14** and **16** to a frequency to dc converter **18** in a control signal circuit **20** (FIG. 3). One form of sensing element **12** is a magnetic pickup device which comprises a permanent magnet inductively coupled to an output coil, the ends of which constitute or are connected to the leads **14** and **16.**

The frequency to dc converter **18** is connected through output leads **22** and **24** to resistors **26** and **28** respectively. Resistor **26** is coupled to the input terminal **30** of an operational amplifier **32** and resistor **28** is similarly coupled to the input terminal **34** of an operational amplifier **36.** As will appear more clearly hereinafter, when the input signal at the terminal **30** causes a negative output to amplifier **32,** a resistor **38** and diode **40** are actively connected in the feedback loop **42** of the operational amplifier **32** and a resistor **44** applies an input voltage to the terminal **30** from a source of positive voltage **46.** When the input signal causes a positive output to amplifier **32,** a resistor **48** and diode **50** are actively connected in the feedback loop **52** of the operational amplifier **32** and a resistor **54** applies the input voltage to the terminal **30** from a source of negative voltage **56.** Similar input and feedback networks are connected to the operational amplifier **36** and these include resistors **58** and **60,** diodes **62** and **64,** and resistors **66** and **68** connected respectively to a source of positive voltage **70** and a source of negative voltage **72.**

An ignition delay circuit **74** which compensates for ignition delay and for variations in ignition delay caused by changes in temperature comprises an operational amplifier **76** having a temperature sensitive element **78** whose impedance varies with temperature, and an input resistor **80** connected to the junction of two resistors **82** and **84** and the input terminal **86** of the operational amplifier **76.** In the present embodiment of the invention the temperature sensitive element **78** has been chosen to be a thermistor. Preferably, the thermistor **78** is connected in the feedback loop **88** of the operational amplifier **76,** as shown, however, it is conceivable that in some applications of the the invention the thermistor **78** and resistor **80** could be interchanged so that the thermistor would be an input resistor.

The output lead **90** of the operational amplifier **76** is connected to a resistor **92** which is coupled to the input terminal **30.** Another resistor **94** is connected between the terminal **30** and the junction of resistors **82** and **84.**

A zone setting circuit **96** comprising a multiposition switch **98** is provided to enable the gunner to set the zone being fired, the "zone" being an indication of the quantity of propellant or the amount of charge in a specific round of ammunition, each round containing a different quantity of propellant than the other rounds. Thus, by setting the switch arm **100** to a selected one of the switch contacts **102–106** the apparatus is set for the corresponding zone or round of ammunition, each of the resistors **108–112** representing a particular zone.

The resistors **108–112** and resistor **84** are interconnected and coupled to a source of positive voltage **114.** The resistors **108–112** have different ohmic values each corresponding to the particular zone represented. Each of the resistors **108–112** together with the switch arm **100** and a common resistor **116** connected between the switch arm **100** and a point of reference potential **118** consitute a voltage dividing network which provides a control signal voltage at the junction **120** between the switch arm **100** and resistor **116.**

The control signal voltage at the junction **120** is applied to a resistor **122** which is coupled to the input terminal **30** of the operational amplifier **32,** and to a resistor **124** which is coupled to the input terminal **34** of the operational amplifier **36.** Control signals are applied to resistors **92** and **94** from the output **90** of operational amplifier **76** and from the junction of resistors **82** and **84** respectively, and control signals will be applied to resistors **26** and **28** by the frequency to dc converter **18** upon initiation of firing of the weapon.

Upon initiation of firing, which will shortly be described, the voltages at the terminals **30** and **34** will initially be positive and the voltages at the output of operationals amplifiers **32** and **36** will initially be negative. These polarities, as well as those illustrated in the drawing have been chosen for this particular embodiment of the invention, but could be opposite or otherwise varied, as desired.

In preparing the weapon for firing a particular round of ammunition, the gunner or operator sets the switch **100** so that it makes contact with the particular contact **102–106** which represents the zone or round to be fired, and then loads the round into the weapon. The gunner then pulls the lanyard or otherwise triggers firing of the weapon. By means forming no part of the present invention, the driving mechanism and gas spring of the weapon system accelerate the recoilable parts forwardly in the direction of the target. As the recoilable parts move forwardly, the magnetic field of the permanent magnet in the sensing element **12** senses or interacts with the toothed surface of the rack **10** and generates in the coil in the sensing element **12** an alternating current (ac) signal, as depicted in the inset **126** (FIG. 2), whose frequency is proportional to the velocity of the recoilable parts and whose voltage is proportional to the clearance between the magnetic pickup **12** and the rack **10.**

The ac signal is fed via leads **14** and **16** into the frequency to dc converter **18** which generates individual direct current (dc) voltages, as depicted in the inset **128** and feeds these dc control signal voltages over leads **22** and **24** to resistors **26** and **28.** As the velocity of the recoilable parts increases, the summation of the control signal voltages at the terminals **30** and **34** becomes less positive and ultimately negative, so that when the proper firing velocity is reached the output **130** of the operational amplifier **32** will switch to a positive value thereby generating a signal to fire the round, and the output **132** of the operational amplifier **36** will likewise switch to a positive value thereby generating a signal to shut off a valve which is part of the mechanism for terminating forward acceleration of the recoilable parts.

Following the firing impulse, the firing cycle will be completed as described previously.

I claim:

1. In a weapon system having recoilable parts adapted for mounting a round of ammunition to be fired, nonrecoilable parts supporting the recoilable parts, and means for accelerating the recoilable parts relative to the nonrecoilable parts during a portion of a firing cycle, the combination comprising a toothed member mounted on one of said recoilable and nonrecoilable parts,

sensing means mounted on the other of said parts and sensitive to the toothed surface of said member during acceleration of the recoilable parts for generating a first electrical signal,

a delay circuit connected to a source of input voltage for generating a second electrical signal which is a function of temperature,

a plurality of networks each connectible for forming a voltage divider and each voltage divider having a terminal whose voltage constitutes a third electrical signal representative of an individual round of ammunition,

first control means responsive to said input voltage and said first, second, and third electrical signals for generating a fourth electrical signal to fire the weapon, and

second control means responsive to said first and third electricals signals for generating a fifth electrical signal to terminate acceleration of said recoilable parts.

2. A combination according to claim **1** wherein said toothed member is a rack constructed of ferrous metal and said sensing means comprises a magnetized element whose magnetic field intercepts said toothed surface.

3. A combination according to claim **1** wherein said delay circuit is a temperature sensitive operational amplifier circuit.

4. A combination according to claim **1** wherein said first electrical signal is an ac signal and said first control means comprises a frequency to dc converter connected to receive said ac signal and generating means responsive to the output of said frequency to dc converter and to said second and third electrical signals and said input voltage for generating said fourth electrical signal.

5. A combination according to claim **4** wherein said generating means comprises an operational ampilfier circuit.

6. A combination according to claim **1** wherein said first electrical signal is an ac signal and said second control means comprises a frequency to dc converter connected to receive said ac signal and generating means responsive to said frequency to dc converter and said third electrical signal for generating said fifth electrical signal.

7. A combination according to claim **6** wherein said generating means comprises an operational amplifier circuit.

8. In a soft recoil weapon system having recoilable parts adapted for mounting a round of ammunition to be fired, nonrecoilable parts supporting the recoilable parts, and means for accelerating the recoilable parts relative to the nonrecoilable parts during a portion of a firing cycle, the combination comprising a rack constructed of ferrous metal and mounted on said nonrecoilable parts,

a magnetized element mounted on the recoilable parts and having a magnetic field which intercepts the teeth of said rack during acceleration of the recoilable parts for generating a first electrical signal,

a temperature sensitive operational amplifier circuit, connected to a source of input voltage for generating a second electrical signal as a function of temperature,

a plurality of networks each connectible for forming a voltage divider and each voltage divider having a terminal whose voltage constitutes a third electrical signal representative of an individual round of ammunition,

first control means responsive to said input voltage and said first, second, and third electrical signals for generating a fourth electrical signal to fire the weapon, and

second control means responsive to said first and third electrical signals for generating a fifth electrical signal to terminate acceleration of said recoilable parts.

9. A combination according to claim **8** characterized further by the provision of a temperature sensitive impedance element connected in the feedback loop of said temperature sensitive operational amplifier.

10. A combination according to claim **8** wherein said first electrical signal is an ac signal and said first control means comprises a frequency to dc converter connected to receive said ac signal and an operational amplifier circuit responsive to the output of said frequency to dc converter and to said second and third electrical signals and said input voltage for generating said fourth electrical signal.

11. A combination according to claim **8** wherein said first electrical signal is an ac signal and said second control means comprises a frequency to dc converter connected to receive said ac signal and an operational amplifier circuit responsive to the output of said frequency to dc converter and to said third electrical signal for generating said fifth electrical signal.

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