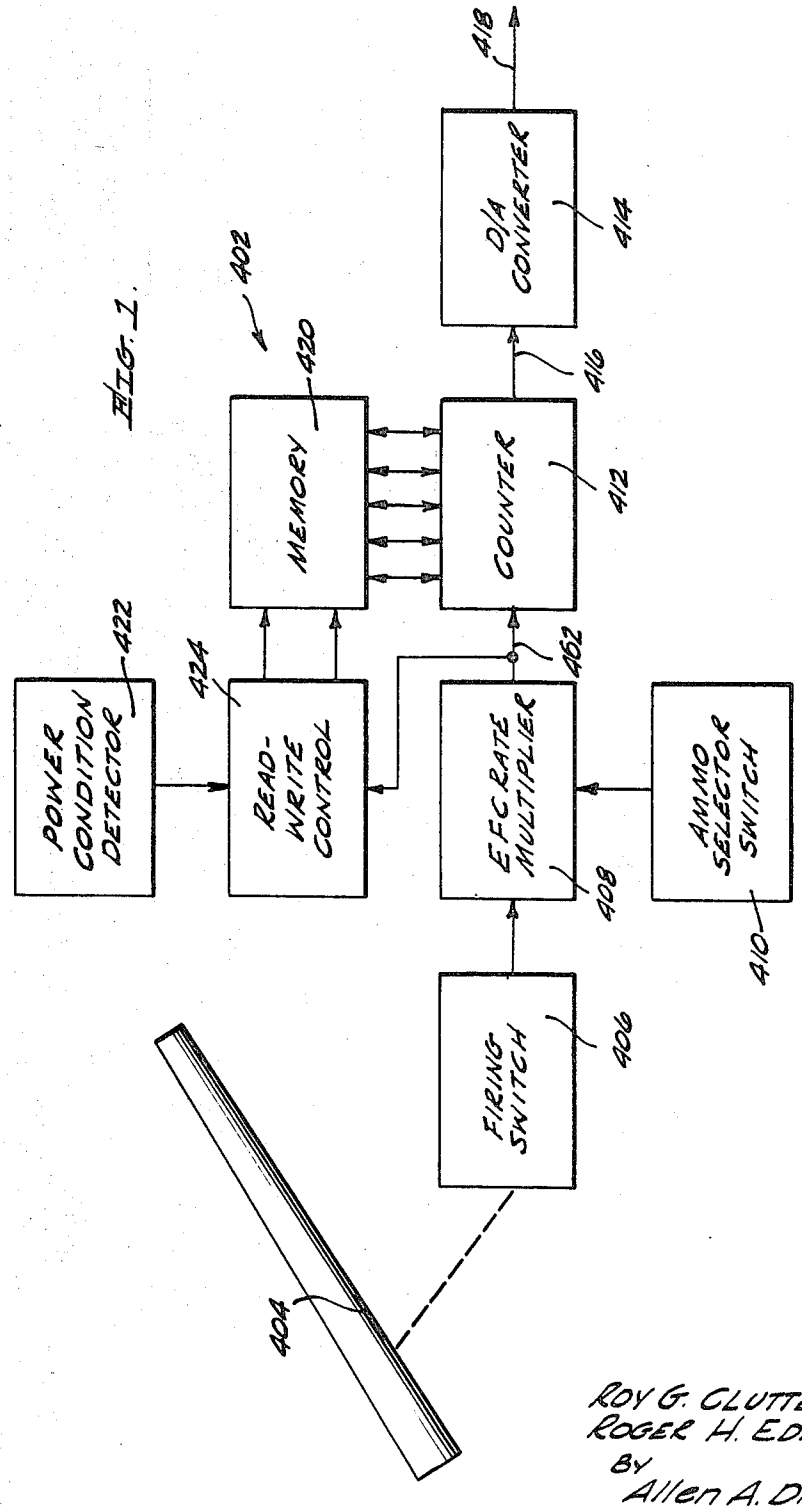
Nov. 3, 1970 R. G. CLUTTERBUCK ET AL 3,538,318

WEAR WEIGHTING FUNCTION GENERATOR FOR THE DETERMINATION OF THE PROPER AIMING OF A GUN

Filed Aug. 21, 1968 2 Sheets-Sheet 1

FIG. 1.



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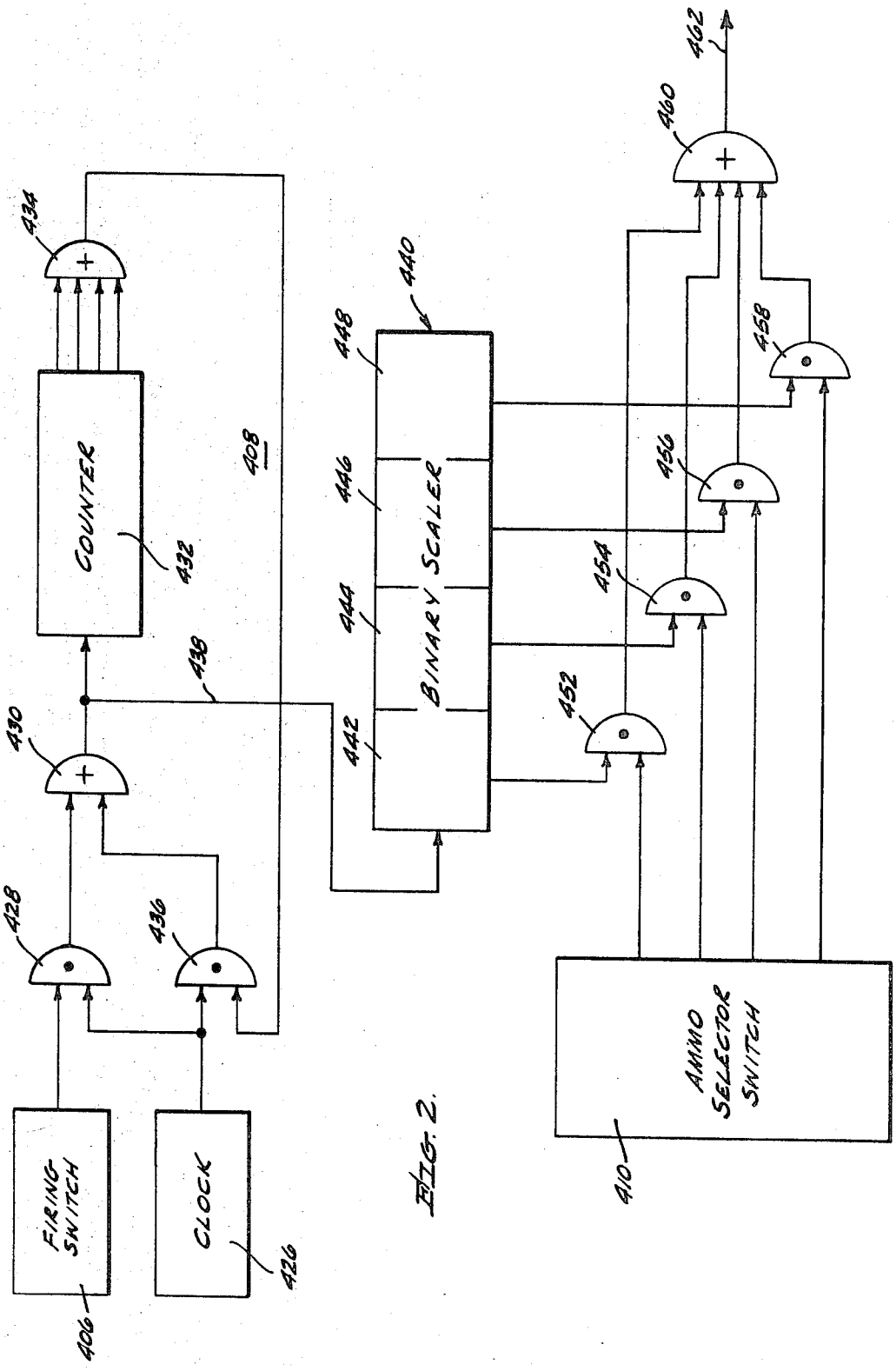


FIG. 2.

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WEAR WEIGHTING FUNCTION GENERATOR FOR THE DETERMINATION OF THE PROPER AIMING OF A GUN

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ABSTRACT OF THE DISCLOSURE

In determination of the proper aiming of a gun, the effects of wear in the gun tube caused by previous rounds must be considered. A firing sensor connected to the gun firing mechanism signals gun firing. An ammunition selector multiplies this gun firing signal by any selected one of a plurality of gun tube wear factors, depending upon the type of ammunition fired, to result in a gun tube wear factor for that particular round. These factors are totalized so that a counter carries the total wear factor accumulated since the gun tube was new. The counted total is stored in a non-volatile memory. The memory is preferably a ferrite core memory or the like, and the counter is a multibit solid-state counter. The counter output signal is connected to a digital-to-analog converter, the signal of which corresponds to gun tube wear since the gun tube was new, and is employed as a correction factor in the gun fire control computer.

BACKGROUND

This invention is directed to a wear weighting function generator which has an output signal which corresponds to the amount of wear in a gun tube, which signal can be employed as a correction factor in a gun fire control computer.

The velocity of a projectile as it leaves the muzzle of a gun is a function not only of the individual characteristics of the projectile and its driving charge, but it is also a function of the condition of the gun barrel. The change in muzzle velocity due to wear has been previously recognized, and previous gun computers have employed inputs corresponding to wear for the correction of gun direction. In the previous units, the gunner was required to periodically measure the gun bore, preferably both at the chamber end and at the muzzle end. After he compared these measurements with prescribed standards, he manually made an adjustment on the gun computer in accordance with his findings as to the state of wear. Of course, during battle, wear would proceed without giving the gunner the opportunity for these required periodic measurements. As a result, at the time when correct aiming was most needed, the change in muzzle velocity due to wear was not continuously updated and inserted into the gun computer, with adverse aiming effects. Other more sophisticated methods have also been attempted.

As an additional factor, gun computers are subject to shocks of high orders of acceleration. The gun shock itself, of course, it not permitted to put out of action the gun computer. Furthermore, a direct artillery hit upon the gun-supporting structure, which does not directly strike the gun computer should not put the gun computer out of service. Thus, those items directly damaged can be replaced and the gun will be back in service. Furthermore, if the hit is not of a critical nature, the gun can remain in service. Such resistance to high accelerations is best accomplished by the use of solid-state circuitry.

SUMMARY

In order to aid in the understanding of this invention, it can be stated in essentially summary form that it is directed to a wear weighting function generator which totalizes the wear in a gun tube resulting from the firing of a plurality of rounds therethrough, even when the rounds are of different wear-poducing nature, for employing the wear function as a correction in a gun fire control computation. The wear weighting function is generated by input signals representing both the number of rounds, and the wear-producing character of each individual round. These individual round wear factors are totalized in a counter, and a parallel non-volatile memory stores the weighted wear function so that a value corresponding to wear is remembered through power cessation. The output of a counter serves as an effective full charge signal for employment in calculation of change of muzzle velocity due to wear, as a correction factor to the gun fire control computer.

Accordingly, it is an object of this invention to provide a wear weighting function generator which employs several inputs, and totalizes them to hold a total count corresponding to the amount of wear in a gun tube. It is a further object to provide a non-volatile storage for the counted total wear function so that upon power failure, or normal system turn off, the number corresponding to total wear is retained. It is a further object to provide a solid state wear weighting function generator which is resistant to high accelerations, and still retains its count. It is still another object to provide a counter which totalizes a number corresponding to total wear, together with a parallel memory therefor so that the memory can serve to reset the counter as required. It is another object to provide a ferrite memory as the memory unit. Other objects and advantages of this invention will become apparent from a study of the following portion of the specification, the claims and the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing the wear weighting function generator.

FIG. 2 is a more detailed schematic drawing showing the details of the effective full charge multiplier as it is related to the rest of the generator.

DESCRIPTION

The wear weighting function generator of this invention is generally indicated at **402** in FIG. 1. It is associated with gun **404** which has a bore which wears out upon firing thereof. Presuming that the gun **404** is capable of firing a plurality of different types of ammunition, and these different types cause different amounts of wear for each shot, it is necessary to provide signals relating to the type of ammunition, and relating to the number of firings.

Firing switch **406** is mechanically connected to gun **404** so that it momentarily closes upon each gun firing. Preferably, it is actuated by the recoil mechanism of the gun. Thus, a firing signal is transmitted to the effective full charge rate multiplier **408** upon the firing of each round. Another signal delivered to the EFC multiplier is from ammunition selector switch **410**.

Assuming four different types of ammunition to be fired through gun **404**, exemplary values of wear rates and wear multipliers are given in the table below:

Ammunition	Rounds to wearout	Wear multiplier
A1	250	12
A2	375	8
A3	200	15
A4	500	6

The number of rounds to wearout, for particular ammunition, is found experimentally. Any convenient means to determine wearout of the barrel can be used, including micrometer measurement of the gun bore, or by change in muzzle velocity, as compared to a new barrel. The least common multiple of the number of rounds to wearout is 3,000. The wear multiplier in the table is the least common multiple divided by the number of rounds of a particular ammunition to wearout. Thus, the wear multiplier is a relative value of wear in the gun barrel, which relates the amount of wear caused in the barrel by the different ammunitions.

With input signals from the firing switch **406** and ammunition selector switch **410**, the effective full charge rate multiplier multiplies the round fired by its wear multiplier. This amount of effective full charge by that particular round is delivered to counter **412** which totalizes the effective full charge units received from the EFC rate multiplier. This amount of effective full charge by that particular round is also applied to the read-write control **424** in order to initiate the write operation, thereby allowing the counter **412** to update the memory **420**. Output of counter **412** is delivered to digital-to-analog converter **414**, which is similar to the digital to analog converter described in U.S. Pat. 2,993,202 issued July 18, 1961, by signal line **416** so that the output of wear weighting function generator **402** appears in signal line **418** as an analog value. It is suitably employed in a gun fire control computer to compensate aiming in accordance with the total wear of the barrel.

In view of the fact that guns to which such aiming equipment is applied are subject to power failure and are subject to being placed in storage with power shutdown for considerable periods, when counter **412** is of solid state, it normally loses count upon power shutdown. Thus, memory **420**, which may be similar to the memory described in U.S. Pat. 2,933,720 issued Apr. 19, 1960, is associated with counter **412** in order to provide the correct count to the counter after such a power shutdown. Power condition detector **422** is connected to the electric power source which serves to retain the count in the counter. Power condition detector **422** is connected to read-write control **424**, which is in turn connected to memory **420** for the purpose of providing in the memory a count of the total on counter **412** when power is off, and for the purpose of writing into the counter the count when power is restored. The power condition detector **422** may be similar to the circuitry shown in FIG. 3 of U.S. Pat. 3,321,747 issued May 23, 1967. Furthermore, the read-write control **424** may be similar to that described and shown from page 19–13 to page 19–21 in volume 2 of the Handbook of Automation Computation and Control published by John Wiley & Sons, Inc., New York (1959). Counter **412** can either update memory **420** with each count of memory **420** can be connected to interrogate counter **412** upon incipient power failure and store the memory in the counter. Memory **420** is preferably a ferrite core memory, although any convenient memory system can be employed.

Referring to FIG. 2, a schematic diagram in more detail of the effective full charge multiplier is shown therein, in connection with associated equipment. Clock **426** either generates a square wave of appropriate frequency, or squares off an available frequency. In some equipment with which the wear weighting function generator is employed, 400 cycle alternating current is available. In such cases, clock **426** need only square the available freqency. The output from firing switch **406** and clock **426** are inputs to AND gate **428**. The output of AND gate **428** goes to OR gate **430**. The output of OR gate **430** is connected to counter **432**.

In the example illustrated, counter **432** is a four-bit counter capable of counting to 16. The four outputs from the four bits of counter **432** are connected to OR gate **434**. The output of OR gate **434** is connected to AND gate **436** which also receives the clock signal as an input thereto. The output of AND gate **436** is the other input to OR gate **430**. Counter **432** has at least one high state output whenever the count thereon is other than zero. Thus, as long as the count is other than zero, there is a signal to OR gate **434**, which provides energization to AND gate **436** so that the clock pulse passes through OR gate **430** to keep the counter **432** counting. This continues until the full count of 16 is made by the counter, when all of the counter outputs are at zero so that there is no output from OR gate **434** into AND gate **436**. Thereupon, the counter stops until the next firing switch energization. This system provides 16 pulses in line **438** each time firing switch **416** is actuated.

Line **438** is connected to the input of binary scaler **440** which has sections **442**, **444**, **446**, and **448**, which may be bistable multivibrators or flip-flops. Thus, each time counter **432** goes through its 16 counts, it delivers 8 counts to AND gate **452**, 4 counts to AND gate **454**, 2 counts to AND gate **456**, and 1 count to AND gate **458**. The ammunition selector switch **410** is connected to each one of AND gates **452** through **458** so that the number of counts desired can be selected by selecting particular ones of the AND gates.

The following table indicates the switch pattern of the ammunition selector switch to obtain the desired number of counts. To accomplish this switch pattern, the ammunition selector switch **410** may comprise four manually operable two-position switches (not shown), each having a "0" output when open and a "1" output when closed. The switch pattern indicates the high or low state of the lines from the ammunition selector switch to AND gates **452** through **458**, reading from top to bottom in FIG. 2.

Ammunition	No. of counts desired	Switch pattern
A1	12	1100
A2	8	1000
A3	15	1111
A4	6	0110

The outputs of AND gates **452** through **458** are connected to OR gate **460** so that the output is totalized and the signal into line **416** is the effective full charge count for the round just fired, and as previously stated, this is delivered to counter **412** through signal line **462** to add to the count on counter **412** the factor corresponding to wear for the firing of the latest round. As a round having a different wear factor is loaded, the ammunition selector switch **410** is changed to a position corresponding to the new round, so that upon firing thereof the wear factor for that round is totalized in counter **412**.

This invention having been described in its preferred embodiment, it is clear that it is susceptible to numerous modifications and embodiments within the ability of those skilled in the art and without the exercise of the inventive faculty. Accordingly, the scope of this invention is defined by the scope of the following claims.

What is claimed is:

1. A wear weighting function generator for totalizing and emitting a signal corresponding to wear caused on a unit by separate acts which each cause a different but predetermined amount of wear on the unit, said wear weighting function generator comprising:

a detector for detecting an act on the unit;

a selector for selecting a value related to the amount of wear caused by the act on the unit;

a multiplier, said detector and said selector being connected to said multiplier so that the multiplier multiplies the number of acts times the value related to the amount of wear;

a counter, said multiplier being connected to said counter so that said counter totalizes the products received from said multiplier;

a memory connected to said counter, said memory

storing the count of said counter so that upon loss of count by said counter said memory can reset said counter, said counter emitting a signal corresponding to the number of acts causing wear on said unit each times its wear factor so that the emitted signal is related to total wear on said unit.

2. The wear weighting function generator of claim 1 wherein said counter is a solid-state counter which is subject to loss of count upon power failure, and said memory is a non-volatile memory so that said memory holds the count during periods of power cessation and can reset said counter.

3. The wear weighting function generator of claim 2 wherein a power condition detector is connected to the source of power which powers said counter, said power condition detector being connected to a read-write control, said read-write control being connected to said memory so that upon power cessation, said memory retains the count of said counter, and upon restoration of power, said power condition detector causes said memory to reset said counter to the remembered value.

4. The wear weighting function generator of claim 3 wherein said unit is a gun capable of firing different ammunitions which cause different amounts of wear, said detector is a firing switch which is connected to said gun and detects each firing of said gun, and said selector is an ammunition selector switch which is settable to different values in accordance with the relative wear of the different types of ammunition firable by said gun, so that the signal emitted by said counter is related to the total amount of wear in said gun.

5. The wear weighting function generator of claim 1 wherein said multiplier comprises a counter, said act detector and a clock having an input to said counter, the output of said counter being connected to the input of said counter so that said counter counts to one more than its full count and thereupon stops so that the input to said counter receives as many pulses as the full count of said counter, a binary scaler connected to the input of said counter, said binary scaler having a plurality of outputs, each emitting a number of counts, said outputs of said scaler being connected to scaler output AND gates, said selector being connected to said scaler output AND

gates to energize particular ones of said scaler output AND gates, the outputs of said scaler output AND gates being summed together in a summer so that said selector selects the number of counts out of said summer.

6. The wear weighting function generator of claim 5 wherein there are first and second AND gates, said clock being connected to said first and second AND gates, said detector being connected to said first AND gate and the output of said counter being connected to the input of said second AND gate, the outputs of said first and second AND gates being connected together to a counter input OR gate, with the output of said counter input OR gate being connected to the input of said counter, the output of said counter input OR gate being also connected to the input of said binary scaler.

7. The wear weighting function generator of claim 6 wherein said unit is a gun, and said detector is a firing switch which emits a signal each time said gun is fired so that upon gun firing said counter is energized through said first AND gate.

8. The wear weighting function generator of claim 7 wherein said selector is an ammunition selector switch connected to said scaler output AND gates so as to energize appropriate of said scaler output AND gates in accordance with the relative wear of a particular type of selected ammunition fired in said gun.

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